

3. Data Quality

This section provides a summary of the results of the evaluation of the QC and QA activities employed to ensure that the conclusions and recommendations presented in this RI report are supported by chemical data of known, acceptable, and documented quality. These QC and QA activities included the following:

- Preparation and analysis of field QC samples including field blanks, equipment rinsate blanks, and field duplicates
- Evaluation of precision and accuracy through data review and validation

Based on the evaluation of the available QC and QA information, the 90 percent completeness goal was achieved for all analyses based on a ratio of the number of usable results (data not rejected due to serious deficiencies) to the total number of results. A small number of samples were rejected, representing approximately 1 percent of the total number of results. The overall findings of the data review and validation indicate that the data are of sufficient quality to support the goals of the RI.

3.1 Field QC

Field QC included preparation of field blanks, equipment rinsate blanks, trip blanks, and field duplicates.

3.1.1 Blanks

During each sampling event, three types of blanks were prepared – field blanks, equipment blanks, and trip blanks. The purpose of these blanks is to verify that contamination is not introduced by sampling techniques, environmental conditions, or during sample shipment or storage. The number and type of blanks prepared are listed in Table 3-1; following is a description of the blanks:

- **Ambient blanks** – These are prepared in the field at the sample collection location to determine if contamination is being introduced from environmental conditions.
- **Equipment blanks** – These are prepared in the field by pouring reagent water over reusable equipment following decontamination to determine the effectiveness of the decontamination process.
- **Trip blanks** – These are prepared at the laboratory from reagent water contained in sealed vials that remain with the samples to determine if contamination is being introduced during collection, shipment, and storage.

Based on the review of the results of the field blanks, no significant contamination issues occurred with the exception of one equipment rinsate blank collected during the fourth quarter groundwater sampling in December 2004.

For the fourth quarter December 2004 sampling, field QC samples included three field blanks and one equipment blank. Although it is not unexpected to find common laboratory contaminants in field, equipment, and trip blanks at concentrations near the reporting limit, several target analytes were detected in the Equipment Blank OC2-OW1A-W-3-84 at concentrations well above the reporting limit. The results for this equipment blank are summarized in the following table:

Sample Identification	Collection Date	Analyte	Results (µg/L)	Detection Limit (µg/L)
OC2-OW1A-W-3-84	12/1/2004	1,1,1-Trichloroethane (1,1,1-TCA)	1.8	0.5
		1,1,2-Trichloro-1,2,2-trifluoroethane (Freon 113)	0.4	0.5
		1,1-Dichloroethene (1,1-DCE)	0.45	0.5
		Acetone	7.4	5
		Benzene	0.57	0.5
		Bromomethane	0.15	0.5
		Carbon disulfide	0.29	0.5
		Chloroform	0.32	0.5
		Chloromethane	1.6	0.5
		NDMA	0.0041	0.002
		PCE	140	0.5
		Toluene	0.2	0.5
		TCE	1.1	0.5

The elevated concentrations of PCE and NDMA in the fourth quarter equipment blank can be attributed to contamination of the 2-inch-diameter submersible pump that was used to purge Well OW1A. Typically, Well OW1A is the last well sampled because of the high concentration of target analytes. Well OW1A was purged on December 1, 2004, before sampling of remaining Wells OW1B and OW3. After purging Well OW1A, the pump was decontaminated and an equipment blank was collected. The equipment blank results indicate the potential for carry over contamination; however, the results for the samples from Wells OW1B and OW3 are consistent with results obtained in previous events and do not appear to be affected by carryover.

As discussed in Appendix A, the results for ambient, equipment, and trip blanks associated with the Omega groundwater and RI sampling events indicate that the procedures used for, and conditions of, sample collection were sufficient to ensure that the results are representative. There were no significant contamination trends, other than discussed in this section, that are expected to have a negative impact on data usability.

3.1.2 Field Duplicates

Field duplicate samples are collocated samples used to evaluate overall reproducibility taking into account both field and analytical variability. The project goal is to collect field

duplicates at a frequency of 10 percent of samples collected. The actual percentage of field duplicates collected is 9.8 percent, slightly less than the project goal.

Field duplicate results are evaluated by comparing the calculated relative percent difference (RPD) to the acceptance criteria specified in Table A-2 of the Omega QAPP. The RPD is calculated as follows:

$$RPD = \frac{100 * (\text{Primary Result} - \text{Field Duplicate Result})}{\frac{1}{2} * (\text{Primary Result} + \text{Field Duplicate Result})}$$

For the Omega data, the RPD was calculated for pairs of results where an analyte was detected in both the primary and field duplicate samples. If the analyte was not detected in either one or both of the duplicate samples, the RPD was not calculated. In cases where the analyte is not detected or detected in one sample, the results are considered acceptable if the magnitude of the reporting limit or reporting limit and result are of similar magnitude. A summary of the field duplicate outliers is presented in Table 3-2. Appendix A.1 presents all field duplicate results obtained during the groundwater and RI sampling events.

The percent of acceptable results based on comparable duplicate pairs by analytical group is as follows:

- 80 percent of the comparable VOC field duplicate results were within the 30 percent acceptance criterion.
- 90 percent of the comparable 1,4-dioxane field duplicate results were within the 30 percent acceptance criterion.
- 92 percent of the comparable hexavalent chromium field duplicate results were within the 30 percent acceptance criterion.
- 67 percent of the comparable NDMA field duplicate results were within the 30 percent acceptance criterion.
- 96 percent of the comparable perchlorate results were within the 50 percent acceptance criterion.

There were only two comparable sets of field duplicate results for 1,2,3-TCP; the RPD in both cases was 44 percent, which is above the 30 percent project acceptance criterion. The concentrations were below the 0.005 µg/L reporting limit and the absolute concentration difference between the results was small. Because of the small difference between the duplicate concentrations, the field duplicate results do not negatively impact data usability. For the entire field duplicate set, there were 675 comparable results; of these, 89 percent were within project acceptance criteria. Field duplicate results are affected by analytical precision, field variations, and the difference in sample matrices. While groundwater is generally considered a homogenous matrix, differences can exist depending on the order of sample collection and overall sample handling in the field and the laboratory. These factors are likely responsible for the observed differences.

3.2 Data Review and Validation

To document that the collected data were of sufficient quality, data review and validation were performed. Data review included Tier 1 review, both automated and manual, and manual Tier 2 review, described as follows:

- **Tier 1A and Tier 2 Review** – Tier 1A and Tier 2 review are manual reviews of essential QC information without review of raw data. Tier 2 is an expanded review of the data that includes review of additional method QC results such as calibration statistics along with all of the elements of the Tier 1A review. Tier 1A review was applied to the data from the EPA Region 9 Laboratory; both Tier 1A and Tier 2 review were applied to some of the emergent chemical results that were analyzed by laboratories outside the EPA CLP, due to the specialized nature of these test methods.
- **Tier 1B Review** – CLP data review involved application of Computer-Aided Data Review and Evaluation (CADRE) software to perform an automated review.

Data review and validation for both the Tier 1A and Tier 1B approaches considered the QC elements listed as follows:

- Sample holding times
 - Method blanks
 - Laboratory control samples
 - Continuing calibration standards
 - MS
 - Sample duplicates and spike duplicates
 - Volatile system monitoring compounds
 - Internal standards
 - Surrogates
- **Tier 3 Review** – Tier 3 validation includes all of the elements of the Tier 1 and Tier 2 reviews along with qualitative and quantitative evaluation of the raw data. The findings of the Tier 3 validation are considered representative of the entire data set and are discussed in detail by event in Appendix A.

Table 3-3 summarizes the overall percentage of samples reviewed by method and validation level. The 10 percent validation goal was achieved for all methods containing site-related analytes. Several of the data packages for emergent chemicals from the 2004 monitoring were not reviewed. Since data from the same laboratories was reviewed according to plan for subsequent events without significant negative findings, the unreviewed data are considered to be of similar quality. This deficiency is not considered to impact the usability of these data.

To organize the results of the validation, a systematic set of reason codes is assigned to each qualified result. These reason codes are summarized in Table 3-4 with a description; Table 3-5 presents a list of the number of qualified results by reason code. A complete listing of all qualified data is presented in Appendix A.3.

The estimation of analytical data is based on associated QC results that do not meet the project or method specifications. In general, measurement data associated with QC results

that do not meet the project precision and accuracy goals contain more uncertainty than results associated with QC results that meet the project goals. Serious QC deficiencies resulted in rejected data. The rejected data are discussed in Section A1.1 of Appendix A. As can be seen in Table 3-5, the amount of rejected data is small, and sufficient usable data are available to meet the project goals.

The only notable analytical issue was associated with the NDMA analyses. In a number of cases, the data validation narrative indicated that the low point standard (0.005 µg/L) mass spectra were insufficient to support the 0.005 µg/L reporting limit. The recommendation of the data validators is to raise the reporting limit to 0.01 to 0.02 µg/L, specifically when the sample mass spectra did not meet the acceptability criteria. It should be noted that the current project-required reporting limit is equal to the California notification level for NDMA and is at the limit of detection for the best available analytical technology. Since all NDMA results below the reporting limit are qualified as estimated, the reported results and current reporting limit are retained for project use, although the possibility of false negatives should be considered.

3.3 Split Samples

Split samples were collected from wells included in the ARCADIS groundwater monitoring program. The split samples were collected from OU2 Monitoring Wells MW12, MW13B, and MW 14 in July 2006. Primarily, the results from these split samples were used to evaluate the concentrations of target analytes not included in the ARCADIS project target analyte list. The split sample results also provided a QA check on the representativeness and comparability of the OU2 results.

The split sample results (Table 3-6) were evaluated in a manner similar to the comparison of the field duplicate results by calculating RPD as follows:

$$\text{RPD} = \frac{100 * (\text{Primary Result} - \text{Split Sample Result})}{\frac{1}{2} * (\text{Primary Result} + \text{Split Sample Result})}$$

The RPD was calculated for results where an analyte was detected in both split samples. If the analyte was not detected in either one or both of the split samples, the RPD was not calculated. For these cases, the reporting limits or reporting limit and positive results were compared and considered acceptable if no large differences were observed.

The ARCADIS samples were analyzed using EPA Method 8260B. The EPA samples were analyzed using EPA Method 524.2. Despite the different methods, the reporting limits are generally comparable with the exception of 1,2,3-TCP, which was reported by ARCADIS at a reporting limit of 0.005 µg/L, compared to the EPA reporting limit of 0.5 µg/L. Based on the ARCADIS results, 1,2,3-TCP is not present in these wells and the difference in the reporting limits is not a significant issue.

An RPD criterion of 30 percent was used as the criteria to evaluate the pairs of positive split sample results. Out of 183 results, one of the split sample result pairs had an RPD above 30 percent. In this case, the actual results for the target analyte, dichlorodifluoromethane, (0.8 µg/L by EPA Method 524.2 and 0.5 µg/L by EPA Method 8260B) are below the reporting limits; the absolute value of the difference is small compared to the reporting

limits and well within the expected analytical error. Based on the comparison of the split samples, the data were comparable and representative of the media sampled.

3.4 Data Qualifiers

Following the validation process, data qualifiers were assigned as follows:

- U Undetected. Samples were analyzed for this analyte, but it was not detected above the detection limit objective. Additionally, the “U” qualifier may be used in those instances where a value was flagged as not detected because of blank contamination.
- UJ Detection limit estimated. The analyte was not detected above the detection limit objective. However, the reported detection limit is approximate and may or may not represent the actual limit of quantification necessary to accurately and precisely measure the analyte in the sample.
- J Estimated. The analyte was positively detected, but the concentration is estimated either because the value was below the analytical reporting limit or because of other QA/QC problems identified during data validation. The analyte was present, but the reported value may not be accurate or precise.
- R Rejected. The data are unusable and are rejected. The analyte was or was not present.
- B The analyte was found in an associated blank, as well as in the sample.
- M A matrix effect was present.
- T Tentatively identified compound.

TABLE 3-1

Summary of Field and Equipment Blanks Collected
Omega Chemical Superfund Site

Sample ID	Collection Date	Sample Type	Analyte/Analytical Method(s)															
			VOCs (CLP)		VOCs (SIM)	VOCs		SVOCs (CLP)	Emergent Compound			General Chemistry Parameters				Metals	Hexavalent Chromium	Perchlorate
			MC VOA	TVOL	SIMVOL	EPA 524_2	EPA 8260B	MC SVOA	1,2,3-TCP	1,4-Dioxane	NDMA	Alkalinity	Anions	CN	TDS	METALS	EPA 218.6	EPA 314
OC2-00-W-2-3	02-Mar-04	AB	X					X		X	X			X		X	X	X
OC2-00-W-2-16	04-Mar-04	AB	X					X		X		X	X	X	X	X	X	X
OC2-00-W-3-24	15-Jun-04	EB	X						X									
OC2-00-W-2-35	21-Jun-04	AB	X					X			X							
OC2-00-W-2-48	23-Jun-04	AB	X						X		X							
OC2-00-W-2-57	13-Sep-04	AB	X						X		X							
OC2-00-W-2-68	15-Sep-04	AB	X						X		X							
OC2-00-W-2-78	30-Nov-04	AB	X						X		X							
OC2-OW1A-W-3-84	01-Dec-04	EB	X						X		X							
OC2-00-W-2-96	06-Dec-04	AB	X						X		X							
OC2-00-W-2-111	09-Dec-04	AB	X						X		X							
OC2-00-W-2-115	28-Feb-05	AB	X						X									
OC2-00-W-2-132	03-Mar-05	AB	X						X									
OC2-MW4A-W-2-136	30-Aug-05	AB	X						X		X							
OC2-MW11-W-2-154	02-Sep-05	AB	X						X		X							
OC2-MW7-W-4-156	06-Mar-06	TB				X			X									
OC2-MW8D-W-2-162	07-Mar-06	AB				X			X									
OC2-MW8D-W-4-160	07-Mar-06	TB				X			X									
OC2-MW9B-W-4-170	08-Mar-06	TB				X			X									
OC2-MW11-W-2-178	09-Mar-06	AB				X			X									
OC2-MW11-W-4-175	09-Mar-06	TB				X			X									
OC2-MW16C-W-3-186	13-Mar-06	EB				X			X									
OC2-MW17B-W-4-182	13-Mar-06	TB				X			X									
OC2-MW16C-W-4-187	14-Mar-06	TB				X			X									
OC2-MW18A-W-2-191	14-Mar-06	AB				X			X									
OC2-MW13B-W-3-202	15-Mar-06	EB				X			X									
OC2-MW15-W-2-200	15-Mar-06	AB				X			X									
OC2-MW23D-W-4-197	15-Mar-06	TB				X			X									
OC2-MW18C-W-2-208	28-Aug-06	AB				X			X									
OC2-TB1-W-4-207	28-Aug-06	TB				X			X									
OC2-TB2-W-4-213	29-Aug-06	TB				X			X									
OC2-MW8D-W-2-221	30-Aug-06	AB				X			X									
OC2-TB3-W-4-220	30-Aug-06	TB				X			X									
OC2-TB4-W-4-227	31-Aug-06	TB				X			X									
OC2-TB5-W-4-233	01-Sep-06	TB				X			X									
OC2-MW17C-W-2-241	05-Sep-06	AB				X			X									
OC2-TB6-W-4-240	05-Sep-06	TB				X			X									
OC2-TB7-W-4-245	07-Sep-06	TB				X			X									
OC2-MW1A-W-2-257	08-Sep-06	AB				X			X									
OC2-TB8-W-4-252	08-Sep-06	TB				X			X									
OC2-TB9-W-4-258	11-Sep-06	TB				X			X									
OC2-EB-W-3-282	10-Jan-07	EB		X	X					X								

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Sample ID	Collection Date	Sample Type	Analyte/Analytical Method(s)															
			VOCs (CLP)		VOCs (SIM)	VOCs		SVOCs (CLP)	Emergent Compound			General Chemistry Parameters				Metals	Hexavalent Chromium	Perchlorate
			MC VOA	TVOL	SIMVOL	EPA 524_2	EPA 8260B	MC SVOA	1,2,3-TCP	1,4-Dioxane	NDMA	Alkalinity	Anions	CN	TDS	METALS	EPA 218.6	EPA 314
OC2-HPRA4-W-2-283	10-Jan-07	AB		X	X							X						
OC2-HP285B-W-3-327	23-Jan-07	EB		X	X							X						
OC2-HPF5B-W-3-336	26-Jan-07	EB		X	X							X						
OC2-HP272B-W-2-341	12-Feb-07	AB		X	X							X						
OC2-HP296A-W-3-349	14-Feb-07	EB		X	X							X						
OC2-HPA6A-W-4-351	15-Feb-07	TB		X	X							X						
OC2-HPA8A-W-2-355	19-Feb-07	AB		X	X							X						
OC2-HPF6A-W-3-361	21-Feb-07	EB		X	X							X						
OC2-HPW8B-W-2-366	22-Feb-07	AB		X	X							X						
OC2-AB1-W-2-457	26-Feb-07	AB		X	X							X						
OC2-AB2-W-2-465	27-Feb-07	AB		X	X							X						
OC2-AB3-W-2-472	28-Feb-07	AB		X	X							X						
OC2-AB4-W-2-478	01-Mar-07	AB		X	X							X						
OC2-AB5-W-2-484	02-Mar-07	AB		X	X							X						
OC2-AB6-W-2-491	05-Mar-07	AB		X	X							X						
OC2-HPW3B-W-2-381	05-Mar-07	AB		X	X							X						
OC2-AB7-W-2-497	06-Mar-07	AB		X	X							X						
OC2-AB8-W-2-506	07-Mar-07	AB		X	X							X						
OC2-HPW6A-W-3-385	07-Mar-07	EB		X	X							X						
OC2-HPW6B-W-4-386	08-Mar-07	TB		X	X							X						
OC2-HPW1A-W-3-393	12-Mar-07	EB		X	X							X					X	
OC2-HP278A-W-4-401	13-Mar-07	TB		X	X							X						
OC2-HP2911A-W-2-407	14-Mar-07	AB		X	X							X						
OC2-HPA13A-W-3-429	21-Mar-07	EB		X	X							X						
OC2-HPA15A-W-2-435	22-Mar-07	AB		X	X							X						
OC2-HP2917A-W-3-440	09-Apr-07	EB		X	X							X						
OC2-HP2923A-W-2-512	11-Apr-07	AB		X	X							X						
OC2-HP2923A-W-3-511	11-Apr-07	EB		X	X							X						
OC2-HPF1B-W-3-523	02-May-07	EB		X	X							X						
OC2-HP2933A-W-3-533	04-May-07	EB		X	X							X						
OC2-HP2938A-W-3-537	07-May-07	EB		X	X							X						
OC2-HP2940A-W-3-544	09-May-07	EB		X	X							X						
OC2-AB1-W-2-556	30-May-07	AB				X			X									
OC2-EB1-W-3-559	01-Jun-07	EB				X			X									
OC2-AB1-W-2-X	09-Jul-07	AB		X	X							X						
OC2-AB2-W-2-X	10-Jul-07	AB		X	X							X						
OC2-AB3-W-2-X	11-Jul-07	AB		X	X							X						
OC2-AB4-W-2-X	12-Jul-07	AB		X	X							X						
OC2-AB5-W-2-X	13-Jul-07	AB		X	X							X						
OC2-AB6-W-2-X	16-Jul-07	AB		X	X							X						
OC2-AB7-W-2-X	17-Jul-07	AB		X	X							X						
OC2-AB8-W-2-X	18-Jul-07	AB		X	X							X						

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			VOCs (CLP)		VOCs (SIM)	VOCs		SVOCs (CLP)	Emergent Compound			General Chemistry Parameters				Metals	Hexavalent Chromium	Perchlorate
			MC VOA	TVOL	SIMVOL	EPA 524_2	EPA 8260B	MC SVOA	1,2,3-TCP	1,4-Dioxane	NDMA	Alkalinity	Anions	CN	TDS	METALS	EPA 218.6	EPA 314
OC2-AB9-W-2-X	19-Jul-07	AB		X	X					X								
OC2-AB10-W-2-X	20-Jul-07	AB		X	X					X								
OC2-AB11-W-2-X	23-Jul-07	AB		X	X					X								
OC2-AB12-W-2-X	24-Jul-07	AB		X	X					X								
OC2-AB13-W-2-X	25-Jul-07	AB		X	X					X								
OC2-AB14-W-2-X	26-Jul-07	AB		X	X					X								

AB - ambient blank

EB - equipment blank

FB - field blank

TB - trip blank

CLP - Contract Laboratory Program

VOCs - volatile organic compounds

SVOCs - semivolatile organic compounds

NDMA - N-nitrosodimethylamine

1,2,3-TCP - 1,2,3-Trichloropropane

CN Cyanide

TDS Total Dissolved Solids

Table 3-2
 Summary of Field Duplicate Outliers
 Omega Chemical Superfund Site

Event	Sample Date	Location ID	Analyte Name	Primary Result	Field Duplicate Result	RPD
2004 QTR1						
	03/03/04	MW6	1,1,2-Trichloro-1,2,2-trifluoroethane (Freon 113)	2 J	1.4 J	35
	03/03/04	MW6	Total Organic Carbon	2.7	3.9	36
2004 QTR2						
	06/17/04	OW3A	1,4-Dioxane (p-dioxane)	1.2	0.7 J	53
	06/17/04	OW3A	Bromide	0.2	0.26	26
	06/21/04	MW4A	1,1,2-Trichloro-1,2,2-trifluoroethane (Freon 113)	280	490	55
	06/21/04	MW4A	bis(2-Ethylhexyl)phthalate	11	3.9 J	95
	06/21/04	MW4A	Total Organic Carbon	17	11	43
	06/21/04	MW4A	Trichlorofluoromethane (Freon 11)	120	200	50
	06/23/04	MW1A	bis(2-Ethylhexyl)phthalate	9.6	42	126
	06/23/04	MW1A	Chloromethane	6.1 J	11 J	57
	06/23/04	MW1A	Methylene chloride	0.62 J	1.9 J	102
	06/23/04	MW1A	Thallium	12.4 J	7.3 J	52
	06/23/04	MW1A	Toluene	1.3 J	2.2 J	51
	06/23/04	MW1A	Trichlorofluoromethane (Freon 11)	33	48	37
2004 QTR3						
	09/13/04	MW4B	1,2,3-Trichloropropane	0.0028 J	0.0044 J	44
	09/13/04	MW4B	Methyl tert-butyl ether	9.2 J	6.6	33
	09/16/04	MW7	1,2,3-Trichloropropane	0.0069	0.0044	44
	09/16/04	MW7	bis(2-Ethylhexyl)phthalate	32 J	17 J	61
	09/16/04	MW7	N-Nitrosodimethylamine	0.0066	0.0027	84
	09/16/04	MW7	Total Organic Carbon	4.7	7.2	42
2004 QTR4						
	12/02/04	OW5	Chromium VI	4.6	7.6	49
	12/02/04	OW5	Lead	0.08 J	0.05 J	46
	12/02/04	OW5	N-Nitrosodimethylamine	0.0046 J	0.002 J	79
	12/06/04	MW4B	1,2-Dibromo-3-chloropropane	5 R	2 R	86
	12/06/04	MW4B	Chemical oxygen demand	5.8 J	8.3 J	35
	12/06/04	MW4B	Zinc	0.65 J	1.7 J	89
	12/07/04	MW7	bis(2-Ethylhexyl)phthalate	4.6 J	1.3 J	112
2005 QTR1						
	02/28/05	MW4A	1,1,2-Trichloro-1,2,2-trifluoroethane (Freon 113)	450	820	58
	02/28/05	MW4A	1,1-Dichloroethene	460	780	52
	02/28/05	MW4A	Chloroform	34	51	40
	02/28/05	MW4A	Tetrachloroethene	400 J	620	43
	02/28/05	MW4A	trans-1,2-Dichloroethene	0.41 J	0.28 J	38
	02/28/05	MW4A	Trichloroethene	130	190	38
	02/28/05	MW4A	Trichlorofluoromethane (Freon 11)	190	350	59
2005 QTR3						
	08/30/05	MW6	1,1-Dichloroethene	11	8	32
	08/30/05	MW6	Methylene chloride	1.1	3.7	108
2006 QTR1						
	03/09/06	MW11	1,1,2-Trichloro-1,2,2-trifluoroethane (Freon 113)	0.3 J	0.2 J	40
	03/15/06	MW15	1,1,2-Trichloro-1,2,2-trifluoroethane (Freon 113)	1400	910	42
	03/15/06	MW15	1,1-Dichloroethene	2000	1000	67
	03/15/06	MW15	Chloroform	440	210	71

