

Executive Summary

ES.1 Introduction

This Conceptual Hydrogeology Technical Memorandum (TM) presents the data and findings obtained between October 2002 and April 2004 as part of the Site Characterization Phase of the Eastern Santa Clara Subbasin Groundwater Study (project), Santa Clarita, California (Figure ES-1). The study area includes the former Whittaker Corporation Bermite Facility (Site) and adjacent areas of the Santa Clarita Valley (Figure ES-2). The scope of work includes an evaluation of the nature and extent of regional groundwater impact from chemicals of interest (COIs), or preliminary chemicals of potential concern (COPCs), including perchlorate, in the study area. This work is performed under contract to the United States Army Corps of Engineers (USACE) "Civil Works" program, with Castaic Lake Water Agency (CLWA) as the nonfederal sponsor. On April 11, 2002, USACE entered into a Feasibility Cost-Sharing Agreement with CLWA, which represents the water purveyors in the eastern Santa Clarita Valley. The California Department of Toxic Substances Control (DTSC) is the lead regulatory agency.

The Site is located in the eastern Santa Clarita Valley, near the confluence of the Santa Clara River and the South Fork of the Santa Clara River, approximately 2 miles northeast of Newhall, in Los Angeles County, California (Figure ES-2). Santa Clarita, LLC (SCLLC) is the current property owner. Previous operations at the Site included the manufacture, storage, and testing of a variety of explosives, munitions, and propellants. Releases of perchlorate, volatile organic compounds (VOCs), and other COIs associated with former operations have impacted soil and groundwater at the Site. Perchlorate and/or VOCs also have been detected in groundwater samples from four municipal water supply or production wells located west of the Site, SC-Saugus 1 and 2, NC-11, and V-157; and one located north of the Site, SC-Stadium (Figure ES-2).

The Site was previously divided into seven operable units (OUs) designated based on the location of known source areas, former Site operations, local surface watersheds, and the affected media. Groundwater impacted by Site operations was grouped into a single OU and designated as OU7. USACE characterization efforts have focused on assessing the nature and extent of impacted groundwater in the study area, which includes OU7 groundwater. The project is implemented under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) procedures. The results are intended to support the ongoing OU7 remedial investigation by Whittaker Corporation (Whittaker), and the CLWA response activities for impacted production wells. Whittaker is currently conducting various remedial investigations onsite and offsite under a Unilateral Order issued by DTSC on November 22, 2002: *Imminent and Substantial Endangerment Determination and Order and Remedial Action Order*. CLWA is the nonfederal cost-sharing sponsor of the project and is also conducting various work under a voluntary *Environmental Oversight Agreement* entered into with the DTSC. Under this agreement, DTSC is providing review

and oversight of the response activities being taken by CLWA related to the detection of perchlorate at the five impacted production wells.

ES.2 Project Objectives

The main objective of the project is to sufficiently characterize the existing groundwater conditions in the study area to develop and evaluate interim, if applicable, and long-term solutions to address perchlorate-impacted groundwater in the study area. The specific objectives for the site characterization activities are as follows:

- Obtain subsurface characterization data, specifically lithologic, hydraulic, and chemical data in the alluvium and Saugus Formation.
- Complete a baseline assessment of the groundwater quality in the study area.
- Complete additional rounds of groundwater sampling in the study area to confirm the results of the baseline assessment.
- Test for chemical parameters that affect the efficiency or applicability of various potential groundwater-treatment processes. (Note: These results are presented but will not be discussed further in this TM; they will be evaluated as part of water treatment/engineering feasibility studies.)

ES.3 Purpose and Scope of TM

The purpose of this TM is to present the conceptual hydrogeology of the study area, which provides the fundamental framework for ongoing work in the eastern Santa Clarita Valley. It summarizes and evaluates the results of site characterization efforts completed by USACE between October 2002 and April 2004, focusing on the regional extent of impacted groundwater and potential contaminant migration pathways. This TM is not intended to be a comprehensive treatise of all previous and ongoing site characterization efforts related to OU7; Whittaker will prepare an OU7 Remedial Investigation Report at a later date. In addition, the CLWA is concurrently preparing groundwater modeling and additional well characterization studies in support of the response activities for the impacted production wells.

