7. Baseline Risk Assessment

This section describes and summarizes a baseline HHRA and ERA prepared as part of the Omega Site OU2 RI Report. The baseline HHRA Report is presented in Appendix L and the baseline ERA Report is presented in Appendix M of this RI Report.

The risk assessment was performed to determine and document whether groundwater contamination in OU2 poses a current or potential future risk to human health. The HHRA provides the basis for determining whether unacceptable human health risks might be caused by exposure to contaminants in OU2 groundwater such that a remedial action is necessary to address contaminated groundwater in OU2. The HHRA also identifies which exposure pathways require mitigation or remediation.

EPA will use the HHRA results in determining the scope of any response action undertaken to address contaminants in the groundwater at OU2.

The HHRA also provides information to help determine whether soil gas contamination in OU2 poses a current or potential future risk to human health. This includes a screening-level risk evaluation of soil vapor intrusion into indoor air at the nearby Whispering Fountains Apartments.

This summary of the baseline HHRA and ERA is organized into the following sections:

- Section 7.1 – Current and Potential Future Uses of Groundwater
- Section 7.2 – Introduction
- Section 7.3 – HHRA Approach
  - Data Evaluation/Hazard Identification
  - Toxicity Assessment/Dose-Response Assessment
  - Exposure Assessment
  - Risk Characterization
- Section 7.4 – Results
- Section 7.5 – Environmental (Ecological Risk) Assessment
- Section 7.6 – Uncertainty Analysis of Current and Potential Future Uses of Groundwater
- Section 7.7 – Conclusions

7.1 Current and Potential Future Uses of Groundwater

Currently, groundwater from deep production wells adjacent to the OU2 study area is used for drinking and domestic purposes. Contaminated groundwater found at shallow depths at the Omega site is not used for any purpose. Potential future use of this OU1 and OU2 groundwater resource can be for drinking water or other domestic purposes. Because OU2 is located in a recharge area of the central basin, there is the potential for contamination in shallow groundwater to reach deeper drinking water aquifers.

7.2 Introduction

The HHRA provides information for use in determining and documenting whether groundwater contamination in OU2 poses a current or potential future risk to human health. The risk assessment presents an evaluation of potential human health effects (i.e., cancer risks and non-cancer health hazards) from exposure to the contaminants in OU2 groundwater. The HHRA also provides information for determining if soil gas contamination in OU2 poses a current or potential future risk to human health. This includes a screening-level risk evaluation of soil vapor intrusion into indoor air at the nearby Whispering Fountains Apartments.

The HHRA was conducted using groundwater data collected from EPA and OPOG monitoring wells. Soil gas data were collected from EPA temporary wells. Supporting risk calculations and summary tables are presented in Appendix L.

7.2.1 Summary of OU1 HHRA

The following is a brief summary of the *HHRA for OU1 On-Site Soils for the Omega Site* prepared by CDM (CDM, 2007b). The risk assessment presents an evaluation of potential cancer risks and non-cancer health hazards associated with exposure to residual soil and groundwater contamination (via soil gas vapor intrusion to indoor air) at the Omega Site. The HHRA was prepared in accordance with Task 2 of the SOW in Consent Decree No. 00-12471 between EPA and OPOG.

The most prevalent contaminants detected in OU1 soil and groundwater were VOCs, primarily PCE and related compounds, TCE, and freons. Chlorinated compounds, including methylene chloride and chloroform, as well as acetone and toluene, are also detected at the downgradient site boundary and offsite. The principal VOCs detected in the soil gas at OU1 and at the highest concentrations are Freon 113, Freon 11, 1,1,1-TCA, and PCE.

Potentially exposed populations evaluated in the HHRA include future onsite residents, current and future on- and offsite indoor industrial workers, future onsite outdoor industrial workers, and a future onsite construction worker for oral, dermal, and inhalation exposure.

Current City of Whittier zoning will allow commercial and retail redevelopment of this site with the construction of multi-level buildings. The zoning of this site as part of the Whittier Boulevard Specific Plan Workplace District allows for the live/work units and multi-family housing.

The results of the OU1 HHRA suggest that contaminated soils at the site could present a significant threat to current and future commercial/industrial workers, future construction workers, and hypothetical future residents. Cancer risk estimates ranged from 4×10^{-7} to greater than 1×10^{-4}. The HI slightly exceeded one for current commercial/industrial workers at parcels other than the Omega Site parcel and was greater than one for future commercial/industrial workers, future construction workers, and future residents. Exposures to soil are unlikely under current conditions because most of the site surface soil is covered with improvements (buildings, concrete, and asphalt). However, future development could result in the removal of existing improvements, and therefore, provide complete exposure pathways for future receptors. Risks and hazards are primarily

attributable to inhalation of indoor air for current and future commercial/industrial indoor workers and future residents and inhalation of ambient air for future outdoor commercial/industrial workers.

Potential risks associated with exposure to vapors intruding into indoor air spaces for current commercial/industrial workers range from $9x10^{-6}$ to $1x10^{-4}$. HI estimates associated with current exposure for vapors intruding into indoor air spaces range from less than 1 to about 8. Possible risks associated with exposure to vapors intruding into indoor air spaces for future commercial/industrial workers range from $8x10^{-7}$ to $5x10^{-4}$. HI estimates for vapors intruding into indoor air spaces for these receptors are in the range of less than 1 to about 7. Risks associated with exposure to vapors intruding into indoor air spaces were highest for hypothetical future residents with risks ranging from $1x10^{-6}$ to $5x10^{-3}$. HI estimates for vapors intruding into indoor air spaces for these residents ranged from less than 1 to 1,089.

Conclusions of the OU1 HHRA are summarized as follows:

- Among receptors potentially exposed to site-related contaminants, the highest cancer risks, and non-cancer hazards are associated with exposure to hypothetical future residents, with cancer risks above $1x10^{-4}$ and HIs above 1.
- The pathway with the highest potential for exposure involves intrusion of vapors into indoor air spaces. Inhalation of these vapors indoors results in the highest estimates of potential cancer risk and non-cancer hazards.
- PCE is the primary COPC at the site. For example, inhalation of indoor air suggests potential total inhalation cancer risks for current industrial workers ranging from $8x10^{-6}$ to $7x10^{-5}$. The cancer risk associated with inhalation exposure to PCE alone ranges from $5x10^{-7}$ to $4x10^{-5}$. The estimated HIs for exposure to indoor air for PCE ranged from 0.01 to 2 when compared to a total inhalation HI ranging from 0.065 to 8.

7.3 HHRA Approach

This section presents the approach and methodology of the OU2 HHRA. This HHRA provides an evaluation of the existing and potential future cancer risks and non-cancer health hazards from residential (adults and children) exposures to VOCs, SVOCs, selected inorganic ions, and metals in OU2 groundwater. The HHRA was developed assuming the use of untreated groundwater for drinking water or for other domestic purposes.

This HHRA also includes a screening-level evaluation of potential future cancer risks and non-cancer health hazard from residential exposure to soil gas vapor intrusion into indoor air for residents of the Whispering Fountains Apartments.

The results and conclusions of the HHRA provide EPA with a health-risk basis for evaluating whether action is warranted to mitigate potential health effects. The HHRA provides an evaluation of “baseline conditions” in which the underlying assumption is that no treatment is implemented to remove contaminants (such as VOCs, SVOCs, inorganic ions, and metals) observed in OU2 groundwater. This allows EPA to decide whether action is necessary to protect human health.

