6. Contaminant Fate and Transport

This section presents the fate, transport, and potential migration pathways of the COPCs at OU2. The discussion is based on the OU2 hydrogeologic conceptualization and the contaminant source identification to provide a framework for subsequent risk evaluations.

An accurate conceptual site model (CSM) can provide a good understanding of the migration and persistence of COPCs in the subsurface at OU2 that is critical to assess the potential impacts to human health and ecological effects. In addition, the CSM can also be adopted as a tool for identification and development of potential remedial alternatives at OU2. The discussion in Section 6 is organized into the following subsections:

- **Section 6.1, Contaminant Transport Processes** – This subsection discusses the factors that influence contaminant transport of the COPCs.
- **Section 6.2, Physical and Chemical Properties of COPCs** – This subsection discusses the sensitivity of physical and chemical properties of the contaminants and their behavior in groundwater.
- **Section 6.3, Fate and Transport in Groundwater** – This subsection presents the migration pathways of COPCs in groundwater.
- **Section 6.4, Migration in Vapor Phase** – This subsection discusses the volatilization of COPCs from shallow groundwater and their vapor-phase transport through the vadose zone.
- **Section 6.5, Groundwater Flow and Solute Transport Model** – This subsection discusses the development and results of the Omega Site groundwater flow and solute transport model.
- **Section 6.6, Conceptual Model of Contamination at OU2** – This subsection presents a summary of the OU2 contamination CSM and COPC migration pathways.

### 6.1 Contaminant Transport Processes

Subsurface contaminant movement depends on both the site environmental, physical, chemical, and biological characteristics and the contaminant chemical properties. Migration pathway, mobility, and persistence are chemical dependent and are also affected by site environment factors, including pH, concentration of other chemicals, oxidation-reduction potential, groundwater geochemistry, organic matter content, and the presence of microorganisms. Mobility is the potential for a contaminant to migrate from a source, and persistence is a measure of how long a contaminant will remain in the environment.

The main sources of information on transport processes used in this report are Kehew, 2001; Zheng and Bennett, 1995; and Domenico and Schwartz, 1990. Figure 6-1 presents some of the potential contaminant fate and transport mechanisms conceptually.
6.1.1 Vadose Zone

At OU2, contaminants occur in the vadose zone mainly at the locations of their release (i.e., source areas). VOCs can also volatilize from groundwater and their vapors can migrate by diffusion from the water table to the ground surface.

Contaminants released at the source areas have infiltrated into the subsurface and migrated generally downward by gravity through the vadose zone. When low-permeability soil units are encountered, the contaminants can also spread laterally along the permeability contrast.

The CVOCs may have been released as DNAPLs or dissolved in water. DNAPLs are expected to partition into pore water, soil, and vapor; equilibrium between all phases can be assumed because the movement of the contaminants is slow relative to the partitioning. PCE and TCE as DNAPLs are expected to migrate through even low permeability soils due to their low viscosity (Kehew, 2001) and high density (Table 6-1); however, DNAPL migration will cease when its saturation in soil decreases and its distribution becomes discontinuous. This residual (discontinuous, immobile) DNAPL can remain in soil for extended periods of time and act as a continuous source of contamination dissolved in pore water. When the soil moisture content is low, pore water movement becomes limited and contamination dissolved in pore water and sorbed to soil can also remain in the vadose zone for long time periods. Vadose zone contamination can thus present a long-term source of shallow groundwater contamination.

VOCs with high vapor pressure (Table 6-1) are expected to volatilize from shallow groundwater and migrate as vapors through the vadose zone. Volatilization from groundwater can result in potential exposure to contaminant vapors in buildings. Higher VOC vapor concentrations and higher contaminant mass flux into buildings would be expected in areas of shallow groundwater with high VOC concentrations. Groundwater with low VOC concentrations, deep or confined groundwater is not expected to present a potential for substantial upward migration of VOC vapors. Volatilization from groundwater in areas away from the source of contamination is expected to be limited by the rate of the contaminant diffusion from groundwater (Figure 6-1).

6.1.2 Saturated Zone

VOCs can be present as nonaqueous phase liquids (NAPLs) or dissolved in groundwater. NAPL presence is expected to be limited to the source areas only, if at all, while dissolved VOCs and other contaminants are present over the entire OU2.

The movement of contaminants dissolved in groundwater is controlled by the mechanisms of advection and hydrodynamic dispersion. Among these mechanisms, advection is the dominant factor that transports the plume in the direction of groundwater flow in the predominantly sandy aquifers at OU2.

6.1.2.1 Advection and Hydrodynamic Dispersion

Advection is the transport of a solute (or dissolved contaminant) by groundwater flow at a rate equal to the velocity of the flowing groundwater. It is the dominant transport mechanism for the contaminants at OU2.
Hydrodynamic dispersion is a combination of mechanical dispersion and molecular diffusion. Dispersion is the effect of non-uniform distribution of flow velocities at the pore scale and also due to aquifer heterogeneities. It results in the spreading of solute along (longitudinal dispersion) and perpendicular (transverse) to the direction of groundwater flow. Increased dispersion results in a larger volume of contaminated aquifer and lower concentrations. Longitudinal dispersion is typically one to two orders of magnitude greater than horizontal transverse dispersion, which, in turn, is one to two orders of magnitude greater than vertical transverse dispersion (Zheng and Bennett, 1995).

Diffusion is driven by the solute concentration gradients according to Fick’s Law. Diffusion is a slow process relative to advection in the highly permeable aquifers at OU2.

6.1.2.2 Sorption

Sorption is the tendency for a chemical to adsorb to the aquifer grains. VOCs are known to adsorb to organic carbon, but also to mineral surfaces and in the vadose zone to the interface between air and water. Because the phase partitioning is fast relative to the advective transport of VOCs, local equilibrium (i.e., instantaneous sorption and desorption) can be assumed. Sorption to organic carbon can be described by a linear partitioning coefficient, $K_{oc}$. Ionic sorption is the main adsorption mechanism for inorganic COPCs.

Sorption reduces the rate of contaminant migration as the solute continuously sorbs and desorbs to maintain local equilibrium. This reduction in migration rate is referred to as retardation of contaminant in groundwater. Sorption properties of the COPCs are shown in Table 6-1. As shown in Table 6-1, all of the COPCS in OU2 have relatively low organic carbon partition coefficients and are not expected to readily sorb to the soil particles. The organic content in the sediments at OU2 is expected to be low, further inhibiting the sorption capacity.

VOCs also adsorb to mineral surfaces, so some sorption is expected even if organic carbon content is low. For PCE, the threshold of organic carbon content is 0.0002 for surfaces of organic materials to be the primary sorption sites. However, sorption onto mineral surfaces is difficult to quantify (Fetter, 1993). The remedial investigation at Omega OU1 (CDM, 2007a) included the collection of 53 samples for the analysis for TOC. The TOC ranged from 510 to 5300 mg/kg, with an average of 1,693 and a median of 1,600 mg/kg (corresponding to mass fractions ranging from 0.0005 to 0.005 with an average of 0.0016). The TOC fractions in the fluvial sands throughout OU2 are expected to be lower than the TOC fractions in the fine-grained alluvial fan deposits at OU1. TOC fractions in soil samples collected near the water table at the OFRP site ranged from 0.0003 to 0.0025 with an average of 0.001. These results indicate that VOC sorption to organic carbon occurs in the groundwater at OU2, but it is not a major factor controlling the contaminant migration.

6.1.2.3 Degradation

Degradation of contaminants is a biochemical or chemical oxidation-reduction reaction within the subsurface. Naturally occurring bacteria within groundwater use organic chemicals as food sources and help break down contaminants into degradation products. Abiotic processes lead to the degradation of chlorinated VOCs without the production of the daughter products associated with the biodegradation pathways; for example, reduced iron reacts with chlorinated VOCs (Matheson and Tratnyek, 1994). Vogel et al. (1987) identified
other strictly abiotic processes, such as dehydrohalogenation and hydrolysis, neither of which involves a transfer of electrons. Dehydrohalogenation is the loss of a chlorine and an adjacent hydrogen ion, forming a C-C bond; it transforms 1,1,1-TCA into 1,1-DCE. The product of degradation by hydrolysis is acetic acid (Vogel et al., 1987). Contaminant concentrations can be reduced by degradation, but some of these processes also increase the concentrations of other contaminants that are degradation products.

Depending on the types of organic compounds, degradation may occur under aerobic and anaerobic conditions. Oxygen is needed for aerobic organisms to degrade organic compounds. Under the aerobic degradation processes, electrons will be transferred from the organic material to oxygen (electron acceptor). This process reduces oxygen and transforms the organic material to carbon dioxide and a new compound. The anaerobic degradation process is similar to the aerobic degradation process except that other common electron acceptors, such as nitrate, sulfate, and inorganic carbon, are used instead of oxygen (Kehew, 2001).

Figures 6-2 and 6-3 present the biological degradation pathways for the chlorinated compounds present at OU2, such as PCE, TCE, cis-1,2-DCE, and carbon tetrachloride. Reductive dechlorination is the primary biological degradation process for these COPCs, where the chlorinated compound is converted to another chemical by replacing chlorine atoms with hydrogen atoms. The sequential reduction of chlorinated VOCs eventually leads to the production of innocuous end-products such as ethene, ethane, and carbon dioxide. Reductive dechlorination occurs in anaerobic environments (Kehew, 2001). Potential biological degradation of the COPCs at OU2 is discussed in Section 6.3.2.