ES.4 Summary of Remedial Investigations

USACE completed remedial investigations in two major phases between October 2002 and April 2004 (Tables ES-1 and ES-2). Below is a summary of the field activities conducted to meet the project objectives:

- To obtain subsurface characterization data in the alluvium (Figure ES-3) and Saugus Formation (Figure ES-4):
 - Drilled a total of almost 8,500 linear feet, with the deepest monitoring well advanced to a depth of almost 1,600 feet.

- Installed 41 monitoring wells at 11 different locations, including five deep multiport (MP) wells.
 - Advanced 17 temporary boreholes by the cone penetrometer testing (CPT) technique to optimally place the shallow alluvium wells, and collected groundwater samples from 10 of the 17 borings advanced.
 - Completed five groundwater sampling events and collected a total of 149 groundwater samples.
 - Collected water level/piezometric surface elevation data nine times.
 - Conducted aquifer testing that consist of slug tests at three MP wells and 3-day-long pumping tests at two production wells, V-205 and NC-13, while monitoring responses to the pumping at adjacent wells.
- To complete a baseline assessment of the groundwater quality in the study area, tested all the wells once initially for a “baseline” suite of analytes, totaling more than 200 parameters, that includes: perchlorate, VOCs, explosive compounds, nitrosamines, and other COIs (i.e., 1,4-dioxane, semivolatile organic compounds [SVOCs], chlorate, gross alpha and gross beta, cyanide, hexavalent chromium). They also were tested for metals (including major cations), major anions, alkalinity, total Kjeldahl nitrogen, nitrate, nitrite, ammonia, total dissolved solids, biochemical oxygen demand, chemical oxygen demand, and total organic carbon.
 - To confirm the results of the baseline assessment, conducted additional (two to four, depending on which phase the wells were first installed) groundwater sampling events. The wells were tested for a more focused suite of analytes during the subsequent sampling events.

ES.5 Findings

Based on the data collected during the project, the following findings are offered:

Hydrostratigraphy

- The study area conceptual hydrostratigraphic model was defined with 10 hydrostratigraphic units (HSUs) to provide a general framework to evaluate the groundwater flow conditions and the migration of COIs. The HSUs include the Quaternary Alluvium, eight HSUs south of the San Gabriel fault, and one Saugus HSU north of the San Gabriel fault; a simplified three-dimensional view of the conceptual hydrogeology is shown in Figure ES-5.
- The HSUs were defined based on hydraulic head data measured, observed pumping responses to Saugus Formation production well extraction, interpretation of geophysical and lithologic logs, and the results of the March 2004 Saugus Formation aquifer tests at production wells NC-13 and V-205.

Aquifer Properties

- Aquifer properties of the Saugus Formation were estimated from USACE testing. The transmissivity values for the Saugus Formation screened by local Saugus production wells range from 5,544 to 47,355 square feet per day (ft²/day), corresponding to bulk hydraulic conductivity (K) values of 3.5 to 34.3 ft/day. Estimated K values for HSUs SIII, SV, and SVII range from 1.9 to 18.8 ft/day, 1.0 to 23.1 ft/day, and 0.1 to 38.6 ft/day, respectively. The K values reported by USACE and other investigators for discrete lithologic intervals within the Saugus Formation vary by nearly three orders of magnitude, consistent with the heterogeneous nature of the Saugus Formation.
- The bulk K values reported for the Quaternary Alluvium are significantly larger than those for the Saugus Formation. The K values of the Quaternary Alluvium have been estimated by other investigators to be 550 ft/day in the Santa Clara River between the Site and Bouquet Junction, and 105 ft/day in the South Fork west of the Site.