Table 3-2
 Summary of Field Duplicate Outliers
 Omega Chemical Superfund Site

Event	Sample Date	Location ID	Analyte Name	Primary Result	Field Duplicate Result	RPD
2006 QTR1						
	03/15/06	MW15	Dichlorodifluoromethane (Freon 12)	4.7	2.7	54
	03/15/06	MW15	N-Nitrosodimethylamine	0.003	0.0048	46
	03/15/06	MW15	Tetrachloroethene	1900	840	77
	03/15/06	MW15	Trichloroethene	540	260	70
	03/15/06	MW15	Trichlorofluoromethane (Freon 11)	670	340	65
2006 QTR3						
	08/29/06	MW4B	Carbon tetrachloride	0.2 J	0.3 J	40
	09/01/06	MW20A	1,1-Dichloroethane	2.3	3.4	39
	09/01/06	MW20A	1,1-Dichloroethene	15	21	33
	09/01/06	MW20A	Chloroform	0.5	0.8	46
	09/01/06	MW20A	cis-1,2-Dichloroethene	1.2	1.8	40
	09/01/06	MW20A	Trichlorofluoromethane (Freon 11)	4.9	7.1	37
	09/07/06	MW10	1,1,2-Trichloro-1,2,2-trifluoroethane (Freon 113)	77	25	102
	09/07/06	MW10	1,1-Dichloroethene	43	23	61
	09/07/06	MW10	1,2-Dichloroethane	0.2 J	0.3 J	40
	09/07/06	MW10	Tetrachloroethene	82	190	79
	09/07/06	MW10	Trichloroethene	110	62	56
	09/07/06	MW10	Trichlorofluoromethane (Freon 11)	34	16	72
	09/11/06	MW23C	1,1,2-Trichloro-1,2,2-trifluoroethane (Freon 113)	790	350	77
	09/11/06	MW23C	1,1,2-Trichloroethane	0.2 J	0.3 J	40
	09/11/06	MW23C	1,1-Dichloroethene	600	270	76
	09/11/06	MW23C	Benzene	0.3 J	0.2 J	40
	09/11/06	MW23C	cis-1,2-Dichloroethene	24	16	40
	09/11/06	MW23C	Dichlorodifluoromethane (Freon 12)	1	0.5 J	67
	09/11/06	MW23C	Perchlorate	3.6	2	57
	09/11/06	MW23C	Tetrachloroethene	500	210	82
	09/11/06	MW23C	trans-1,2-Dichloroethene	1.5	0.9	50
	09/11/06	MW23C	Trichloroethene	610	230	90
	09/11/06	MW23C	Trichlorofluoromethane (Freon 11)	250	120	70
2007 QTR1HP						
	01/23/07	HP28-5A (90')	1,1-Dichloroethene	1.5	0.95	45
	01/23/07	HP28-5A (90')	Carbon disulfide	0.15 J	0.26 J	54
	01/23/07	HP28-5A (90')	Tetrachloroethene	0.18 J	0.12 J	40
	02/13/07	HP29-2A (97')	1,1-Dichloroethene	4.2 J	1.5 J	95
	02/13/07	HP29-2A (97')	1,4-Dioxane (p-dioxane)	5.6 J	4.1 J	31
	02/13/07	HP29-2A (97')	Chloroform	0.52 J	0.78 J	40
	02/13/07	HP29-2A (97')	cis-1,2-Dichloroethene	24 J	12 J	67
	02/13/07	HP29-2A (97')	Methyl tert-butyl ether	1.4 J	0.86 J	48
	02/13/07	HP29-2A (97')	trans-1,2-Dichloroethene	6.2 J	2.8 J	76
	02/13/07	HP29-2A (97')	Trichloroethene	8.9 J	4.2 J	72
	02/13/07	HP29-2A (97')	Trichlorofluoromethane (Freon 11)	0.22 J	1.1 J	133
	02/13/07	HP29-2A (97')	Vinyl chloride	2.3 J	0.86 J	91
	03/09/07	HPW-5B (50')	1,1-Dichloroethene	6	2.5	82
	03/09/07	HPW-5B (50')	Aluminum	293	1670	140
	03/09/07	HPW-5B (50')	Carbon disulfide	0.15 J	0.28 J	60
	03/09/07	HPW-5B (50')	Carbon tetrachloride	0.42 J	0.2 J	71
	03/09/07	HPW-5B (50')	Chloroform	7.6	5.1	39

Table 3-2
 Summary of Field Duplicate Outliers
 Omega Chemical Superfund Site

Event	Sample Date	Location ID	Analyte Name	Primary Result	Field Duplicate Result	RPD
2007 QTR1HP						
	03/09/07	HPW-5B (50')	Chromium	4.4	10.1	79
	03/09/07	HPW-5B (50')	Cobalt	2.4	4.5	61
	03/09/07	HPW-5B (50')	Copper	0.89 J	8.2	161
	03/09/07	HPW-5B (50')	Iron	51.4 J	1230	184
	03/09/07	HPW-5B (50')	Selenium	3 J	2.1 J	35
	03/09/07	HPW-5B (50')	Tetrachloroethene	95	27	111
	03/09/07	HPW-5B (50')	Trichloroethene	3 J	1.7	55
	03/09/07	HPW-5B (50')	Vanadium	1.6	10.5	147
	03/09/07	HPW-5B (50')	Zinc	7	16.3	80
	03/13/07	HP27-7A (87')	1,1,2-Trichloro-1,2,2-trifluoroethane (Freon 113)	1.2	0.59 J	68
	03/13/07	HP27-7A (87')	trans-1,2-Dichloroethene	0.93 J	0.53 J	55
	03/13/07	HP27-7A (87')	Vinyl chloride	0.46 J	0.3 J	42
2007 QTR3						
	07/09/07	MW24A	Dichlorodifluoromethane (Freon 12)	1.8 J	2.7	40
	07/09/07	MW24A	Tetrachloroethene	590 J	320	59
	07/09/07	MW24A	Total Organic Carbon	0.54	0.81	40
	07/12/07	MW27B	1,1,2-Trichloroethane	0.43 J	10	184
	07/12/07	MW27B	1,1-Dichloroethene	360 J	150	82
	07/12/07	MW27B	Di-n-butyl phthalate	4.3 J	1.2 J	113
	07/12/07	MW27B	Tetrachloroethene	220	120	59
	07/12/07	MW27B	Total kjeldahl nitrogen	0.15 J	0.23 J	42
	07/12/07	MW27B	Trichloroethene	220	140	44
	07/12/07	MW27B	Zinc	2.6 J+	3.7 J+	35
	07/17/07	MW12	1,1-Dichloroethene	4.2	18	124
	07/17/07	MW12	Chloroform	0.19 J	0.41 J	73
	07/17/07	MW12	Chromium VI	0.99	1.7	53
	07/17/07	MW12	Tetrachloroethene	1.1	22 J	181
	07/17/07	MW12	Trichloroethene	6.6	160 J	184

Notes

RPD - Relative Percent Difference = $\{ (\text{Primary Sample} - \text{Field Duplicate}) / (\text{Primary Sample} + \text{Field Duplicate}) / 2 \} \times 100$
 RPD is calculated and shown only when both the primary and Field Duplicate samples are detected above the Reporting Limit
 Field duplicate RPD goal is 50% for Perchlorate, 25% for Anions, Total dissolved solids, Biological oxygen demand, and Total kjeldahl nitrogen, and 30% for all others .

µg/L - micrograms per liter

mg/L - milligrams per liter

U - Not detected at or above the reporting limit.

UJ - Not detected at or above the reporting limit. The reporting limit is an estimate.

J - Estimated value.

J+ estimated result with high bias.

Table 3-3
 Summary of Data Review and Validation Performed
 Omega Chemical Superfund Site

Category	Percentage of Tier 1 Reviewed Results	Percentage of Tier 2 Reviewed Results	Percentage of Tier 3 Reviewed Results	Percentage of Unvalidated Results
VOCs (SIM)	54%	29%	18%	0%
VOCs (EPA 524.2/SW8260B)	86%	0%	13%	0%
VOCs (CLP)	65%	16%	19%	0%
SVOCs (SIM)	0%	100%	0%	0%
SVOCs (CLP)	65%	19%	16%	0%
Perchlorate	95%	0%	5%	0%
Metals	67%	0%	33%	0%
Hexavalent Chromium	8%	57%	15%	20%
General Chemistry Parameters	95%	0%	3%	2%
Emergent Compounds (1)	43%	27%	15%	15%

Notes:

(1) Emergent compounds include 1,4 Dioxane, 1,2,3-Trichloropropane and N-Nitrosodimethylamine

TABLE 3-4
 Summary of Reason Codes
Omega Chemical Superfund Site

Basis	Reason Code	Reason Code Definition	Description
Flags Applied Based on Analyte Contamination	A1	LCS Recovery	The recovery from the laboratory control sample did not meet acceptance criteria. High recoveries result in qualification of positive results with a high bias; recoveries below the lower recoveries result in qualification of positive results with a high bias; recoveries below the lower control limit result in qualification of quantitation limit.
	A2	MS/MSD Recovery	The recovery from the matrix spike and/or matrix spike duplicate did not meet acceptance criteria. High recoveries result in qualification of positive results with a high bias; recoveries below the lower control limit result in qualification of both positive results and quantitation limits.
	A3	Surrogate Recovery	The surrogate recovery did not meet the acceptance criteria; the results and quantitation limits for associated analytes are qualified as estimated, with a low bias. High surrogate recoveries result in qualification of positive results with a high bias.
	B1	Laboratory Blank Contamination	The analyte was detected in the sample at a concentration less than 5 times (10 times for common laboratory contaminants) the amount found in the associated laboratory blank. The results are raised to the reporting limit or qualified as not detected at the amount reported (if above the reporting limit)
	B2	Equipment Blank Contamination	The analyte was detected in the sample at a concentration less than 5 times (10 times for common laboratory contaminants) the amount found in the associated equipment blank. The results are raised to the reporting limit or qualified as not detected at the amount reported (if above the reporting limit)
	B3	Field Blank Contamination	The analyte was detected in the sample at a concentration less than 5 times (10 times for common laboratory contaminants) the amount found in the associated field blank. The results are raised to the reporting limit or qualified as not detected at the amount reported (if above the reporting limit)

TABLE 3-4
 Summary of Reason Codes
Omega Chemical Superfund Site

Basis	Reason Code	Reason Code Definition	Description
Qualifications Affecting Accuracy	B4	Trip Blank Contamination	The analyte was detected in the sample at a concentration less than 5 times (10 times for common laboratory contaminants) the amount found in the associated trip blank. The results are raised to the reporting limit or qualified as not detected at the amount reported (if above the reporting limit)
	B5	Initial Calibration Blank Contamination	The analyte was detected in the initial calibration blank. For associated samples, detected results less than the reporting limit are qualified as not detected at the reporting limit.
	B6	Continuing Calibration Blank Contamination	The analyte was detected in the continuing calibration blank. For associated samples, detected sample results less than the reporting limit are qualified as not detected at the reporting limit.
	B7	Source Blank Contamination	The analyte was detected in the source water used to prepare equipment and field blanks. The information is used to evaluate the suitability of the water as a final decontamination rinse.
	B8	Storage Blank Contamination	The analyte was detected in the sample at a concentration less than 5 times (10 times for common laboratory contaminants) the amount found in the storage blank, used in the laboratory to evaluate potential cross contamination. The results are raised to the reporting limit or qualified as not detected at the amount reported (if above the reporting limit)
	C1	Initial Calibration Relative Standard Deviation	ICAL%RSD The percent relative standard deviation for the initial calibration response factor did not meet the linearity acceptance criterion and quantitation may be more imprecise and inaccurate than expected.
	C2	Initial Calibration Response Factor	The average response factor from the initial calibration did not meet the acceptance criterion and analytical sensitivity may be less than expected.

TABLE 3-4
 Summary of Reason Codes
Omega Chemical Superfund Site

Basis	Reason Code	Reason Code Definition	Description
	C3	Calibration Percent Difference	The percent difference between the response factor in the continuing calibration standard and the average response factor from the initial calibration standard exceeded the acceptance criteria. Analytical precision may be larger than expected.
	C4	Continuing Calibration Percent Recovery	The recovery of the analyte in the continuing calibration verification standard did not meet the method acceptance criteria. Positive results are qualified as estimated if the standard recovery is high; both positive results and quantitation limits are qualified as estimated if the standard recovery is low.
	C5	Continuing Calibration Response Factor	The response factor in the continuing calibration did not meet the acceptance criterion and analytical sensitivity may be less than expected.
	C6	Initial Calibration Verification	An initial calibration verification standard is analyzed to test the accuracy of the initial calibration using a second source standard. When analyte recoveries do not meet the acceptance criteria, the initial calibration may be inaccurate.
	Carryover Contamination	Carryover Contamination	The result is qualified as estimated because the previous sample in the run had a high concentration of the target analyte; there is the potential for a high bias in the qualified result.
	D2	MS/MSD Duplicate Relative Percent Difference	The precision between matrix spike and matrix spike duplicate samples did not meet acceptance criteria, and higher than expected variability may be present.
	D3	Sample Duplicate Relative Percent Difference	The precision between laboratory duplicates did not meet acceptance criteria, and higher than expected variability may be present.
	D4	Field Duplicate Relative Percent Difference	The precision between field duplicate samples did not meet acceptance criteria, and higher than expected variability may be present (no qualification is applied based on field duplicates only).

TABLE 3-4
 Summary of Reason Codes
Omega Chemical Superfund Site

Basis	Reason Code	Reason Code Definition	Description
Qualifications Affecting both Accuracy and Precision	Q1	Result Over Calibration Range	Reported result exceeded the concentration of the highest concentration standard. The result is qualified as estimated and is considered to represent the minimum sample concentration. The true concentration may be higher than reported.
	Q2	Failed Spectral Match	The GC/MS spectral match criteria were not met. As a result, the analyte is reported as not
	Q4	Holding Time Exceeded	The holding time was exceeded. Positive results and quantitation limits are qualified as estimated; positive results may be biased low due to analyte losses during storage.
	Q6	Quantitation Limit Standard Recovery	The quantitation limit standard did not meet the control limit (EPA Region 9 Laboratory specific QC). The ability of the analytical system to meet the quantitation may be impaired.
	Q7	Serial Dilution Recovery	The agreement between diluted and undiluted analyses did not meet acceptance criteria and a matrix effect may be present.
	Q8	Interference	Interferences from other analytes may affect quantitation. Reporting limit may be raised.
	Tr	Result Below Reporting Limit	The result is above the MDL but below the quantitation limit; there is some associated uncertainty in results as the limit of detection is approached.

Table 3-5
 Summary of Number of Qualified Results by Event and Reason Codes
 Omega Chemical Superfund Site

Event Analysis	Reason Code and Description	Tier 1/ Tier 2		Tier 3		
		Number J's	R's	Number J's	R's	
2004_QTR1						
BOD: EPA 405.1	A1	LCS Recovery	3	0	0	0
BOD: EPA 405.1	A2	MS/MSD Recovery	2	0	0	0
CN	A2	MS/MSD Recovery	1	0	0	0
METALS	A2	MS/MSD Recovery	1	0	0	0
TOC	A2	MS/MSD Recovery	1	0	0	0
SVOCs: MC SVOA	A3	Surrogate Recovery	8	0	15	0
VOCs: MC VOA	A3	Surrogate Recovery	85	4	0	0
SVOCs: MC SVOA	C1	Initial Calibration Relative Standard Deviation	0	0	1	0
VOCs: MC VOA	C1	Initial Calibration Relative Standard Deviation	15	0	2	0
VOCs: MC VOA	C2	Initial Calibration Response Factor	1	0	5	0
SVOCs: MC SVOA	C3	Calibration Percent Difference	44	0	2	0
VOCs: MC VOA	C3	Calibration Percent Difference	20	0	2	0
VOCs: MC VOA	C5	Continuing Calibration Response Factor	1	0	5	0
VOCs: MC VOA	D2	MS/MSD Duplicate Relative Percent Difference	16	0	0	0
1,4-Dioxane	Q4	Holding Time Exceeded	7	0	0	0
Anions: EPA 300	Q4	Holding Time Exceeded	9	0	0	0
BOD: EPA 405.1	Q4	Holding Time Exceeded	7	0	0	0
VOCs: MC VOA	Q5	Internal Standard	0	7	0	0
2004_QTR2						
BOD: EPA 405.1	A1	LCS Recovery	9	0	0	0
METALS	A2	MS/MSD Recovery	38	0	0	0
TKN: EPA 351.2	A2	MS/MSD Recovery	1	0	0	0
1,4-Dioxane	A3	Surrogate Recovery	1	0	0	0
SVOCs: MC SVOA	A3	Surrogate Recovery	17	0	0	0
VOCs: MC VOA	A3	Surrogate Recovery	16	0	0	0
SVOCs: MC SVOA	B1	Laboratory Blank Contamination	30	0	0	0
VOCs: MC VOA	B1	Laboratory Blank Contamination	22	0	0	0
METALS	B5	Initial Calibration Blank Contamination	8	0	0	0
METALS	B6	Continuing Calibration Blank Contamination	20	0	0	0
SVOCs: MC SVOA	C1	Initial Calibration Relative Standard Deviation	1	0	0	0
SVOCs: MC SVOA	C2	Initial Calibration Response Factor	0	29	0	0
METALS	C3	Calibration Percent Difference	22	1	0	0
SVOCs: MC SVOA	C3	Calibration Percent Difference	50	29	0	0
VOCs: MC VOA	C3	Calibration Percent Difference	4	0	0	0
SVOCs: MC SVOA	C5	Continuing Calibration Response Factor	0	29	0	0
METALS	D3	Sample Duplicate Relative Percent Difference	13	0	0	0
METALS	D4	Field Duplicate Relative Percent Difference	11	0	0	0
VOCs: MC VOA	Q1	Result Over Calibration Range	4	0	0	0
METALS	Q10	Quality Control Analysis Not Performed	0	0	78	12
BOD: EPA 405.1	Q4	Holding Time Exceeded	3	0	0	0

Table 3-5
 Summary of Number of Qualified Results by Event and Reason Codes
 Omega Chemical Superfund Site

Event Analysis	Reason Code and Description	Tier 1/ Tier 2 Number		Tier 3 Number		
		J's	R's	J's	R's	
2004_QTR2						
1,4-Dioxane	Q5	<i>Internal Standard</i>	4	0	0	0
METALS	Q5	<i>Internal Standard</i>	120	60	0	12
METALS	Q7	<i>Serial Dilution</i>	0	0	15	0
Anions: EPA 300	Q8	<i>Interference (Quantitation Limit Raised</i>	0	0	0	0
2004_QTR3						
BOD: EPA 405.1	A1	<i>LCS Recovery</i>	9	0	0	0
TOC: EPA 415.1	A2	<i>MS/MSD Recovery</i>	1	0	0	0
SVOCs: MC SVOA	A3	<i>Surrogate Recovery</i>	0	0	54	0
VOCs: MC VOA	A3	<i>Surrogate Recovery</i>	2	0	12	0
SVOCs: MC SVOA	B1	<i>Laboratory Blank Contamination</i>	0	0	10	0
VOCs: MC VOA	B1	<i>Laboratory Blank Contamination</i>	0	0	27	0
VOCs: MC VOA	B3	<i>Field Blank Contamination</i>	0	0	17	0
METALS	B5	<i>Initial Calibration Blank Contamination</i>	19	0	0	0
METALS	B6	<i>Continuing Calibration Blank Contamination</i>	24	0	0	0
SVOCs: MC SVOA	C1	<i>Initial Calibration Relative Standard Deviation</i>	0	0	42	0
VOCs: MC VOA	C1	<i>Initial Calibration Relative Standard Deviation</i>	0	0	27	0
SVOCs: MC SVOA	C2	<i>Initial Calibration Response Factor</i>	0	0	14	0
VOCs: MC VOA	C2	<i>Initial Calibration Response Factor</i>	0	0	66	0
CR6: EPA 218.6	C3	<i>Calibration Percent Difference</i>	4	0	0	0
METALS	C3	<i>Calibration Percent Difference</i>	54	4	0	0
SVOCs: MC SVOA	C3	<i>Calibration Percent Difference</i>	0	0	14	0
VOCs: MC VOA	C3	<i>Calibration Percent Difference</i>	0	0	53	0
SVOCs: MC SVOA	C5	<i>Continuing Calibration Response Factor</i>	0	0	14	0
VOCs: MC VOA	C5	<i>Continuing Calibration Response Factor</i>	0	0	66	0
CR6: EPA 218.6	C6	<i>Initial Calibration Verification</i>	4	0	0	0
VOCs: MC VOA	Q1	<i>Result Over Calibration Range</i>	0	0	5	0
SVOCs: MC SVOA	Q2	<i>Failed Spectral Match</i>	0	0	2	0
BOD: EPA 405.1	Q4	<i>Holding Time Exceeded</i>	7	0	0	0
VOCs: MC VOA	Q4	<i>Holding Time Exceeded</i>	0	0	47	0
METALS	Q5	<i>Internal Standard</i>	8	15	0	0
Anions: EPA 300	Q8	<i>Interference (Quantitation Limit Raised</i>	0	0	0	0
2004_QTR4						
1,4-Dioxane	A3	<i>Surrogate Recovery</i>	2	0	0	0
NDMA: EPA 162.5	A3	<i>Surrogate Recovery</i>	16	0	4	0
SVOCs: MC SVOA	A3	<i>Surrogate Recovery</i>	22	0	0	0
VOCs: MC VOA	A3	<i>Surrogate Recovery</i>	19	0	0	0
BOD: EPA 405.1	A4	<i>Standard Reference Material Recovery</i>	1	0	0	0
NDMA: EPA 162.5	B1	<i>Laboratory Blank Contamination</i>	1	0	0	0
SVOCs: MC SVOA	B1	<i>Laboratory Blank Contamination</i>	29	0	0	0
VOCs: MC VOA	B1	<i>Laboratory Blank Contamination</i>	6	0	0	0