### 6.2 Physical and Chemical Properties of COPCs

The fate and transport of COPCs in OU2 is affected by physical, chemical, and biological processes of the compounds or subsurface environments. The applicable properties, including the solubility, vapor pressure, density, and sorption, are listed in Table 6-1. Discussion of each property is briefly described as follows.

#### 6.2.1 Water Solubility

Water solubility is the maximum quantity of a chemical that can dissolve in a fixed quantity of water at a given temperature and pH. Solubility is compound dependent. The chemical 1,4-dioxane is miscible in water; its concentrations are not limited by solubility. MTBE, NDMA, and perchlorate are highly soluble and PCE and TCE are less soluble in water. Contaminants with low solubility may be present in the vadose and saturated zone as pools or droplets of NAPL. Hexavalent chromium is soluble in the form of complex anions (hydrochromate, chromate, or dichromate) (EPA, 1998).

#### 6.2.2 Vapor Pressure/Henry’s Law Constant

Evaporation of a chemical can occur wherever a contaminant is exposed to the atmosphere, generally at the ground surface, in the vadose zone, and at the water table. Vapor pressure provides an indication of the rate at which a chemical volatilizes. Chemicals with higher vapor pressures are expected to enter the atmosphere much more readily than chemicals with lower vapor pressures. Henry’s Law constant (H) is a conventional measure of
volatility, and defines the potential for a dissolved contaminant to evaporate. H is more accurate than vapor pressure in estimating releases from water to air. Chemicals with H values higher than \(10^{-3}\) atmosphere-cubic meter per mole (atm-m\(^3\)/M) indicate a greater tendency for a dissolved contaminant to partition into the vapor phase. Compounds with relatively high H and low solubility, such as PCE, TCE, benzene, Freon 11, Freon 113, and carbon tetrachloride (Table 6-1) easily volatilize from water to air; whereas 1,4-dioxane, 1,2,3-TCP, and NDMA are relatively non-volatile due to their low H values and high solubility. Perchlorate is a salt and does not volatilize.

6.2.3 Density and Viscosity

Most of the COPCs, such as PCE, TCE, Freon 11, and Freon 113 are denser than water. When present in free phase, these compounds would form DNAPL, which has a potential for gravity-driven vertical migration through soils. Because of the high density and low viscosity (relative to water) of the chlorinated hydrocarbons found at the highest concentrations at the Omega Site (such as PCE and TCE), DNAPLs would have the ability to flow through fine-grained soils faster than groundwater. However, the density of these compounds has a negligible effect when they are dissolved in groundwater. For example, PCE at its solubility (150,000 µg/L) increases the density of pure water by only about 0.0057 percent. Naturally occurring dissolved inorganic compounds have much greater effect on the density of groundwater than dissolved PCE.

6.3 Fate and Transport in Groundwater

This subsection provides a discussion of the migration and transformation of 1,1,1-TCA, PCE, TCE, Freon 11, Freon 113, 1,4-dioxane, and hexavalent chromium within OU2. These contaminants are the focus of this subsection because they are generally present at higher concentrations and/or frequency at OU2 compared to the remaining COPCs. Hexavalent chromium is discussed because its transport characteristics differ from those of VOCs. The results of this assessment are used as initial input to the numerical flow and transport model presented in Section 6.5.

6.3.1 Contaminant Migration

The Omega Site history and estimated extent of the contamination in groundwater provide an indication of the contaminant migration rate. The following discussion is focused on two of the major sources of contamination at OU2 with documented history of operations and hazardous substance releases—the Omega property and the former Angeles and McKesson facilities. The AMK are treated as one source area of contamination at OU2 because the properties are adjacent, used similar chemicals, and operated over similar time frames. Other sources of contamination are known to exist west of AMK and elsewhere at OU2 (Section 5.5). Contaminant releases from these facilities are believed to have followed pathways overlapping or parallel to those from AMK and the former Omega Chemical property, and the contaminants from all these sources have commingled throughout OU2 (the mixing is enhanced by transverse dispersion). The hazardous substance releases at the former Omega property and AMK are used for the estimation of the apparent plume expansion rate and advective velocity at OU2 because they are located approximately along the same migration pathway. The purpose of this evaluation is to (1) estimate the apparent
plume expansion rate so that the future plume movement can be predicted, (2) estimate the advective velocity at OU2, and (3) demonstrate the rationale for the commingling of contamination from various sources.

The times when contamination first impacted groundwater and how the mass fluxes of contaminants into the aquifer varied over time (i.e., the contaminant mass release history) at Omega and Angeles/McKesson are unknown. For the rate calculations, it was assumed that groundwater was impacted at both Omega and AMK during the first year of operation, 1976 (the former Omega facility and AMK started their operations in the same year). Because 1,4-dioxane was used as solvent stabilizer, it can be assumed that groundwater was impacted with PCE, TCE, and 1,4-dioxane at the same time. Similarly, the same (or nearly the same) time of groundwater impact can be expected for the parent compounds and their degradation products (e.g., PCE and TCE, and their daughter products such as 1,1-DCE and cis-1,2-DCE).

For the purpose of the plume expansion rate and advective velocity estimation, the plume length was defined as the distance from the Omega and AMK source areas along the main transport pathway (i.e., plume centerline) to the leading edge of the plume in 2007 shown by the 5 µg/L contour (3 µg/L contour for 1,4-dioxane). The 5 µg/L contour is an arbitrary definition of the plume. For example, PCE has much higher concentrations at the Omega property than Freon 113, and for that reason, the 5 µg/L PCE contour is farther downgradient and also extends farther laterally than the same contour for Freon 113. A simple solute transport model illustrates this difference (Figure 6-4).

The thickness of the plume is another indication of the source of the contaminants; the contamination from the former Omega facility (including Freons) has spread over a considerable saturated thickness in the area upgradient of AMK (e.g., at Well MW23) while the AMK contamination seems to be limited to shallow groundwater (Figure 4-7).

The increasing VOC concentrations in the peripheral wells at McKesson over time (see time series for MW-01, MW-02, and MW-03 in Appendix J) indicate the spreading of the high-concentration zone extending from the former Omega facility.

6.3.1.1 Advective Velocities Estimated by Monte Carlo (MC) Simulation

Advective velocity (v) of a sorbing compound (such as PCE, TCE, Freons, etc.) in a porous medium can be calculated using the relation,

$$v = \frac{K \Gamma}{n R}$$

where the hydraulic conductivity K has units of length/time (ft/d in this calculation) and the remaining variables (i = gradient, n = effective porosity, and R = retardation coefficient) are dimensionless.

Because there is a range of plausible values for each of the input variables, an MC-type simulation is the preferred way for estimating the probable value of the advective velocity. Major advantages of results from a MC simulation derive from two factors. First, establishing the range and distribution of input variables is a transparent process, based on a range of reasonably expected values, taken from the literature and a range of site-specific measures. Second, and perhaps even more important, the simulation generates a
distribution of results which can be probabilistically assessed. The methodology and results
of the simulations are presented in Appendix J.3. Based on the MC simulations, the most
probable value of the average advective velocity (accounting for sorption) across OU2 is
620 feet per year (ft/y). The MC simulations provided consistent best estimates, regardless
of assumed input distribution, and indicated a broad range of possible velocities.

6.3.1.2 Advective Velocities Estimated by Analytical Solute Transport Modeling
To estimate the advective transport velocity in groundwater at OU2, the transport of
selected compounds was simulated using a two-dimensional analytical solute transport
model (Wexler, 1992).

The simulations were based on additional simplifying assumptions, including the following:

• Source concentrations at Omega and AMK (Table 6-2) were constant between 1976 and
2007.

• The selected compounds do not sorb (sorption was included in one comparison
simulation only) nor degrade.

• Porosity of 0.3, longitudinal dispersivity of 100 feet, and transverse dispersivity of 5 feet
are uniform at OU2. The porosity and longitudinal dispersivity values were assumed,
and longitudinal dispersivity value was selected to approximately match the observed
PCE plume width in the model.

• The gradient of 0.0049 ft/ft has been uniform at OU2 between 1976 and 2007. The
gradient was measured over OU2 in 2007.

The distances from the source area (Omega or AMK) to the plume edge in 2007 for the
selected compounds are shown in Table 6-2. Hydraulic conductivity was varied to achieve a
fit between the calculated and observed plume length for each compound (e.g., to calculate
PCE concentration of 5 µg/L at a distance of 23,400 feet from Omega along the plume
centerline). The results are shown in Table 6-3. The calculated concentration versus distance
profile for Freon 113 is shown in Figure 6-5.

The PCE transport from Omega was also simulated using the advective velocity of 511 feet
per year estimated for the transport of Freon 113. Using this model, the calculated PCE
concentration at the leading edge of the plume at 23,400 feet from Omega was 0.17 µg/L,
less than the 5 µg/L at this distance. The 5 µg/L contour for PCE simulated in this scenario
would be 21,900 feet from Omega.

In a simulation of PCE transport from both Omega and AMK (by linear superposition of the
two sources), advective velocity of 420 feet per year was required to match the PCE
concentration of 5 µg/L at the plume leading edge. This velocity is also considered
unrealistic, because it is substantially lower than the advective velocity required for the
transport of Freon 113 in the model.

Because of the simplifying model assumptions, mainly the uniform source concentrations
over time, the model results should only be used for the relative comparison of transport
velocities for the selected compounds.
The results lead to the following conclusions:

- The velocities estimated for the transport from the former Omega facility to the leading edge of the plume are consistent with the advective velocity calculated by the MC method.

