



RICHARD C. SLADE & ASSOCIATES LLC
CONSULTING GROUNDWATER GEOLOGISTS

**ASSESSMENT
OF THE HYDROGEOLOGIC FEASIBILITY
OF INJECTION AND RECOVERY
OF WATER
IN THE SAUGUS FORMATION,
SANTA CLARITA VALLEY, CALIFORNIA**

**Prepared for
Newhall Ranch Company**

February 2001

**by
Richard C. Slade & Associates LLC
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RCS Job No. 2039



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INTRODUCTION

General Statement

Presented in this report are the findings and conclusions of our assessment of the hydrogeologic feasibility of injection and recovery of water in the Saugus Formation in the Santa Clarita Valley portion of northern Los Angeles County, California. Figure 1 – Location Map – illustrates the general location of the testing that was performed for this feasibility study, in relation to the geologically-mapped surface limits of the Saugus Formation. Also depicted on Figure 1 for reference purposes are: the alignments of the Santa Clara River and Castaic Creek; the local freeways; and the Los Angeles–Ventura County line. Situated within this mapped area are the city of Santa Clarita and the communities of Castaic, Canyon Country, Newhall, Saugus, and Valencia.

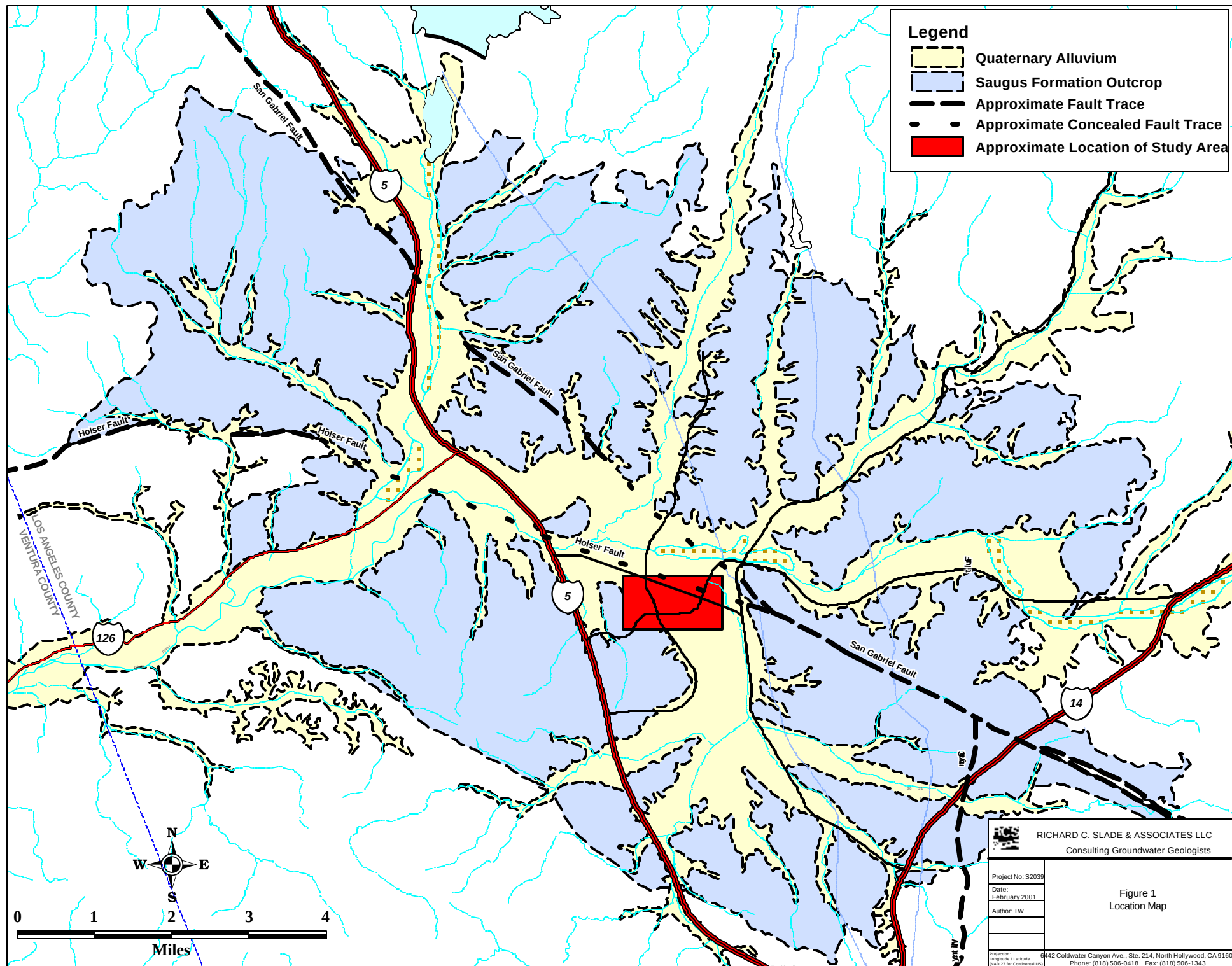
Purpose

There were two principal purposes for this project: 1) to collect the field data necessary to provide an assessment of the hydrogeologic feasibility of injection and recovery of water in the Saugus Formation in the area; and 2) to collect the field data and evaluate possible water level interactions between the alluvial aquifer system and the underlying Saugus Formation during injection into, and pumping from, the Saugus Formation.

Introductory Statements

This study was divided into three separate phases:

- ◆ Phase 1: Designed to assess the feasibility of injecting water into the Saugus Formation.
- ◆ Phase Two: Designed to evaluate the feasibility of recovering injected water from the Saugus Formation.
- ◆ Phase Three: Designed to evaluate the effects of pumping from the Saugus Formation on water levels in the overlying Alluvial Aquifer.