Table 3-5
 Summary of Number of Qualified Results by Event and Reason Codes
 Omega Chemical Superfund Site

Event Analysis	Reason Code and Description	Tier 1/ Tier 2 Number		Tier 3 Number		
		J's	R's	J's	R's	
2004_QTR4						
METALS	B5	<i>Initial Calibration Blank Contamination</i>	7	0	1	0
VOCs: MC VOA	B5	<i>Initial Calibration Blank Contamination</i>	14	0	0	0
METALS	B6	<i>Continuing Calibration Blank Contamination</i>	21	0	3	0
SVOCs: MC SVOA	C1	<i>Initial Calibration Relative Standard Deviation</i>	90	25	0	0
VOCs: MC VOA	C2	<i>Initial Calibration Response Factor</i>	0	30	0	0
SVOCs: MC SVOA	C3	<i>Calibration Percent Difference</i>	111	25	0	0
VOCs: MC VOA	C3	<i>Calibration Percent Difference</i>	23	0	0	0
SVOCs: MC SVOA	C5	<i>Continuing Calibration Response Factor</i>	1	25	0	0
BOD: EPA 405.1	Q4	<i>Holding Time Exceeded</i>	4	0	0	0
NDMA: EPA 162.5	Q4	<i>Holding Time Exceeded</i>	5	0	0	0
NDMA: EPA 162.5	Q5	<i>Internal Standard</i>	16	0	4	0
SVOCs: MC SVOA	Q5	<i>Internal Standard</i>	19	0	0	0
VOCs: MC VOA	Q5	<i>Internal Standard</i>	13	0	0	0
2005_QTR1						
NDMA: EPA 162.5	A3	<i>Surrogate Recovery</i>	0	0	0	0
VOCs: MC VOA	A3	<i>Surrogate Recovery</i>	0	0	20	0
VOCs: MC VOA	B1	<i>Laboratory Blank Contamination</i>	0	0	23	0
VOCs: MC VOA	B3	<i>Field Blank Contamination</i>	0	0	23	0
VOCs: MC VOA	C3	<i>Calibration Percent Difference</i>	0	0	40	0
VOCs: MC VOA	C5	<i>Continuing Calibration Response Factor</i>	0	0	9	0
VOCs: MC VOA	D2	<i>MS/MSD Duplicate Relative Percent Difference</i>	0	0	1	0
NDMA: EPA 162.5	Q5	<i>Internal Standard</i>	0	0	0	0
2005_QTR3						
NDMA: EPA 162.5	A3	<i>Surrogate Recovery</i>	0	0	0	0
VOCs: MC VOA	A3	<i>Surrogate Recovery</i>	38	0	5	0
VOCs: MC VOA	B1	<i>Laboratory Blank Contamination</i>	9	0	6	0
VOCs: MC VOA	B3	<i>Field Blank Contamination</i>	0	0	6	0
VOCs: MC VOA	B5	<i>Initial Calibration Blank Contamination</i>	5	0	0	0
VOCs: MC VOA	B7	<i>Source Blank Contamination</i>	0	0	6	0
VOCs: MC VOA	C1	<i>Initial Calibration Relative Standard Deviation</i>	13	1	2	0
VOCs: MC VOA	C3	<i>Calibration Percent Difference</i>	6	1	0	0
VOCs: MC VOA	Q4	<i>Holding Time Exceeded</i>	0	1	0	0
NDMA: EPA 162.5	Q5	<i>Internal Standard</i>	0	0	0	0
2006_QTR1						
VOCs: EPA 524.2	A2	<i>MS/MSD Recovery</i>	3	0	0	0
VOCs: EPA 524.2	B2	<i>Equipment Blank Contamination</i>	0	0	3	0
VOCs: EPA 524.2	B4	<i>Trip Blank Contamination</i>	0	0	3	0
VOCs: EPA 524.2	C1	<i>Initial Calibration Relative Standard Deviation</i>	44	0	1	0
VOCs: EPA 524.2	C3	<i>Calibration Percent Difference</i>	18	0	0	0
VOCs: EPA 524.2	C4	<i>Continuing Calibration Percent Recovery</i>	1	0	0	0

Table 3-5
 Summary of Number of Qualified Results by Event and Reason Codes
 Omega Chemical Superfund Site

Event Analysis	Reason Code and Description	Tier 1/ Tier 2 Number		Tier 3 Number			
		J's	R's	J's	R's		
2006_QTR1							
VOCs: EPA 524.2	D2	<i>MS/MSD Duplicate Relative Percent Difference</i>		1	0	0	0
VOCs: EPA 524.2	Q6	<i>Quantitation Limit Standard Verification</i>		9	0	0	0
2006_QTR3							
VOCs: EPA 524.2	A1	<i>LCS Recovery</i>		2	0	8	0
CR6: EPA 218.6	A2	<i>MS/MSD Recovery</i>		1	0	0	0
VOCs: EPA 524.2	A2	<i>MS/MSD Recovery</i>		3	0	0	0
VOCs: EPA 524.2	C1	<i>Initial Calibration Relative Standard Deviation</i>		110	0	26	0
VOCs: EPA 524.2	C3	<i>Calibration Percent Difference</i>		14	0	9	0
VOCs: EPA 524.2	D2	<i>MS/MSD Duplicate Relative Percent Difference</i>		1	0	5	0
NDMA: EPA 162.5	Q4	<i>Holding Time Exceeded</i>		6	0	0	0
VOCs: EPA 524.2	Q6	<i>Quantitation Limit Standard Verification</i>		35	0	3	0
2007_QTR1							
VOCs: EPA 524.2	A2	<i>MS/MSD Recovery</i>		1	0	0	0
VOCs: TVOL	A3	<i>Surrogate Recovery</i>		53	0	0	0
VOCs: TVOL	B1	<i>Laboratory Blank Contamination</i>		1	0	0	0
VOCs: EPA 524.2	C1	<i>Initial Calibration Relative Standard Deviation</i>		8	0	0	0
1,4-Dioxane	C2	<i>Initial Calibration Response Factor</i>		0	0	0	0
VOCs: SIMVOL	C2	<i>Initial Calibration Response Factor</i>		9	0	6	0
VOCs: TVOL	C2	<i>Initial Calibration Response Factor</i>		37	0	0	0
VOCs: EPA 524.2	C3	<i>Calibration Percent Difference</i>		4	0	0	0
VOCs: TVOL	C3	<i>Calibration Percent Difference</i>		15	0	0	0
VOCs: TVOL	C5	<i>Continuing Calibration Response Factor</i>		37	0	0	0
VOCs: TVOL	D2	<i>MS/MSD Duplicate Relative Percent Difference</i>		22	0	0	0
VOCs: TVOL	Q1	<i>Result Over Calibration Range</i>		2	0	0	0
VOCs: EPA 524.2	Q6	<i>Quantitation Limit Standard Verification</i>		12	0	0	0
2007_QTR1HP							
1,4-Dioxane	A3	<i>Surrogate Recovery</i>		16	7	10	0
VOCs: TVOL	A3	<i>Surrogate Recovery</i>		142	0	20	0
VOCs: TVOL	B1	<i>Laboratory Blank Contamination</i>		34	0	0	0
METALS	B2	<i>Equipment Blank Contamination</i>		0	0	9	0
VOCs: TVOL	B3	<i>Field Blank Contamination</i>		1	0	0	0
METALS	B5	<i>Initial Calibration Blank Contamination</i>		3	0	3	0
METALS	B6	<i>Continuing Calibration Blank Contamination</i>		4	0	6	0
VOCs: TVOL	B7	<i>Source Blank Contamination</i>		41	0	0	0
1,4-Dioxane	C2	<i>Initial Calibration Response Factor</i>		26	29	15	3
VOCs: TVOL	C2	<i>Initial Calibration Response Factor</i>		2	1	51	0
METALS	C3	<i>Calibration Percent Difference</i>		0	0	1	0
VOCs: TVOL	C3	<i>Calibration Percent Difference</i>		2	0	0	0
1,4-Dioxane	C5	<i>Continuing Calibration Response Factor</i>		35	33	15	3
VOCs: TVOL	C5	<i>Continuing Calibration Response Factor</i>		2	1	51	0

Table 3-5
 Summary of Number of Qualified Results by Event and Reason Codes
 Omega Chemical Superfund Site

Event Analysis	Reason Code and Description	Tier 1/ Tier 2 Number		Tier 3 Number		
		J's	R's	J's	R's	
2007_QTR1HP						
VOCs: TVOL	D2	<i>MS/MSD Duplicate Relative Percent Difference</i>	0	0	0	0
METALS	D3	<i>Sample Duplicate Relative Percent Difference</i>	4	0	0	0
VOCs: TVOL	Q1	<i>Result Over Calibration Range</i>	0	0	2	0
METALS	Q7	<i>Serial Dilution</i>	4	0	9	0
2007_QTR2						
VOCs: EPA 524.2	A2	<i>MS/MSD Recovery</i>	4	0	0	0
VOCs: EPA 524.2	C1	<i>Initial Calibration Relative Standard Deviation</i>	26	0	0	0
VOCs: EPA 524.2	C3	<i>Calibration Percent Difference</i>	1	0	0	0
VOCs: EPA 524.2	Q6	<i>Quantitation Limit Standard Verification</i>	13	0	0	0
2007_QTR2HP						
1,4-Dioxane	A3	<i>Surrogate Recovery</i>	2	3	0	0
VOCs: TVOL	A3	<i>Surrogate Recovery</i>	45	0	0	0
VOCs: TVOL	B1	<i>Laboratory Blank Contamination</i>	7	0	0	0
METALS	B5	<i>Initial Calibration Blank Contamination</i>	1	0	0	0
METALS	B6	<i>Continuing Calibration Blank Contamination</i>	1	0	0	0
VOCs: EPA 524.2	C1	<i>Initial Calibration Relative Standard Deviation</i>	16	0	0	0
1,4-Dioxane	C2	<i>Initial Calibration Response Factor</i>	18	19	0	0
VOCs: EPA 524.2	C2	<i>Initial Calibration Response Factor</i>	4	0	0	0
1,4-Dioxane	C5	<i>Continuing Calibration Response Factor</i>	18	19	0	0
VOCs: TVOL	D2	<i>MS/MSD Duplicate Relative Percent Difference</i>	0	0	0	0
VOCs: EPA 524.2	Q6	<i>Quantitation Limit Standard Verification</i>	9	0	0	0
METALS	Q7	<i>Serial Dilution</i>	8	0	0	0
2007_QTR3						
1,4-Dioxane	A3	<i>Surrogate Recovery</i>	0	0	13	0
SVOCs: CSVOL	A3	<i>Surrogate Recovery</i>	28	3	0	0
VOCs: TVOL	A3	<i>Surrogate Recovery</i>	24	0	10	0
VOCs: TVOL	B1	<i>Laboratory Blank Contamination</i>	74	0	3	0
VOCs: TVOL	B2	<i>Equipment Blank Contamination</i>	0	0	30	0
VOCs: TVOL	B8	<i>Storage Blank Contamination</i>	23	0	0	0
1,4-Dioxane	C2	<i>Initial Calibration Response Factor</i>	0	2	4	0
SVOCs: CSVOL	C2	<i>Initial Calibration Response Factor</i>	22	0	0	0
SVOCs: SIMSVOL	C2	<i>Initial Calibration Response Factor</i>	16	5	0	0
VOCs: TVOL	C2	<i>Initial Calibration Response Factor</i>	0	0	16	0
SVOCs: CSVOL	C3	<i>Calibration Percent Difference</i>	30	0	0	0
SVOCs: SIMSVOL	C3	<i>Calibration Percent Difference</i>	17	0	0	0
1,4-Dioxane	C5	<i>Continuing Calibration Response Factor</i>	0	2	0	0
SVOCs: CSVOL	C5	<i>Continuing Calibration Response Factor</i>	22	0	0	0
SVOCs: SIMSVOL	C5	<i>Continuing Calibration Response Factor</i>	0	5	0	0
VOCs: TVOL	Q1	<i>Result Over Calibration Range</i>	0	0	1	0
1,4-Dioxane	Q5	<i>Internal Standard</i>	0	0	1	0

Table 3-5
 Summary of Number of Qualified Results by Event and Reason Codes
 Omega Chemical Superfund Site

Event Analysis	Reason Code and Description	Tier 1/ Tier 2 Number		Tier 3 Number	
		J's	R's	J's	R's

Notes.

See Table A1-17 for additiona description of reason codes.

Table 3-6
 Summary of Split Samples
 Omega Chemical Superfund Site

Location ID	Sample Date	Analyte Name	CH2M Result	ARCADIS Result	RPD, %
MW12	07/06/06	1,1,1,2-Tetrachloroethane	0.5 U	1 U	NC
		1,1,1-Trichloroethane	0.5 U	0.5 U	NC
		1,1,2,2-Tetrachloroethane	0.5 U	0.5 U	NC
		1,1,2-Trichloro-1,2,2-trifluoroethane (Freon 113)	0.5 U	1 U	NC
		1,1,2-Trichloroethane	0.5 U	0.5 U	NC
		1,1-Dichloroethane	0.5 U	0.5 U	NC
		1,1-Dichloroethene	9.6	8.1	17
		1,1-Dichloropropene	0.5 U	0.5 U	NC
		1,2,3-Trichlorobenzene	0.5 U	1 U	NC
		1,2,3-Trichloropropane	0.5 U	0.005 U	NC
		1,2,4-Trichlorobenzene	0.5 U	1 U	NC
		1,2,4-Trimethylbenzene	0.5 U	0.5 U	NC
		1,2-Dibromo-3-chloropropane	2 U	1 U	NC
		1,2-Dibromoethane	0.5 U	0.5 U	NC
		1,2-Dichlorobenzene	0.5 U	0.5 U	NC
		1,2-Dichloroethane	0.5 U	0.5 U	NC
		1,2-Dichloropropane	0.5 U	0.5 U	NC
		1,3,5-Trimethylbenzene	0.5 U	1 U	NC
		1,3-Dichlorobenzene	0.5 U	0.5 U	NC
		1,3-Dichloropropane	0.5 U	0.5 U	NC
		1,4-Dichlorobenzene	0.5 U	0.5 U	NC
		1,4-Dioxane (p-dioxane)	0.5 J	1.9 U	117
		2,2-Dichloropropane	0.5 U	1 U	NC
		2-Chlorotoluene	0.5 U	1 U	NC
		4-Chlorotoluene	0.5 U	1 U	NC
		Acetone	4 UJ	10 U	NC
		Benzene	0.5 U	0.5 U	NC
		Bromodichloromethane	0.5 U	0.5 U	NC
		Bromoform	0.5 UJ	0.72	NC
		Bromomethane	0.5 U	0.5 U	NC
		Carbon tetrachloride	0.5 U	0.5 U	NC
		Chlorobenzene	0.5 U	1 U	NC
		Chloroethane	0.5 U	0.5 U	NC
		Chloroform	0.3 J	0.27 J	11
		Chloromethane	0.5 U	1 U	NC
		cis-1,2-Dichloroethene	0.5 U	0.5 U	NC
		cis-1,3-Dichloropropene	0.5 U	0.5 U	NC
		Dibromochloromethane	0.5 U	0.53 J	NC

Table 3-6
 Summary of Split Samples
 Omega Chemical Superfund Site

Location ID	Sample Date	Analyte Name	CH2M Result	ARCADIS Result	RPD, %
MW12	07/06/06	Dibromomethane	0.5 U	1 U	NC
		Dichlorodifluoromethane (Freon 12)	0.5 UJ	1 U	NC
		Ethylbenzene	0.5 U	0.5 U	NC
		Hexachlorobutadiene	0.5 U	1 U	NC
		Isopropylbenzene	0.5 U	0.5 U	NC
		m,p-Xylenes	1 U	1 U	NC
		Methyl ethyl ketone	4 UJ	5 U	NC
		Methyl tert-butyl ether	2 U	1 U	NC
		Methylene chloride	0.5 U	1 U	NC
		Naphthalene	0.5 U	2 U	NC
		N-butylbenzene	0.5 U	1 U	NC
		n-Propylbenzene	0.5 U	1 U	NC
		o-Xylene	0.5 U	1 U	NC
		sec-Butylbenzene	0.5 U	1 U	NC
		Styrene	0.5 U	0.5 U	NC
		t-Butylbenzene	0.5 U	1 U	NC
		Tetrachloroethene	20	17	16
		Toluene	0.2 J	0.22 J	10
		trans-1,2-Dichloroethene	0.5 U	0.5 U	NC
		trans-1,3-Dichloropropene	0.5 U	0.5 U	NC
		Trichloroethene	96	91	5
		Trichlorofluoromethane (Freon 11)	0.5 U	1 U	NC
		Vinyl chloride	0.5 U	0.5 U	NC
MW13B	07/06/06	1,1,1,2-Tetrachloroethane	0.5 U	1 U	NC
		1,1,1-Trichloroethane	0.5 U	0.5 U	NC
		1,1,2,2-Tetrachloroethane	0.5 U	0.5 U	NC
		1,1,2-Trichloro-1,2,2-trifluoroethane (Freon 113)	0.5 U	1 U	NC
		1,1,2-Trichloroethane	0.5 U	0.5 U	NC
		1,1-Dichloroethane	0.5 U	0.5 U	NC
		1,1-Dichloroethene	0.5 U	0.5 U	NC
		1,1-Dichloropropene	0.5 U	0.5 U	NC
		1,2,3-Trichlorobenzene	0.5 U	1 U	NC
		1,2,3-Trichloropropane	0.5 U	0.005 U	NC
		1,2,4-Trichlorobenzene	0.5 U	1 U	NC
		1,2,4-Trimethylbenzene	0.5 U	0.5 U	NC
		1,2-Dibromo-3-chloropropane	2 U	1 U	NC
		1,2-Dibromoethane	0.5 U	0.5 U	NC
		1,2-Dichlorobenzene	0.5 U	0.5 U	NC

Table 3-6
 Summary of Split Samples
 Omega Chemical Superfund Site

Location ID	Sample Date	Analyte Name	CH2M Result	ARCADIS Result	RPD, %
MW13B	07/06/06	1,2-Dichloroethane	0.7	0.67	4
		1,2-Dichloropropane	0.5 U	0.5 U	NC
		1,3,5-Trimethylbenzene	0.5 U	1 U	NC
		1,3-Dichlorobenzene	0.5 U	0.5 U	NC
		1,3-Dichloropropane	0.5 U	0.5 U	NC
		1,4-Dichlorobenzene	0.5 U	0.5 U	NC
		1,4-Dioxane (p-dioxane)	0.9 U	1.9 U	NC
		2,2-Dichloropropane	0.5 U	1 U	NC
		2-Chlorotoluene	0.5 U	1 U	NC
		4-Chlorotoluene	0.5 U	1 U	NC
		Acetone	4 UJ	10 U	NC
		Benzene	0.5 U	0.5 U	NC
		Bromodichloromethane	0.5 U	0.5 U	NC
		Bromoform	0.5 UJ	0.5 U	NC
		Bromomethane	0.5 U	0.5 U	NC
		Carbon tetrachloride	0.5 U	0.5 U	NC
		Chlorobenzene	0.5 U	1 U	NC
		Chloroethane	0.5 U	0.5 U	NC
		Chloroform	0.5 U	1 U	NC
		Chloromethane	0.5 U	1 U	NC
		cis-1,2-Dichloroethene	0.5 U	0.5 U	NC
		cis-1,3-Dichloropropene	0.5 U	0.5 U	NC
		Dibromochloromethane	0.5 U	1 U	NC
		Dibromomethane	0.5 U	1 U	NC
		Dichlorodifluoromethane (Freon 12)	0.2 J	1 U	133
		Ethylbenzene	0.5 U	0.5 U	NC
		Hexachlorobutadiene	0.5 U	1 U	NC
		Isopropylbenzene	0.5 U	0.5 U	NC
		m,p-Xylenes	1 U	1 U	NC
		Methyl ethyl ketone	4 UJ	5 U	NC
		Methyl tert-butyl ether	2 U	0.6 J	NC
		Methylene chloride	0.5 U	1 U	NC
		Naphthalene	0.5 U	2 U	NC
		N-butylbenzene	0.5 U	1 U	NC
		n-Propylbenzene	0.5 U	1 U	NC
		o-Xylene	0.5 U	1 U	NC
		sec-Butylbenzene	0.5 U	1 U	NC
		Styrene	0.5 U	0.5 U	NC

Table 3-6
 Summary of Split Samples
 Omega Chemical Superfund Site

Location ID	Sample Date	Analyte Name	CH2M Result	ARCADIS Result	RPD, %
MW13B	07/06/06	t-Butylbenzene	0.5 U	1 U	NC
		Tetrachloroethene	2.8	2.5	11
		Toluene	0.5 U	0.5 U	NC
		trans-1,2-Dichloroethene	0.5 U	0.5 U	NC
		trans-1,3-Dichloropropene	0.5 U	0.5 U	NC
		Trichloroethene	0.3 J	0.26 J	14
		Trichlorofluoromethane (Freon 11)	0.5 U	1 U	NC
		Vinyl chloride	0.5 U	0.5 U	NC
MW14	07/07/06	1,1,1,2-Tetrachloroethane	0.5 U	1 U	NC
		1,1,1-Trichloroethane	0.2 J	0.5 U	86
		1,1,2,2-Tetrachloroethane	0.5 U	0.5 U	NC
		1,1,2-Trichloro-1,2,2-trifluoroethane (Freon 113)	290	280	4
		1,1,2-Trichloroethane	0.5 U	0.5 U	NC
		1,1-Dichloroethane	0.4 J	0.48 J	18
		1,1-Dichloroethene	200	180	11
		1,1-Dichloropropene	0.5 U	0.5 U	NC
		1,2,3-Trichlorobenzene	0.5 U	1 U	NC
		1,2,3-Trichloropropane	0.5 U	0.005 U	NC
		1,2,4-Trichlorobenzene	0.5 U	1 U	NC
		1,2,4-Trimethylbenzene	0.5 U	0.5 U	NC
		1,2-Dibromo-3-chloropropane	2 U	1 U	NC
		1,2-Dibromoethane	0.5 U	0.5 U	NC
		1,2-Dichlorobenzene	0.5 U	0.5 U	NC
		1,2-Dichloroethane	2.1	1.6	27
		1,2-Dichloropropane	0.5 U	0.5 U	NC
		1,3,5-Trimethylbenzene	0.5 U	1 U	NC
		1,3-Dichlorobenzene	0.5 U	0.5 U	NC
		1,3-Dichloropropane	0.5 U	0.5 U	NC
		1,4-Dichlorobenzene	0.5 U	0.5 U	NC
		1,4-Dioxane (p-dioxane)	11	6.6	50
		2,2-Dichloropropane	0.5 U	1 U	NC
		2-Chlorotoluene	0.5 U	1 U	NC
		4-Chlorotoluene	0.5 U	1 U	NC
		Acetone	4 UJ	10 U	NC
		Benzene	0.5 U	0.5 U	NC
		Bromodichloromethane	0.5 U	0.5 U	NC
		Bromoform	0.5 UJ	0.5 U	NC
		Bromomethane	0.5 U	0.5 U	NC

Table 3-6
 Summary of Split Samples
 Omega Chemical Superfund Site

Location ID	Sample Date	Analyte Name	CH2M Result	ARCADIS Result	RPD, %
MW14	07/07/06	Carbon tetrachloride	0.5 U	0.5 U	NC
		Chlorobenzene	0.5 U	1 U	NC
		Chloroethane	0.5 U	0.5 U	NC
		Chloroform	18	16	12
		Chloromethane	0.5 U	1 U	NC
		cis-1,2-Dichloroethene	0.7	0.77	10
		cis-1,3-Dichloropropene	0.5 U	0.5 U	NC
		Dibromochloromethane	0.5 U	1 U	NC
		Dibromomethane	0.5 U	1 U	NC
		Dichlorodifluoromethane (Freon 12)	0.8 J	0.5 J	46
		Ethylbenzene	0.5 U	0.5 U	NC
		Hexachlorobutadiene	0.5 U	1 U	NC
		Isopropylbenzene	0.5 U	0.5 U	NC
		m,p-Xylenes	1 U	1 U	NC
		Methyl ethyl ketone	4 UJ	5 U	NC
		Methyl tert-butyl ether	2 U	0.6 J	NC
		Methylene chloride	0.5 U	1 U	NC
		Naphthalene	0.5 U	2 U	NC
		N-butylbenzene	0.5 U	1 U	NC
		n-Propylbenzene	0.5 U	1 U	NC
		o-Xylene	0.5 U	1 U	NC
		sec-Butylbenzene	0.5 U	1 U	NC
		Styrene	0.5 U	0.5 U	NC
		t-Butylbenzene	0.5 U	1 U	NC
		Tetrachloroethene	250	230	8
		Toluene	0.5 U	0.5 U	NC
		trans-1,2-Dichloroethene	0.3 J	0.29 J	3
		trans-1,3-Dichloropropene	0.5 U	0.5 U	NC
		Trichloroethene	39 J	36	8
		Trichlorofluoromethane (Freon 11)	100	110	10
		Vinyl chloride	0.5 U	0.5 U	NC

Notes

Results reported in micrograms per liter (µg/L)
 RPD - Relative Percent Difference = $\{ (CH2M - CDM) / (CH2M + CDM) / 2 \} \times 100$
 RPD goal is 30
 J - Estimated value.