- The hydraulic conductivity values used in the model to simulate the plume length fall within the range of values estimated from aquifer tests conducted in OU2. Therefore, these values and their corresponding advective velocities are considered plausible. It is noted that a slightly lower value of effective porosity, such as 0.2, would be plausible for the OU2 aquifer material; the corresponding hydraulic conductivities for the same advective velocities would still be within a plausible range for OU2.

- If sorption at OU2 was significant (but not accounted for in the mode), the more sorbing compounds (e.g., Freon 113) would require higher velocity in the model to match the observed plume length than the non-sorbing compounds (e.g., 1,4-dioxane). The results indicate that sorption is not significant because 1,4-dioxane required higher velocity than sorbing compounds such as Freon 113, cis-1,2-DCE, and PCE, also the less sorbing TCE required higher velocity than the more sorbing PCE and Freon 113. Sorption (represented by a retardation factor of two) results in much higher simulated velocity required for Freon 113 (1,022 feet per year) than is required for 1,4-dioxane (680 feet per year); this is further indication that sorption is insignificant at OU2. Advection and hydrodynamic dispersion are thought to affect the transport of VOCs at OU2 to a much greater degree.

- The transport of Freon 113 from the Omega property requires higher velocity than the transport from AMK of all the remaining compounds considered; this indicates that groundwater at AMK was impacted later than groundwater at the Omega property because otherwise the AMK contamination would have traveled farther that the current leading edge of the OU2 plume. The additional simulation of PCE transport from the Omega property using the advective velocity estimated for Freon 113 shows that the simulated PCE plume reaches the leading edge of the observed plume, although at lower concentrations than 5 µg/L. This also indicates that contamination from both the Omega property and AMK (and other sources) has likely commingled near the leading edge of the OU2 plume.

### 6.3.1.3 Apparent Plume Expansion Rate

The apparent plume expansion rate along the flow path in shallow groundwater represents the rate of advance of the plume leading edge over time. This expansion rate accounts for all sources of contamination and includes the effects of solute transport processes such as advection, dispersion, sorption, and degradation; this rate can be either faster or slower than the groundwater velocity at OU2.

The plume expansion rates are calculated as the distance from the Omega property or AMK divided by 31 years (i.e., contaminant transport time from 1976 to 2007). If groundwater was first impacted at a later time than the first year of operation at the Omega property or AMK (i.e., 1976), the actual plume expansion rate is faster than the rate calculated in Table 6-2. However, without historical information on the plume advance over time, it is not possible to determine its actual expansion rate. The objective of this evaluation was to estimate the
minimum plume expansion rate; as noted previously, the actual rate could be higher and may also vary over time.

The estimated plume expansion rates are an empirical quantification of the advance of the commingled OU2 plume. This rate will become an important consideration in the development of the OU2 groundwater remedy.

Table 6-2 summarizes the distances of the leading edge (5 µg/L) of the TCE, PCE, Freon 11, Freon 113, cis-1,2-DCE, 1,1-DCE, chloroform, and 1,4-dioxane plumes from the source areas of the former Omega facility and AMK; it also shows the data for hexavalent chromium transport from Foss Plating. Generally, the expansion rates calculated for different compounds from their respective plume lengths measured from the Omega property are expected to be similar; a significantly higher rate for a particular compound would be indicative of AMK being also source of contamination of this compound.

Table 6-2 also shows the reduction of contaminant concentrations over the distance traveled, which can be indicative of a common source area for different contaminants. The plume expansion rates for the individual compounds are discussed as follows.

**Freon 11 and Freon 113 Plume Expansion Rate**
The downgradient extent of Freon 11 and Freon 113 is subject to uncertainty (Section 5.7.3). Based on the available information, the former Omega facility is the only known source of Freons at OU2. The plume expansion rates for Freon 11 and Freon 113 are estimated to be 530 and 620 feet per year, respectively, similar to the plume expansion rates for PCE and TCE calculated for transport from AMK.

**PCE and TCE Plume Expansion Rate**
The measured distances in 2007 of the leading edge PCE and TCE plumes (5 µg/L) are 24,236 and 23,394 feet, respectively, downgradient from the former Omega facility, and 16,917 and 16215 feet, respectively, downgradient from AMK. The plume expansion rates for PCE and TCE are 520 and 550 feet per year, respectively. The rates for both PCE and TCE calculated for the distance from the Omega property seem to be overestimated because they are much higher than the rates calculated for Freons and are not considered representative of the minimum expansion rate.

**1,1-DCE Plume Expansion Rate**
The chemical 1,1-DCE is a daughter product of PCE. Its main sources are at the former Omega facility and AMK. The apparent plume expansion rate is 480 feet per year for the distance from AMK to the leading edge of the 1,1-DCE plume. The rate of 700 feet per year calculated for the distance from the former Omega facility seems to be overestimated and is not considered representative (it is also similar to the rate calculated for PCE and TCE).

**1,4-Dioxane Plume Expansion Rate**
The 1,4-dioxane plume expansion rate calculated for the transport from AMK is 530 feet per year, similar to the rates for PCE and TCE. The rate of 770 feet per year calculated for the transport from the former Omega facility is not considered representative (it is similar to the rates calculated for PCE, TCE, and 1,1-DCE).
Cis-1,2-DCE Plume Expansion Rate
The cis-1,2-DCE plume expansion rate calculated for the transport from AMK is 380 feet per year, lower compared to the rates for 1,4-dioxane, 1,1-DCE, PCE, and TCE; the rate of 610 feet per year calculated for the transport from the former Omega facility is higher than the rates calculated for Freons and lower than the rates calculated for PCE and TCE. These rates are not considered representative.

Hexavalent Chromium Plume Expansion Rate
The hexavalent chromium migration rate calculated for the transport from Foss Plating is 260 feet per year. The migration rate is lower than the rates calculated for VOCs. This may be an indication that its release occurred later than assumed, but the lower migration rate may also result from the effect of ionic sorption that retards the transport of hexavalent chromium by its adsorption to free iron and manganese oxides in clayey soils; however, in general, hexavalent chromium is highly mobile in soils (EPA, 1992).

The evaluation of the apparent plume expansion rates for the selected compounds indicates that the following:

• The average minimum plume expansion rate is 540 feet per year; this is the minimum distance the plume leading edge is expected to advance in 1 year.

• The apparent plume expansion rates for (relatively) highly sorbing compounds (Freon 113 and PCE), less sorbing compounds (TCE, Freon 11), and nonsorbing compounds (1,4-dioxane) are very similar. This indicates that sorption (i.e., retardation) of these compounds is not significant at OU2.

• The decreases of PCE and cis-1,2-DCE from the source concentrations to the 5 µg/L level are greater decreases than those of TCE, Freons, 1,4-dioxane, and 1,1-DCE concentrations. This indicates that at OU2, PCE, and cis-1,2-DCE likely degrade more than the other compounds considered.

• The average minimum plume expansion rate is slightly less than the 50th percentile advective velocity calculated by the MC method, indicating that the estimated expansion rate is plausible.

6.3.2 Contaminant Degradation
Figures 6-2 and 6-3 present the degradation pathways for the chlorinated compounds found at OU2. Reductive dechlorination is the primary biological degradation process for these COPCs, where the chlorinated compound is converted to another chemical by replacing chlorine atoms with hydrogen atoms. The rate of reductive dechlorination decreases as the compound becomes less chlorinated. For example, the more complex chemicals, such as PCE and 1,1,1-TCA, break down faster than less complex compounds such as vinyl chloride. Reductive dechlorination mainly occurs in anaerobic (low-oxygen) environments.

A discussion of potential biological degradation of the chlorinated COPCs follows. Sources of information are mainly from the TOXNET Web site (http://toxnet.nlm.nih.gov), Kehew (2001), and the Handbook of Degradation Rates (Howard et al., 1991).

• PCE, TCE, cis-1,2-DCE, trans-1,2-DCE, and Vinyl Chloride – These chemicals most commonly biodegrade in anaerobic conditions by reductive dechlorination. The
resulting daughter product of PCE dechlorination is TCE. TCE may be similarly reduced to cis-1,2-DCE, trans-1,2-DCE, and 1,1-DCE. These daughter products may be further reduced to vinyl chloride. PCE and TCE extend from the Omega property to approximately 4.5 miles downgradient in OU2. TCE has been detected with occurrences of PCE; however, the majority of the detections are believed to be associated with separate sources (e.g., the TCE source at Whittier Boulevard).

Detections of trans-1,2-DCE and vinyl chloride are not as high or as frequent as PCE and TCE detections, and these OU2 COPCs are considered to be daughter products of PCE and TCE degradation. The infrequent occurrence and low concentrations of trans-1,2-DCE and vinyl chloride indicate that these compounds are not widely generated by the degradation of their parent products at OU2, or that they degrade rapidly at OU2.

Detections of cis-1,2-DCE are commonly associated with detections of TCE and are believed to be a degradation product of TCE. The extent of cis-1,2-DCE is similar to that of PCE and TCE. The cis-1,2-DCE plume starts downgradient of the Omega property near Well MW2, indicating that cis-1,2-DCE is being produced in the aquifer and not at the Omega source area, or that it may be associated with another (unknown) source. The AMK area is a source of cis-1,2-DCE. The extent of cis-1,2-DCE downgradient of AMK is consistent with its release or generation at the AMK area (where the highest concentrations are found) rather than generation in the aquifer downgradient of AMK.