The methods used to conduct this HHRA are consistent with the following EPA and Cal-EPA regulatory guidelines:

- *Risk Assessment Guidance for Superfund, Volume I, Human Health Evaluation Manual (Part A)* (EPA, 1989)
- *Risk Assessment Guidance for Superfund, Volume I, Human Health Evaluation Manual (Part D)* (EPA, 2001c)
- *Risk Assessment Guidance for Superfund, Volume I, Human Health Evaluation Manual (Part E)* (EPA, 2004f)
- *Supplemental Guidance for Human Health Multimedia Risk Assessments of Hazardous Waste Sites and Permitted Facilities* (DTSC, 1992)
- *User's Guide for Evaluating Subsurface Vapor Intrusion into Buildings* (EPA, 2004a)
- *Role of the Baseline Risk Assessment in Superfund Remedy Selection Decisions, Memorandum* (EPA, 1991a)
- *Risk Assessment Guidance for Superfund, Human Health Evaluation Manual, Supplemental Guidance for Default Exposure Factors* (EPA, 1991b)
- *Preliminary Endangerment Assessment Guidance Manual* (DTSC, 1994)

The EPA and DTSC risk assessment framework consists of the following basic steps:

- Data Evaluation/Hazard Identification
- Exposure Assessment
- Toxicity Assessment
- Risk Characterization
- Uncertainty Analysis

Evaluation of exposures and risks and hazards was performed using the *Risk Assessment Guidance for Superfund* (EPA, 2001c), RAGS Part D tables, risk calculations, methodology, and summary tables to support EPA RI Report documentation. Exposure routes considered include ingestion, inhalation of VOCs, and dermal contact with groundwater. The OU2 HHRA is conducted for the following residential receptors:

- Adult – reasonable maximum exposure (RME)
- Child – RME

The screening evaluation of exposures and risk and hazards from soil gas vapor intrusion to indoor air exposure for residents at Whispering Fountains Apartments follows the EPA's *Guide for Evaluating Subsurface Vapor Intrusion into Buildings* (EPA, 2004a). The exposure route evaluated is the inhalation of VOCs from indoor air. The HHRA for the Whispering Fountains Apartments was conducted for adult residential receptors.

7.3.1 Data Evaluation/Hazard Identification

PCE is the major groundwater contaminant from the Omega property and has the largest groundwater plume footprint and the highest groundwater contour concentrations

(Figure 7-1). The PCE groundwater contamination starting from and including the Omega property and extending downgradient approximately 1 mile southwest, with a groundwater PCE concentration of at least 500 µg/L, defines the extent of the groundwater contour, which is evaluated in the OU2 groundwater HHRA (Figure 5-11). Groundwater data from EPA and OPOG groundwater wells inside the 500 µg/L PCE contour (including wells used to construct the 500 µg/L contour) are evaluated in the OU2 HHRA.

This step consists of reviewing, evaluating, and compiling available groundwater analytical results for all detected VOCs, SVOCs, selected inorganic ions, and metals in OU2. The HHRA evaluates chemical contaminants, which were detected in groundwater during the last 2 years (March 2004 through September 2006) of quarterly and semiannual groundwater sample collection from 13 wells (seven EPA monitoring wells and six OPOG wells, Figure 5-11). Soil gas data collected from four temporary wells in the Whispering Fountains Apartments area of OU2 in early 2007 were reviewed, evaluated, and compiled (Figure 2-10).

Analytical results from the following 13 monitoring wells represent the sitewide groundwater data used to characterize the potential health risks and hazards from groundwater contamination in OU2:

EPA Monitoring Wells – The HHRA provides an evaluation of the groundwater data collected from the following seven EPA monitoring wells to estimate cumulative cancer risks and non-cancer hazards from contaminants in groundwater at locations of interest in OU2:

- MW2
- MW4A
- MW4B
- MW5
- MW14
- MW15
- MW23C

OPOG Monitoring Wells – The HHRA also uses the groundwater data collected from the following six OPOG monitoring wells to estimate cumulative cancer risks and non-cancer hazards from contaminants in groundwater at locations of interest in OU2:

- OW1A
- OW2
- OW3
- OW4A
- OW5
- OW8A

Temporary Soil Gas Sampling Wells – Data from four EPA temporary soil gas monitoring wells provide the soil gas data used to estimate potential health risks and hazards from soil gas contamination in the area surrounding the Whispering Fountains Apartments (Figure 7-2). The soil gas wells are identified as follows:

- SGRA-1
- SGRA-2

- SGRA-3
- SGRA-4

Soil gas samples were collected at three depth intervals from each location and analyzed by EPA Method TO-15 (VOCs). Soil samples were also collected for each soil gas well location and depth interval to determine site-specific soil physical properties to support the soil gas risk evaluation. The soil gas monitoring data are used to estimate screening-level cancer risk and non-cancer hazards from soil gas vapor intrusion into indoor air for residents at the Whispering Fountains Apartments.

Classes of groundwater contaminants evaluated in the HHRA include the following:

- VOCs
- SVOCs
- Emergent compounds (1,2,3-trichloropropane, 1,4-dioxane, NDMA, and perchlorate)
- Metals

Detected chemicals in groundwater and soil gas are evaluated for risks and hazards. Background metals concentrations in groundwater from wells upgradient/cross-gradient of the Omega Site are used for the screening of metals in groundwater. Only metals with concentrations above background levels in groundwater, including arsenic, hexavalent chromium, and nickel, are evaluated for risks and hazards. The selection criteria for COPCs are designed to be conservative and health-protective.

Analytical results reviewed to date at EPA and OPOG monitoring wells are very consistent among sampling events; therefore, data from the most recent (last 2 years) sampling events are used in the HHRA to represent current conditions.

The 95 percent upper confidence limit (UCL) of the mean of the groundwater sample COPC concentration for EPA and OPOG monitoring wells in the subject groundwater plume were calculated using EPA's ProUCL 4 software. The 95 percent UCL was compared to the maximum detected concentration, and the lesser COPC concentration was used as the exposure point concentration (EPC) to represent RME conditions for this baseline risk assessment.

All COPC concentrations detected in soil gas at various depths were evaluated for screening-level exposure estimation using the Johnson and Ettinger soil gas model.

7.3.2 Toxicity Assessment/Dose-Response Assessment

Several EPA and Cal-EPA sources are used to obtain toxicity criteria (cancer slope factors and non-carcinogenic reference doses) used in the evaluation of cancer risks and non-cancer health hazards for the VOCs, SVOCs, selected inorganic ions, and metals observed in OU2 groundwater and soil gas samples.

The list of sources includes the following:

- EPA, *Integrated Risk Information System* (2007)
- EPA, *Health Effects Assessment Summary Table* (1997b)

- EPA, Provisional National Center for Environmental Assessment, *TCE Toxicity Value* (from the Region 9 PRG tables) (EPA, 2004g)
- Cal-EPA OEHHA, *Toxicity Criteria Database* (Cal-EPA, 2007)

The use of EPA and Cal-EPA toxicity values is in accordance with the EPA *Office of Solid Waste and Emergency Response Directive 9285.7-53* (EPA, 2003), which defines the EPA hierarchy of human health toxicity values for use in HHRAs and ensures the use of high-quality toxicity criteria for the estimation of risks and hazards during the HHRA process. When EPA and Cal-EPA have toxicity criteria, this HHRA uses the more conservative toxicity value comparing both Cal-EPA and EPA.

Because of the ongoing EPA assessment of the TCE toxicity criteria, this HHRA uses the TCE toxicity value from OEHHA (Cal-EPA, 2007).

7.3.3 Exposure Assessment

The exposure assessment component of the HHRA describes how individuals in or near OU2 could be in contact with chemicals in groundwater. The assessment addresses exposures that could result under existing conditions in OU2 and from reasonably anticipated potential land uses of OU2 and surrounding areas in the future. The exposure assessment contributes to the HHRA by describing the following:

- Populations that might be exposed
- Routes and exposure pathways by which individuals could become exposed
- Magnitude, frequency, and duration of potential exposures

7.3.3.1 Site and Potential Receptors

For OU2, the HHRA evaluates exposures and cancer risks (and non-cancer health hazards) from groundwater used as domestic tap water. For groundwater exposure, adult and child residents are evaluated as potential receptors.

Exposures and risks (and health hazards) from soil gas vapor intrusion are evaluated at one representative location. The screening-level risk assessment for soil gas exposure evaluates potential risks to adult receptors at the Whispering Fountains Apartments as because of the relatively shallow depth and elevated VOC concentrations in this area of the OU2 groundwater plume.

7.3.3.2 Conceptual Exposure/Pathway Analysis

Groundwater used as tap water and soil gas vapor intrusion to indoor air were evaluated.

Groundwater exposure routes include the following:

- **Ingestion** (primary exposure route for VOCs, SVOCs, and metals) – Potential use of groundwater for potable use presents risks of human health exposure to the contaminants through ingestion of drinking water and use in food.
- **Inhalation** (primary exposure route for VOCs) – Potential use of groundwater for domestic purposes presents risks of human health exposure to VOCs through inhalation during activities such as bathing and dishwashing.

- **Dermal** (not a primary exposure pathway for VOCs) – Potential use of groundwater for domestic purposes presents risks of human health exposure to VOCs, SVOCs, and metals through skin during activities such as bathing.