4. Physical Characteristics of the Study Area

This section provides a general description of the Omega Site conditions including location and topography, surface water features, climate, land use, ecological resources, and regional hydrogeology of the central basin where the former Omega facility is located. The Omega Site hydrostratigraphy was developed using the geological data acquired during the field investigations and the general hydrogeologic conditions of the study area. A description of the aquifer test results is also provided in this section.

4.1 Location and Topography

The former Omega Chemical property is located at 12504 and 12512 East Whittier Boulevard in Whittier, California (Figure 1-1). The city of Santa Fe Springs is located southwest of the former Omega Chemical property. OU2 of the Omega Site (i.e., the plume of contaminated groundwater) extends into the city of Norwalk.

The former Omega Chemical property is located along the base of the La Habra piedmont slope descending from the southwestern flank of the Puente Hills, at an elevation of approximately 220 feet above mean sea level (msl; Weston, 2003). The piedmont slope descends toward the southwest at a slope of approximately 2.5 percent to an area approximately 2,800 feet southwest of the former Omega facility. In this area, the ground surface flattens into a broad basin or plain, at an elevation of approximately 150 to 155 feet above msl. In the southwestern part of OU2, the ground surface rises gently to approximately 160 feet above msl at the northwest end of the Santa Fe Springs plain (Weston, 2003). OU2 and surrounding areas are completely developed.

OU1 includes the former Omega Chemical property, located at 12504 and 12512 East Whittier Boulevard, and approximately 100 feet west-southwest of Putnam Street. OU2 generally includes the groundwater contaminated area that extends from OU1 approximately 4.5 miles to the south-southwest (Figure 1-4).

4.2 Surface Water Features

The San Gabriel River, Rio Hondo, spreading basins, and the Sorensen Avenue Drain form the two principal surface water features in the study area (Figures 1-1 and 4-1). The San Gabriel River lies just west of Interstate 605 and generally flows from northeast to southwest; Rio Hondo is further west of the San Gabriel River. The spreading basins are located along the channel of the San Gabriel River and Rio Hondo, and receive imported and treated water to artificially recharge the basin. The Sorensen Avenue Drain is a small, concrete-lined drain that flows across the basin toward the southeast from a point near the intersection of Dice Road and Slauson Avenue. This channel bends toward the south beyond the limits of OU2 to become La Canada Verde Creek, which cuts through a low gap between the Coyote Hills on the east and the Santa Fe Springs plain on the west.

The San Gabriel River channel is unlined in the Montebello Forebay and the river is a losing stream in this area. The river channel is lined south of the Montebello Forebay and the recharge from the lined portion of the river is expected to be limited.

The San Gabriel and the Rio Hondo spreading basins are the major groundwater replenishment sources for the Central Basin. Areal recharge including infiltration from precipitation and return flow from irrigation and mountain front recharge occurring along the basin boundaries are the remaining, but much smaller, groundwater recharge components in the Central Basin. Even before the artificial recharge program began, the Montebello Forebay was a major recharge area because of the unconfined conditions and the presence of the San Gabriel River and Rio Hondo. Recharge from other streams and storm water drains is limited because most of them are concrete lined (Reichard et al., 2003).

The San Gabriel River Watershed falls within Los Angeles County. In 1999, the Los Angeles County Board of Supervisors directed the Los Angeles Department of Public Works (LADPW) (in cooperation with the County Departments of Parks and Recreation and Regional Planning) to prepare a San Gabriel River Master Plan. A watershed management plan for the Coyote Creek sub-watershed is in development by the LARWQCB.

Several small creeks drain the southwestern slopes of the Puente Hills including the Turnbull Canyon and Wosham Creek northeast of the former Omega facility (Figure 4-1). Runoff from the Puente Hills is an expected source of increased mountain front recharge along the northeastern margin of the basin in the Whittier area.

4.3 Climate

The climate in the Omega Site area is semiarid with moderate temperatures that rarely drop below freezing. Highest temperatures generally occur during the months of July, August, and September. Rainfall occurs primarily during the winter and spring months. Figure 4-2 provides annual rainfall totals in the City of Whittier between water years 1956 and 2006. The 50-year mean annual rainfall over this time period is 14.3 inches per year (LADPW, website, <http://dpw.lacounty.gov>). The cumulative departure from the mean annual rainfall (Figure 4-2) indicates that rainfall has increased since the mid-1970s; the annual rainfall was lower in the period between 1956 and 1976 compared to the period between 1977 and 2006 (with two shorter, but notable dry periods around 1990 and 2004). The start of the period of higher than average rainfall coincides with the start of former Omega facility operations.

The 50-year mean annual infiltration rate (the fraction of rainfall that infiltrates into the subsurface and reaches groundwater) in the central basin is 1.55 inches per year (or 11 percent of rainfall). The infiltration rate is higher (2.07 inches per year or 14 percent of rainfall) in the Montebello Forebay (between the San Gabriel River and Rio Hondo) and also at the edge of the basin, in a narrow strip along Puente Hills (Reichard et al., 2003).

4.4 Land Use

Figure 4-3 shows the current land use within and near OU2. Most of the OU2 area is used for industrial and business purposes; however, residential buildings are present in the southern portion of OU2 (south of Lakeland Road and west of Balsam Street), north of

Washington Boulevard near its intersection with Crowndale Avenue, and west of the intersection of Lambert Road and Santa Fe Springs Road. Zones with residential buildings also surround OU2 on the southeast, northwest, and west.

The northern portion of OU2 was irrigated agricultural land in early 1900s (USGS, 1905) and agricultural use persisted through 1950s. The former Omega Chemical property was first developed in 1951.

4.5 Hydrogeology

This section summarizes the site regional hydrogeological setting and site-specific hydrogeologic conditions. The regional hydrogeological setting (Section 4.5.1) is largely based on the California Department of Water Resources (CDWR) Bulletin 104 (CDWR, 1961). Site conceptual hydrogeology (Section 4.5.2.6) was developed using the information on the regional hydrogeologic setting and geological data acquired during the field investigation, as well as unpublished deep seismic exploration data.

4.5.1 Regional Hydrogeology

The Omega Site is located in the Whittier area of the central basin, a sub-basin of the coastal plain of Los Angeles County. The coastal plain is bounded on the west and south by the Pacific Ocean and by mountains on the north, east, and southeast. The coastal plain is underlain by an extensive groundwater basin in Los Angeles and Orange Counties.

4.5.1.1 Hydrostratigraphy

Water-bearing sediments identified in the Whittier area extend to an approximate depth of at least 1,000 feet bgs. The identified geologic units consist of recent alluvium, the upper Pleistocene Lakewood Formation, and the lower Pleistocene San Pedro Formation. The Pliocene and Miocene marine sediments below the San Pedro Formation generally contain saline water in the Whittier area, although locally, it can contain freshwater. These units are considered nonwater-bearing where exposed in the Puente Hills and include the Pliocene Pico and Repetto Formations and the Upper Miocene Puente Formation, but are not further addressed in this report. Figure 4-4 shows a generalized stratigraphic column of fresh water-bearing sediments in the coastal plain of Los Angeles.

The recent alluvium primarily comprises streambed-deposited gravel, sand, silt, and clay. Hydrostratigraphic units found within the recent alluvial deposits include the semiperched aquifer, the Gaspur aquifer, and the Bellflower aquiclude. The semiperched aquifer is comprised of unsaturated sand and gravel deposits and is found on or near the surface of much of the coastal plain. The most important areas where this aquifer appears are in the Los Angeles and the Montebello Forebay areas, and irregular patches throughout the rest of the coastal plain. The Bellflower aquiclude comprises all the fine-grained sediments that extend from the ground surface, or from the base of the semiperched aquifer, down to the first aquifer below. The Gaspur aquifer is mainly sand and gravel with a small amount of interbedded clay of continental origin. The Gaspur aquifer is only found within the recent alluvium. However, the CDWR considers the semiperched aquifer and the Bellflower aquiclude to be present in both the recent alluvium and the upper part of the Lakewood Formation (CDWR, 1961). CDWR (1961, Plate 26A) shows Gaspur deposits extending into

OU2 from the west (Figure 4-5). In the northern part of OU2, the Gaspur aquifer is shown as far as midway between MW17 and MW23, between MW7 and MW23, and at MW3 and MW14. In the southern part of OU2, the Gaspur aquifer extends to the plume south of MW28 (Figure 4-9). The margin of the Gaspur aquifer in the central part of OU2 approximately coincides with the western OU2 boundary.

The Lakewood Formation consists of non-marine deposits of late Pleistocene age and its base occurs at a depth of about 70 feet at OU2 (Section BB' on Plate 6A, CDWR, 1961). The Gage aquifer is the major water-bearing hydrostratigraphic unit and comprises the basal lithologic unit of the Lakewood Formation. It consists of about 30 feet of sand with some interbedded clay (CDWR, 1961). The Gage aquifer does not appear to be an important source of drinking water in the Whittier area, based on elevated TDS concentrations measured in groundwater samples collected at OU2; none of the local water supply wells produce water from this aquifer.

According to the CDWR (1961), sands and gravels with interbedded clay found underlying the Lakewood Formation are of marine origin; they are assigned to the San Pedro Formation. The base of the San Pedro Formation occurs at a depth of about 900 feet at OU2 (Section BB' on Plate 6A, CDWR, 1961). The San Pedro Formation unconformably underlies the Lakewood Formation. The San Pedro Formation has been subdivided into five named aquifers separated by clay members. A fine-grained layer is also typically present at the top of the sequence; although, in localized areas, the uppermost San Pedro Formation aquifer may be merged with the overlying aquifer, and one or more of the five aquifers may also be merged (CDWR, 1961). The five aquifers defined within the San Pedro Formation include, from top to bottom, the Hollydale, Jefferson, Lynwood, Silverado, and Sunnyside aquifers. The Hollydale aquifer has been identified by the CDWR (1961) only in the western portion of the Whittier area. It is merged with the overlying Gage aquifer in the vicinity of South Whittier. The other aquifers within the San Pedro Formation are thought to be present over most or all of the Whittier area. The thickness of the aquifers increases with depth. The shallow Hollydale aquifer ranges from 10 to 25 feet, whereas the deepest Sunnyside aquifer ranges from 200 to 300 feet. The base of the Sunnyside aquifer reaches a maximum depth of about 1,000 feet bgs (CDWR, 1961). The San Pedro Formation aquifers are the primary source of water for the production wells in the area.

4.5.1.2 Geologic Structures

The major geologic structures in the area include a homocline that underlies the La Habra piedmont slope, the northwest-trending La Habra syncline underlying the alluvial basin, and the west-northwest trending Santa Fe Springs (also named Coyote) anticline situated below the slightly uplifted Santa Fe Springs plain (CDWR, 1961). The anticline crest (Figure 4-5) coincides with the extent of exposed Pleistocene alluvial deposits (Saucedo et al., 2003). The La Habra syncline affects the San Pedro Formation and, to a lesser extent, the Lakewood Formation, and has a surface expression as the axis of the basin. The Santa Fe Springs anticline folds both the San Pedro and Lakewood Formations; shallow aquifers thin across the crest of the anticline. The Santa Fe Springs anticline plunges to the west-northwest and the La Habra syncline to the northwest (CDWR, 1961). Saucedo et al. (2003) and CDWR (1961) differ slightly in the location of the fold axes for both the Santa Fe Springs anticline and the La Habra syncline. The extent of the Gaspur aquifer as shown in CDWR (1961) is also consistent with the folding in the OU2 area. The Gaspur aquifer extends from

the San Gabriel River channel to the east into the La Habra syncline, is absent across the crest of the Santa Fe Springs anticline at OU2, and extends to the east again along the southwestern limb of the anticline.

4.5.1.3 Faults

The west-northwest trending Whittier fault is located northeast of the site in the Puente Hills (CDWR, 1961). The Whittier fault is the closest known major fault to the former Omega property; because this fault cuts through the Puente Formation in the Puente Hills northeast of the Omega property, it is not expected to significantly affect groundwater flow in the shallow unconsolidated deposits at OU2. The west-northwest trending Norwalk fault, located just south of OU2 (approximately along Interstate 5), is thought to act as a partial barrier to groundwater flow (Reichard et al., 2003). The Norwalk fault is also referred to as the Stearn fault and is thought to be part of the Puente Hills and Coyote Hills blind thrust fault system (Meigs et al., 2008).

4.5.1.4 Groundwater Flow

Groundwater in the Montebello Forebay flows generally to the southwest, and then turns to the south-southwest in the central basin pressure area. The groundwater flow in the central basin is mainly controlled by natural and artificial recharge in the Montebello Forebay and production pumping. Groundwater response to the increased rainfall since the mid-1970s is not readily recognized on hydrographs for groundwater monitoring wells (Reichard et al., 2003). Artesian conditions now present in the pressure area of the Central Basin extended north to MW23 prior to 1900 and to MW20 in 1903 (USGS, 1905).

4.5.1.5 Oil Fields

The Santa Fe Springs oil field occurs near the anticline crest; the extent of the oil field approximately coincides with the surface exposure of Pleistocene alluvium (Figure 4-5). The oil-bearing deposits are below the depth extent of the drinking water aquifers.

4.5.2 Site Hydrogeology

This section describes the lithology of the subsurface material at Omega OU1 and OU2, the occurrence of groundwater and flow patterns, and the major hydrostratigraphic units.

4.5.2.1 Lithology

The lithology within the Omega OU1 and OU2 areas has been characterized using borings and downhole geophysical logs. The Omega Site investigations targeted shallow deposits found at depths of up to approximately 200 feet; investigations at other sites within OU2 provided data from much shallower depths.

4.5.2.2 OU1 Lithology

The vadose zone at OU1 (Figure 1-3) has been characterized by a combination of soil borings and a membrane interface probe (MIP) investigation; conductivity logging was performed in most of the MIP borings. The conductivity logs and also continuous soil boring logs indicate alternating thin lenses of relatively fine- and coarse-grained soils. The soils at and immediately near the former Omega Chemical property are predominantly fine-grained from the ground surface to about 130 feet (the maximum depth drilled at Well OW1B) and

mostly brown. The soils were classified as silt based on grain-size distribution analysis of soil samples (CDM, 2007a); visual soil classification appears to have been biased toward clays (e.g., OW1 and OW7 boring logs, Appendix A.1). The fine-grained units are likely alluvial fan deposits that originated from the southwestern slopes of the Puente Hills.

A sandy unit was found between 45 and 60 feet bgs along Putnam Street (west of the former Omega Chemical property). The unit is characterized by fine to medium sands and is up to 35 feet thick (at downgradient Well OW4). This sandy unit is not present beneath the former Omega property. This unit appears to be thin or transition into fine-grained soils (silts and clays) toward the north along Putnam Street; it is, however, continuous along Putnam Street within OU1 (CDM, 2007a) and southwest from OU1. A second sand unit was found starting at about 120 feet bgs (at Wells MW13, OW3B, and OW8B) along Putnam Street. Its extent beneath the former Omega Chemical property is not known. The unit appears to continue to Well OW4 and farther southwest. The two sandy units consist of light brown, poorly graded sands with subangular to rounded granitic and metamorphic clast. The shallow sands at Putnam Street are fine- to medium-grained while the deeper sands are mostly medium-grained with occasional gravel.

4.5.2.3 OU2 Lithology

Near-surface soils at OU2 (Figure 1-4) consist of sands and silts that are of various shades of brown, from light olive to yellowish. The color indicates that the sediments had undergone weathering under oxidized conditions and are believed to largely consist of continental deposits. Some of the color changes and the high content of clays within the Pleistocene deposits may indicate the presence of fossil soil horizons.

Dark greenish grey, poorly to well-graded sands with intervening pale brown or olive brown sands were found below about 30 feet at Wells MW19 and MW23A, below about 60 feet bgs at Wells MW12, MW27, MW29, and MW30, and below about 100 to 140 feet at Wells MW24, MW26, and MW28. Dark olive brown sands are present at similar or greater depths throughout OU2. The color is likely indicative of the soil oxidation states rather than of the depositional environment. The sands are fine to coarse, with occasional gravels. The clast is largely subrounded, and of granitic and metamorphic origin. The fine-grained soils found at OU2 are olive brown to greenish grey silts and clays.

The extent of the fluvial deposits shown in CDWR (1961; Figure 4-5) is supported by the OU2 investigation results. The lithologic logs for Wells MW14, MW16, MW18, MW19, MW20, MW21, MW22, MW23, MW27, and MW31 describe igneous and metamorphic clast. The log for MW25 describes quartz clast. The igneous and metamorphic (and quartz) material is believed to have been eroded from the San Gabriel Mountains and transported by a river. The shallow fluvial deposits likely correlate with the Gaspur Aquifer. However, the fluvial material was also found at greater depths (e.g., up to 150 feet at MW16, up to 180 feet at MW23, 195 to 220 feet at MW25) indicating that these deeper deposits likely predate the Gaspur aquifer. The materials found at OU2 are not as coarse as the Holocene deposits reported in the San Gabriel River channel (CDWR, 1961).

The rocks exposed in the western Puente Hills belong to the Fernando formation of Pliocene age and to the Puente formation of Miocene to Pliocene age (e.g., Saucedo et al., 2003). They include sandstones, siltstones, conglomerates, and minor limestones and tuffs. The alluvial

fan material derived from the Puente Hills has a different character than the river deposits; it is mostly finer-grained and does not include igneous and metamorphic clast (these materials could be present only as a result of secondary deposition of clast from conglomerates). The fine-grained units within OU2 are interpreted as alluvial fan deposits that originated from the southwestern slopes of the Puente Hills, namely the Turnbull Canyon and Wosham Creek northeast of the former Omega facility (Figure 4-1).

The transition from alluvial to fluvial deposits occurs throughout OU2. Alluvial fans were eroded, and sands were deposited during river incursions to the east. The fluvial sands were covered by the fan material when the river retreated. An example of this transition is the lithology encountered at Well MW31 (Appendix A.1); the log describes sands and gravels with igneous clast indicative of fluvial origin with overlying, predominantly silty soils with frequent calcium carbonate stringers indicative of an alluvial depositional environment. The deposition of the Lakewood formation was primarily controlled by sea level changes (Bulletin 104, Page 16); during low sea level stages and increased erosion, the river eroded in its channel west of OU2 and the alluvial fans expanded. During high sea levels and lower-energy depositional environment, the river meandered and deposited sands at OU2. The main river channel likely remained west of OU2, which explains why coarse gravels and cobbles are not found at OU2.

4.5.2.4 Groundwater Levels

The depth to groundwater at OU1 and OU2 ranges from 22.90 feet bgs at Well MW7 to 92.07 feet bgs at Well MW27C (Table 4-1). The water table slopes from 135 feet above msl at the former Omega Chemical property to about 15 feet above msl (Well MW30) near the southern edge of OU2, approximately 4.5 miles away.

The hydrographs for all Omega wells are shown in Appendix I.1. The water level record starts in 2001 for wells near the former Omega Chemical property; hydrographs are not shown for the wells installed in 2007 because the data record is too short. Water levels at OU1 and OU2 declined between 2001 and 2004, rebounded after heavy precipitation in 2005, and remained approximately steady in the following years. The 2005 rebound was similar in magnitude in both water table and deep well screens, with the water levels in the deep screens rebounding faster than in the shallow screens at the same locations (e.g., Wells MW4, MW8, OW1, and OW4). Water levels at other sites within OU2 (Appendix I.1) follow a similar pattern over time.

At cluster wells, water levels measured in deeper screens are generally lower than water levels in shallower screens. The greatest difference between water levels in adjacent screens is 25.69 feet between Wells MW25C and MW25D. Water level differences of 10 to 20 feet were measured at six locations (or wells)—between OW3 and OW3B, OW8 and OW8B, MW17B and MW17C, MW20B and MW20C, MW26B and MW26C, and MW27B and MW27C; higher water elevations were measured at the shallower screens at all of these wells. The differences in the water levels indicate that at these locations, there is substantial hydraulic separation between the aquifer units screened. The water levels are nearly the same at all three screens at Well MW18, indicating that there may be little or no hydraulic separation of the screened units in this area.

Water table contours for the study area were developed from groundwater elevations at the shallow (water table) wells including 29 EPA monitoring wells, eight OPOG monitoring wells, six WDI monitoring wells, 22 CENCO Refining Company (CENCO) monitoring wells, and two OFRP monitoring wells (Figure 4-6). The water level contours were generated using the natural neighbor interpolation method in SURFER 8.01 (Golden Software, Inc., 2002). This method is based on the Thiessen polygon-weighting procedure and is suitable for irregularly distributed data; it does not extrapolate outside of the data coverage. The computed contours were adjusted based on professional judgment. August 2008 water table contours for the Ashland Chemical facility (URS, 2008) were added to the OU2 water table map to extend the contours to the east.

The water table contours (Figure 4-6) indicate that groundwater flows from the former Omega Chemical property to the southwest past Sorensen Avenue, and then the flow direction changes to the south-southwest near Los Nietos Road. The flow turns further to the south at Florence Avenue and to the south-southeast past (south of) Lakeland Avenue. Section 4.5.2.6 presents an explanation of the flow pattern.