**Carbon Tetrachloride, Chloroform, and Chloromethane** – Carbon tetrachloride generally biodegrades in anaerobic conditions by reductive dechlorination forming chloroform and dichloromethane as the primary degradation products. Dichloromethane can further be reduced to chloromethane. The former Omega facility is a source of carbon tetrachloride. Detectable concentrations are present in OU2 between the Omega property and Monitoring Well MW20. Concentrations decrease quickly in the downgradient direction from the Omega property. Chloroform and chloromethane are generally present less frequently and at lower concentrations at OU2, and are considered to be daughter products of carbon tetrachloride.

**1,1,1-TCA, 1,1-DCE, 1,1-DCA, and Chloroethane** – These chemicals most commonly degrade by dehydrochlorination. Detections of 1,1,1-TCA and 1,1-DCA extend throughout OU2 and are generally localized near the Omega property and other suspected source areas, with the maximum concentrations found at AMK. The degradation rates for 1,1,1-TCA and 1,1-DCA are relatively fast, compared to the degradation rates for other chlorinated VOCs in OU2, which explains their limited extent. The chemical 1,1-DCE is much more widespread at OU2 than its parent compounds and its extent is consistent with its generation at the source areas for 1,1,1-TCA; the maximum 1,1-DCE concentrations are found at AMK. Only trace concentrations of chloroethane were detected in OU2. Its presence in groundwater is likely the result of the dehydrochlorination of 1,1-DCA. The chemical 1,1,1-TCA is subject to abiotic transformations under aerobic or anaerobic conditions, and biological transformations under anaerobic conditions; it may be transformed abiotically to form 1,1-DCE. The widespread occurrence of 1,1-DCE at OU2 is at least partially attributable to the degradation of 1,1,1-TCA. Under anaerobic conditions, 1,1,1-TCA may also be rapidly transformed by biotic processes into 1,1-DCA, which may be further reduced to
chloroethane. Chloroethane is relatively stable biologically under anaerobic conditions, but is transformed rapidly to ethanol and chloride by hydrolysis.

- **Freon 11 and Freon 113** – Freons generally do not degrade and are expected to be persistent in groundwater at OU2.

Reductive dechlorination may be enhanced in areas where large fuel hydrocarbon plumes resulted in the depletion of dissolved oxygen in groundwater due to the aerobic degradation of aromatic hydrocarbons. Chlorinated hydrocarbons are almost absent within the fuel hydrocarbon plumes at OFRP and CENCO. The low concentration zone with PCE and TCE between 5 and 100 µg/L is much narrower east of the plume core (the zone of concentrations higher than 100 µg/L) than on its western side. However, it is also possible that the contaminant sources west of AMK have caused the wider extent of PCE and TCE in the western portion of OU2.

Hexavalent chromium is a strong oxidizing agent and may react with organic matter or other reducing agents to form trivalent chromium. The trivalent chromium will eventually be precipitated as \( \text{Cr}_2\text{O}_3\cdot\text{xH}_2\text{O} \) (EPA, 1998).

### 6.4 Migration in Vapor Phase

Soil gas samples were collected and analyzed at the Whispering Fountains Apartments to evaluate the volatilization of groundwater VOCs into the vadose zone and any possible threat of VOC intrusion into residential buildings. The information on the VOC vapor migration processes discussed in this section was mainly taken from EPA’s vapor intrusion guidance document (EPA, 2004a) and soil venting methodology (EPA, 2001d).

VOCs located in subsurface soils or in groundwater can volatilize, migrate through soil gas, and subsequently be transported into indoor spaces, potentially producing inhalation exposure. VOCs in soil gas will primarily migrate and spread out by vapor diffusion. Advective transport of VOC vapors (i.e., by the convective flow of soil gas) is expected to occur near the ground surface as a result of atmospheric pressure variations and operation of HVAC systems in buildings. A secondary spreading mechanism for VOCs in the vadose zone is the migration of soil moisture due to infiltration or evapotranspiration.

The main mechanism controlling vapor phase transport of VOCs from groundwater into the vadose zone is molecular diffusion; the Henry’s Law coefficient has a comparatively negligible effect. The transport of VOC vapors from groundwater into the vadose zone is water-side limited, meaning that the diffusion from groundwater is slower than the diffusion in vadose zone air. The diffusive mass flux from groundwater is controlled by the thickness of the capillary fringe and the soil properties, such as porosity and tortuosity (Mendoza and McAlary, 1990).

Within the soil system, the distribution of a chemical in soil gas, interstitial water, gas-water interface, and adsorbed to carbon is in dynamic equilibrium (i.e., the partitioning occurs almost instantaneously relative to the speed of the movement of the contaminant through soil). VOC vapors migrating into previously clean soil will partition between solid and liquid phases according to the properties (i.e., Henry’s Law and sorption coefficients) of each chemical (EPA, 2001d).
Transport of volatile contaminants from groundwater and soil sources to soil gas and ultimately into indoor air occurs by a combination of diffusive and convective mechanisms. Molecular diffusion moves the VOC towards the soil surface until it reaches the zone of influence of a building. Convective air movement within the soil column transports the vapors through cracks between the foundation and the basement slab floor. This convective sweep effect is induced by a negative pressure within the structure caused by a combination of wind effects (wind pressure on the building exterior) and the stack effect due to building heating and mechanical ventilation. The contaminants are expected to diffuse from groundwater upward through the capillary zone and into the unsaturated zone, where convection near the ground surface can transport VOC vapors into a structure.

Conditions generally thought to increase the potential for vapor intrusion include floor cracks, spaces between floor-wall joints, utility conduits (gas, electric, sewer, or water) intrusions (penetrations) in floors and walls, floor drains or sumps, and basements. In addition, utility corridors are generally suspected to potentially represent a preferential pathway for contaminant migration. Even where there are no penetrations from the utilities, there may be accumulation of contaminated vapors close to the surface and within the zone of influence of the building. An additional consideration is how the potential for soil gas to migrate into a building is influenced by the “sealing” of the ground around it. Richly landscaped grounds, and the associated moisture near-surface, would serve as an impervious collar around a building, and tend to direct soil gas into the building if it is under negative pressure. Likewise, if the sub-slab material is moist (e.g., due to soil vapor condensation or leaks in plumbing) but the surrounding ground is dry, the soil gas will tend to exit through the ground around the building (a well-sealed foundation slab provides the same effect).

The concentration of VOCs in indoor air resulting from VOC intrusion into a structure under the pressure-driven air flow scenario is related to numerous factors including, but not limited to, the building volume (length, width, and height), the building configuration (size of enclosed spaces within the building), the building ventilation type (maintaining negative or positive pressure inside), and the ventilation rate (number of air exchanges per hour).

The evaluation of concentrations attributable to vapor intrusion from a subsurface source is often complex, as contaminated vapors can also be present from aboveground sources. Indoor or operational sources (chemicals used or stored onsite within a structure) can off-gas and produce significant concentrations of chemicals in indoor air. In many industrial areas, ambient air can contain concentrations of chemicals that are COPCs in the subsurface. Vapors from these sources can enter a building through windows, doors, or ventilation systems, or spread from within by advective transport, and accumulate in enclosed spaces.

The chemicals of concern in soil gas within the Whispering Fountains study area include PCE and TCE (Section 5.6.3).

### 6.5 Groundwater Flow and Solute Transport Model

A numerical groundwater flow model (Omega model) was developed with the objective of simulating groundwater flow and contaminant migration at OU2. The anticipated future use of the model is to serve as a tool for evaluation and development of remedial
alternatives for OU2. The model development, calibration, and results are presented in Appendix K and summarized in the following sections.

6.5.1 Model Development

The Omega model is based on the conceptual hydrogeological model outlined in Section 4 and depicted in Cross-sections AA’, BB’, and CC’ (Figure 4-6). The basis for the Omega model was a finite difference model for the Central and the West Coast Basin in Los Angeles, California (Reichard et al., 2003), developed by the USGS and WRD, hereinafter referred to as the USGS model. The USGS model was developed as a numerical tool to assist in water management activities in the two basins. The model was developed using MODFLOW (McDonald and Harbaugh, 1988).

The USGS model was calibrated for a 30-year period between 1971 and 2000, and used a yearly stress period. The USGS model domain covers the central and the southwestern blocks of the Los Angeles Basin, an area of approximately 180 square miles, and used a uniform grid spacing of 0.5 by 0.5 mile.

The Omega model was developed by refining the USGS model in the vicinity of OU2 to meet the modeling objectives. Compared with the USGS model, the Omega model has a smaller model domain, finer spatial discretization (model mesh), refined model layering based on the site conceptual model (more model layers), and more detailed representation of recharge and discharge conditions pertinent to groundwater flow at OU2.

The Omega model was developed using FEFLOW (Diersch, 2005). The numerical scheme used in FEFLOW, finite-element, allowed for an efficient refinement of the model mesh in the OU2 area while keeping coarser mesh near the model boundaries.