Exposure routes for soil gas vapor intrusion to indoor air are as follows:

- **Inhalation of Indoor Air –** Volatile contaminants from contaminated groundwater are released into soil gas. 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. These contaminants can accumulate in indoor air if there is poor ventilation. In addition, building heating (and other associated HVAC system operations) can create negative pressure that can enhance the flow of soil gas into indoor air. Since VOCs at OU2 are found in shallow soil gas samples at the Whispering Fountains Apartments in close proximity to the OU2 PCE groundwater plume, exposure levels due to inhalation of indoor air were evaluated for the residents of Whispering Fountains Apartments.

7.3.3.3 Site Conceptual Model

The human health conceptual site model diagram shown in Figure 7-3 summarizes information about contamination and transport through the environment to potential human receptors in a schematic presentation (EPA, 1989a). The human health conceptual site model consists of the following components.

- Potential primary contamination sources (Omega Site)
- Contamination release mechanisms (spills and leaks)
- Potential secondary contamination sources (contaminated soil)
- Contaminant transport mechanisms (for example, infiltration to groundwater)
- Contaminated exposure media (for example, groundwater, soil gas, indoor air)
- Exposure routes (ingestion, direct dermal contact, and inhalation of VOCs during domestic water use, inhalation of VOCs from indoor air)
- Potentially exposed receptors (residents)

Based on an evaluation of potential human exposures and health risks from OU2 groundwater used as tap water or for other domestic uses by residents (adult and child), the following exposure routes are determined to have potentially complete exposure pathways.

Receptor	Exposure Related Activities	Exposure Route
Residential adult and child	Consumption of drinking water	Ingestion.
	Showering/bathing	Dermal contact
	Typical domestic activities (e.g., toilet flushing, dishwashing, and laundering)	Inhalation (VOCs only)
Residential adult	Inhalation of indoor air	Inhalation (indoor vapor intrusion, VOCs only)

7.3.3.4 Exposure Assessment

OU2 consists of residential areas and industrial/commercial areas. However, residential exposures represent the potential maximally exposed population; therefore, quantitative risk evaluation for groundwater exposures uses residential exposures for adult and child receptors.

The assumptions used in this HHRA provide an RME estimate for adult and child residents. The RME scenario includes the following assumptions for adult and child residents (EPA 1989a; EPA 1997c).

Assumption	Adult	Child
Exposure Duration	30 years	6 years
Exposure Frequency	350 days/year	350 days/year
Groundwater Ingestion Rate	2 liters/day	1 liter/day
Inhalation Rate	20 cubic meters/day	10 cubic meters/day
Body Weight	70 kilograms	15 kilograms
Averaging Time (Cancer)	25,550 days	25,550 days
Averaging Time (Non-Cancer)	8,760 days	2,190 days

This combination of several upper-bound assumptions provides assurance that the estimated risks presented under the RME scenario represent the high end of plausible exposure.

Soil gas exposures are estimated for adults based on the onsite soil gas values and supporting soil parameters data using the soil gas screening-level version of the Johnson and Ettinger model (Version 3.1, EPA, 2004d).

7.3.4 Risk Characterization

This HHRA follows EPA guidance to estimate future potential residential health hazards and risks from exposure to untreated groundwater used for drinking water and other domestic use (EPA, 1989a; 1991a; 1991b; and 1991c). Exposures, potential cancer risks, and non-cancer hazards are estimated assuming residents are the most likely receptors to be exposed to contaminants in groundwater on a daily basis. The HHRA assumes continued, unrestricted use of groundwater in the future.

In the risk characterization step, results of the exposure assessment (estimated chemical intakes) are combined with the results of the dose-response assessment (toxicity values identified in the toxicity assessment) to provide numerical estimates of potential cancer and non-cancer health effects. The quantification approach differs for potential non-cancer and cancer effects.

7.3.4.1 Cancer Effects

The potential for cancer effects is evaluated by estimating excess lifetime cancer risk (ELCR), the incremental increase in the probability of developing cancer during one's lifetime in addition to the background probability of developing cancer (that is, if no exposure to

chemicals occurs). For example, a $2x10^{-6}$ ELCR means that, for every 1 million people exposed to OU2-related carcinogens throughout their lifetimes, the average incidence of cancer might increase by two cases of cancer.

EPA developed cancer slope factors that represent upper-boundary estimates; therefore, cancer risk estimates in this assessment should be regarded as an upper boundary of the potential cancer risks rather than a representation of true cancer risk. The actual cancer risk is likely to be less than that predicted in the HHRA (EPA, 1989a).

Although synergistic or antagonistic interactions might occur between cancer-causing chemicals and other chemicals, information to predict the effects of these potential interactions quantitatively is generally unavailable in toxicological literature. Therefore, in this HHRA, the total cancer risk for an exposure route is calculated by adding cancer risks for individual chemicals for that exposure route, which is consistent with EPA guidelines on chemical mixtures (EPA, 1989a).

EPA guidance (EPA, 2004a) for the Johnson and Ettinger model is used to calculate the screening-level ELCR associated with each VOC detected in soil gas.

7.3.4.2 Non-Cancer Effects

For non-cancer effects, the likelihood that a receptor will develop an adverse effect is estimated by comparing the predicted level of exposure for a particular chemical (chronic daily intake) with the highest level of exposure that is considered protective (i.e., its reference dose [RfD]).

A hazard quotient (HQ) greater than 1 (i.e., exposure that exceeds the reference dose) indicates potential non-cancer health effects. To assess the potential for non-cancer health effects posed by exposure to multiple chemicals, an HI approach is used according to EPA guidance (EPA, 1989a). This approach assumes that the non-cancer hazard associated with exposure to more than one chemical is additive; therefore, synergistic or antagonistic interactions between chemicals will not occur.

The HI could exceed 1 even if all the individual HQs are less than 1. In this case, similar mechanisms of toxicity and toxicological effects could be criteria to segregate the chemicals. Separate HIs then could be derived based on mechanism and effect.

Additionally, for each receptor, cumulative cancer risks across all relevant exposure routes are evaluated. Risks for oral, inhalation, and dermal contact routes of exposure are summed, as available. In a similar manner, cumulative non-cancer health hazards are summed across routes.

EPA guidance (EPA, 2004a) for the Johnson and Ettinger model is used to calculate the HQ associated with VOCs detected in soil gas.

7.4 Results

This section presents results from the estimation of potential cancer risks and non-cancer health hazards from the domestic use of untreated groundwater from OU2. The results from the estimation of potential cancer risks and non-cancer hazards due to inhalation exposure

from soil gas vapor intrusion to indoor air at Whispering Fountains Apartments are also presented. For this baseline HHRA, the potential for unacceptable cancer risks and non-cancer health hazards is identified using the following criteria:

- ELCR values are compared to a risk management range of one-in-a-million (10^{-6} or 1E-06) to 1-in-10,000 (10^{-4} or 1E-04) (EPA, 2004e). ELCR values within or exceeding this range are actionable. This can then lead to a risk management decision that includes evaluating site-specific characteristics and exposure scenario factors to assess whether remedial action is warranted.
- An HI (the ratio of chemical intake to the RfD) greater than 1 indicates that there may be concern for potential non-cancer health effects associated with exposure to the contaminants of concern (EPA, 1989a).

7.4.1 Carcinogenic Risks

Potential future carcinogenic risks are estimated for the domestic use of untreated groundwater as tap water from EPA and OPOG monitoring wells in the OU2. The HHRA evaluates a scenario of RME for an adult, child, and lifetime (adult plus child) resident.