The shallow groundwater gradient between the former Omega Chemical property and Sorensen Avenue is about 0.0012 foot per foot (ft/ft) to the southwest. The gradient becomes steeper, 0.0076 ft/ft, between Sorensen Avenue and Florence Avenue and its direction gradually turns from the southwest to the south-southwest. Near Lakeland Road, the gradient is due south. Between Lakeland Road and Imperial Boulevard, the gradient decreases to 0.0030 ft/ft and turns to the south-southeast. The gradient calculations are shown in Appendix I.2. The average shallow groundwater gradient along the flow path from the former Omega Chemical property to Well MW30, the farthest downgradient well, is 0.0049 ft/ft (the difference in water levels between Wells OW8A and MW30 is 119.12 feet over a distance of 24,080 feet). The areas of flat water table gradient coincide with the extent of the Gaspur aquifer, indicating that groundwater flows through more permeable materials. The gradient steepens across the anticline as groundwater flows through less permeable, largely alluvial fan material. South of the anticline the gradient flattens again as the flow re-enters the Gaspur aquifer.

Historical records from the Omega Site and other sites suggest that the shallow groundwater flow patterns at OU2 have not changed much at least over the past decade. Local groundwater gradients measured between more closely spaced monitoring wells at other sites are in good agreement with gradients estimated for OU2. The historical gradients are available for the following areas at OU2 (Figure 4-6):

- **Omega property to Sorensen Avenue** – Minimal changes in groundwater flow direction and gradients in the area covered by Wells OW1 to OW8 and MW1 to MW11 were observed since 2003 (Weston, 2003; CH2M HILL, 2004a).
- **North of Los Nietos Road, east of Santa Fe Springs Road** – The shallow groundwater gradient at WDI was generally to the south in the 1990s. The gradient steepens from 0.002 ft/ft in the western portion of the site to 0.035 ft/ft in the southwestern corner of the site. The water levels in shallow wells are higher than those in wells screened at greater depths; the apparent vertical gradients ranged from 0.008 to 0.052 ft/ft (EPA, 2002a). The gradient at WDI was 0.002 ft/ft to the southwest in July 2007, consistent with the groundwater flow regime in the upgradient portion of OU2.

- **Sorensen Avenue to Los Nietos Road** – At Angeles Chemical, the shallow groundwater gradient was 0.005 ft/ft to the southwest in February 2004 (Shaw, 2004). At McKesson Chemical, the shallow groundwater gradient was 0.006 ft/ft to the west-southwest in November 2005 (Geosyntec, 2005). The shallow groundwater gradient at Phibro-Tech of 0.0036 ft/ft to the southwest was calculated from October 2006 groundwater elevations (Iris Environmental, 2006a). At Pilot Chemical, shallow groundwater flow is generally toward the southwest at gradients ranging from 0.002 ft/ft to 0.003 ft/ft (McLaren/Hart, 1998).
- **Near Telegraph Road** – At the OFRP site, the average gradient between 1994 and 1996 was 0.0080 ft/ft to the south-southwest (it ranged from 0.0058 to 0.0135). The area with the steepest gradient was near the intersection of Telegraph Road and Santa Fe Springs Road between former Monitoring Wells MW12 and MW13 (McLaren/Hart, 1996). In September 2006, the shallow groundwater gradient was 0.012 ft/ft to the west-southwest (calculated from water levels that CH2M HILL collected during semiannual groundwater monitoring); the gradient direction is probably distorted because the remaining three wells are far apart and the flow is turning to the south in this area.
- **South of Florence Avenue** – The average shallow groundwater gradient at CENCO was 0.01 ft/ft to the south between 2001 and 2005 (Versar, 2001; TRC, 2002; Blasland, Bouck, and Lee [BBL], 2005). At the southern portion of the CENCO site, the gradient was 0.0051 ft/ft to the south-southeast in July 2007 (calculated from data received electronically from DTSC).

4.5.2.5 Stratigraphic Boundaries

The stratigraphic interpretation is based on available boring logs and downhole geophysical logs of the OU1 and OU2 monitoring wells and nearby production wells and piezometric heads. In addition, the OU2 stratigraphic interpretation relied on information on the deeper structure of the basin to infer the locations of fold axes and the dip of hydrostratigraphic units. The USGS provided a preliminary interpretation of oil industry seismic reflection surveys and of the shallow sediments at OU2 based on the data collected during this RI (USGS, 2007). The seismic survey covered an area larger than OU2. The data show major seismic reflectors (soil density contrasts that reflect sound waves) below 300 feet and were used to support geophysical log and lithologic correlations of shallower units, particularly the location of the fold axes and the dip of stratigraphic units. The USGS performed this work for the EPA under Interagency Agreement #DW 1495567601.

A site lithologic and stratigraphic model has been developed and is illustrated by the Cross-sections AA', BB', and CC' (Figure 4-7). Sections AA' and CC' are oriented sub-parallel, and BB' is oriented perpendicular to the major groundwater flow direction. Figure 4-7 also shows the location of the cross-sections in relation to the major geological features, including the La Habra syncline and the Santa Fe Springs anticline presented in Figure 4-5.

The locations of the fold axes and their plunge were inferred from the seismic sections. The dip of the shallow deposits was inferred from the correlation of the geophysical logs and the location relative to the fold axes.

Eight stratigraphic boundaries (SBs) have been defined for OU2. These boundaries separate stratigraphic units and some of them may represent depositional sequence boundaries. The

SBs are numbered sequentially from the top, starting with SB1 corresponding to the base of Holocene deposits; similarly, SBs 2 to 7 correspond to the Pleistocene deposits. The age of the underlying deposits (below SB7) is undetermined in this report as age determination was not the focus of this investigation.

One Holocene and six Pleistocene stratigraphic units were identified through OU2. The deposition of the units is thought to be largely controlled by base level changes; consequently, lateral facies transitions reflect different depositional environments (for example, near-shore marine, floodplain, etc.) within each stratigraphic unit. Coarse sand units formed where fluvial channels dissected the floodplain or, possibly, as shallow marine (beach, proximal delta, and near-shore) deposits. A thin veneer of recent alluvium derived from the Puente Hills covers the floodplain sediments at and northeast of the former Omega property. Generally, coarser materials are found at the base of the stratigraphic units that transition upward into finer-grained materials, as indicated by relatively high and low resistivity, respectively, on geophysical logs. This stacking pattern suggests most of these deposits are of floodplain, rather than of marine origin.

As shown in Sections AA' and CC', the main structural features identified at OU2 are the La Habra syncline and the Santa Fe Springs anticline. The principal Santa Fe Springs anticline crest lies between Wells MW25 and MW26; the La Habra syncline axis is near Well MW15. Both fold axes are near to their locations shown in Saucedo et al. (2003). The sections indicate that the syncline and anticline are related, so the deformations are of the same age, with folding seen postdating the deposition of both the Lakewood and San Pedro formations. However, the thickening of the Holocene in the basin and unit thinning over the anticline crest indicate that folding was also syn-depositional at least since San Pedro.

4.5.2.6 Conceptual Hydrogeology

The conceptual hydrogeology is based on available boring logs and downhole geophysical logs of the OU1 and OU2 monitoring wells and nearby production wells, piezometric heads, and contaminant concentrations. The piezometric head symbols in Figure 4-7 are color-coded to show which stratigraphic unit each well is screened in (the symbols have the same color as the underlying SB). A listing of screen depths and water levels is provided in Table 4-1. Figure 4-8 shows the depth extent of PCE in groundwater. The contaminant distribution is discussed in detail in Section 5.

Fine-grained units are shown on the cross-sections where geophysical logs indicated their presence and where piezometric heads or contaminant distribution suggest hydraulic separation of the screened zones. The presence of these aquitards is also generally supported by the visual description of drill cuttings. Aquitards are generally not contiguous over OU2 as indicated by piezometric heads (e.g., Wells MW18 and MW23) and contaminant distribution (e.g., Well MW23). Only one aquitard is manifested by differences in piezometric heads at most well locations; however, the head drop occurs at different depths at different well clusters indicating that there is no single, continuous aquitard present at OU2.

Near-surface fine-grained soils are also found in the vicinity of the former Omega property and are depicted on Section AA'.

Unsaturated Holocene deposits (above SB1) are found at and near the former Omega Chemical property and in the downgradient area of OU2 (Sections AA' and CC'). The Holocene deposits are absent across the anticline (between Wells MW25 and MW27).

As illustrated by Cross-section AA', the former Omega Chemical property is underlain by relatively low permeability silty and clayey soils to a depth of about 120 feet bgs. These fine-grained soils transition into a sand unit that has been encountered approximately 200 feet southwest of the facility beneath Putnam Street; this unit contains the shallowest groundwater near the Omega property. Groundwater at OU1 generally occurs at a depth of approximately 70 feet bgs. A deeper aquifer unit was found at a depth of about 112 feet bgs along Putnam Street. The shallow aquifer is composed of well-sorted, fine to medium sands, and the deeper aquifer is composed of fine, well-sorted sands with interbedded silts and clays along Putnam Street. Piezometric heads in the deeper aquifer (below SB2) are about 7 to 13 feet lower compared to the heads in the water table aquifer in this area (based on July through August 2007 measurements), indicating substantial hydraulic separation between the two units.

A distinct lithologic horizon at an approximate depth of 30 feet bgs (referred to as the 30-foot unit) was found at OU1 dipping to the west and southwest. The 30-foot unit is between 3.5 to 11 feet thick and has a characteristic double peak signature on the MIP conductivity logs, with a lower conductivity interval in the middle of the unit likely corresponding to coarser materials and higher conductivity below and above, possibly due to higher clay content. The top of the zone slopes generally to the west-southwest beneath the former Omega Chemical property (CDM, 2007a). The 30-foot marker bed is near the top of HSU2 and likely is an overbank deposit. It was also recognized on gamma logs at OU1, but its extent outside OU1 is not known.

Away from the former Omega Chemical property, an unsaturated coarse unit (above SB2) was found near the surface at the locations of Well Clusters MW16, MW17, and MW20. The apparent dip of this unit suggests that it was affected by the uplift demonstrated by the Santa Fe Springs anticline, and is therefore considered to be part of the Lakewood Formation. This unit likely becomes saturated south of Well MW30 and west of Well MW22. The sediments above SB3 form the first saturated sandy unit within most of the study area, approximately between Wells MW23 and MW30.

Section BB' shows that the degree of vertical hydraulic separation varies over OU2, as seen in uniform piezometric levels at Well MW18. The fine-grained units pinch out or transition into coarser grained sediments between Wells MW23 and MW18. The orientation of the SBs in Section BB' is a manifestation of the anticline plunging northwest. Section BB' shows diminished correlation of lithologic units relative to the unit correlation along Sections AA' and CC', which supports the interpretation that the sediments are part of an alluvial fan complex. The lateral termination of the intervening aquitards can allow vertical hydraulic communication between aquifer units; because of generally downward gradients, shallow groundwater is expected to enter into the underlying units in areas where aquitards are missing.

The site hydrogeologic model generally matches the regional hydrogeology as described in the CDWR Bulletin 104. It is consistent with OU2 being largely located in the recharge area of the Los Angeles basin, in a transition zone between the piedmont slope (alluvial fan) and

the margins of the floodplain (Montebello Forebay). The hydrogeologic interpretation based on the seismic survey and Omega Site investigation data differs in details from the regional hydrogeology described in CDWR (1961). SB6 may represent the contact between the Lakewood Formation and the San Pedro Formation. No correlation of the sandy units with regionally recognized aquifers (e.g., Gage Aquifer, etc.) was attempted.

The shallow, unconfined aquifer spans two stratigraphic units. Piezometric heads measured in OU2 wells generally, but not always, decline with the depth of the hydrostratigraphic unit that the well is screened in; the differences between heads at multiple-screen wells are up to about 25 feet (based on July through August 2007 measurements). Vertical head differences between shallow and deeper well screens along Putnam Street are over 10 feet, indicating hydraulic separation between the shallow and deeper sands. Farther northeast of the Omega Chemical property, near the apex of the alluvial fan complex along the Puente Hills, hydraulic continuity across the shallow unconsolidated deposits may be expected because of the generally coarser alluvial fan material.

The groundwater gradient in the sand below SB5 is 0.0049 to 0.013 ft/ft to the southwest (measured between Wells MW16C, MW17C, MW20C, MW23D, and MW25C; see Appendix I.2). The gradient is steeper but generally in the direction of the shallow groundwater gradient in this area. This flow pattern is expected for a layered aquifer system where production pumping from deep units dominates the groundwater flow regime. Based on the gradient, PCE distribution, and piezometric head drop at most well locations across SB5, it appears that the fine-grained material below SB5 is a laterally continuous aquitard at OU2, at least along the sections constructed.

The groundwater gradients measured in the sands between SB3 and SB5 were inconsistent, indicating that the intervening fine-grained units provide local hydraulic separation.

The effect of the syncline on groundwater flow at OU2 is manifested by the area of flattened groundwater gradient between Wells OW8 and MW8, which coincides with the extent of the Gaspur aquifer. The anticline seems to have even more significant influence on groundwater flow and contaminant transport at OU2. The contaminant plume and the groundwater flow curve to the south around the Santa Fe Springs anticline, and there is a fairly sharp increase in the shallow groundwater gradient that more or less coincides with the curve in the plume. This transition also coincides with mapped changes in surface geology related to the anticline (Saucedo et al., 2003).

The increased shallow groundwater gradient around the anticline can be explained by forcing groundwater to flow across the units north of the anticline axis (e.g., between Wells MW23 and MW16 on Section AA' and between Wells MW23 and MW25 on Section CC') and causing the uppermost Pleistocene unit to change from an unconfined to confined aquifer south of the anticline crest. The flow across the unit will result in the steepening of the gradient because the permeability (vertically) across the units is expected to be much lower than parallel to their depositional direction. When a unit changes from an unconfined to confined condition, its restricted saturated thickness results in the steepening of the groundwater gradient.

South of the anticline, the gradient flattens again as the flow re-enters the Gaspur aquifer. The groundwater flow southwest of the anticline is also likely more influenced by the

regional flow in the Central Basin, which is toward the south-southwest. Therefore, the change in the groundwater flow direction south of the anticline crest may be the result of transitioning from a pure piedmont slope flow (from the natural infiltration areas at the foothills of the Puente Hills to the southwest) to the basin flow regime that is affected by infiltration in the Montebello Forebay and production pumping in the Central Basin.

4.5.2.7 Hydrostratigraphic Interpretation at Other Sites

Regional aquifer units were identified during environmental investigations at other sites within OU2. The conclusions made by various consultants were based on site investigation data and also on the consultants' interpretation of CDWR (1961). CH2M HILL compiled these assessments of shallow local hydrogeology (Attachment 1) as part of the process of acquisition of information from other sites within OU2. The comparison of the site assessments shows that the correlation of local hydrogeology with regionally recognized aquifers is ambiguous, for example, as shown from the description of the aquifer units at the Angeles, McKesson, and Phibro-Tech sites (e.g., the Gaspur aquifer is identified at the Angeles site, but not at the adjacent McKesson site; the Gage aquifer is described as saturated at the Angeles and McKesson sites, but as unsaturated at the Phibro-Tech site, yet this unit dips from Angeles/McKesson to Phibro-Tech, etc.). The discrepancies in the interpretation of hydrogeology for the individual sites only became apparent when they were reviewed together.

4.5.3 Aquifer Properties

Aquifer properties were estimated during several previous investigations at OU2.

4.5.3.1 Results of Previous Aquifer Testing

Aquifer tests that have been performed in Omega wells at OU1 included slug tests and pumping tests.

Short-term constant discharge testing (approximately 4 hours) was performed on Wells OW2, OW3, OW4a, and OW8 in 2003. The estimated transmissivity values were 170 square feet per day (ft²/d) for Well OW2; 2,691 ft²/d for Well OW4A; and 1,616 ft²/d for Well OW8A; the OW3 test was not analyzed (CDM, 2005c). An approximately 24-hour long constant rate pumping test was conducted in 2003 on Well OW8A with drawdown monitored in several observation wells/piezometers and yielded estimates of transmissivity between 563 and 810 ft²/d (CDM, 2005c).

A constant discharge test of approximately 24-hours long was performed in September 2006 on five extraction wells installed along Putnam Street in mid-2006 (Wells EW1 through EW5) as part of the Phase 1a area interim groundwater remedy. Drawdown was also measured at multiple observation wells. The geometric mean hydraulic conductivity of the unconfined sandy unit calculated from the extraction well testing was 153 feet per day (ft/d) and the geometric mean transmissivity was 2,760 ft²/d (CDM, 2006). The estimated conductivity is representative of the unconfined aquifer formed by the shallow sandy unit.

Hydraulic conductivity values of 0.6 to 1.6 ft/d were estimated from a slug test at Well OW1A and step-drawdown pumping test at Well OW2 (Weston, 2003). Well OW1A is installed in fine-grained sediments, largely silts, and Well OW2 is screened across sand and

silt near the termination of the shallow sandy unit; the estimated hydraulic conductivities are representative of the shallow fine-grained sediments near the former Omega Chemical property. The hydraulic conductivity of 1.6 ft/d for Well OW2 is lower than the value corresponding to the transmissivity that CDM estimated (8.5 ft/d for a screen length of 20 feet) (CDM, 2005c).

Slug tests were performed on several wells at the McKesson facility. Due to very high hydraulic conductivity, the recovery response of the slug tests was too quick to allow for their analysis; the subsequent testing included constant rate pumping tests. The hydraulic conductivity of the perched zone was estimated to be 0.6 ft/d. The hydraulic conductivity of the lower aquifer zone ranges from 9 to 59 ft/d (Harding Lawson Associates, 1991).

McLaren/Hart Inc. conducted slug tests and estimated the hydraulic conductivity of the shallow, unconfined aquifer at the OFRP site to range between 3 and 97 ft/d with a mean of 23 ft/d. The shallow aquifer transmissivity estimated from observation well data for a constant-rate pumping test using two observation wells at a distance of 24 feet from the pumping Well MW10, ranged between 0.84 and 1.2 square feet per minute (ft²/min). No drawdown response was recorded at 136 feet from the pumping well (McLaren/Hart, Inc., 1996). Assuming a saturated thickness of 20 feet, the hydraulic conductivity would be between 60 and 86 ft/d.

The hydraulic conductivity of the shallow aquifer at Phibro-Tech is 55 to 307 ft/d and storativity is 0.01 to 0.009 (CDM, 2003b). The storativity value seems to be overestimated for the shallow aquifer thickness.

4.5.3.2 Results of OU2 Aquifer Testing

CH2M HILL performed slug tests and pumping tests to characterize hydraulic conductivity distribution within OU2 as part of this investigation.

Slug Test Results

Slug tests were performed in all Omega wells and analyzed using the Kansas Geological Survey model (KGS; Hyder *et al.*, 1994), Butler (1998) method, and Bouwer and Rice (1976) method. The results are summarized in Table 4-2. The testing procedures and analysis are presented in Appendix H.1. Table H1-3 shows the methods used for each well in addition to the results of each parameter. The average horizontal hydraulic conductivity (K_r) for all wells is 54 ft/d. The minimum K_r of 0.5 ft/d was estimated for Well MW24D and the maximum of 264 ft/d for Well MW2. The average K_r for the shallow (water table) wells is higher, 68 ft/d (Table H1-5), than for the deeper wells, 40 ft/d (Table H1-6). Slug testing at the additionally installed shallow Well MW31 provided a K_r of 1.9 ft/d.

Pumping Test Results

Pumping tests were performed at six wells, primarily along the main contaminant transport pathway from the former Omega Chemical property at locations where future remedial pumping may be considered. The drawdown response to pumping in the extraction wells stabilized quickly at all the tested locations, indicating that the wells are installed in permeable aquifer material. These wells were screened in sand units that likely represent the most permeable aquifer material at OU2. The well screens were not installed in fine-grained materials that comprise a significant portion of the sediments at OU2. Therefore, the aquifer properties estimated from the pumping tests are characteristic of the material within

the main contaminant transport pathway, but not of the bulk aquifer properties in the basin. The results are summarized in Table 4-3. The test analysis is presented in Appendix H.2.

The tests at nested wells and well clusters allowed the evaluation of hydraulic continuity of the aquifer near the tested wells. During the EW-1 pumping tests, all four well screens at Well MW8 were monitored. Wells MW8A, MW8B, and MW8C responded to the pumping while Well MW8D did not. The drawdown responses and model-fitting (Appendix H.2) indicated that the units screened by the upper three screens at Well MW8 (A-C) responded hydraulically as one aquifer. The aquifer zone screened by Well MW8D is separated by fine-grained sediments from the overlying unit. This conclusion is further supported by the difference in heads and contaminant concentrations measured in Well MW8D and those measured in the three shallower wells (MW8A-C).

During the pumping tests at nested wells (MW23A, MW24A, MW24C, MW26A, MW26B, MW27A, MW27B, and MW30), water levels in adjacent screen intervals (above and below, as applicable) were monitored with pressure transducers. Drawdown response was recorded at Well MW24B during pumping from Well MW24C, indicating hydraulic communication between the two screened zones. No other observation wells responded to pumping, indicating that the fine-grained units between the well screens act at least as partial groundwater flow barriers. The drawdown response at Well MW24 indicated that the fine-grained unit separating Wells MW24B and MW24C is not an effective barrier to groundwater flow and contaminant migration. The fine-grained unit between Wells MW24A and MW24B likely is a barrier to groundwater flow, as evidenced by the lack of hydraulic response and also by the difference in head and contaminant concentrations. Wells MW24C and MW24D are likely separated by a low permeability unit because no response to pumping from Well MW24C was recorded in Well MW24D. No drawdown response in the adjacent screens was recorded during the pumping tests at Wells MW26 and MW27, indicating that the well screens are hydraulically separated by intervening fine-grained layers.

The time-drawdown data were analyzed using the general well function (GWF; Perina and Lee, 2006) for pumping from partially penetrating wells installed in confined, unconfined, or leaky aquifers. GWF accounts for well skin properties; frictional well loss is included as an additional drawdown component (e.g., Kawecki, 1995). The plots of observed and computed time-drawdown data are included in Appendix H.2 and the estimated aquifer properties are summarized in Table H2-1. All the tests were analyzed as a confined aquifer response including those conducted on shallow (water table) wells because of the short duration of pumping.

The representative K_r results range from a minimum value of 45 ft/d at Well MW27B to 404 ft/d for Well EW1. The K_r values are higher than those estimated from slug tests on the same wells. This is a common test outcome because the hydraulic disturbance caused by pumping is expected to affect a much larger section of the tested aquifer than the disturbance from the slug tests, more flow pathways (i.e., zones of relatively high K_r) were active during the pumping than during the slug tests. The average specific capacity of the pumped wells is 62 gpm per foot.

The drawdown response in observation wells at the EW1 test location allowed for the estimation of the vertical to horizontal anisotropy ratio K_z/K_r (and other parameters; see

Appendix H.2). The low estimated K_z/K_r ratio of 0.0092 is indicative of the layering in the aquifer with alternating coarse- and fine-grained soils (i.e., sands and silts/clays). Such low vertical hydraulic conductivity K_z also explains head differences between shallow and deep-screened wells (e.g., at Wells MW8A–D) and is expected to limit the downward migration of contaminants. Low K_z/K_r is also expected to be applicable to large-scale groundwater flow (i.e., for flow across fine-grained subunits) throughout OU2.