Groundwater Flow

- Groundwater flows westward in the Quaternary Alluvium (Figure ES-6) in the Santa Clara River and northward in the South Fork Santa Clara River. The horizontal hydraulic gradient is approximately 0.005 foot per foot (ft/ft) in the main reach, 0.0007 ft/ft in the South Fork, and 0.003 ft/ft downstream of the confluence of these drainage systems. Depending on the location, the vertical hydraulic gradients can be either upward (AL-4, approximately 0.07 ft/ft) or downward (at AL-9, 0.04 ft/ft).
- Groundwater in the Saugus Formation flows northwest in HSUs SI and SIII (Figures ES-7 and ES-8), subparallel to the trace of the San Gabriel fault, and west-southwest in HSU SVII (Figure ES-9). The average horizontal hydraulic gradient in HSUs SI, SIII, and SVII is approximately 0.001 ft/ft, 0.002 ft/ft, and 0.001 ft/ft, respectively. The horizontal gradient in HSU SIII is steeper northwest of MP-1 (0.004 ft/ft) than onsite (0.001 ft/ft), apparently due to the pumping influence from production wells V-205, V-201, and V-160. The westerly flow direction observed in HSU SVII may be due, in large part, to groundwater extraction at production wells NC-13 and NC-12. The groundwater flow direction in HSU SV is assumed to be toward the west, based on the similar pumping responses observed in HSUs SVII and SV.
- The direction of the vertical hydraulic gradient across the Saugus HSUs is generally downward, with the exception of the gradient between HSUs SVIII and SVII. Because little groundwater extraction occurs from HSU SVIII, the piezometric surface elevations are higher (greater than 100 feet) in HSU SVIII than in the overlying units. Gradient reversals between HSUs SV and SVII have occurred (as observed at MP-1); this phenomenon is likely a result of the combined extraction from production wells V-205, V-201, and V-160 being substantially larger than at production wells NC-12 and NC-13. The magnitude of the vertical gradients across the HSUs ranges from approximately 0.8 ft/ft to 0.02 ft/ft and varies seasonally with changes in Saugus Formation groundwater extraction.

Water Quality

- Although a large number of COIs, or potential COPCs, including perchlorate, VOCs, SVOCs, nitroaromatics and nitroamines (explosive compounds), and nitrosamines, were tested, perchlorate, trichloroethylene (TCE), and tetrachloroethylene (PCE) appear to be the primary COIs in groundwater in the study area (Table ES-3). Where TCE and PCE were detected, they generally occurred with perchlorate. Other analytes were detected; however, the detections were inconsistent and/or the concentrations were less than regulatory action levels.
- All three primary COIs (perchlorate, TCE, and PCE) were detected at concentrations that exceed their regulatory action levels onsite. The maximum concentrations of perchlorate (64,500) micrograms per liter [$\mu\text{g/L}$], TCE (2,000) $\mu\text{g/L}$, and PCE (10 $\mu\text{g/L}$) were detected at the same location (MP-2 Screen 1) onsite. Perchlorate and TCE were detected above their regulatory action levels offsite; PCE was detected at concentrations less than, but close to, its regulatory action level offsite.
- Perchlorate, TCE, and PCE were detected in the alluvium as far as Bouquet Junction, which is located approximately 1 mile west of the Site (Figure ES-10). Perchlorate was detected approximately 2,500 feet southwest of Bouquet Junction. The results are consistent with contaminant migration via the alluvium, where the COIs from onsite source areas appear to have migrated in the alluvium west from the Site along the southern margin of the Santa Clara River into the confluence of the Santa Clara River and the South Fork.
- Perchlorate also was detected in the alluvium in the South Fork as far south as the mouth of Oakdale Canyon, which drains major onsite source areas (Figure ES-10). The results are consistent with contaminant migration via infiltration of impacted surface water runoff. Impacted groundwater appears to have migrated vertically into the Saugus Formation in this area and may have impacted NC-11. Whittaker implemented short-term measures to minimize perchlorate impacts to surface water during the 2003/2004 rainy season, and a feasibility study for the mitigation of perchlorate in surface water runoff is in progress and will be reported separately.
- Perchlorate was detected in the Saugus Formation onsite at MP-2 and offsite as far west as MP-5 (Figures ES-11 and ES-12). The distance between the two wells is more than 2 miles. The groundwater impact appears to be limited to the upper portion of the Saugus Formation. Available data suggest HSUs SI and SIII are impacted (maximum perchlorate concentration is 11.9 $\mu\text{g/L}$); this translates to approximately 200 feet of saturated thickness onsite and more than 900 feet deep offsite. The distribution of perchlorate concentrations at MP-2, MP-1, SC-Saugus 1, and V-157 is consistent with contaminant migration in HSU SIII via vertical downward migration of perchlorate through the Saugus Formation vadose zone and lateral migration away from the source areas. NC-11 also may have been impacted by a similar mechanism.