To provide an estimate of maximum potential cancer risk, the total adult plus child risks due to ingestion, inhalation, and dermal exposure of chemicals in groundwater were estimated and are presented in the following table:

Chemical of Potential Concern	Cancer Risk	% Contribution
1,2-DCA	2E-03	<0.5
1,4-Dioxane	1E-03	<0.5
Chloroform	4E-03	<0.5
Methylene Chloride	9E-04	<0.5
PCE	9E-01	98
TCE	1E-03	<0.5
1,1,1,2-Tetrachloroethane	9E-06	<0.5
1,1,2,2-Tetrachloroethane	1E-05	<0.5
1,1,2-TCA	1E-03	<0.5
1,1-DCA	2E-05	<0.5
1,2,4-Trichlorobenzene	7E-08	<0.5
1,2-Dibromo-3-Chloropropane	4E-03	<0.5
1,2-Dichloropropane	1E-05	<0.5
1,4-Dichlorobenzene	3E-06	<0.5
Benzene	2E-04	<0.5
Bromodichloromethane	5E-06	<0.5
Bromoform	4E-07	<0.5
Carbon Tetrachloride	4E-06	<0.5
Chloroethane	5E-08	<0.5
Dibromochloromethane	1E-05	<0.5
Ethylbenzene	1E-06	<0.5
MTBE	4E-07	<0.5
Naphthalene	5E-06	<0.5

Chemical of Potential Concern	Cancer Risk	% Contribution
Tetrahydrofuran	4E-04	<0.5
Vinyl Chloride	3E-05	<0.5
1,2,3-TCP	3E-06	<0.5
DEHP	7E-06	<0.5
Isophorone	7E-08	<0.5
N-Nitrosodimethylamine	1E-04	<0.5
Pentachlorophenol	7E-06	<0.5
Arsenic	2E-03	<0.5
Total	**9E-01**	**100**

7.4.1.1 Summary Results and Key Findings

- Total adult plus child cancer risks from potential exposure through ingestion, inhalation, and dermal contact to untreated groundwater from EPA and OPOG OU2 monitoring wells is $9x10^{-1}$, with PCE contributing 98 percent of cancer risk.
- Ingestion (56 percent contribution) is the major contributing route of exposure to total cancer risks.
- PCE, 1,2-DCA, 1,4-dioxane, chloroform, 1,2-dibromo-3-chloropropane, arsenic, methylene chloride, TCE, 1,1,2-TCA, benzene, tetrahydrofuran, and NDMA are the primary contributors to total cancer risks for the OU2 groundwater monitoring wells and each contributes $1x10^{-4}$ or more risk.

7.4.2 Non-Carcinogenic Health Hazards

Potential future non-carcinogenic health hazards are estimated for the domestic use of untreated groundwater at EPA and OPOG monitoring wells in the OU2. The HHRA evaluates a scenario of RME for an adult and child resident.

Chemicals that showed total HQ equal to 1 or greater than 1 for the child receptor due to ingestion, inhalation, and dermal exposure of chemicals in groundwater are presented in the following table:

Chemical of Potential Concern	Non-Cancer HQ	% Contribution
1,1-DCE	18	0.6
1,2-DCA	57	2
Chloroform	17	0.5
Methylene Chloride	3	<0.5
PCE	2,700	84
TCE	330	10
1,1,2-TCA	17	0.5
1,2,4-Trimethylbenzene	1	<0.5
1,2-Dibromo-3-Chloropropane	38	1
Benzene	1	<0.5
Bromomethane	7	<0.5
Tetrahydrofuran	3	<0.5

Chemical of Potential Concern	Non-Cancer HQ	% Contribution
N-Nitrosodimethylamine	2	<0.5
Arsenic	3	<0.5
Total (All COPCs)	**3,236**	

7.4.2.1 Summary Results and Key Findings

- Total estimated HIs for child receptors from potential ingestion, inhalation, and dermal exposure to untreated groundwater from EPA and OPOG monitoring wells are a total of 3,236.
- Inhalation (69 percent contribution) is the major contributor route of exposure to non-cancer hazards.
- PCE (84 percent contribution) and TCE (10 percent contribution) are the major contributors to non-cancer hazards for all monitoring wells, followed by 1,2-DCA, 1,2-dibromo-3-chloropropane, chloroform, 1,1-DCE, and 1,1,2-TCA.

7.4.3 Soil Gas Screening Risk Evaluation

A soil gas screening risk evaluation was conducted for the nearby Whispering Fountains Apartments to evaluate potential current and future carcinogenic risks and non-carcinogenic hazards from inhalation exposure to VOCs in indoor air due to vapor intrusion from the subsurface. Soil gas samples were collected from four locations at three depth intervals.

Screening level cancer risks and non-cancer health hazards are evaluated for the following contaminants detected in soil gas samples: benzene, chloroform, ethylbenzene, PCE, toluene, TCE, Freon 11, Freon 113, 1,2,4-trimethylbenzene, 1,3,5-trimethylbenzene, m,p-xylene, and o-xylene. Except for 1,2,4-trimethylbenzene, 1,3,5-trimethylbenzene, ethylbenzene, toluene, m,p-xylene, and o-xylene, these contaminants are also detected in HydroPunch® groundwater samples collected at the same locations as the soil gas samples.

The results of these collocated samples (soil gas and groundwater) support the connection between the OU2 groundwater VOC contamination and potential indoor air vapor intrusion. However, the soil gas COPCs not detected in the HydroPunch® groundwater samples are also OU2 groundwater COPCs and are evaluated in the soil gas screening-level evaluation for completeness.

The screening-level soil gas assessment using EPA's Johnson and Ettinger soil gas screening model evaluates potential soil gas exposures in indoor air and the subsequent cancer risk and non-cancer health hazards for adult receptors. The screening-level soil gas risk assessment was performed on each soil gas sample for all COPCs detected in the samples.

7.4.3.1 Summary Results and Key Findings

- Estimated cancer risk from potential exposure of chemicals detected in soil gas, through inhalation of indoor air for residents of the Whispering Fountains Apartments, is less than $1x10^{-6}$. The estimated potential cancer risk for the four locations evaluated range from $3x10^{-8}$ to $3x10^{-7}$.

- Estimated non-cancer hazards from potential exposure of all chemicals detected in soil gas, through inhalation of indoor air for residents of the Whispering Fountains Apartments, is less than 1. The potential estimated non-cancer hazard for the four locations evaluated range from 0.0002 to 0.004.

7.5 Environmental (Ecological Risk) Assessment

A Scoping Assessment was conducted to determine whether plants or animals at OU1 and OU2 may be exposed to COPCs and whether further Screening Level Ecological Risk Assessment (SLERA) work is required. Risk can occur only when there is a chemical source, a receptor, and a route of exposure between the source and receptor. A SLERA is recommended only if the Scoping Assessment has shown that there is a source of contaminants, receptors are or will be present, and current or future land-use or offsite contaminant migration indicates that receptors may be exposed. The Scoping Assessment is included in Appendix M.

Ornamental trees and small areas of landscaped grass represent extremely limited habitat and a very limited diversity of ecological receptors. One small urban park within OU2 and two urban parks adjacent to the OU2 boundary offer recreational areas for residents, but provide little habitat for wildlife. Bird species tolerant of urban settings (e.g., crows, pigeons, and sparrows) were the only wildlife observed at the Omega Site. The closest water body to the site is the San Gabriel River. It runs parallel to the site about 1 mile northwest of the northwestern OU2 plume boundary. All other surface water drains over the site into concrete-lined washes and drains where there is no potential for contact with contaminated groundwater because the drains are above the water table.

There are no complete exposure pathways between contaminants and receptors and no potential for risk to ecological receptors because of the depth to contaminated groundwater at the Omega Site (30 to 100 feet bgs). Ecological receptors are also not present at OU1 and OU2 due to the lack of suitable habitat. Although VOC vapors have been detected in buildings at or near the surface of OU1, wildlife does not occupy these buildings and there is no potential for exposure to these vapors. There are no naturally occurring burrowing birds or mammals at OU1 due to the lack of suitable habitat. Therefore, there is no potential for exposure of wildlife to contaminated soil at OU1. The conclusion of the Scoping Assessment is that there is no potential for risk to ecological receptors from groundwater or soil contaminants at OU1 and OU2. Therefore, no further action is warranted. Scoping assessments may be required for the facilities that are sources of contamination at OU2, depending on the specific conditions at these facilities.

7.6 Uncertainty Analysis of Current and Potential Future Uses of Groundwater

The HHRA presents quantitative estimates of potential future cancer risks and health hazards; however, these numbers do not predict actual health outcomes. Using approaches and methodologies based on EPA and Cal-EPA guidance documents, the health risks and hazards are calculated in a conservative, health-protective manner that tends to overestimate risks. Thus, any actual health effects are likely to be lower than these estimates.

Domestic water consumption assumptions used in the HHRA are based on the use of RME water consumption exposure factors and, therefore, are likely to overestimate actual exposures and risks.

The EPA risk assessment paradigm includes an uncertainty analysis (EPA, 1989a). The goal of the uncertainty analysis is to inform risk managers about the type of uncertainties that affect the range of potential risks and hazards estimated in the HHRA. Sources of uncertainty in the development of the OU2 HHRA include selection of COPCs, environmental data quality, sampling and analysis, fate and transport estimation, exposure estimation, Johnson Ettinger model, and toxicological data and risk characterization. The potential effects of these uncertainties are qualitatively analyzed and discussed in Appendix L.