Aquifer Properties at OU2

The estimated aquifer properties are representative of coarse-grained sub-units because the monitoring wells were installed with screens across coarse soil intervals. Furthermore, the pumping tests were conducted on wells installed in thick, sandy units and located along the suspected main contaminant transport pathway (see Section 6). Therefore, the estimated hydraulic conductivities are biased toward the properties of these coarse-grained sub-units. Because these sub-units have likely been formed by river channels, they are expected to be elongated in the southwest direction; although the channels are likely interconnected, they are expected to have somewhat limited lateral extent. The K_r of the shallow, coarse sub-units is on the order of 100 ft/d. The bulk aquifer material, on the basin scale, is expected to have lower hydraulic conductivity in proportion to the thickness of the fine- and coarse-grained units. The regional groundwater flow is expected to be reflective of the bulk aquifer properties, while the transport of contaminants at OU2 is expected to be largely dependent on the properties of the coarse-grained sub-units that provide the main transport pathways.

The principal orientation of hydraulic conductivity is expected to be parallel with the SBs. The permeability across the stratigraphic units is expected to be generally lower because of sediment particle orientation and also because of the presence of fine-grained sub-units (i.e., clayey and silty lenses) and more laterally extensive aquitards. However, the hydraulic properties of individual stratigraphic units are also expected to vary laterally due to facies changes from coarse-grained to fine-grained materials. The potential for vertical hydraulic communication is increased where coarse facies of overlying stratigraphic units are adjacent (e.g., near Well MW18).

Horizontal anisotropy was not detected in the one multiple-well test (at EW1), likely because of the proximity and number of the test wells and because of aquifer heterogeneity. The OU2 deposits are expected to exhibit horizontal anisotropy of varying orientation throughout the OU2 area; however, designing aquifer tests to estimate the horizontal anisotropy on OU2's scale is not practical.

The specific storage and specific yield could not be reliably calculated from the test data; however, these aquifer properties can be constrained to a fairly narrow range of plausible values for the unconsolidated sediments found at OU2 (Appendix H).

4.6 Water Production Wells

Active and inactive production wells exist within OU2. Information on the status, construction, and water quality is not readily available for production wells in general. The following discussion summarizes the information obtained during the first (Weston, 2003) and second (this report) phase of the OU2 investigations. The EPA continues collecting

further data and information on these production wells and on other wells in the vicinity of OU2.

Based on a records search by England-Hargis, six water supply wells are within 1.5 miles of the former Omega Chemical property (England and Associates and Hargis, 1996). The nearest well (02S/11W30-R3, also known as SFS No. 1) is located 1.3 miles to the west-southwest of the Omega property, at the Santa Fe Springs Fire Station on Dice Road near Burke Street. This well is screened from 200 to 288 feet bgs and 300 to 900 feet bgs, and operates at a rate of approximately 900 gpm. According to Weston, aquifers that are tapped by SFS No. 1 include the Silverado and Sunnyside aquifers, both of which occur within the lower part of the Lower Pleistocene San Pedro Formation (Weston, 2003). However, as shown in Cross-section B-B', SFS No. 1 appears to receive a portion of its water from HSU5, which contains high VOC concentrations at Well MW23C (located 0.4 mile east-southeast of SFS No. 1).

The Los Nietos water supply well (02S/11W30-Q5) was located about 1.5 miles southwest of the former Omega Chemical property (about 1,500 feet west-northwest of SFS No. 1). This well was screened from 152 to 370 feet bgs. PCE and TCE were detected at unknown concentrations from 1986 to 1990 (Weston, 2003). The source of this contamination is unknown. The total depth of the well was 225 feet when it was destroyed in 1997 (Mutual Water Owners Association of Los Nietos, 1997). The well locations are shown in Figure 2-1.

The remaining wells (2S/11W-29E5, 2s/11W-32G3, 2S/11W-33M1, and 2S/11W-32J4) are no longer operating, used for irrigation, have no water-quality data available, or their exact locations are unknown (Weston, 2003).

Database searches by CH2M HILL identified a total of 12 production wells within OU2 – 2S/11W-30R03S (SFS No. 1), 3S/11W-06D03S, 3S/11W-06C03S, 3S/11W-06M03S, 3S/11W-06M05S, 3S/11W-06M06S, 3S/11W-06D02S, 3S/11W-06N01S, 3S/11W-06N02S, 3S/11W-06Q03S, 3S/11W-06Q04S, and 3S/11W-07B05S. Four of these wells are screened at depths greater than 300 feet bgs or are nonoperational.

An additional 38 production wells exist within about 1 mile of OU2. Five of the production wells in the OU2 area (Figure 4-9) are known to have been impacted by VOCs. The well nearest to the former Omega Chemical property is SFS No. 1, described previously.

In addition, the search identified four active production wells located downgradient (south and southwest) of the leading edge of OU2 – 3S/12W-12A02S, 3S/11W-07E01S, 3S/11W-07E02S, and 3S/11W-18G05S. These wells are owned and operated by GSWC. Well 3S/11W-07E01S, known as GSWC Pioneer #1, is screened from 193 to 216 feet bgs and currently operates at about 540 gpm; Well 3S/11W-07E02S, known as GSWC Pioneer #2, is screened in two depth intervals, from 196 to 206 feet bgs and from 460 to 472 feet bgs, and currently operates at about 388 gpm; Well 3S/12W-12A02S, known as GSWC Pioneer #3, is screened from 194 to 218 feet bgs and currently operates at about 520 gpm; Well 3S/11W-18G05S, known as GSWC Dace #1, is screened in two depth intervals, from 200 to 260 feet bgs and from 266 to 402 feet bgs, and currently operates at about 310 gpm (Moore, 2009).

Figure 4-10 shows water supply and irrigation wells that were mapped throughout OU2 in early 1900s (USGS, 1905). No records of the status, destruction, or abandonment of these wells were available at the time of the preparation of this report. Because the artesian area

extended as far north as MW23 prior to 1900, and the water table near the former Omega Chemical property in 1901 was about 25 feet higher than today (USGS, 1905), it is likely that many of these wells were shallow. The wells installed between MW23 and the former Omega Chemical property, an unconfined area prior to 1900, were likely screened starting at the water table.

4.7 Oil Wells

OU2 overlaps the central portion of the Santa Fe Springs Oil Field (Figure 4-11). The California Department of Conservation, Division of Oil and Gas (Website, <http://gis.ca.gov/catalog/BrowseCatalog.epl?id=1064>) lists a total of 1,378 wells in the Santa Fe Springs Oil Field. Some of these wells are active, but a majority of them were abandoned. It is possible that oil production wells abandoned prior to about 1965 were not completely sealed (they were likely pressure grouted in the production interval, but not all the way to the ground surface) and that their corroded and collapsed steel casings could provide conduits for downward groundwater flow and contaminant migration.

Attachment 1—Hydrogeology of Other Sites at OU2

The following is a summary of occurrences of the major aquifers, as interpreted by various other parties during site investigations.

Angeles Chemical

The Gaspar aquifer is listed as being impacted by chemicals near the former Angeles Chemical site (Blakely Environmental Investigations, 2004). The Gaspar aquifer is described as the old San Gabriel River and other old river channel deposits; it is 40 feet thick with its base about 80 to 100 feet bgs at the Angeles site. The Gaspar aquifer may be hydraulically connected with the Gage or Hollydale aquifers (Shaw, 2004). The Gage aquifer is impacted by chemicals near the former Angeles Chemical site (Blakely Environmental Investigations, 2004). The Gage and Hollydale aquifers were encountered at 20 to 35 feet bgs; they are undistinguished and site monitoring wells are described as Gage/Hollydale monitoring wells (Blakely Environmental Investigations, 2002). The Gage aquifer is not present at the former Angeles Chemical site (Shaw, 2004). The Hollydale aquifer is impacted by chemicals near the former Angeles site (Blakely Environmental Investigations, 2004). The Hollydale aquifer is approximately 30 feet thick with its top at about 70 to 100 feet bgs (Shaw, 2004).

McKesson Chemical

The former McKesson Chemical site is underlain by silt and clay, silty sand, and sand to a depth of at least 140 feet bgs. The coarse-grained water-producing units are contained within three zones, which have been correlated with the Gage, Hollydale, and Jefferson aquifers. Geomatrix defines these respective units as the perched zone, A zone, and B zone (Geomatrix, 1995). The fine-grained units that separate the coarse-grained units consist of silt and clay (Geomatrix, 1995). The Gage aquifer is approx 30 feet thick at the McKesson site and vicinity (Harding Lawson Associates, 1991). The Hollydale aquifer has a maximum thickness of 100 feet in this area. The Jefferson aquifer underlies the Hollydale aquifer at the site; they are separated by aquicludes of the San Pedro Formation. The Lynwood, Silverado, and Sunnyside aquifers are the three main deep aquifers that range in thickness from 50 to 500 feet; however, no site borings penetrated into these units (Harding Lawson Associates, 1991).

Phibro-Tech, Inc.

The Gage aquifer is unsaturated, approximately 15 feet thick with its top at 15 to 30 feet bgs at Phibro-Tech. The Hollydale aquifer is approximately 40 feet thick beneath the site with its top at 50 to 100 feet bgs. Sixteen of the site monitoring wells are screened in the upper portion of the Hollydale aquifer and six wells are screened in the lower portion. Well

MW15D may be screened in both Hollydale and Jefferson as the two aquifers possibly merge in the southwest portion of the site. Groundwater appears to flow from the Hollydale aquifer into the underlying Jefferson aquifer below the Phibro-Tech site. The Jefferson aquifer underlies and potentially merges with the Hollydale aquifer at the site. Because no site wells are screened in the Jefferson aquifer, its thickness is unknown (CDM, 2003b).

Pilot Chemical Corporation

The Gaspur aquifer extends from approximately 50 to 100 feet bgs at the former Pilot Chemical site. The top of the Gardena aquifer is at a depth of approximately 110 feet bgs. The two aquifers are separated by clayey units. The nearest drinking water well taps the Gardena aquifer (CH2M HILL, 1986); this well is not identified, but its location (1/4 mile northwest from the former Pilot Chemical property) corresponds to the location of Santa Fe Springs Well No. 1 (SFS No. 1).

Waste Disposal Inc.

Recent alluvium with a maximum thickness of 80 feet is near the site. This alluvium overlies the Lakewood Formation (Artesia and Gage aquifers) and San Pedro Formation (Hollydale, Jefferson, Lynwood, Silverado, and Sunnyside aquifers). The thicknesses or depths of the aquifers are not specified (TRC, 2001). If present beneath the WDI site, the Hollydale aquifer would first be encountered from 85 to 100 feet bgs (CDM, 1999b).

Site F

The Gaspur aquifer is found at approximately 50 feet and the top of the Gardena aquifer is at a depth of 143 feet at West Bent Bolt (CH2M HILL, 1990).

76 Station

The 76 Station is located at 11026 East Washington Boulevard in Whittier. Recent alluvium is present to 120 feet bgs at the former 76 Station, with the Gaspur aquifer comprising approximately 80 feet of the alluvium thickness. The underlying Lakewood Formation is approximately 50 feet thick (TRC, 2004).

CENCO

The presence of the Hollydale aquifer is noted, but not its depth (TRC, 2002).

OFRP

Localized perched aquifers were found at shallow depths (Kleinfelder, 1986). The first saturated zone (starting at about 60 feet bgs) was correlated with the Exposition aquifer; the Exposition and Gage aquifers appear to be merged and could not be distinguished at the site (McLaren/Hart, 1996).

Table 4-1
 Summary of Water Levels and Stratigraphic Units
 Omega Chemical Superfund Site

Well Name	SB	Depth to Screen Top (feet bgs)	Depth to Screen Bottom (feet bgs)	Depth to Water Jul-Aug 2007 (feet)	Water Level Elevation (feet msl)
OW1A	2	63	77.5	76.17	136.33
OW1B	3	110	120	77.68	129.5
OW2	2	60	80	68.6	133.7
OW3A	2	63	83	64.81	133.72
OW3B	3	112	122	76.5	120.56
OW4A	2	49.8	69.8	57.88	126.79
OW4B	3	112	122.3	64.42	120.08
OW5	2	30	50	30.67	123.49
OW6	2	38	58	46.78	125.96
OW7	2	70.9	90.9	76	138.21
OW8A	2	60.4	80	66.7	133.94
OW8B	3	116	126	79.86	120.96
MW1A	2	45	60	33.55	124.16
MW1B	3	75	85.4	33.42	124.63
MW2	2	45	60	30.08	124.13
MW3	2	38	48	28.76	122.72
MW4A	2	42.7	53	25.51	121.29
MW4B	3	69.7	80	25.49	121.35
MW4C	3	88.7	99	27.32	119.78
MW5	2	43.3	53.3	27.55	123.05
MW6	2	37.1	47.5	27.5	122.78
MW7	2	35.8	46	22.9	120.38
MW8A	2	30	45	28.91	121.23
MW8B	3	65	75	28.73	121.3
MW8C	3	86.7	91.7	29.63	120.4
MW8D	4	110	120	34.63	115.28
MW9A	2	25	35	27.39	121.45
MW9B	2	49.8	60	32.28	116.62
MW10	2	52	62	33.96	113.49
MW11	2	40	50	36.59	114.3
MW12	2	82	97	83.53	137.34
MW13A	1-2	56	66	dry	
MW13B	3	123	133	83.26	122.62
MW14	2	60	75	46.78	125.85
MW15	2	50	70	25.49	122.79
MW16A	3	45	60	47.11	106.08
MW16B	5	106	116	48.23	104.96
MW16C	6	149	164	51.69	101.57
MW17A	3	56	71	64.11	94.92
MW17B	4	94	104	63.66	95.24
MW17C	6	172	182	81.24	77.76
MW18A	2-3	56	71	27.48	116.25
MW18B	5	90	100	27.45	116.38
MW18C	6	146	161	30.38	113.45
MW19	3	56	71	68.22	90.51
MW20A	3	75	90	66.84	74.47
MW20B	4	122	132	67.32	74

Table 4-1

Summary of Water Levels and Stratigraphic Units
Omega Chemical Superfund Site

Well Name	SB	Depth to Screen Top (feet bgs)	Depth to Screen Bottom (feet bgs)	Depth to Water Jul-Aug 2007 (feet)	Water Level Elevation (feet msl)
MW20C	5	180	190	85.85	55.5
MW21	3	64	79	50.96	77.85
MW22	3	74	89	63.25	87.57
MW23A	2	35	55	28.17	120.59
MW23B	3	82	97	29.25	119.81
MW23C	5	145	160	32.98	116.09
MW23D	6	175	185	33.4	114.64
MW24A	2	50	70	37.01	125.03
MW24B	3	110	125	42.08	119.95
MW24C	5	140	160	42.41	119.61
MW24D	6	173	178	42.64	119.41
MW25A	3	45	65	37.8	110.1
MW25B	4-5	90	110	38.09	109.75
MW25C	6	140	150	41.85	106.01
MW25D	7	194	209	67.55	80.32
MW26A	3	70	90	67.04	88.58
MW26B	4	105	120	67.12	88.33
MW26C	6	145	160	80.55	74.86
MW26D	6	185	205	82.44	72.93
MW27A	3	90	110	76.97	62.27
MW27B	4	144	164	76.84	62.34
MW27C	5	180	190	92.07	47.1
MW27D	5	200	210	91.85	47.28
MW28	3	85	105	74.29	45.62
MW29	3	90	110	81.03	26.07
MW30	2-3	95	115	91.88	14.82
EW1	3	65	75		

Notes:

HSU = Hydrostratigraphic Unit

bgs = below ground surface

msl = mean sea level

Table 4-2
 Slug Test Results
Omega Chemical Superfund Site

Well ID	Method of Analysis	K (feet/minute)	K (feet/day)
MW1A	Butler	0.1554	224
MW1B	KGS	0.0040	5.7
MW2	Butler	0.1832	264
MW3	KGS	0.0053	7.7
MW4A	Butler	0.0979	141
MW4B	Butler	0.0260	37.4
MW4C	KGS	0.0272	39.2
MW5	KGS	0.0388	55.9
MW6	B&R, Butler	0.1349	194
MW7	Butler	0.1440	207
MW8A	KGS	0.0790	114
MW8B	KGS	0.0261	37.6
MW8C	KGS	0.0335	48.2
MW8D	KGS	0.0104	15.0
MW9A	KGS	0.0009	1.3
MW9B	KGS	0.0366	52.7
MW10	Butler	0.0267	38.5
MW11	B&R	0.0591	85.2
MW12	B&R	0.0005	0.8
MW13B	Butler	0.0916	132
MW14	Butler	0.0777	112
MW15	KGS	0.0014	2.0
MW16A	B&R	0.0101	14.5
MW16B	Butler	0.0742	107
MW16C	KGS	0.0132	19.0
MW17A	KGS	0.0011	1.6
MW17B	Butler	0.0732	105
MW17C	KGS	0.0196	28.2
MW18A	Butler	0.0192	27.7
MW18B	Butler	0.0254	36.5
MW18C	KGS	0.0035	5.1
MW20A	Butler	0.0299	43.0
MW20B	Butler	0.0879	127
MW20C	Butler	0.0833	120
MW21	Butler	0.0353	50.8
MW22	Butler	0.0275	39.6
MW23A	B&R	0.0104	15.0
MW23B	KGS	0.0042	6.0
MW23C	KGS	0.0033	4.8
MW23D	KGS	0.0059	8.5
MW24A	Butler	0.0547	78.7
MW24B	Butler, KGS	0.0119	17.1
MW24C	KGS	0.0315	45.4
MW24D	KGS	0.0003	0.5
MW25A	B&R	0.0365	52.5
MW25B	KGS	0.0047	6.8
MW25C	KGS	0.0006	0.9
MW25D	Butler	0.0571	82.2

Table 4-2
 Slug Test Results
Omega Chemical Superfund Site

Well ID	Method of Analysis	K (feet/minute)	K (feet/day)
MW26A	B&R	0.0355	51.1
MW26B	Butler	0.0588	84.7
MW26C	KGS	0.0014	2.0
MW26D	Butler, KGS	0.0046	6.6
MW27A	B&R	0.0103	14.8
MW27B	Butler	0.0084	12.0
MW27C	KGS	0.0015	2.1
MW27D	Butler	0.0688	99.1
MW28	Butler	0.0194	27.9
MW29	Butler	0.0459	66.0
MW30	Butler	0.0416	59.9
MW31	KGS	0.0014	2.0
OW3B	Butler	0.0050	7.1
OW4A	KGS	0.0188	27.1
OW4B	KGS	0.0116	16.6
OW5	KGS	0.0409	58.8
OW6	Butler	0.0685	98.6
OW7	B&R	0.0007	1.0
OW8B	Butler	0.0261	37.6

Notes:

B&R = Bouwer and Rice (1976)

Butler (1998)

KGS (Hyder et al., 1994)

Table 4-3

Pumping Test Results
Omega Chemical Superfund Site

Well	K_r (ft/min)	K_{rs} (ft/min)	C (min ² /ft ⁵)	S_s (ft ⁻¹)	R^2	specific capacity (gpm/ft drawdown)	K_r (ft/day)
MW23A	0.066	N/A	0.138	4.00E-05	0.998	5	95
MW24A	0.24	N/A	0.0395	4.00E-05	0.983	139	342
MW24C	0.18	0.0062	0.0637	4.00E-05	0.999	53	255
MW26A	0.13	N/A	0.0630	4.00E-05	0.989	104	186
MW26B	0.22	N/A	0	4.00E-05	0.922	86	316
MW27A	0.037	0.0071	0.686	4.00E-05	0.993	16	54
MW27B	0.032	N/A	0.797	4.00E-05	0.985	14	45
MW30	0.20	0.012	0	4.00E-05	0.999	81	289

Well	K_z/K_r	K_r (ft/min)	S_s (ft-1)	K_{rs} (ft/min)	C	R^2	K_r (ft/day)
EW1	0.0092	0.28	2.07E-05	3.03E-03	0.188	0.9996	404

Notes:

K_r = Hydraulic Conductivity of the aquifer

K_{rs} = Hydraulic Conductivity of well skin

C = well loss coefficient

S_s = Specific Storage

K_z/K_r = anisotropy ratio where z is vertical and r is horizontal

N/A = Not considered in the model (meaning $K_{rs} = K_r$).

ft = foot (feet)

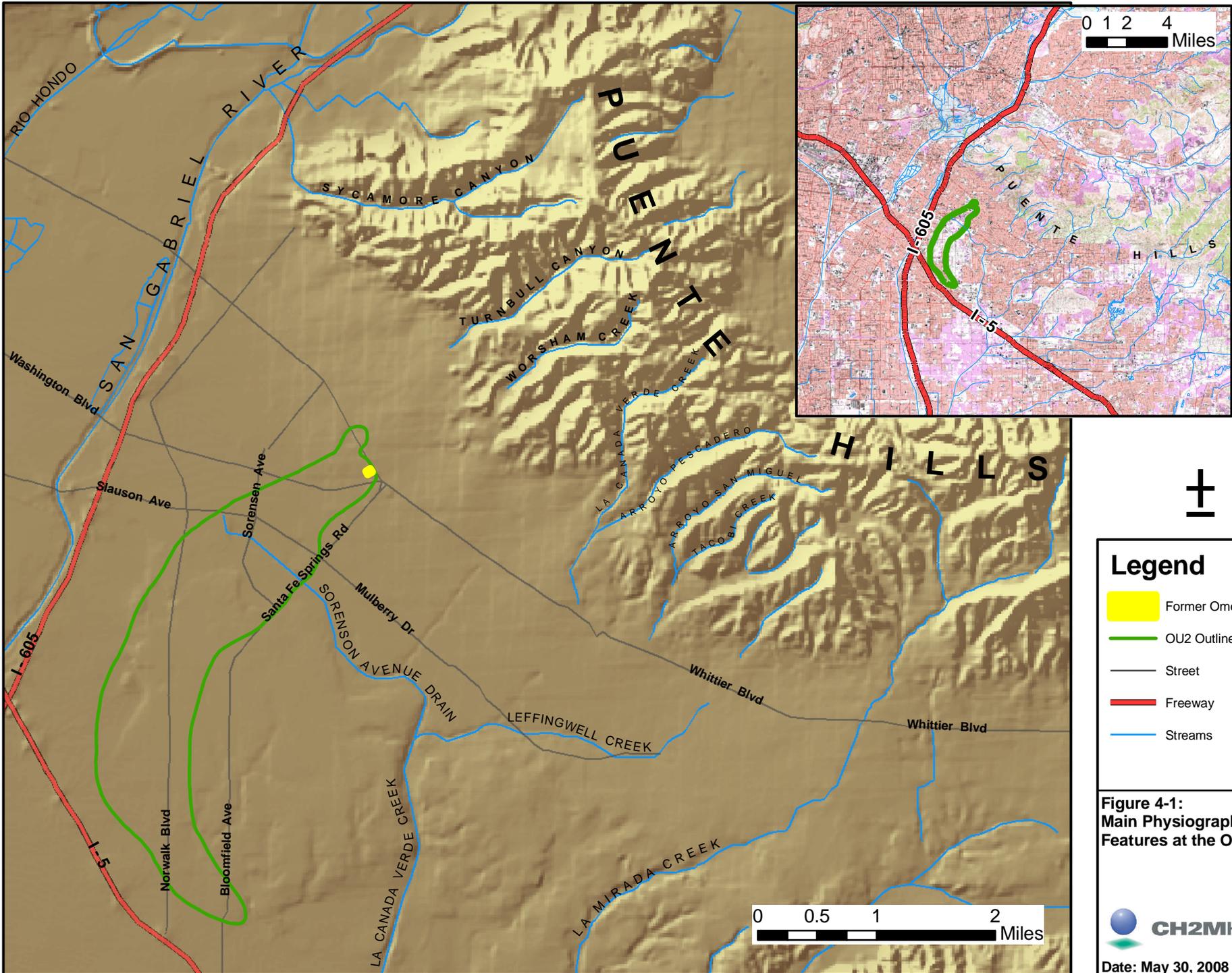
gpm = gallons per minute

min = minute

R^2 = Pearson product moment correlation coefficient squared (computed for model fit and data).