ES.6 Recommendations

The site characterization data obtained during the project, integrated with pertinent data made available to USACE by CLWA and Whittaker, provided the basis for the conceptual

hydrogeology presented in Section 4, a robust working framework for ongoing work in the eastern Santa Clarita Valley. The body of data also provided the basis for refining the primary conceptual migration pathways. USACE recommends continuing groundwater monitoring activities to confirm the results of the baseline assessment and to evaluate potential changes in groundwater concentrations over time.

Although a large amount of data is now available and a good understanding of the subsurface in the study area is achieved, there is a need for additional data to continue defining the lateral and vertical extent of impacted groundwater in the Quaternary Alluvium and the Saugus Formation. Additional site characterization is recommended to:

- Continue defining the horizontal and vertical extent of groundwater impact in the alluvium at the confluence of the Santa Clara River and the South Fork.
- Define the vertical extent of groundwater impact in the Saugus Formation, specifically whether groundwater impact extends into HSU SV west of the Site.
- Define the horizontal extent of groundwater impact in the Saugus Formation west of the Site and the three northern impacted production wells, V-157, SC-Saugus 1, and SC-Saugus 2.
- Continue defining the horizontal and vertical extent of groundwater impact in the Saugus Formation in the vicinity of production wells NC-11 (impacted) and NC-13 (not impacted).

Working in conjunction with CLWA and Whittaker, USACE has proposed a program for additional site characterization that addresses these data needs.

Executive Summary Tables

TABLE ES-1
Site Characterization Phase Drilling Activities

Well/Boring	Depth (feet)	Comment
Saugus Formation (Phase 1) – October to December 2002		
MP-1	1,588	Westbay® multiport well, completed with 10 screens; drilled using flooded dual-tube reverse mud rotary; screen intervals selected based on geophysical logs of and lithology observed at MP-1 borehole
MP-2	1,330	Westbay® multiport well, completed with 6 screens; drilled using flooded dual-tube reverse mud rotary; screen intervals selected based on geophysical logs of and lithology observed at MP-2 borehole and MP-1
MP-3	800	Westbay® multiport well, completed with 4 screens; drilled using flooded dual-tube reverse mud rotary; screen intervals selected based on geophysical logs of and lithology observed at MP-3 borehole
MP-4	1,248	Westbay® multiport well, completed with 5 screens; drilled using flooded dual-tube reverse mud rotary; screen intervals selected based on geophysical logs of and lithology observed at MP-4 borehole, MP-1, and MP-2
SS-1	435	Single-screened; drilled using air rotary, reamed using flooded dual-tube reverse mud rotary
Alluvium (Phase 2) – August to September 2003		
17 Reconnaissance Sampling Points	17-97	Advanced borings using cone-penetration testing (CPT) technique; groundwater samples collected at 10 locations (2-3 depths at each location) using HydroPunch® technique, and tested for perchlorate and volatile organic compounds
7 Monitoring Wells: AL-1, AL-3, AL-4A/B, AL-6, and AL-9A/B	65-117	Completed single-screened wells at 5 separate locations (2-well clusters at 2 locations) using hollow-stem-auger technique
Saugus Formation (Phase 2) – August to September 2003		
CW-1	305 (CW-1A) 435 (CW-1B) 568 (CW-1C)	3-well cluster, each well singly-screened; CW-1A was drilled using air rotary, ODEX casing advance system, and CW-1B and CW-1C were drilled using flooded dual-tube reverse mud rotary; screen intervals selected based on geophysical logs of and lithology observed at CW-1C pilot borehole, MP-1, and MP-2
MP-1A	165	Single-screened; drilled using air rotary, ODEX casing advance system; installed well to evaluate interval above the top screen of MP-1
MP-5	995	Westbay® multiport well, completed with 4 screens; drilled using flooded dual-tube reverse mud rotary; screen intervals selected based on geophysical logs of and lithology observed at MP-5 borehole and existing wells
SS-1	435	Well destroyed in accordance with Los Angeles Department of Environmental Health requirements