7.7 Conclusions

The HHRA and ERA results will help in determining whether contaminants at OU2 pose a current or potential risk to human health and the environment in the absence of any remedial action. The risk assessment will assist EPA in the following areas:

- Evaluating the need for a comprehensive remedial action to address contaminated groundwater throughout OU2
- Providing justification for performing a remedial action
- Determining what exposure pathways need to be remediated

The baseline HHRA uses an approach for assessing risks that optimizes the available data set. Total baseline risk was estimated using data from all the groundwater wells within a 500 µg/L contour of PCE for groundwater exposure. Additionally, a screening-level approach is used to estimate total risk for soil gas vapor intrusion to indoor air from monitoring wells affected by VOCs identified in OU2 groundwater in the Whispering Fountains Apartments. The HHRA provides an evaluation of the need for a comprehensive remedial action for the entire OU2, rather than discrete actions at individual wells.

As appropriate, remedial actions could include restoring currently contaminated portions of the drinking water aquifers and protecting portions of the drinking water aquifers that are unaffected, so that unimpeded future use of these aquifers is possible. Thus, the HHRA will help EPA in its effort to protect groundwater at and outside OU2 as a resource and for the potential use of the groundwater as a source of domestic water supply.

For the baseline HHRA, the potential for unacceptable cancer risks and non-cancer health hazards is identified using the following criteria:

- ELCR values are compared to a risk management range of one-in-a-million (10^{-6} or 1E-06) to one-in-10,000 (10^{-4} or 1E-04) (EPA, 2004c). ELCR values within or exceeding this range are actionable. This can then lead to a risk management decision that includes evaluating site-specific characteristics and exposure scenario factors to assess whether remedial action is warranted.

- An HI (the ratio of chemical intake to the RfD) greater than 1 indicates that there may be concern for potential non-cancer health effects associated with exposure to the contaminants of concern (EPA, 1989a).

The baseline HHRA for the Omega Site OU2 RI confirms that VOCs have adversely affected the groundwater resources in OU2. The VOCs most commonly encountered during this assessment and which serve as potential risk drivers are PCE and TCE.

7.7.1 Key Findings

Key findings are presented for the HHRA and ERA.

7.7.1.1 HHRA

- The estimated potential future cumulative cancer risk of $9x10^{-1}$ from exposure to untreated OU2 groundwater used as residential tap water greatly exceeds the cancer risk management range of one-in-a-million (10^{-6} or 1E-06) to one-in-10,000 (10^{-4} or 1E-04).
- PCE, 1,2-DCA, 1,4-dioxane, chloroform, 1,2-dibromo-3-chloropropane, TCE, 1,1,2-TCA, and arsenic are the primary contributors to cancer risks for all routes of exposure and contribute cancer risks of $1x10^{-3}$, or greater.
- The estimated potential future cumulative health hazard index of 3,236 for child receptors greatly exceeds an HI of 1. PCE and TCE are the primary contributors to the HI for all three routes of exposure.
- Inhalation exposure due to soil gas vapor intrusion into indoor air does not pose significant risk to the residents of Whispering Fountains Apartments; the estimated cancer risks are less than $1x10^{-6}$ and the HI is significantly less than 1.

7.7.1.2 Ecological Risk Assessment

- There are no complete exposure pathways between contaminants and receptors and no potential for risk to ecological receptors because of the depth to contaminated groundwater at the Omega Site (30 to 100 feet bgs). Ecological receptors are also not present at OU1 and OU2 due to the lack of suitable habitat. Although VOC vapors have been detected in buildings at or near the surface of OU1, wildlife does not occupy these buildings, and there is no potential for exposure to these vapors. There are no naturally occurring burrowing birds or mammals at OU1. Therefore, there is no potential for exposure of wildlife to contaminated soil at OU1.
- The conclusion of the Scoping Assessment is that there is no potential for risk to ecological receptors from groundwater or soil contaminants at OU1 and OU2.

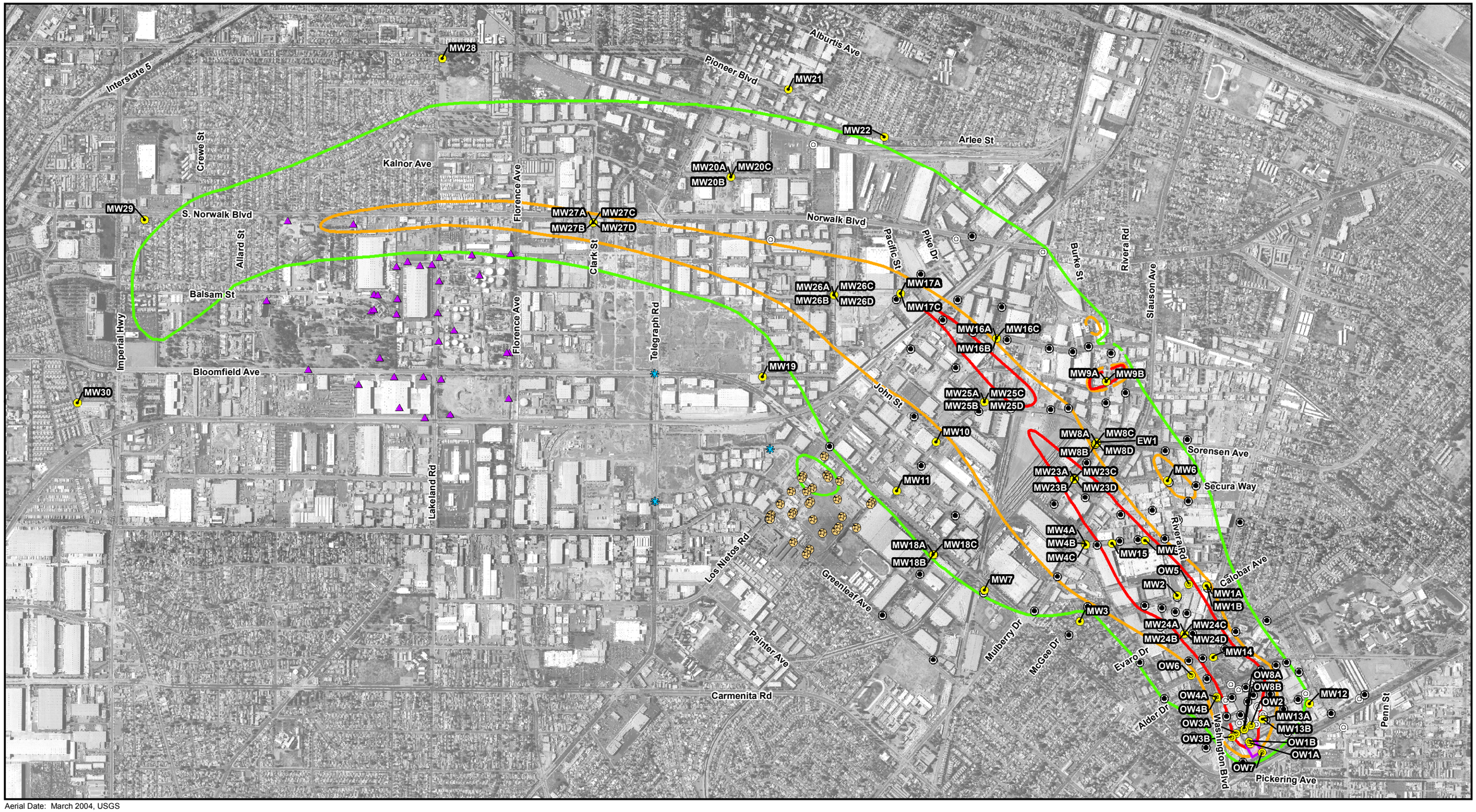
7.7.2 Recommendations

This HHRA provides EPA with a human health risk basis for evaluating whether mitigation, remediation, or removal action is warranted to mitigate potential health effects from VOCs, SVOCs, selected inorganic ions, and metals in OU2 groundwater.

Results of the OU2 HHRA confirm that groundwater resources have been significantly contaminated by VOCs in groundwater and it is unsuitable as a source of tap water for

domestic use. It is recommended that further action be taken to protect potential receptors in OU2, as well as to protect and restore the groundwater resources.

Based on the scoping ERA, there is no current or future risk to ecological receptors from groundwater contaminants at OU1 and OU2 and no further action to address risks to ecological receptors is warranted. Scoping assessments may be required for the facilities that are sources of contamination at OU2, depending on the specific conditions at these facilities.