The Omega model domain covers only the eastern portion of the Central Basin (Figure K-5). The southeast boundary where the Los Angeles County Basin and Orange County Basin meet was kept unchanged from the USGS model; the northeast boundary along the Puente Hills of the USGS model was refined to more precisely represent the alluvium extent; the northwestern boundary was intentionally placed perpendicular to the water level contours simulated by the USGS model, and the southeastern boundary was placed along the NIU fault zone. The boundary conditions included no-flow for the northeast boundary along the Puente Hills, specified head boundary representing the groundwater inflow from the San Gabriel Basin through the Whittier Narrows, specified head boundaries for the southeast and the northwest boundaries representing the limited groundwater exchange between the modeled and the adjacent areas, and specified flux boundary representing the minor outflow across the NIU (Figure K-6).

The layering in the Omega model is a refinement of the USGS model layering based on the stratigraphic interpretation illustrated in Cross-sections AA’, BB’, and CC’ (Figure 4-6). The top seven stratigraphic units, one Holocene and six Pleistocene, are represented by nine FEFLOW layers in the Omega model. With the exception of Stratigraphic Units 3 and 4, each stratigraphic unit is represented by one FEFLOW model layer. Stratigraphic Units 3 and 4 have relatively extensive silty lenses within otherwise sandy layers and are represented by two FEFLOW layers. The Upper and the Lower San Pedro formation, represented by the two bottom layers in the USGS model, are outside the focus of this RI. In the Omega model, the top and bottom elevations and thicknesses for these aquifer units remain unchanged.
from those represented by the USGS model. Each of the two bottom USGS model layers is evenly split into two layers and thus the San Pedro formation is represented by four FEFLOW layers in the Omega model. The Omega model consists of 13 layers, separated by 14 finite-element mesh slices.

The Omega model simulates groundwater flow in the study area for a period of 36 years, between Water Years 1971 and 2006 (October 1970 to September 2006). For the period between 1971 and 2000 where the Omega model overlaps with the USGS model, yearly stress periods were used. Monthly stress periods were used for the period after 2000 to more accurately represent the aquifer conditions during this time; the majority of the water level and concentration data for the Omega site were collected after 2000.

The initial head distribution representing the groundwater flow conditions in 1971 was obtained from the USGS model.

6.5.2 Model Calibration

The Omega model was calibrated to water levels from monitoring wells located within OU2 and also to water levels from several regional monitoring wells. Observed water levels from all the OU1 and OU2 monitoring wells installed before 2006 (OW1 through OW8 and MW1 through MW23, respectively) were included in the model calibration.

In addition, hydrographs from monitoring wells from other sites located within the Omega OU2 area were included in the calibration to increase the spatial coverage of the calibration data set. Only monitoring wells with relatively long histories of water level measurements and available well construction information were used. The selected wells included the McKesson Well MW-7, Phibro-tech Well MW-3, and OFRP Wells MW-4, MW-5, MW-8, MW-12, MW-19, and MW-21.

Six regional monitoring wells, with state Identification Numbers of 3S/12W-26C2, 4S/12W-10G1, 2S/12W-14J1, 3S/12W-01A6, 3S/13W-21R1 and 4S/12W-25E1, were also selected as calibration wells. These regional wells have relatively long histories of water level measurements that represent the regional head distribution in the basin.

The calibration evaluation included numeric criteria, visual inspection of the measured and computed water levels, visual inspection of the plot of simulated versus observed heads, and particle tracking.

The numeric calibration criteria included the mean error (ME) between the model simulated and measured heads, root of the mean squared error (RMSE) between the model simulated and measured heads, and the ratio of RMSE to the maximum observed water level change over the calibration period (%RMSE). The calibrated model had ME of 4.8 feet, RMSE of 18.0 feet, and %RMSE of 7 percent for all observation data used in the calibration. The %RMSE is less than 10 percent, indicating a good fit. For Omega wells only, the ME was 0.1 foot, RMSE was 3.8 feet, and %RMSE was 5 percent, indicating that at OU2, the simulated heads matched the observed heads closer than overall in the model (Table 2 of Appendix K).

The model reproduced the observed spatial and temporal water level changes at OU2. The simulated water table contours closely match the contours prepared from the water
level measurements (Figure K-13). The model also simulated the water level decline between 2001 and 2004, rebound after heavy precipitation in 2005, and the approximately steady water levels in the following years (Figure K-12). The scatter plots of observed versus simulated heads suggest that there was a largely random error between the model simulated and measured heads (Figure K-11).

Particle tracking demonstrated that the model can reproduce the main PCE transport pathways at OU2 (Figure K-14), indicating the model is able to represent the advective transport of contaminants in the groundwater at OU2.

Water budget analysis conducted for the calibrated model indicated that recharge through spreading basins and pumping are the respective dominant recharge and discharge components. Except for a section of the northwest boundary near the spreading basins, water exchanges through the model boundaries are relatively small compared to the recharge through spreading basins. The budget analysis suggests that groundwater flow in the model domain is predominantly driven by the spreading and pumping activities and is less dependent on the specifications of model boundaries.

### 6.5.3 Solute Transport Modeling

Solute transport simulations were performed to complement the particle tracking analysis by further evaluating the capability of the model to replicate the contaminant transport history and further testing the model capability of simulating the groundwater flow regime at OU2. The model simulated the PCE plume. Although transport parameters were varied to achieve a simulated PCE plume that is in good agreement with the measured PCE distribution, these efforts did not constitute model calibration.

The transport model was constructed by expanding the calibrated FEFLOW flow model to include solute transport. Advection and hydrodynamic dispersion were the only solute transport mechanisms represented in the model. Other processes such as sorption and degradation that are likely occurring in the groundwater at OU2 were considered to be less significant and were not included in the transport simulation. It is expected that the uncertainty in the quantification of the source terms in the model (the duration and magnitude of the contaminant mass flux from sources of groundwater contamination at OU2) have a greater impact on the model results than the effects of sorption and degradation, especially for compounds widely present at OU2 (e.g., PCE).

The model simulated the development of the PCE plume at OU2 between 1976 and 2006. It was assumed that the groundwater at OU2 was free of PCE contamination prior to 1976, the year when operations at Omega and AMK started, and that groundwater was impacted immediately following the startup of operations at these facilities. These two source areas were represented in the model because their operational histories are known and because they are associated with two extensive zones of high PCE contamination in groundwater (greater than 500 µg/L). Other sources of PCE, although known, were not included in the simulation in order to keep the transport model simple.

Figure K-15 shows model simulated PCE plume for the different model layers at the end of the model simulation. The model in general reproduced the lateral and vertical extent of the PCE plume, and also the two high concentration zones associated with the two source areas. The simulated plume is narrower than the observed one. This is mainly because there are
other PCE sources that were not considered in the transport simulation. Also, the transverse dispersivity value used in the model had to be small to simulate a realistic vertical extent of the PCE plume. FEFLOW uses a single transverse dispersivity to represent the hydrodynamic dispersion (Diersch, 2005, Equation 3-5). At OU2, lateral dispersion is expected to be greater than vertical dispersion during predominantly horizontal groundwater flow because of sediment layering.

The transport simulation showed that the model can represent the development of the PCE plume over the historical period of activities at Omega and AMK. Other sources of PCE can be included and the development of other contaminant plumes can be represented in future simulations if needed.

### 6.6 Conceptual Model of Contamination at OU2

This section presents the CSM that includes the nature and extent of contamination, sources of contamination, contaminant fate and transport, and the potential exposure and receptor pathways.

#### 6.6.1 Nature and Extent of Contamination

OU2, defined by the presence of Omega Site contaminants in groundwater, extends about 4.5 miles southwest from the Omega property. The known depth extent of the Omega Site contaminants is limited to about 200 feet bgs at OU2. The contamination is shallow near the Omega property and its depth extent increases farther downgradient. It is possible that abandoned irrigation and water supply wells (Figure 4-9) act as conduits to downward contaminant migration; such pathways could explain the presence of contamination at MW23C. The contamination from the former Omega facility has commingled with contamination from other sources at OU2 (Figure 6-6). Besides the Omega Site contaminants, other COPCs—both naturally occurring and manmade—are present at OU2.

The contamination found at MW23C may be laterally limited, but it may also extend to Production Well 2S/11W-30R3; the contamination at this Production Well (Well SFS No. 1) could also have originated from nearby sources and migrated vertically to the top of the well screen. The contamination found at GSWC Wells Pioneer 1, Pioneer 2, Pioneer 3, and Dace 1 likely extends to their upper screen intervals centered at about 200 feet bgs; however, VOC contamination was not found in the shallow groundwater (near the water table) in this area.

The contaminant distribution follows the main direction of groundwater flow at OU2, initially toward the southwest from the Omega property, then curving around the Santa Fe Springs anticline to the south. Groundwater flows primarily via interconnected sand units, locally separated by fine-grained units. The groundwater flow field, contaminant distribution, and stratigraphic framework suggest that the La Habra syncline and Santa Fe Springs anticline are the main features controlling groundwater flow and contaminant transport at OU2.
6.6.2 Sources of Contamination

The main sources of contamination at OU2 have been identified and are summarized in Table 6-4. Other smaller sources of contamination may exist that impact the groundwater quality at OU2. Some contaminants, such as perchlorate, may derive from multiple small sources that may be difficult to identify.

6.6.3 Contaminant Fate and Transport

6.6.3.1 Groundwater

The fate and transport of contaminants in groundwater at OU2 is affected by a variety of chemical, physical, and biological processes. Some of the chemical and biological processes are destructive and result in contaminant mass removal from the groundwater. The presence of daughter products of the degradation of 1,1,1-TCA, PCE, and TCE throughout OU2 indicates that these compounds undergo transformation. However, because PCE and TCE are found across OU2, their degradation is slow relative to their migration rate. Only 1,1,1-TCA breaks down rapidly and does not extend far from its source areas (e.g., Omega Site and AMK). The extent of 1,4-dioxane is similar to the extent of PCE and TCE because 1,4-dioxane does not readily degrade in groundwater and was released at OU2 generally at the same source areas as PCE and TCE. This also indicates that PCE and TCE do not break down rapidly at OU2.