S_s was held constant for monitoring well pumping test analyses at 4.0E-05

K_z/K_r was held constant for monitoring well pumping test analyses at 0.1



Legend

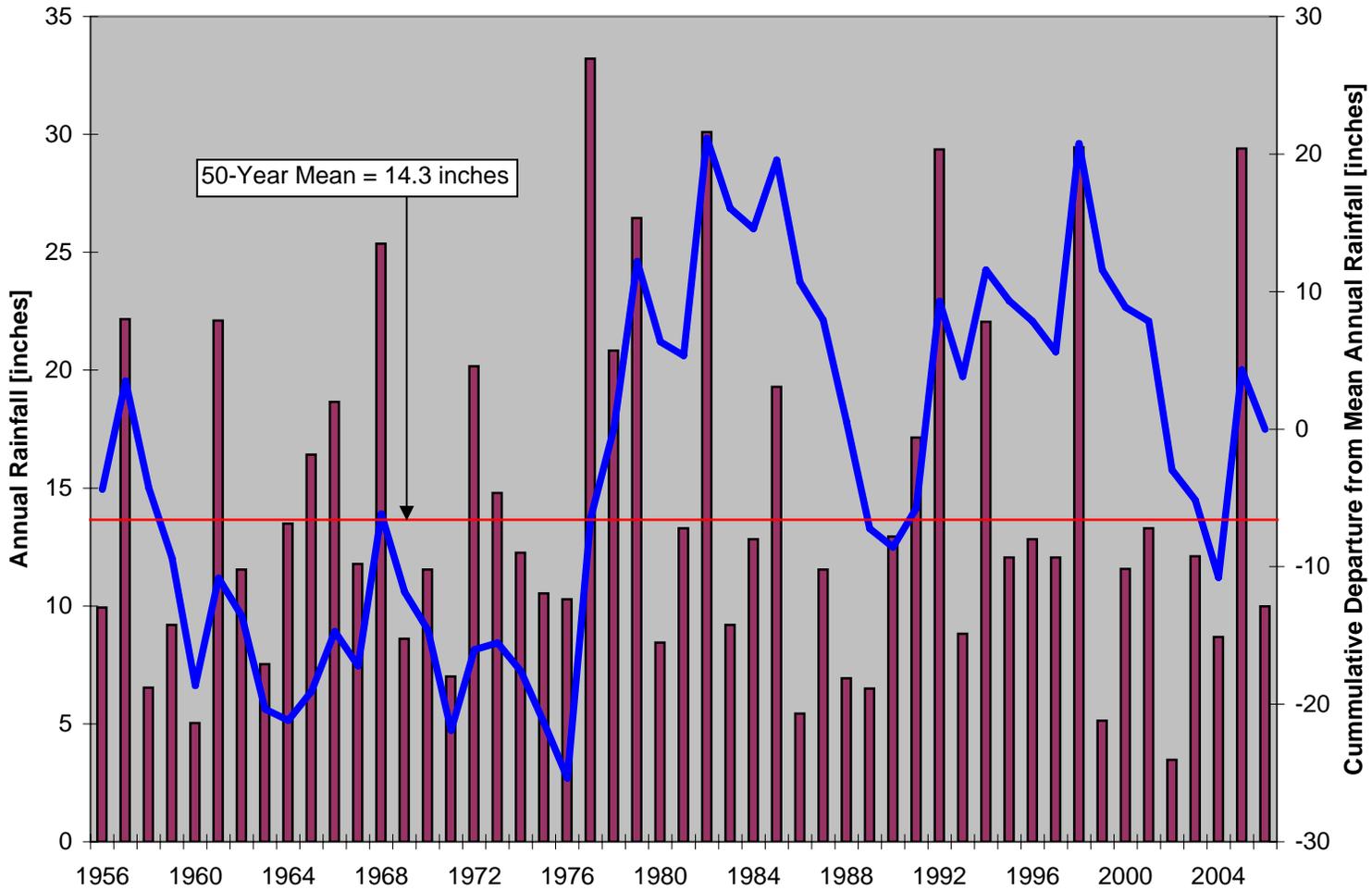
- Former Omega Facility
- OU2 Outline
- Street
- Freeway
- Streams

**Figure 4-1:
Main Physiographic
Features at the OU2 Area**



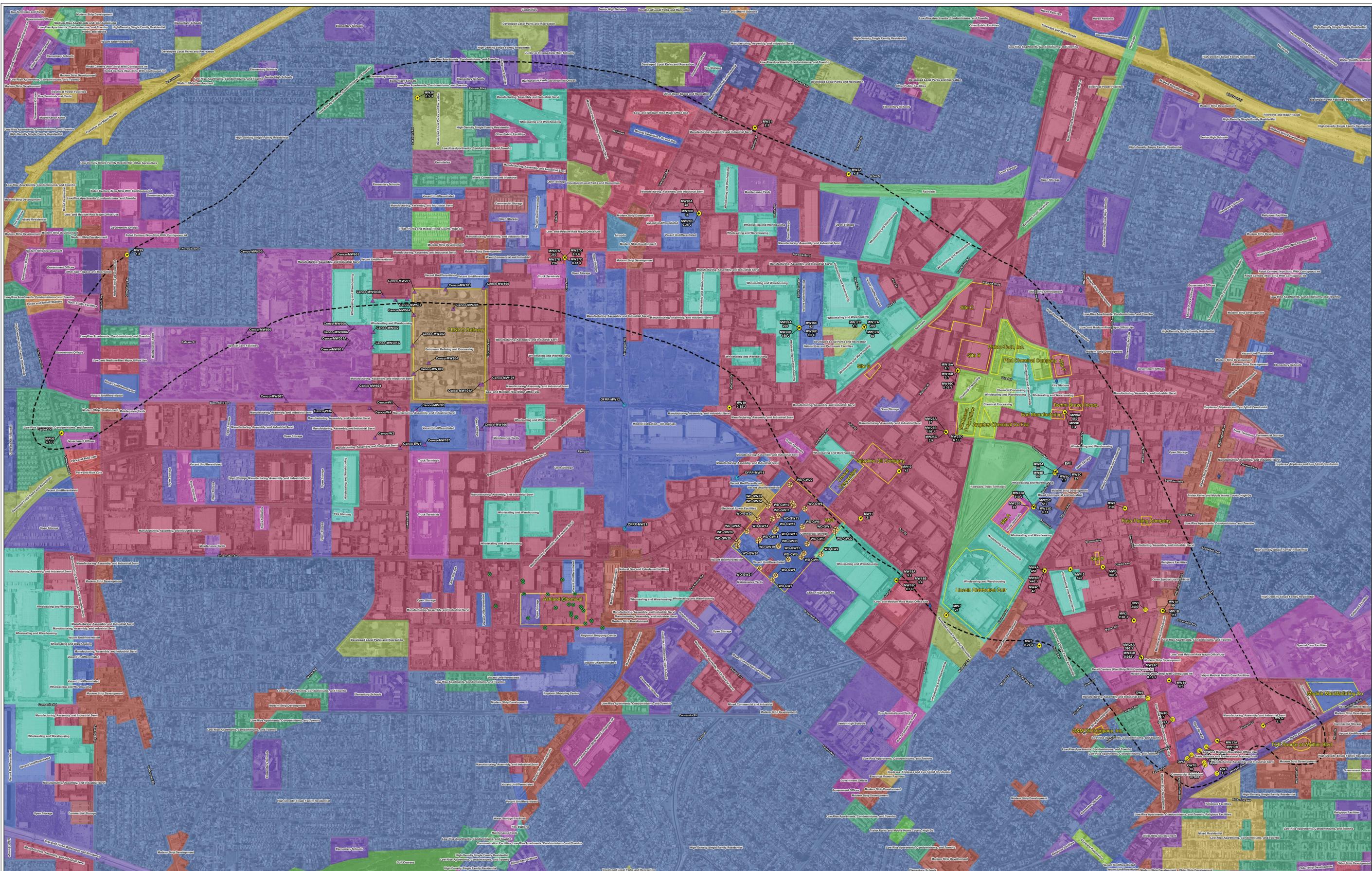
Date: May 30, 2008

Figure 4-2
 City of Whittier Annual Rainfall Totals
 Omega Chemical Superfund Site



Note: Annual rainfall data from rain gage 106F - City of Whittier Storage Yard.

■ Rainfall — Cumulative Departure



- Legend**
- EPA Monitoring Well
 - Omega Potentially Responsible Parties Organized Group (OPOG) Monitoring Well
 - Ashland Chemical Well
 - Oil Field Reclamation Project (OFRP) Well
 - Waste Disposal, Inc. (WDI) Well
 - Production Well
 - CENCO Wells
 - Limit of Operable Unit 2
 - Approximate Boundary of Other Facilities
 - Former Omega Facility

Notes: 1) NS - Not Sampled
 2) J - Estimated Value
 3) U - Non-Detect
 4) E - Estimated value as the concentration exceeds upper level of instrument calibration range.
 5) Phibro Tech data is from July 2005
 6) Ashland Chemical well IDs may be found in Appendix N

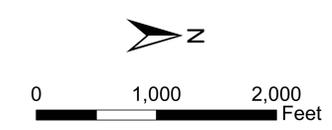


Figure 4-3
Land Use
 Omega Chemical Superfund Site

SYSTEM	SERIES	FORMATION	LITHOLOGY	AQUIFER AND AQUICLUDE	MAX. THICKNESS (FEET)	PREVIOUS FORMATION NAMES*	PREVIOUS AQUIFER NAMES*	
QUATERNARY	RECENT	ACTIVE DUNE SAND		SEMIPERCHED	60	ALLUVIUM	SEMIPERCHED [†]	<p>LEGEND OF LITHOLOGY</p>
		ALLUVIUM		BELLFLOWER AQUICLUDE	140		GASPUR [†]	
	UPPER PLEISTOCENE	OLDER DUNE SAND		SEMIPERCHED BELLFLOWER AQUICLUDE	200	TERRACE COVER	"50 FOOT GRAVEL" [†]	
		LAKEWOOD FORMATION		EXPOSITION ARTESIA	140	PALOS VERDES SAND	SEMIPERCHED [†]	
				GARDENA	160	UNNAMED UPPER PLEISTOCENE	GARDENA [†]	
				GAGE	160		"200 FOOT SAND"	
				UNCONFORMITY		LOCAL UNCONFORMITY		
	LOWER PLEISTOCENE	SAN PEDRO FORMATION		HOLLYDALE	100	SAN PEDRO FORMATION	"400 FOOT GRAVEL" [†]	
				JEFFERSON	140			
				LYNWOOD	200			
SILVERADO				500				
SUNNYSIDE				500				
LOCAL UNCONFORMITY		UNCONFORMITY						
TERTIARY	UPPER PLIOCENE	PICO FORMATION		UNDIFFERENTIATED		PICO FORMATION		

*DESIGNATIONS AND TERMS UTILIZED IN "REPORT OF REFEREE" DATED JUNE 1952 PREPARED BY THE STATE ENGINEER COVERING THE WEST COAST BASIN

† DESIGNATED AS "WATER BEARING ZONES" IN ABOVE NOTED REPORT OF REFEREE

Figure 4-4
Generalized Stratigraphic Column
Coastal Plain of Los Angeles County
Omega Chemical Superfund Site





Geologic map of the Long Beach 30' x 60' quadrangle

Legend

- Norwalk Fault
- Approximate Extent of the La Habra Piedmont Slope
- Limit of Operable Unit 2
- Former Omega Facility
- Pleistocene alluvium
- Holocene alluvium
- Gaspur Aquifer

Tf = Fernando Formation (Pliocene)
 l = Lower Member; c = conglomerate/silty sandstone
 Tpsc = Sycamore Canyon Member, Puente Formation (Miocene). Sandstone/conglomerate.
 Qw = Active channel and wash deposits (late Holocene)
 Qyf = Young alluvial fan and valley deposits (Holocene and Pleistocene)
 a = sand, s = silt, c = clay
 Qof = Old alluvial fan and valley deposits (Pleistocene)
 a = sand, s = silt, c = clay

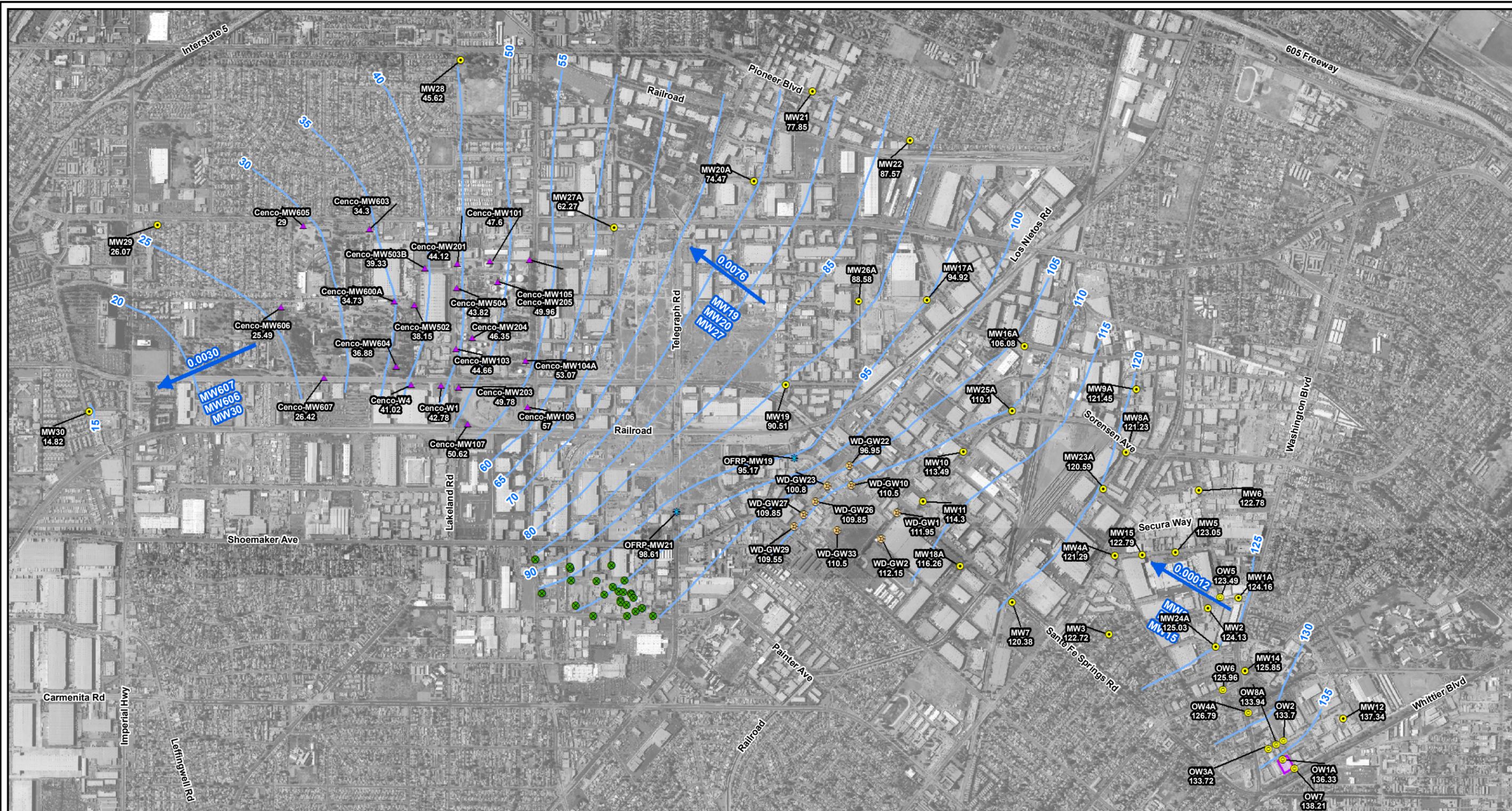


Figure 4-5
Main Geologic Features
 Omega Chemical Superfund Site



Date: 5/30/2008

Notes: Geologic features are from Saucedo et al., 2003; Norwalk Fault location is from Reichard et al., 2003; Gaspur aquifer extent is from CDWR, 1961
 \\galt\proj\Omega\2007\MapFiles\8_5x11_GeologicFeat_v1.mxd



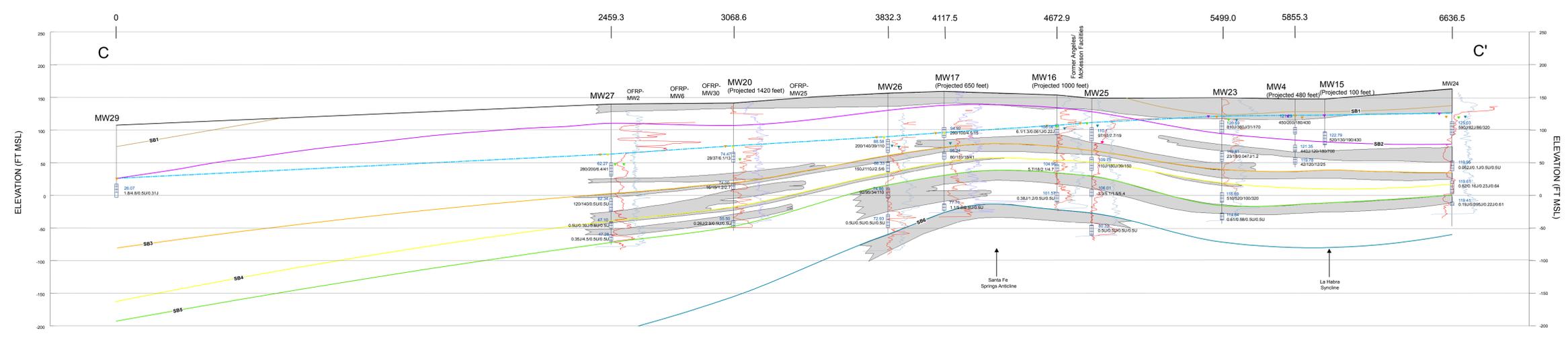
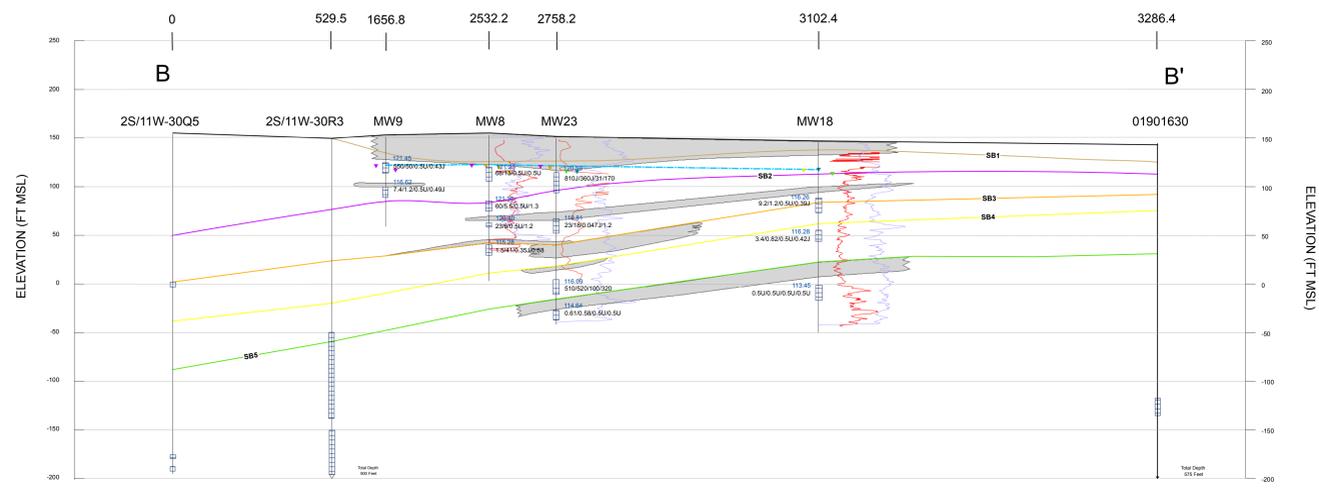
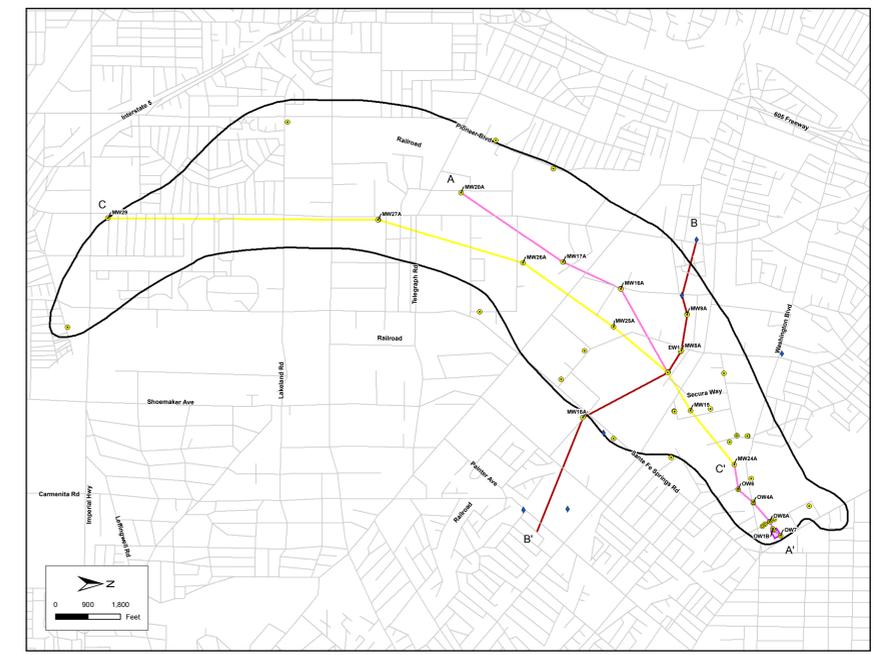
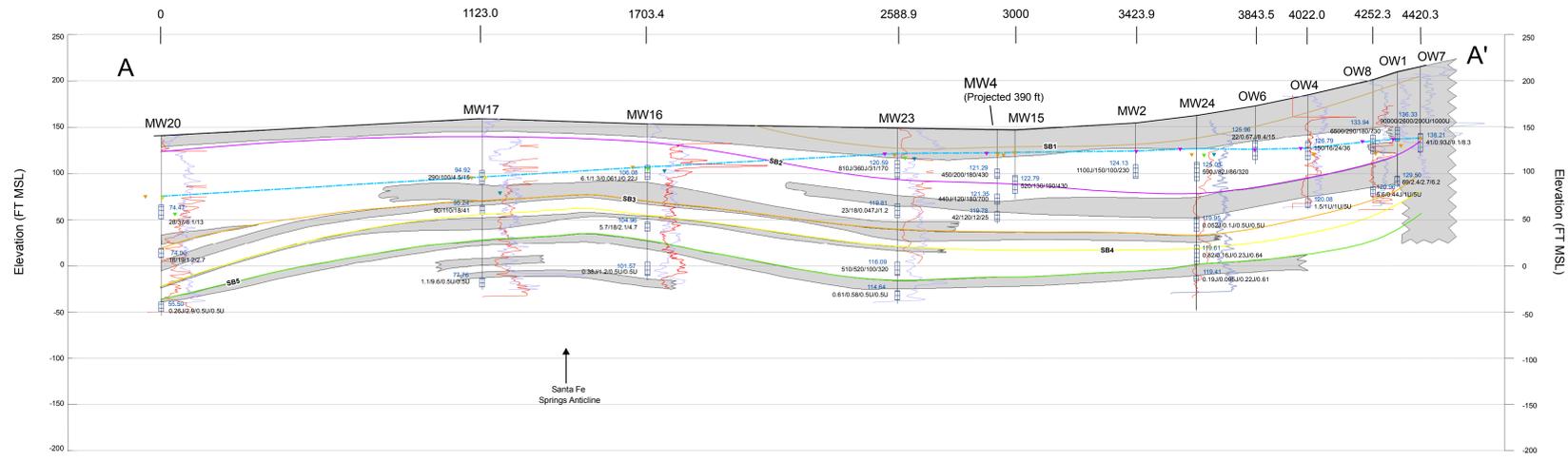
Legend