Aerial Date: March 2004, USGS

Legend

- EPA Monitoring Well
- Omega Potentially Responsible Parties Organized Group (OPOG) Monitoring Well
- Oil Field Reclamation Project (OFRP) Well
- Waste Disposal, Inc. (WDI) Well (4th Quarter, 2002)
- CENCO Wells (November 2006)
- Production Well

Historical Boring Locations

- Auger Boring
- CPT Boring

- Former Omega Facility

Composite PCE Plume Extent

- 5 ug/L (Dashed where Approximate)
- 100 ug/L (Dashed where Approximate)
- 500 ug/L (Dashed where Approximate)

N

0 1,600 3,200 Feet

Figure 7-1
PCE Plume Extent and Monitoring Well Location Map
Omega Chemical Superfund Site

CH2MHILL

Date: December 18, 2007

\\galt\proj\Omega\2007\MapFiles\11x17_OperableLoc_v1.mxd

LEGEND

- Hydropunch
- Soil Gas Probe
- Soil Sample
- EPA Monitoring Well
- Approximate Residential Area Boundary
- 32-35 Depth of Hydropunch Sample (Feet below ground surface)

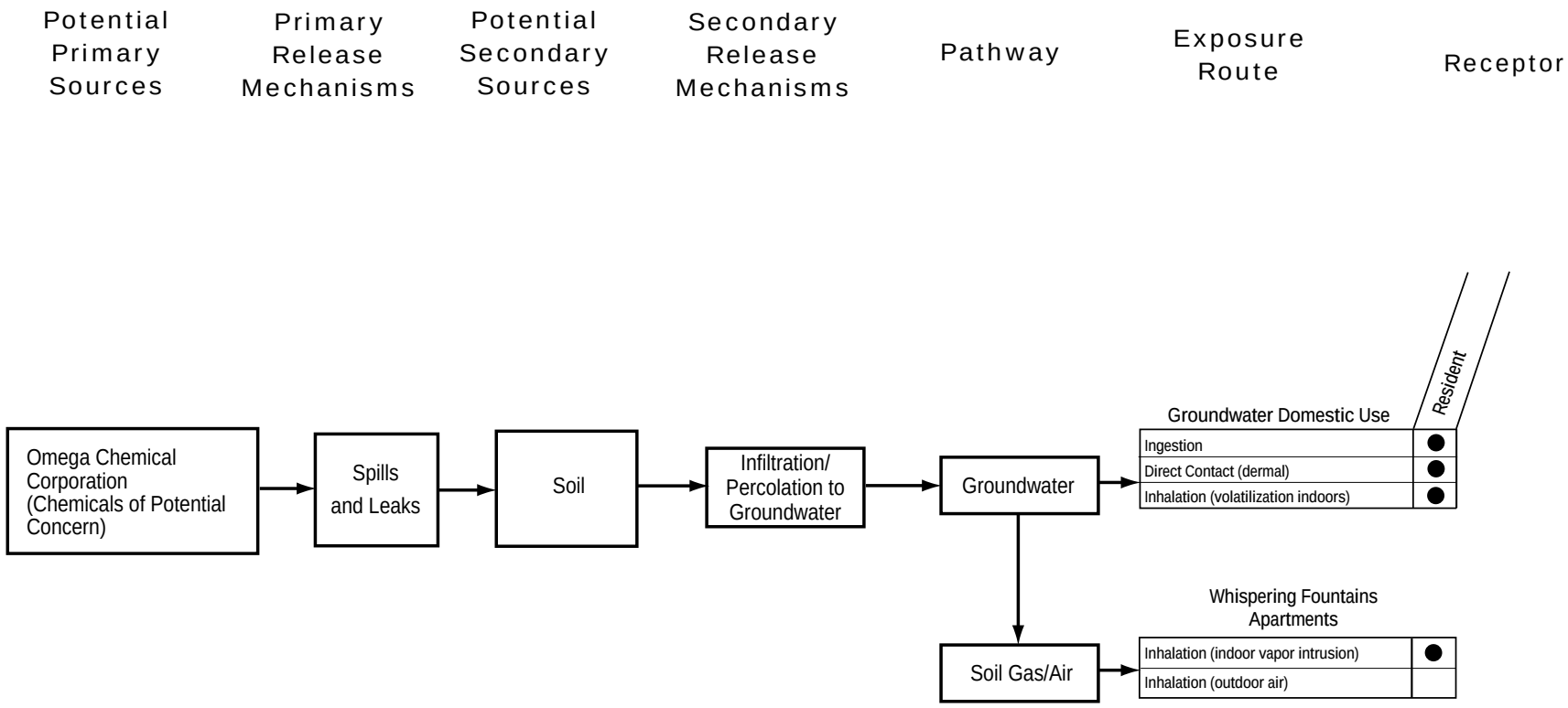
N

0 50 100 Feet

Figure 7-2
Soil Gas Investigation Sample Location Map
Omega Chemical Superfund Site

Date: 12/18/2007

SCO \\GALT\PROJ\OMEGA\2007\MAPFILES\SECTION2\11X17_SOILGASINVEST.MXD 11X17_SOILGASINVEST.MXD 9/10/2007



LEGEND:

● = Potentially Complete Pathway

Figure 7-3
Human Health Conceptual Site Model Diagram
Omega Chemical Superfund Site

CH2MHILL

ES102007012SCO335392.RA.01 Omega_sitemodel73.ai 1/08

8. Summary and Conclusions

To evaluate the nature and extent of groundwater contamination in OU2 and assess the potential risk to human health and the environment from regional groundwater contamination, the EPA completed the RI by addressing the following tasks:

- Characterize the lateral and vertical extent of the groundwater contamination at OU2
- Conduct field investigations and other research to identify potential sources of contamination in groundwater
- Conduct human health and ecological risk assessments

Section 8 is organized as follows:

- **8.1 Summary –** This subsection summarizes the results of the RI with respect to nature and extent of contamination, contaminant fate and transport, and risk assessment.
- **8.2 Conclusions –** This subsection presents conclusions regarding the adequacy of the RI data, recommendations for further monitoring and data collection, and recommendations for remedial action objectives.

8.1 Summary

The Omega facility was a refrigerant and solvent recycling facility that operated from approximately 1976 to 1991. Waste solvents and chemicals were re-processed to produce commercial products. Environmental regulatory action at the Omega facility began with several notices of violations from the California Department of Health Services beginning in 1990. In 1995, the EPA became the lead agency at the Omega Site. The Omega Site was placed on the NPL in January 1999.

The RI was conducted with the primary goal of characterizing the nature and extent of contamination in groundwater at OU2 to the extent necessary for assessing the risk these contaminants pose to human health and the environment, and for determining whether remedial action is required. The second goal of the RI was to obtain information necessary for developing and evaluating remedial action alternatives to eliminate, reduce, or control risks to human health and the environment at the Omega Site.

8.1.1 Nature and Extent of Contamination

The Omega Contaminants are chemicals found at concentrations exceeding their screening levels at OU1 Wells OW1A, OW1B, OW2, OW3A, OW3B, OW8A, and OW8B. The Omega Contaminants are believed to have been introduced to groundwater as a result of the release of hazardous substances at the former Omega facility. The hazardous substances released at the Omega property have entered into the aquifer and while migrating with groundwater flow have commingled with contaminants originating from releases of hazardous substances at other source areas. Major chemical constituents of the releases at the former

Omega facility and the downgradient sources are the same (e.g., PCE and TCE). Freon 11 and Freon 113, however, are considered tracers for the Omega Contaminants because the Omega facility was the only confirmed source of Freons in OU2 groundwater based on the data available at the time of this RI. However, the downgradient extent of some Omega Contaminants (e.g., PCE and TCE) is greater than the extent of Freons because their source concentrations (at OU1) are greater than the source concentrations of Freons and because other sources of PCE and TCE are also present within OU2. PCE and TCE concentrations of 90,000 and 2,600 µg/L, respectively, were detected at OW1A in August 2007. Freon 11 and Freon 113 were nondetect in samples from the same well at detection limits of 200 and 1,000 µg/L, respectively. Immediately downgradient at Well OW8A, Freon 11 and Freon 113 concentrations were 180 and 730 µg/L, respectively (the highest concentration of Freon 11 at OU1 of 240 µg/L was at Extraction Well EW2 on Putnam Street). Historically, PCE and TCE concentrations exceeded the concentrations of Freon 11 and Freon 113 by a similar factor (Table 5-5). Freons generally do not degrade in groundwater; PCE and TCE do degrade in groundwater, but their degradation at OU2 seems to be limited. Thus the overall extent of the Freon, PCE, and TCE plumes is mainly determined by their source concentrations, and the presence of other sources of PCE and TCE at OU2.