The extent of PCE and TCE is greater than that of their degradation products. The degradation products would be expected to be present along with PCE and TCE if the parent compounds degraded in the aquifer. The smaller extent of the daughter products may be an indication that PCE and TCE degrade primarily at the source areas and not farther downgradient, or that the daughter products break down faster than PCE and TCE. It may also be possible that the VOC degradation at OU2 do not exactly follow the pathways shown in Figures 6-2 and 6-3.

Other contaminant transport mechanisms are non-destructive and only result in redistribution of the contaminant mass between phases, affect contaminant migration rates, and result in contaminant spreading. These processes include volatilization from groundwater into the vapor phase, sorption, diffusion, advection, and dispersion. Phase partitioning (including volatilization and sorption) depends on the properties of individual contaminants while the remaining processes affect most chemicals similarly.

The leading edge of the contaminant plume migrating from the former Omega facility and AMK has advanced at a minimum average rate of about 540 feet per year; this rate includes the combined effects of the rate of contaminant mass release in the source areas (presumably varying over time), advection, sorption, dispersion, and degradation, and assumes a travel time of 31 years. The most likely value for advective velocity, conservatively accounting for sorption, was estimated at 620 feet per year. The travel time from the former Omega facility to AMK (a distance of 1.3 miles) corresponding to this velocity is 11 years; this calculation neglects the effects of dispersion, which would shorten the travel time. Because a wide range of advective velocities is plausible, the actual travel time could be longer or shorter. The range of possible travel times across OU2 can account for delayed contaminant mass release in the source areas. For example, the likely travel time from the former Omega facility to the edge of the Freon 113 plume (using the velocity of 620 feet per year and

6-18
neglecting dispersion, which would decrease the travel time) is 31 years; however, the range of possible velocities includes values that are several times higher and would correspond to proportionally shorter travel times.

The main migration pathway starts at the former Omega property and continues generally southwest to near the AMK area, then turns more southerly to the area near Wells MW29 and MW30. Contamination from other source areas within OU2 (e.g., the sources west of AMK) follows a parallel pathway. The contamination from the former Omega facility is commingled with contamination released from multiple other sources.

The numerical modeling results support the conceptual understanding of groundwater flow and contaminant transport at OU2. The Omega model simulated the groundwater flow conditions at OU2 and the development of the PCE plume during the historical period of operations at Omega and AMK. The Omega model simulated the main contaminant transport pathways from Omega and AMK and showed that the simulated contamination from these two source areas has commingled. Other sources of contamination were not represented in the model.

6.6.3.2 Vadose Zone
The potential for the migration of VOC vapors into the vadose zone exists throughout OU2. Because of expected, predominantly aerobic conditions, little to no degradation of PCE and TCE is expected to occur in the vadose zone; no degradation products of PCE and TCE were found in the soil gas at Whispering Fountains. The migration rate for the vapor phase contamination in the vadose zone was not quantified; the vapor transport, however, is fast relative to the transport in groundwater, and steady contaminant mass flux in the vapor phase can be assumed at most locations within OU2.

6.6.4 Potential Exposure and Receptor Pathways
The potential exposure pathways and receptors are summarized for the contamination dissolved in groundwater and for contaminant vapors in the vadose zone resulting from the volatilization of the dissolved contaminants. The exposure pathways and receptors are discussed in detail in Section 7 – Baseline Risk Assessment.

6.6.4.1 Groundwater
An unrestricted use of shallow groundwater at OU2 would result in ingestion, dermal, and inhalation exposure of residents. For groundwater exposure, adult and child residents are evaluated as potential receptors. Groundwater exposure routes include ingestion, inhalation, and dermal contact. Ingestion is a primary exposure route for VOCs, SVOCs, and metals because the groundwater may potentially be used for potable use. Inhalation is a primary exposure route for VOCs when the groundwater is used for domestic purposes, such as bathing and dishwashing, that may expose people to VOCs through inhalation. Dermal contact is not a primary exposure pathway for VOCs, but use of groundwater for domestic purposes, such as bathing, may expose people to VOCs, SVOCs, and metals through the skin.

Production Well SFS No. 1 has been affected by the former Omega facility contaminants, and a wellhead treatment system is in place. Groundwater production from wells installed
in deep aquifers in the central basin, downgradient from OU2, may result in contaminant migration into deep and yet unimpacted aquifers. The mixing of meteoric water with deep groundwater in the central basin has been documented (Reichard et al., 2003); therefore, shallow groundwater contamination also has the potential to impact deep aquifers.

The scoping Ecological Risk Assessment (ERA) (Section 7.5) concluded that there is no risk to ecological receptors from groundwater contaminants at OU1 and OU2, and from soil contamination at OU1.

6.6.4.2 Vadose Zone

The main impact to residential buildings from VOC vapor intrusion would occur in areas with high VOC concentrations in groundwater and shallow depth to the water table. Contaminants in soil gas at shallow depths can be transported below buildings and enter into indoor air through cracks between the foundation and basement slab floor. Contaminants can potentially accumulate indoors if there is poor ventilation; heating systems can also create negative pressure, which may enhance the flow of soil gas into indoor air.

At OU2, the Whispering Fountains community was identified as an area of the highest potential risk because the depth to the water table is shallow and the VOC concentrations in groundwater are high relative to other residential areas of OU2.

The screening level risk assessment for soil gas exposure evaluates the vapor intrusion exposure scenario based on data collected at the Whispering Fountain Apartments. The primary exposure route is inhalation of indoor air.
### Table 6-1