- EPA Monitoring Well
- Omega Potentially Responsible Parties Organized Group (OPOG) Monitoring Well
- Oil Field Reclamation Project (OFRP) Well
- Waste Disposal, Inc. (WDI) Well
- ▲ CENCO Wells
- Ashland Chemical Well
- Water Level Contours July - August 2007
- Former Omega Facility
- Shallow groundwater flow gradient in feet/feet calculated from groundwater elevations at the three wells listed



0 1,600 3,200 Feet

Figure 4-6
Shallow Groundwater Contours
 Omega Chemical Superfund Site



Legend

Cross Sections

Geophysical Logs

- Gamma
- Resistivity
- Fine-Grained Unit

Water Level

- Water Level Elevation (ft msl)
- Water Table

Stratigraphic Boundaries

- SB1
- SB2
- SB3
- SB4
- SB5
- SB6

Concentration

120.25 Water Level
0.61/0.58/0.5U/0.5U = PCE/TCE/Freon 11/Freon 113 collected in July-August 2007

Cross Section Location Map

- EPA Monitoring Well (July 2007)
- Omega Potentially Responsible Parties Organized Group (OPOG) Monitoring Well (August 2007)
- Production Well
- Limit of Operable Unit 2

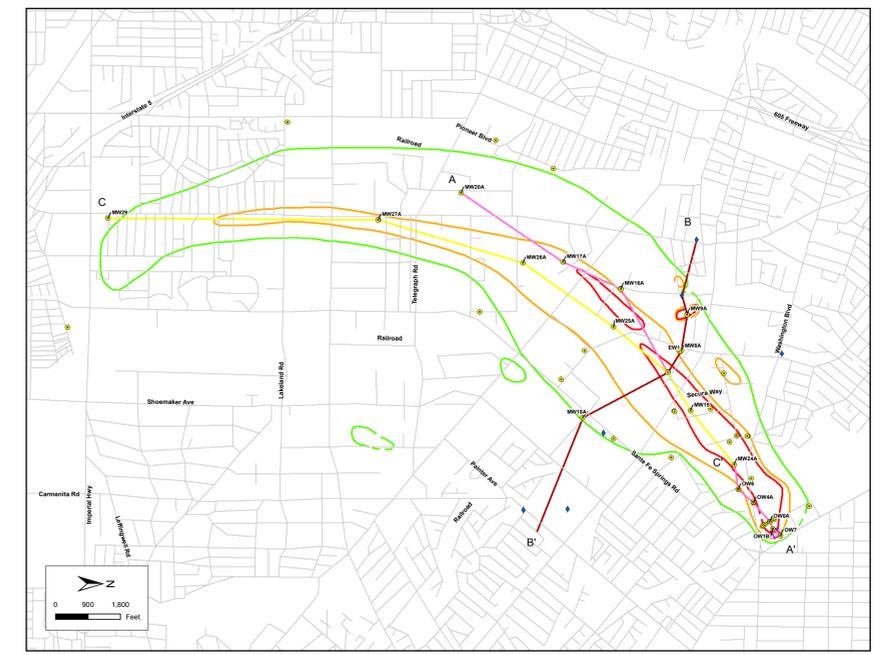
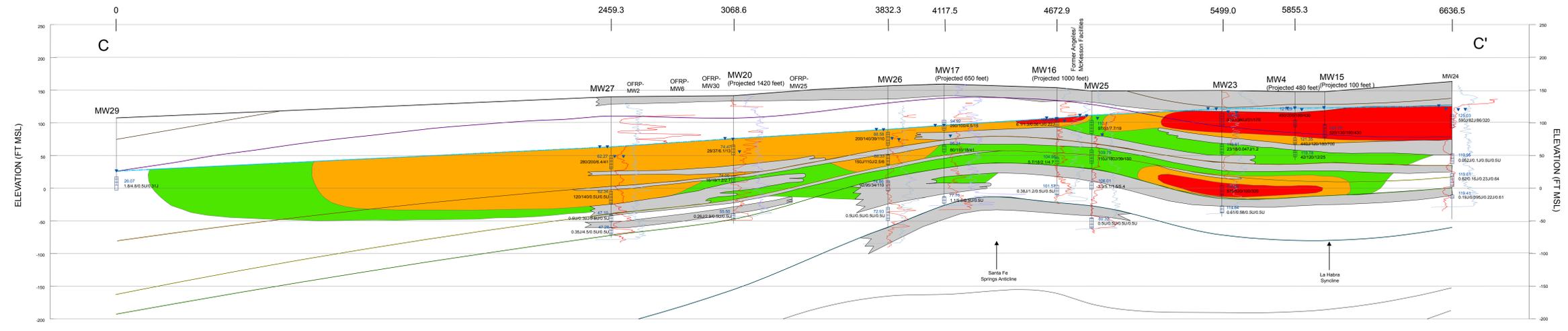
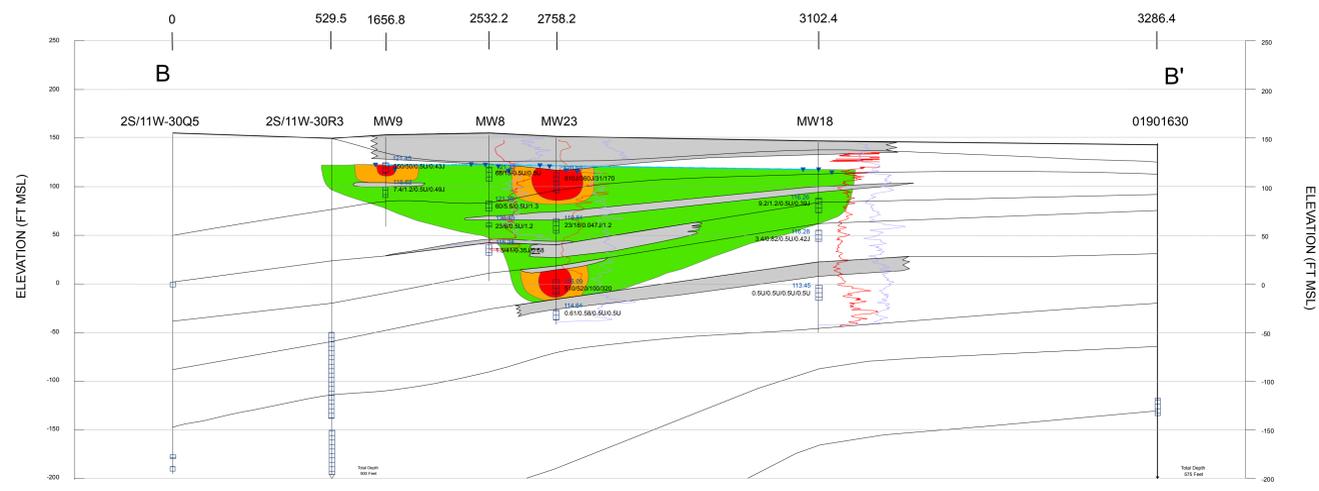
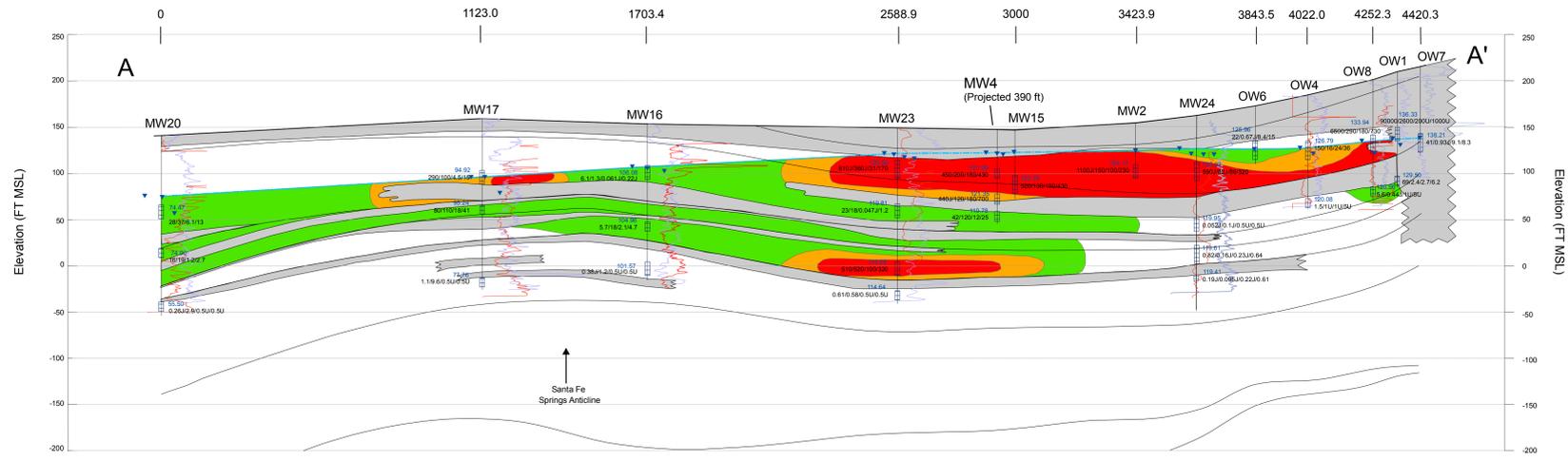
Cross Section

- AA'
- BB'
- CC'
- Former Omega Facility

Notes:

- 1) PCE = Tetrachloroethene
- 2) TCE = Trichloroethene
- 3) F 11 = Freon 11
- 4) F 113 = Freon 113
- 5) U = Non-Detect; J = Estimated Value; R = Rejected Value
- 6) SB = Stratigraphic Boundary
- 7) FT MSL = Feet Above Mean Sea Level
- 8) Colors of the water level elevations indicate above which stratigraphic boundary the well is screened
- 9) Smooth (finger-like) lateral termination of fine-grained units represents facies change into coarse-grained material. Jagged termination is used when extent is unknown.
- 10) Stratigraphic interpretation is also based on deep seismic reflection data (not shown)

Figure 4-7
Stratigraphic Sections
with Location Map
Omega Chemical Superfund Site



Legend

Geophysical Logs

- Gamma
- Resistivity
- Fine-Grained Unit

Water Level

- Water Level Elevation (ft msl)
- Water Table
- Stratigraphic Boundaries

Composite PCE Distribution

- > 5 ug/L
- > 100 ug/L
- > 500 ug/L

Cross Section Location Map

- EPA Monitoring Well (July 2007)
- Omega Potentially Responsible Parties Organized Group (OPOG) Monitoring Well (August 2007)
- Production Well

Cross Section

- AA'
- BB'
- CC'

Composite PCE Plume Extent

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

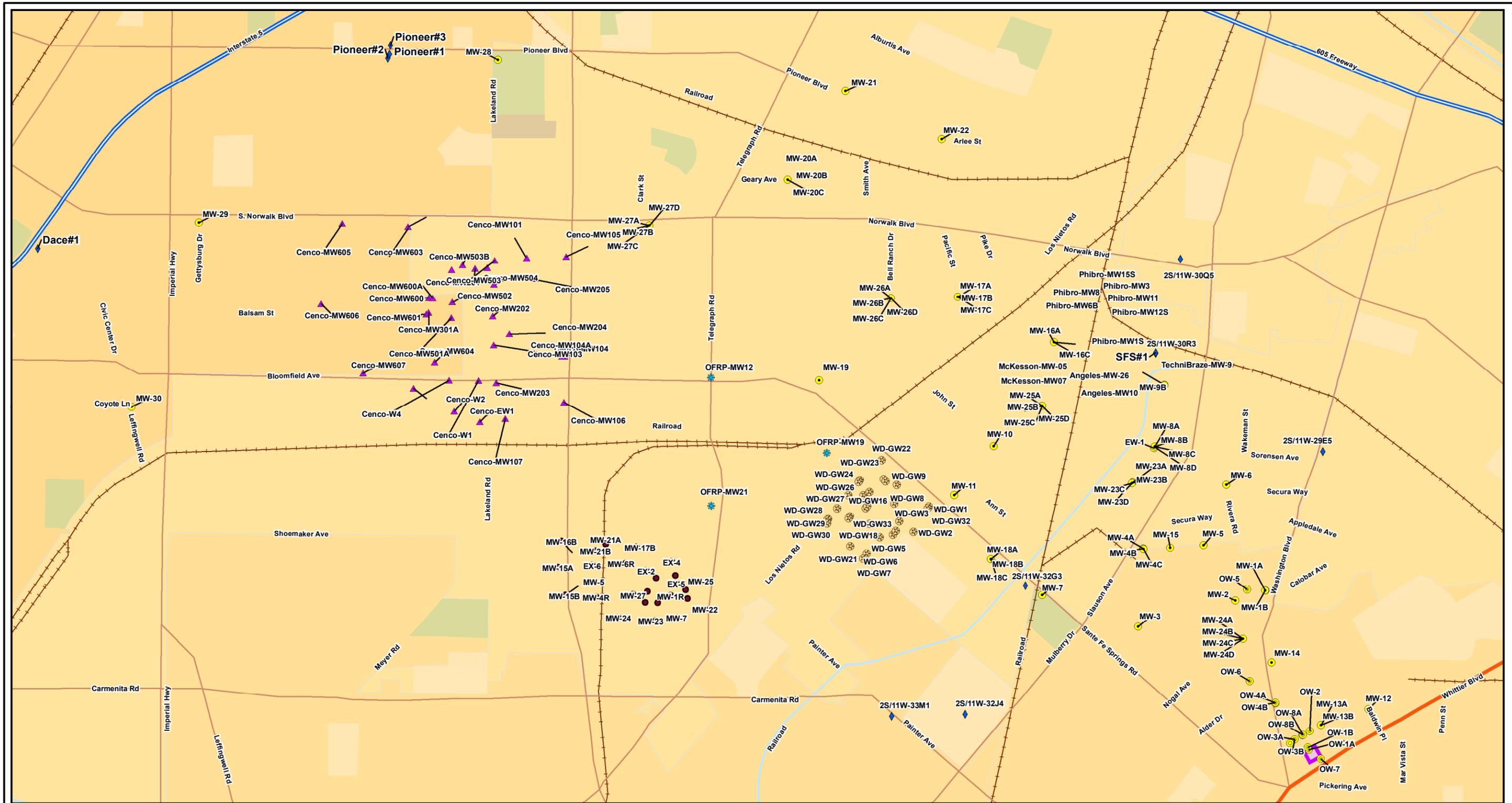
Notes:

- 1) PCE = Tetrachloroethene
- 2) TCE = Trichloroethene
- 3) F11 = Freon 11
- 4) F113 = Freon 113
- 5) U = Non-Detect, J = Estimated Value; R = Rejected Value
- 6) SB = Stratigraphic Boundary
- 7) FT MSL = Feet Above Mean Sea Level
- 8) Smooth (finger-like) lateral termination of fine-grained units represents facies change into coarse-grained material. Jagged termination is used when extent is unknown.
- 9) Stratigraphic interpretation is also based on deep seismic reflection data (not shown)

Concentration
120.25
0.61/0.58/0.5U/0.5U = PCE/TCE/Freon 11/Freon 113 collected in July-August 2007

Water Level

Figure 4-8
Hydrogeologic Cross Sections
with Location Map
Omega Chemical Superfund Site



Legend

- EPA Monitoring Well
- Omega Potentially Responsible Parties
- Organized Group (OPOG) Monitoring Well
- Oil Field Reclamation Project (OFRP) Well
- Waste Disposal, Inc. (WDI) Well
- ◆ Active Production Well (Locations shown are approximate)
- ▲ CENCO Wells
- Former Omega Facility

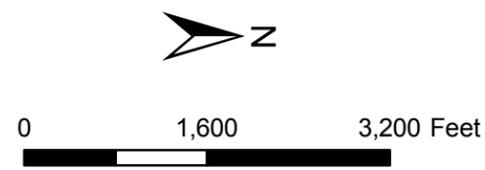
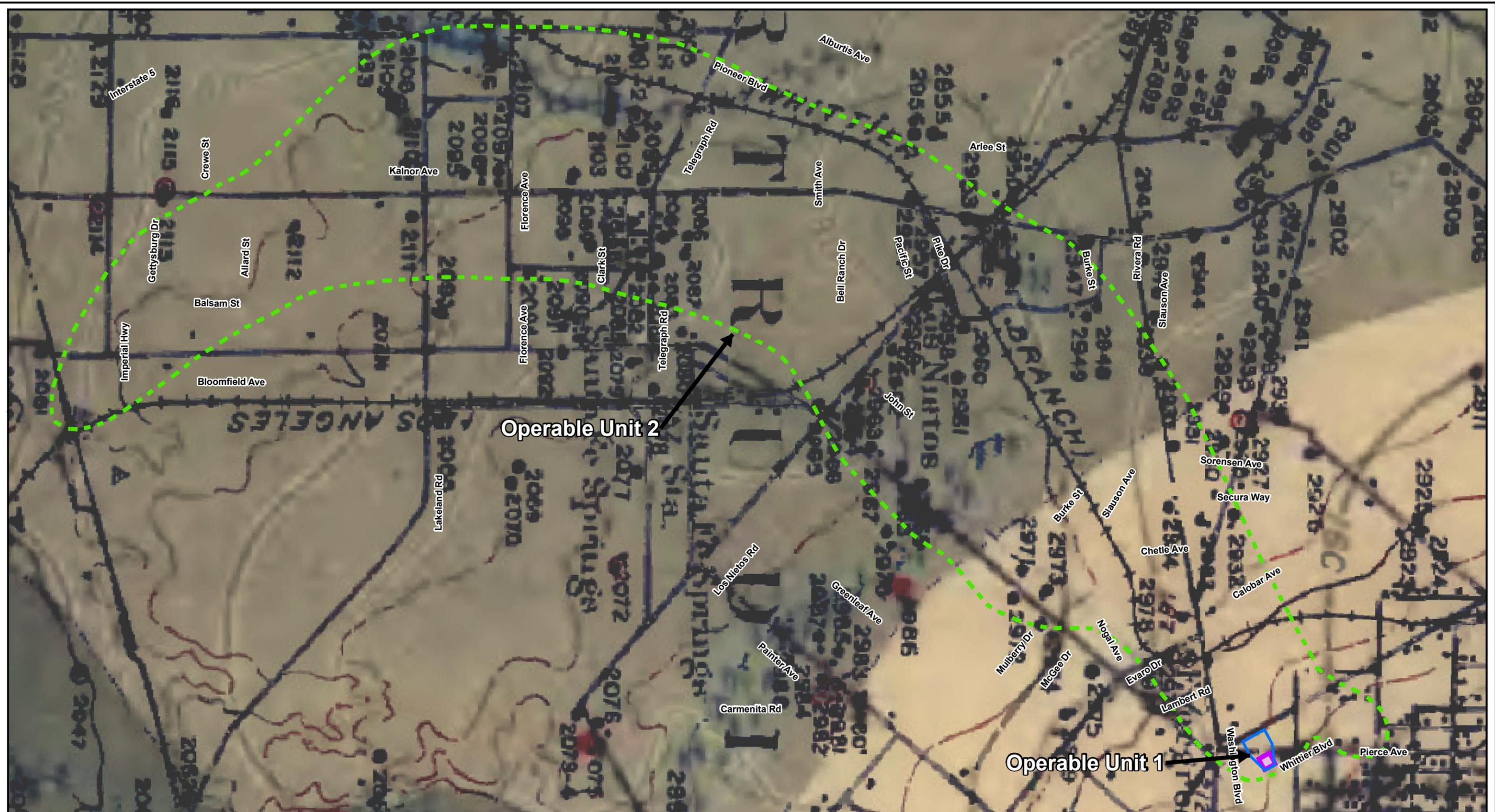


Figure 4-9
Well Locations
 Omega Chemical Superfund Site

Notes: 1) J - Estimated Value upper level of instrument calibration range. 2) U - Non-Detect 3) E - Estimated value as the concentration exceed upper level of instrument calibration range. 4) NS - Not Sampled
 \\GALTPROJ\OMEGA\2010\MAPFILES\FIGURE4-9_WELL_LOCATIONS.MXD AOMALLEY 3/25/2010 12:55:49



Aerial Date: March 2004, USGS

Legend

-  Operable Unit 1
-  Operable Unit 2
-  Former Omega Facility



0 1,600 3,200 Feet

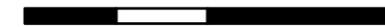


Figure 4-10
Locations of Historical Water
Production Wells
 Omega Chemical Superfund Site



Date: March 25, 2010



Aerial Date: March 2004, USGS

Legend

- California Oil and Gas Wells
- California Oil Fields
- Operable Unit 1
- Operable Unit 2
- Former Omega Facility

Reference: The California Department of Conservation, Division of Oil and Gas
 (Website, <http://gis.ca.gov/catalog/BrowseCatalog.epl?id=1064>)

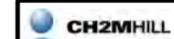
\\GALT\PROJ\OMEGA\2010\MAPFILES\FIGURE4-11_CAGASWELLS.MXD AOMALLEY 3/25/2010 13:41:11



0 1,700 3,400 Feet



Figure 4-11
Santa Fe Springs Oil Field
 Omega Chemical Superfund Site



Date: March 25, 2010