TABLE ES-2
Site Characterization Phase Groundwater Monitoring Activities

Event Date	Wells Monitored	Comment
November 2002 to February 2003	<ul style="list-style-type: none"> Phase 1 Saugus wells (MP-1, MP-2, MP-3, MP-4, and SS-1) Existing Exxon-Mobil service station⁽¹⁾ wells (EM-1 and EM-2) 	<ul style="list-style-type: none"> Collected water level/piezometric surface elevation data Tested groundwater samples for "baseline" suite of analytes⁽²⁾
April 2003	<ul style="list-style-type: none"> Phase 1 Saugus wells (MP-1, MP-2, MP-3, and MP-4) 	<ul style="list-style-type: none"> Collected water level/piezometric surface elevation data
July 2003	<ul style="list-style-type: none"> Phase 1 Saugus wells (MP-1, MP-2, MP-3, and MP-4) Existing Exxon-Mobil service station⁽¹⁾ wells (EM-1, EM-2, and EM-3) 	<ul style="list-style-type: none"> Collected water level/piezometric surface elevation data Tested groundwater samples for perchlorate and volatile organic compounds (VOCs) only⁽²⁾
September to October 2003	<ul style="list-style-type: none"> Phase 2 Alluvium wells (AL-1, AL-3, AL-4A/B, AL-6, and AL-9A/B) Phase 2 Saugus wells (MP-1A, MP-5, and CW-1A/B/C) Phase 1 Saugus wells (MP-1, MP-2, MP-3 and MP-4) 	<ul style="list-style-type: none"> Collected water level/piezometric surface elevation data for all (Phases 1 and 2) wells Tested Phase 2 wells for "baseline" suite of analytes⁽²⁾ No Phase 1 wells were sampled for chemical analysis
November to December 2003;	<ul style="list-style-type: none"> Phase 2 Alluvium wells (AL-1, AL-3, AL-4A/B, AL-6, and AL-9A/B) 	<ul style="list-style-type: none"> Collected water level/piezometric surface elevation data for all (Phases 1 and 2) wells
February to March 2004	<ul style="list-style-type: none"> Phase 1 and Phase 2 Saugus wells (MP-1A, MP-1, MP-2, MP-3, MP-4, MP-5, and CW-1A/B/C) 	
January 2004	<ul style="list-style-type: none"> Phase 2 Alluvium wells (AL-1, AL-3, AL-4A/B, AL-6, and AL-9A/B) Phases 1 and 2 Saugus wells⁽³⁾ (MP-1A, MP-1, MP-2, MP-3, MP-4, MP-5, and CW-1A/B/C) 	<ul style="list-style-type: none"> Collected water level/piezometric surface elevation data for all (Phases 1 and 2) wells Tested all (Phases 1 and 2) wells for perchlorate and volatile organic compounds⁽²⁾ Tested Phase 1 wells for select metals (specifically major cations), anions, alkalinity, and total dissolved solids⁽²⁾
April 2004	<ul style="list-style-type: none"> Phase 2 Alluvium wells (AL-1, AL-3, AL-4A/B, AL-6, and AL-9A/B) Phases 1 and 2 Saugus wells⁽⁴⁾ (MP-1A, MP-1, MP-2, MP-3, MP-4, MP-5, and CW-1A/B/C) 	<ul style="list-style-type: none"> Collected water level/piezometric surface elevation data for all (Phases 1 and 2) wells Tested select Phase 1 wells (MP-1 and MP-3) and all Phase 2 wells (MP-1A, MP-5, and CW-1A/B/C) for perchlorate, volatile organic compounds, select metals (specifically major cations), anions, alkalinity, and total dissolved solids⁽²⁾

Notes:

(1) The Exxon-Mobil service station is located on the southeast corner of Bouquet Junction.

(2) See Table 3-7, Request for Analyses.

(3) To better focus the sampling effort, only the top four screens of MP-1 and the top two screens of MP-4 were sampled.

(4) To better focus the sampling effort, only the top four screens of MP-1 were sampled.

Executive Summary Figures