**Summary of Chemical Properties for OU2 COPCs**

*Omega Chemical Superfund Site*

<table>
<thead>
<tr>
<th>Compound</th>
<th>Molecular Formula</th>
<th>Density</th>
<th>Solubility in Water</th>
<th>Henry’s Law Constant</th>
<th>K&lt;sub&gt;OC&lt;/sub&gt;</th>
<th>Half-Life</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>g/cm³</td>
<td>mg/L</td>
<td>atm⁻³/mol</td>
<td>ml/g</td>
<td>year</td>
</tr>
<tr>
<td><strong>Volatile Organic Compounds (VOCs)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1,1,1-Trichloroethane (1,1,1-TCA)</td>
<td>C₂H₃Cl₃</td>
<td>1.338 @ 20°C</td>
<td>4,400 @ 20°C</td>
<td>8.00E-03</td>
<td>183</td>
<td>0.4–1.5</td>
</tr>
<tr>
<td>1,1,2-Trichloro-1,2,2-trifluoroethane (Freon 113)</td>
<td>C₂ClF₃</td>
<td>1.564 @ 25°C</td>
<td>170 @ 25°C</td>
<td>5.30E-01</td>
<td>316</td>
<td>1–2</td>
</tr>
<tr>
<td>1,1,2-Trichloroethane (1,1,2-TCA)</td>
<td>C₂H₃Cl₂</td>
<td>1.442 @ 20°C</td>
<td>4,500 @ 20°C</td>
<td>8.24E-04</td>
<td>83–209</td>
<td>0.4–2</td>
</tr>
<tr>
<td>1,1,2,2-Tetrachloroethane (R-130)</td>
<td>C₂H₄Cl₄</td>
<td>1.595 @ 20°C</td>
<td>2,900 @ 20°C</td>
<td>3.67E-04</td>
<td>79</td>
<td></td>
</tr>
<tr>
<td>1,1-Dichloroethane (1,1-DCA)</td>
<td>C₂H₄Cl₂</td>
<td>1.235 @ 20°C</td>
<td>8,690 @ 25°C</td>
<td>1.18E-03</td>
<td>33</td>
<td>0.3–1</td>
</tr>
<tr>
<td>1,1-Dichloroethene (1,1-DCE)</td>
<td>C₂H₂Cl₂</td>
<td>1.089 @ 15°C</td>
<td>1.790 @ 25°C</td>
<td>5.56E-03</td>
<td>85</td>
<td>0.03–2</td>
</tr>
<tr>
<td>1,2-Dibromo-3-Chloropropane (DBCP)</td>
<td>C₃H₅Br₃Cl</td>
<td>2.080 @ 20°C</td>
<td>1,230 @ 20°C</td>
<td>1.50E-04</td>
<td>40–149</td>
<td></td>
</tr>
<tr>
<td>1,2-Dichloroethane (DCA)</td>
<td>C₂H₄Cl₂</td>
<td>1.235 @ 20°C</td>
<td>8,690 @ 25°C</td>
<td>1.18E-03</td>
<td>33</td>
<td>0.3–1</td>
</tr>
<tr>
<td>Carbon disulfide</td>
<td>CS₂</td>
<td>1.263 @ 20°C</td>
<td>2,160 @ 25°C</td>
<td>1.44E-02</td>
<td>270</td>
<td></td>
</tr>
<tr>
<td>Carbon tetrachloride (Freon 10)</td>
<td>CCl₄</td>
<td>1.484 @ 20°C</td>
<td>7,710 @ 25°C</td>
<td>3.76E-03</td>
<td>153–196</td>
<td>0.2–5</td>
</tr>
<tr>
<td>Chlorobenzene</td>
<td>C₆H₅Cl</td>
<td>1.106 @ 20°C</td>
<td>502 @ 25°C</td>
<td>3.77E-03</td>
<td>71</td>
<td>&lt;1–88</td>
</tr>
<tr>
<td>Chloroform (Freon 20)</td>
<td>CHCl₃</td>
<td>1.235 @ 20°C</td>
<td>8,690 @ 25°C</td>
<td>1.18E-03</td>
<td>33</td>
<td>0.3–1</td>
</tr>
<tr>
<td>cis-1,2-Dichloroethene (cis-1,2-DCE)</td>
<td>C₂H₂Cl₂</td>
<td>1.284 @ 20°C</td>
<td>6,410 @ 25°C</td>
<td>4.08E-03</td>
<td>250</td>
<td>0.14–9.9</td>
</tr>
<tr>
<td>cis-1,3-Dichloropropene (cis-1,3-DCP)</td>
<td>C₃H₄Cl₂</td>
<td>1.224 @ 20°C</td>
<td>2,700 @ 25°C</td>
<td>2.70E-03</td>
<td>20–42</td>
<td>0.03–0.15</td>
</tr>
<tr>
<td>Methyl t-butyl ether (MTBE)</td>
<td>C₅H₁₂O</td>
<td>0.741 @ 20°C</td>
<td>51,000 @ 25°C</td>
<td>5.87E-04</td>
<td>6</td>
<td>0.2–1</td>
</tr>
<tr>
<td>Methylene Chloride (DCM or Freon 30)</td>
<td>C₂H₄Cl₂</td>
<td>1.326 @ 20°C</td>
<td>13,000 @ 25°C</td>
<td>3.25E-03</td>
<td>24</td>
<td></td>
</tr>
<tr>
<td>Tetrachloroethene (PCE)</td>
<td>C₂Cl₄</td>
<td>1.623 @ 20°C</td>
<td>150 @ 25°C</td>
<td>1.77E-02</td>
<td>200–237</td>
<td>1–2</td>
</tr>
<tr>
<td>trans-1,2-Dichloroethene (trans-1,2-DCE)</td>
<td>C₂H₂Cl₂</td>
<td>1.257 @ 20°C</td>
<td>4,520 @ 25°C</td>
<td>9.28E-03</td>
<td>330</td>
<td>&lt;0.2</td>
</tr>
<tr>
<td>trans-1,3-Dichloropropene (trans-1,3-DCP)</td>
<td>C₃H₄Cl₂</td>
<td>1.224 @ 20°C</td>
<td>2,800 @ 25°C</td>
<td>8.70E-04</td>
<td>28</td>
<td>0.02–0.05</td>
</tr>
<tr>
<td>Trichloroethene (TCE)</td>
<td>C₂H₃Cl</td>
<td>1.464 @ 20°C</td>
<td>1,280 @ 25°C</td>
<td>9.85E-03</td>
<td>101</td>
<td>0.9–4.5</td>
</tr>
<tr>
<td>Trichlorofluoromethane (Freon 11)</td>
<td>C₂ClF₃</td>
<td>1.494 @ 17.2°C</td>
<td>1,100 @ 25°C</td>
<td>9.70E-02</td>
<td>97</td>
<td>1–2</td>
</tr>
<tr>
<td>Vinyl chloride</td>
<td>C₂H₃Cl</td>
<td>0.911 @ 20°C</td>
<td>8,800 @ 25°C</td>
<td>2.78E-02</td>
<td>57</td>
<td>0.2–2.9</td>
</tr>
<tr>
<td><strong>Emergent Compounds</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1,2,3-Trichloropropane (1,2,3-TCP)</td>
<td>C₃H₅Cl₃</td>
<td>1.389 @ 20°C</td>
<td>1,750 @ 25°C</td>
<td>3.43E-04</td>
<td>77–95</td>
<td>1–2</td>
</tr>
<tr>
<td>1,4-Dioxane (p-Dioxane)</td>
<td>C₄H₈O₂</td>
<td>1.033 @ 20°C</td>
<td>Miscible</td>
<td>4.80E-06</td>
<td>29</td>
<td>0.2–1</td>
</tr>
<tr>
<td>Chromium VI</td>
<td>Cr⁶⁺</td>
<td>7.140</td>
<td>Soluble in ionic form</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>N-Nitrosodimethylamine (NDMA)</td>
<td>C₂H₅NO</td>
<td>1.005 @ 20°C</td>
<td>Very soluble</td>
<td>1.82E-06</td>
<td>12</td>
<td>0.1–1</td>
</tr>
<tr>
<td>Perchlorate - Ammonium</td>
<td>ClHOₓNₓ</td>
<td>1.950</td>
<td>2.00E+05</td>
<td>25°C</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Perchlorate - Magnesium</td>
<td>ClHOₓMgₓ</td>
<td>2.200</td>
<td>9.93E+05</td>
<td>25°C</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Perchlorate - Potassium</td>
<td>ClHOₓKₓ</td>
<td>2.530</td>
<td>1.50E+04</td>
<td>25°C</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Perchlorate - Sodium</td>
<td>ClHOₓNaₓ</td>
<td>2.520</td>
<td>2.10E+06</td>
<td>25°C</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Semi-volatile Organic Compounds (SVOCs)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bis(2-ethylhexyl)phthalate (BEHP)</td>
<td>C₂₄H₃₈O₄</td>
<td>0.986 @ 20°C</td>
<td>0.01% @ 25°C</td>
<td>1.30E-07</td>
<td>570,000</td>
<td>0.04–0.06</td>
</tr>
</tbody>
</table>

**Notes:**
- °C = degrees Celsius
- g/cm³ = grams per cubic centimeter
- mg/L = milligrams per liter
- atm⁻³/mol = atmosphere-cubic meter per mole
- ml/g = milliliters per gram
Table 6-2
Apparent Plume Expansion Rates
Omega Chemical Superfund Site

<table>
<thead>
<tr>
<th>Source</th>
<th>TCE</th>
<th>PCE</th>
<th>Freon11</th>
<th>Freon113</th>
<th>1,4-Dioxane</th>
<th>1,1DCE</th>
<th>cis-1,2DCE</th>
<th>Chloroform</th>
<th>Cr⁶⁺</th>
</tr>
</thead>
<tbody>
<tr>
<td>Foss Plating</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Omega</td>
<td>24,200</td>
<td>23,400</td>
<td>16,300</td>
<td>19,200</td>
<td>24,000</td>
<td>21,800</td>
<td>19,000</td>
<td>6,200</td>
<td>10,000</td>
</tr>
<tr>
<td>AMK</td>
<td>16,900</td>
<td>16,200</td>
<td>16,300</td>
<td>14,900</td>
<td>11,700</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Min plume width</td>
<td>2,700</td>
<td>1,700</td>
<td>1,800</td>
<td>1,800</td>
<td>1,800</td>
<td>1,800</td>
<td>570</td>
<td>600</td>
<td></td>
</tr>
<tr>
<td>Max plume width</td>
<td>4,300</td>
<td>4,900</td>
<td>2,600</td>
<td>2,500</td>
<td>3,800</td>
<td>2,700</td>
<td>1,800</td>
<td>800</td>
<td></td>
</tr>
</tbody>
</table>

From start of plume (near MW24)

<table>
<thead>
<tr>
<th>Source</th>
<th>TCE</th>
<th>PCE</th>
<th>Freon11</th>
<th>Freon113</th>
<th>1,4-Dioxane</th>
<th>1,1DCE</th>
<th>cis-1,2DCE</th>
<th>Chloroform</th>
<th>Cr⁶⁺</th>
</tr>
</thead>
<tbody>
<tr>
<td>From Omega</td>
<td>780</td>
<td>750</td>
<td>530</td>
<td>620</td>
<td>770</td>
<td>700</td>
<td>610</td>
<td>200</td>
<td>0</td>
</tr>
<tr>
<td>From AMK</td>
<td>550</td>
<td>520</td>
<td>530</td>
<td>480</td>
<td>380</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>From Foss Plating</td>
<td>260</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Mean (of values in bold)

<table>
<thead>
<tr>
<th>Source</th>
<th>TCE</th>
<th>PCE</th>
<th>Freon11</th>
<th>Freon113</th>
<th>1,4-Dioxane</th>
<th>1,1DCE</th>
<th>cis-1,2DCE</th>
<th>Chloroform</th>
<th>Cr⁶⁺</th>
</tr>
</thead>
<tbody>
<tr>
<td>Foss Plating</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AMK</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Omega</td>
<td>2,500</td>
<td>87,000</td>
<td>200</td>
<td>1,000</td>
<td>280</td>
<td>700</td>
<td>60</td>
<td>160</td>
<td></td>
</tr>
<tr>
<td>Plume Edge</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>3</td>
<td>6</td>
<td>6</td>
<td>80</td>
<td>11</td>
</tr>
<tr>
<td>C_edge/C (Omega)</td>
<td>0.20%</td>
<td>0.01%</td>
<td>2.50%</td>
<td>0.50%</td>
<td>1.07%</td>
<td>0.86%</td>
<td>10.00%</td>
<td>50.00%</td>
<td></td>
</tr>
<tr>
<td>C_edge/C (AMK)</td>
<td>0.23%</td>
<td>0.46%</td>
<td>2.50%</td>
<td>0.004%</td>
<td>0.03%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C_edge/C (FossPlat)</td>
<td></td>
<td>1.2%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Notes:
1 = source area for 1,1-DCE and cis-1,2-DCE is near MW24; see Figures 5-19 and 5-20.
AMK = former Angeles Chemical and former McKesson Chemical source area
PCE = Tetrachloroethene
TCE = Trichloroethene
DCE = Dichloroethene
Cr⁶⁺ = Hexavalent Chromium
µg/L = micrograms per liter
ft/y = feet per year
Bold values indicate representative plume expansion rates
Rate = distance/(2007-1976) for Omega, AMK
Rate = distance/(2007-1968) for Foss Plating.
Table 6-3
Estimated Advective Velocities
Omega Chemical Superfund Site