COPCs for OU2 are defined as chemicals found at OU2 at concentrations exceeding their screening levels (e.g., California or federal Primary MCL, or California Department of Health Services Notification Level, etc.). They may have originated from the former Omega facility or from other known and unknown sources; they may also include naturally occurring compounds. Regardless of their origin, some or all of the COPCs will likely have to be addressed by the future OU2 remedy.

Omega Contaminants in groundwater extend about 4.5 miles to the southwest from the Omega property. The known depth extent of the contamination is up to about 200 feet bgs. The extents of the plumes of individual compounds were estimated based primarily on the analytical results from the July through August 2007 sampling event. Historical concentration data from CPT borings and monitoring wells obtained during Omega Site investigations and information from other facilities at OU2 were also considered.

A brief summary of the extent of COPCs in July through August 2007 follows:

- The maximum PCE detection of 90,000 µg/L was found in Well OW1A. The PCE plume with concentrations greater than 5 µg/L extends approximately 4.5 miles downgradient west-southwest of the former Omega facility to an area located between EPA Wells MW29 and MW30. PCE concentrations exceeding 100 µg/L form a relatively narrow zone that extends from the Omega property to between CENCO Refinery Wells MW-603 and MW-605. Two distinct zones of concentrations exceeding 500 µg/L are present. One is associated with the Omega property which extends into the deeper aquifer zone at Well MW23; the second zone is associated with AMK. Other, more localized zones of high PCE concentrations present west of AMK are associated with other industrial facilities.

- The maximum TCE detection of 2,600 µg/L was found in Well OW1A. The extent and characteristics of the observed TCE plume are similar to those of the PCE plume. TCE concentration up to 100x MCLs were found to be associated with the Omega property and AMK. There is a separate zone of TCE concentrations exceeding 100 µg/L near Well

MW9A co-located with the zone of PCE concentrations. A distinct lobe of TCE concentrations greater than 500 µg/L west of the Omega property is associated with a source area at Whittier Boulevard.

- The maximum Freon 11 detection of 210 µg/L was found in Well OW5. The Freon 11 plume is narrower than PCE or TCE plumes and it does not extend as far downgradient. The maximum Freon 113 detection of 730 µg/L was found in Well OW8A. The Freon 113 plume extent is similar to the extent of Freon 11 plume. No sources for the Freons other than the former Omega facility have been identified; Freons are, therefore, considered the tracer compounds for the Omega property. However, because both Freons are present at much lower concentrations than PCE and TCE at OU1 (i.e., the source area), their extent in groundwater at OU2 is smaller than the extent of the release of hazardous substances from the Omega property.
- The maximum 1,4-dioxane detection of 290 µg/L was found in Well OW1A. The extent of 1,4-dioxane (Figure 5-16) is similar to the extent of PCE and TCE except that it is wider between Wells MW21 and MW28. The 1,4-dioxane concentrations decrease rapidly downgradient from the Omega property; there is a separate zone of high concentrations extending from the AMK area.
- The maximum hexavalent chromium detection of 200 µg/L was found at Well MW8A. The extent of hexavalent chromium does not follow a pattern similar to the VOC plumes; it extends from Well MW1A to the southwest. Historical concentrations near the Omega property have been low, suggesting that the Omega facility is probably not a significant source for hexavalent chromium contamination. Separate zones of concentrations exceeding 50 µg/L extend from the Foss Plating and Phibro-Tech, Inc. facility properties, respectively.
- Perchlorate contamination was found at low concentrations with the maximum detection of 7.5 µg/L found at Well MW16A. Laterally, the contamination of perchlorate is spotty and does not follow a simple pattern. There are three zones of contamination above the MCL for perchlorate (6 µg/L). Sources for perchlorate contamination cannot be easily identified.
- The maximum 1,1-DCE detection of 710 µg/L was found at Well OW1A. The extent of 1,1-DCE in groundwater was found to be similar to that of PCE and TCE, including the relatively high concentrations associated with the Omega property and the AMK.
- The maximum cis-1,2-DCE of 300J µg/L was found at Well MW17A. Three separate zones of cis-1,2-DCE contamination above MCL (6 µg/L) were identified, indicating the possibility of multiple sources.
- The maximum chloroform detection of 170 µg/L was found at Well OW5. Chloroform is present at low concentrations, generally less than 1 µg/L, throughout OU2. The plume extends approximately from Well MW24 to just beyond Well MW23.
- The maximum acetone detection of 26 µg/L was found at Well MW24A. Detections for acetone extend from Wells MW24 to MW27, indicating a possible source upgradient of Well MW24.

- The maximum carbon tetrachloride detection of 4.7 µg/L was found at Well MW2. Detections for carbon tetrachloride extend from the Omega property to Well MW20.
- The maximum 1,1-DCA detection of 170 µg/L was found in Well MW17A. Detections for 1,1-DCA (Figure 5-24) extend from the Omega property to Well MW27. Concentrations decrease quickly downgradient of the Omega property. Concentrations are much higher at AMK.
- The maximum Freon 12 detection of 3.6 µg/L was found at Well MW15. All other detections in EPA wells are below 3 µg/L. Detections of Freon 12 extend from Wells MW14 to MW29.
- The maximum 1,1,1-TCA detection or 2,200 µg/L was found at Well OW1A. Detections of 1,1,1-TCA extend from the Omega property and quickly decrease to Well MW21. High concentrations of 1,1,1-TCA are found at AMK, Site B, and Site C.
- Several plumes of fuel hydrocarbons found at OU2 are associated with known sources. The full extent of the fuel hydrocarbons at OU2 is not known.

8.1.2 Sources of Contamination

The former Omega Chemical facility is the main source of groundwater contamination at OU2. The Omega plume is over 4 miles long, and because it flows under a densely developed commercial-industrial area, there are additional facilities whose releases of hazardous substances have reached groundwater and become commingled with the Omega contamination. Other sources of groundwater contamination at OU2 have been identified based on information obtained from file reviews and findings from field investigations. This investigation may have not identified all sources of contamination within the OU2 area, and the EPA may conduct additional investigations in the future.

8.1.3 Contaminant Fate and Transport

8.1.3.1 Groundwater

The current contaminant distribution in groundwater in the OU2 area has resulted from the migration of the contaminants from their source areas. The migration pathways are dictated by the regional groundwater flow regime, which is driven by the recharge occurring in the Montebello Forebay area and the predominantly deep (from depths exceeding 200 feet bgs) production pumping in the central basin. The migration of contaminants is also impacted by the presence of localized permeable, coarse-grained materials that may form preferential pathways and relatively impermeable, fine-grained deposits, which may limit the contaminant migration. Water table contours for the OU2 area indicate that groundwater flows to the southwest in the upgradient part of OU2 (southwest, or downgradient of the Omega property), then turns toward the south and south-southeast around the axis of the Santa Fe Springs anticline. The observed PCE, TCE, 1,1-DCE, 1,2-DCE, and 1,4-Dioxane plumes also agree well with the groundwater contours, suggestive of advection being the predominant transport mechanism. The presence of contamination at MW23C suggests that migration pathways exist between MW23 and the former Omega property that allow contaminant transport downward across aquitard units. Abandoned old irrigation and water supply wells may act as such vertical conduits.

The estimated value for advective velocity is 620 feet per year (see discussion in 6.3.1), with a broad range of possible velocities. The range of possible transport velocities and corresponding travel times across OU2 can account for delayed contaminant mass release in the source areas. The average minimum plume expansion rate (or apparent, long-term average rate of advance of the plume leading edge) of the Omega Contaminants along the flow path in the shallow groundwater at OU2 is estimated to be about 540 feet per year. This rate is based on the known plume extent and estimated maximum timeframe for the releases that occurred at Omega, Angeles, and McKesson, and it accounts for the effects of contaminant degradation, sorption, and dispersion. The actual plume expansion rate is likely higher, in light of the estimated advective velocity and the likely delay of the contaminant impact to groundwater at the source areas due to the migration of the released contaminant mass through the vadose zone. It is expected that the plume will continue to expand at a similar rate, in a direction dictated by the groundwater flow. The transport of the VOCs at OU2 is not significantly affected by their sorption to the aquifer material. The comparison of the transport of 1,4-dioxane, Freon 11, Freon 113, PCE, and TCE indicates that near the leading edge of the OU2 plume, contamination from Omega has likely commingled with contamination from Angeles, McKesson, and other source areas.