<table>
<thead>
<tr>
<th>Transport from Omega</th>
<th>Transport from AMK</th>
</tr>
</thead>
<tbody>
<tr>
<td>$R = 1$</td>
<td></td>
</tr>
<tr>
<td>1,4-dioxane</td>
<td>114</td>
</tr>
<tr>
<td>1,1-DCE</td>
<td>100.4</td>
</tr>
<tr>
<td>cis-1,2-DCE</td>
<td>104.6</td>
</tr>
<tr>
<td>Freon 11</td>
<td>78.4</td>
</tr>
<tr>
<td>Freon 113</td>
<td>85.7</td>
</tr>
<tr>
<td>PCE</td>
<td>92.6</td>
</tr>
<tr>
<td>TCE</td>
<td>107</td>
</tr>
<tr>
<td>$R = 2$</td>
<td></td>
</tr>
<tr>
<td>Freon 113</td>
<td>171.4</td>
</tr>
</tbody>
</table>

Explanation:
Transport of selected compounds was simulated using a two-dimensional analytical solute transport model (Wexler, 1992).
Source concentrations (Table 6-2) were assumed to be constant between 1976 and 2007.
The distances from the source area (Omega or AMK) to the plume edge in 2007 for the selected compounds are shown in Table 6-2.
Additional assumptions: no sorption ($R=1$), no degradation, porosity of 0.3, gradient of 0.0049 ft/ft, longitudinal dispersivity 100 feet, transverse dispersivity 5 feet, source width 150 feet.
Hydraulic conductivity was varied to achieve a fit between the calculated and observed plume length for each compound (e.g., to calculate PCE concentration of 5 µg/L at a distance of 23,400 feet from Omega along the plume centerline).
One simulation with sorption ($R = 2$) was performed for PCE.
AMK = Angeles Chemical and McKesson Chemical source area.
cm$^3$/g = Cubic centimeters (milliliters) per gram.
K = Hydraulic conductivity.
Koc = Partitioning coefficient between solute and organic carbon (source: TOXNET).
R = Retardation coefficient.
v = Advective velocity.

Reference:
### Table 6-4
**Summary of Sources of Contamination**

**Omega Chemical Superfund Site**

<table>
<thead>
<tr>
<th>Facility Name</th>
<th>Facility Address</th>
<th>Main Contaminants</th>
</tr>
</thead>
<tbody>
<tr>
<td>TCE Source at Whittier Boulevard</td>
<td>12353 Whittier Boulevard (and adjacent lot), Whittier</td>
<td>TCE, 1,1-DCE, benzene</td>
</tr>
<tr>
<td>Former McKesson Facility</td>
<td>9005 Sorensen Avenue, Santa Fe Springs</td>
<td>PCE, TCE, 1,4-Dioxane, 1,1,1-TCA, 1,1-DCA, 1,1-DCE, cis-1,2-DCE, acetone</td>
</tr>
<tr>
<td>Angeles Chemical Co Fac</td>
<td>8915 Sorensen Avenue, Santa Fe Springs</td>
<td>PCE, TCE, 1,4-Dioxane, 1,1,1-TCA, 1,1-DCA, 1,1-DCE, cis-1,2-DCE, acetone</td>
</tr>
<tr>
<td>Lincoln Distribution Cntr</td>
<td>12500 Slauson Avenue, Santa Fe Springs</td>
<td>PCE, TCE</td>
</tr>
<tr>
<td>Modine Manufacturing Co</td>
<td>12252 Whittier Boulevard, Whittier</td>
<td>PCE, TCE</td>
</tr>
<tr>
<td>Techni-Braze, Incorp.</td>
<td>11845 Burke Street, Santa Fe Springs</td>
<td>PCE, TCE, 1,1-DCE</td>
</tr>
<tr>
<td>Valvoline Oil Company</td>
<td>9520 John Street, Santa Fe Springs</td>
<td>PCE, TCE</td>
</tr>
<tr>
<td>The Fine Line Paint Corp</td>
<td>1200 Los Nietos Road, Santa Fe Springs</td>
<td>PCE, TCE, 1,1-DCA, 1,1-DCE, 1,2-DCA, cis-1,2-DCE</td>
</tr>
<tr>
<td>Phibro-Tech, Inc.</td>
<td>8851 Dice Road, Santa Fe Springs</td>
<td>PCE, TCE, carbon tetrachloride, 1,1-DCA, 1,1-DCE, cis-1,2-DCE, chloroform, hexavalent chromium</td>
</tr>
<tr>
<td>Pilot Chemical Company</td>
<td>11756 Burke Street, Santa Fe Springs</td>
<td>Hydrocarbons</td>
</tr>
<tr>
<td>Technichem, Inc.</td>
<td>8421 S. Chetle Avenue, Santa Fe Springs</td>
<td>PCE, TCE, 1,1-DCE, 1,2-DCA, chloroform, cis-1,2-DCE, Freon 11</td>
</tr>
<tr>
<td>Nu-Car Prep Systems</td>
<td>12202 Slauson Avenue (formerly 12140 Slauson Avenue), Santa Fe Springs</td>
<td>PCE, TCE, Freon 113, 1,1-DCE</td>
</tr>
<tr>
<td>G&amp;M Oil Company, Inc.</td>
<td>12559 Lambert Road, Whittier</td>
<td>Hydrocarbons</td>
</tr>
<tr>
<td>Whittier Engraving Comp</td>
<td>12631-12637 Los Nietos Road, Santa Fe Springs</td>
<td>PCE, TCE</td>
</tr>
<tr>
<td>Earl Manufacturing</td>
<td>11862 Burke Street, Santa Fe Springs</td>
<td>PCE, TCE, 1,1-DCA, 1,1-DCE, cis-1,2-DCE</td>
</tr>
<tr>
<td>Los Nietos Business Ctr</td>
<td>9210-9169 South Norwalk Boulevard and 11924-11933 East Los Nietos Road in Santa Fe Springs</td>
<td>PCE, TCE, 1,1,1-TCA, 1,1-DCA, 1,1-DCE, chloroform</td>
</tr>
<tr>
<td>CENCO</td>
<td>12345 Lakeland Road, Santa Fe Springs</td>
<td>Hydrocarbons</td>
</tr>
<tr>
<td>Foss Plating Company</td>
<td>8140 Secura Way, Santa Fe Springs</td>
<td>PCE, TCE, 1,1-DCE, chloroform, hexavalent chromium</td>
</tr>
<tr>
<td>West Bent Bolt</td>
<td>8625 South Dice Road, Santa Fe Springs</td>
<td>PCE, TCE, 1,1-DCE, carbon tetrachloride, 1,4-dioxane</td>
</tr>
<tr>
<td>Diversey Wynadotte Corp.</td>
<td>8921 Dice Road, Santa Fe Springs</td>
<td>PCE, TCE, 1,1,1-TCA, 1,1-DCA, 1,1-DCE, cis-1,2-DCE</td>
</tr>
<tr>
<td>OFRP</td>
<td>10737 South Shoemaker Avenue, Santa Fe Springs</td>
<td>Hydrocarbons</td>
</tr>
<tr>
<td>Former Unocal Corp.</td>
<td>9645 South Santa Fe Springs Road, Santa Fe Springs</td>
<td>Hydrocarbons</td>
</tr>
</tbody>
</table>

**Notes:**
- PCE = Tetrachloroethene
- TCE = Trichloroethene
- DCE = Dichloroethene
- DCA = Dichloroethane
- TCA = Trichloroethane
Figure 6-1
Conceptual Diagram of Contaminant Fate and Transport Mechanisms in the Subsurface
Omega Chemical Superfund Site
Figure 6-2
Degradation Pathways
Omega Chemical Superfund Site
Figure 6-3
Degradation Pathways
Omega Chemical Superfund Site

- Reductive Dechlorination
- Dehydrochlorination
- Dichloro-elimination
- Methanogenic Dechlorination
- Abiotic Reaction
- Aerobic Reaction

Compound Detected at OU1, OU2 during July-August 2007 Sampling Event
Figure 6-4 - Calculated PCE and Freon 113 Concentrations along Plume Centerline
Figure 6-5 Freon 113 Transport along Plume Centerline

Freon 113 Concentration [ug/L]

Distance from Omega [feet]

Calculated

- OW1A
- OW2
- OW8A
- MW14
- MW2
- MW4A
- MW4B
- MW23A
- MW23C
- MW25A
- MW25B
- MW26A
- MW26C
- MW27A
- MW603

5 ug/L
Figure 6-6
Conceptual Model of Contaminant Migration at Omega
Omega Chemical Superfund Site

- Central Basin Production Wells
- Volatilization
- Water table
- Mixing of contamination

Explanation:
- Historical contamination migration from Omega
- Historical contamination migration from other sources
- Potential contamination migration from Omega
- Potential contamination migration from other sources