The contamination is also expected to migrate into deeper aquifer zones, due to vertical gradients at OU2 that are induced by regional production pumping, and artificial and natural recharges. This is corroborated by the fact that VOCs present in the OU2 plume have been found in five production wells. Well SFS#1 of the City of Santa Fe Springs, screened from 200 to 1,000 feet bgs, has been impacted by the Omega Contaminants, and a wellhead treatment system is in place. Four wells owned by GSWC—Pioneer 1, Pioneer 2, Pioneer 3, and Dace 1—have also been impacted by the Omega Contaminants and wellhead treatment is in place at each well. These wells extract contaminated groundwater from a depth of about 200 feet bgs (this is the depth of the single screens at Pioneer 1 and Pioneer 3, and shallow screens at Pioneer 2 and Dace 1). It is also expected that contamination currently present at OU2 will migrate into deep and yet un-impacted aquifers if no action is taken, based on the deep mixing of meteoric water in this part of the central basin (Reichard et al., 2003), vertical head differences, and groundwater flow patterns.

The Omega model was able to approximately reproduce the spatial extent of the Omega Contaminants released from two source areas—Omega and AMK. The simulation results support the conceptual understanding of the hydrogeology and main contaminant transport mechanisms at OU2.

8.1.3.2 Soil Vapor

The potential for the migration of VOC vapors into the vadose zone exists throughout OU2. VOCs are expected to partition from groundwater into vapor phase and diffuse through the vadose zone toward the ground surface, where they can potentially enter buildings. VOC concentrations in groundwater and depth to the water table are the main factors controlling the mass flux of contaminants into indoor air. Areas with shallow groundwater together with high VOC concentrations are locations where high mass flux in soil vapor is expected, whereas deep groundwater with low VOC concentrations would result in lower contaminant mass flux in soil vapor. As such, the investigation of potential vapor intrusion focused on one residential area, Whispering Fountains Apartments. This location was selected for risk evaluation because of shallow depth to groundwater with high VOC

concentrations. Groundwater is deeper and VOC concentrations are lower at the several other residential areas at OU2 compared to the Whispering Fountains Apartments, and the risk to residents from VOC vapors in these other areas is expected to be lower compared to Whispering Fountains Apartments.

The presence of daughter products of the degradation of 1,1,1-TCA, PCE, and TCE throughout OU2 groundwater indicates that these compounds undergo at least some transformation. The extent of PCE and TCE is greater than that of their degradation products, indicating that degradation of PCE and TCE is slow relative to their migration rate in groundwater and that their daughter products may further break down at OU2. Compared to PCE and TCE, the more complex 1,1,1-TCA and 1,1-DCA degrade more rapidly and do not extend as far from their source areas (e.g., Omega, AMK, Phibro-Tech). Freon 11, Freon 113, and 1,4-dioxane do not readily degrade in groundwater and therefore are widespread at OU2.

Because of expected, predominantly aerobic conditions, little to no degradation of PCE and TCE volatilizing from groundwater is expected to occur in the vadose zone; no degradation products of PCE and TCE were found in the soil gas at Whispering Fountains Apartments.

8.1.4 HHRA

Based on the HHRA conducted as part of the RI, the estimated potential future cumulative cancer risk from exposure to untreated OU2 groundwater used as residential tap water is $9x10^{-1}$. PCE contributes 98 percent of the cancer risk; all of the other COPCs each contribute less than 0.5 percent of the cancer risk.

Besides PCE, 1,2-DCA, 1,4-dioxane, chloroform, 1,2-dibromo-3-chloropropane, TCE, 1,1,2-TCA, and arsenic are the primary contributors to cancer risks for all routes of exposure and each contributes cancer risks of at least $1x10^{-3}$.

The estimated potential future cumulative health HI of 3,236 for child receptors greatly exceeds an HI of 1. PCE and TCE are the primary contributors to HI for all three routes of exposure (i.e., ingestion, inhalation, and dermal contact) and contribute 84 and 10 percent of hazards, respectively.

Inhalation exposure due to soil gas vapor intrusion into indoor air does not pose significant risk to the residents of Whispering Fountains Apartments. The estimated cancer risks are less than $1x10^{-6}$ and range from $3x10^{-8}$ to $3x10^{-7}$. The HI is less than 1 and ranges from 0.0002 to 0.004. As explained earlier, it is expected that the risk at other residential areas at OU2 is lower compared to the risk at Whispering Fountains Apartments.

8.1.5 Scoping Ecological Risk Assessment

There are no complete exposure pathways between OU2 groundwater contamination and ecological receptors. As a result, there is no potential risk to ecological receptors from contaminants in groundwater at OU2.

8.2 Conclusions

8.2.1 Data Limitations and Recommendations for Future Work

The information and data collected as part of the remedial investigation are sufficient for conducting the feasibility study for OU2. As described in the following subsection, groundwater monitoring should continue in order to better inform the evaluations made during the feasibility study. In addition, the collection of additional data and information may be needed for remedial design work

8.2.1.1 Groundwater Monitoring

Semiannual groundwater sampling at Omega wells should continue to monitor the temporal and spatial trends in contaminant distribution throughout OU2. The groundwater samples collected semiannually should be analyzed for VOCs and 1,4-dioxane. The data for inorganics, SVOCs, etc., from samples collected to date provide sufficient information for performing the feasibility study; routine sampling for these analytes can be discontinued. However, additional analytes should be added in the future as new contaminants are identified or as necessitated by the development and evaluation of response actions for OU2. Also, resampling for inorganics, SVOCs, etc., may be needed in the future, depending on the selected remedy or potentially changing conditions at OU2. The collection of depth to water measurements at all Omega wells should continue at least semiannually.

Groundwater monitoring data, including water levels, should be routinely acquired, to the extent practical, for all sites within OU2 that are under state oversight and for production wells. The information should be maintained in the project database to be used in support of the evaluation of alternatives and the selection of remedial actions at OU2.

The evaluation of groundwater monitoring data from the Omega wells and from other sites, including the assessment of the extent of contamination and groundwater conditions, should be performed on an annual basis. This synthesis of all OU2 data will provide the EPA with a comprehensive assessment of the conditions at OU2 to aid risk management decisions.

The collection of untreated, extracted groundwater quality data for operating production wells at and near OU2 should continue. The EPA may consider installation of sentinel wells for the monitoring of contaminants migrating toward the impacted production wells to allow timely modifications of the wellhead treatment if needed. Such sentinel wells may be located upgradient of the GSWC Production Wells Pioneer 1, Pioneer 2, Pioneer 3, and Dace 1, and Santa Fe Springs Well SFS#1. The installation of these wells would also allow a better characterization of the contaminant distribution upgradient of the production wells.

The collection of additional information may be required in support of remedial design. Such information may include, but not be limited to, the following:

- Conduct pumping tests on production wells and monitor the drawdown response at nearby wells to investigate the source of contamination, impacts to production wells, and to assess the hydraulic continuity between aquifer units

- Continue gathering and evaluating information about other production wells at and near OU2 to determine whether other wells have been impacted, to detect the potential future movement of the contamination, and to identify wells that may act as conduits for vertical migration of contaminants
- Continue gathering and evaluating information about other sources of contamination at and near OU2

The site conceptual model should be revised as new information on the regional (and OU2) hydrogeology, central basin groundwater management, emergent contaminants, and other relevant issues becomes available. Coordination of remedial activities and information sharing with the DTSC, RWQCB, USGS, WRD, and local municipalities and water agencies should be maintained.

8.2.2 Recommendations for Remedial Action Objectives

Results of the OU2 HHRA confirm that contaminated groundwater in OU2 poses a significant potential future risk to human health, and thus the untreated OU2 groundwater is unsuitable for domestic use. It is recommended that the EPA develop and evaluate alternatives to prevent further migration of the plume and expansion of the "hot spots" of contamination within the plume, protect (or reduce further impacts to) water supply production wells in the OU2 area, and restore the groundwater quality of the contaminated aquifer.

Inhalation exposure due to soil gas vapor intrusion into indoor air does not pose significant risk to the residents of Whispering Fountains Apartments. No further action is warranted at Whispering Fountains Apartments or other residential areas at OU2 because VOC volatilization from groundwater is not expected to pose a significant risk at OU2. This recommendation does not apply to the various source areas at OU2 that were not part of this evaluation and where exposure risks to occupants and workers may exist due to the presence of VOC contamination in the shallow subsurface.

9. References

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