The study was carried out by personnel from Richard C. Slade & Associates, LLC (RCS), with logistical support from the staff of the Valencia Water Company (VWC).

During Phase One, approximately 24 million gallons (74 acre feet, AF) of municipal water were injected into Valencia Water Company Well 205 (VWC 205). Water was injected in three continuous injection steps at rates of approximately 500 gallons per minute (gpm), 800 gpm, and 1,100 gpm; each injection step was continued for 7 days. The piezometric or pressure levels in the aquifers (herein simply called water levels) were monitored continuously in the injection well, in two nearby Saugus Formation water wells, and in the new Alluvial Monitoring well (VWC AMW). Water levels were monitored for 22 days prior to injection, during the entire injection period, and for 9 days after the cessation of injection into the Saugus Formation.

During Phase Two, approximately 33 million gallons (101 AF) of water were pumped from VWC 205 at an average rate of approximately 2300 gpm, over a period of 10 days. Water levels were monitored continuously in the pumping well, in two nearby Saugus Formation water wells and in the new Alluvial Monitoring well during the test, and for three days after the cessation of pumping from the Saugus Formation. Also during Phase Two, a flow meter survey was performed on VWC 205, and a series of depth-discrete groundwater samples were collected from the well.

During Phase 3, approximately 35 million gallons (107 AF) of water were pumped from Valencia Water Company Well 201 (VWC 201) at a rate of approximately 2400 gpm, over a period of 10 days. Water levels were monitored continuously in the pumping well, in the two nearby Saugus wells, and in the Alluvial Monitoring well during the test, and for 3 days after the cessation of pumping from the Saugus Formation.

Table 1 – Summary of Testing Activities – provides a detailed summary of monitoring and testing activities performed during the three phases of work for this project. Figure 2 – Location of Injection, Pumping, and Monitoring Wells – illustrates the location of the various Saugus Formation water wells and the new Alluvial Monitoring well used in this study. It also

Table 1
Summary of Testing Activities

Date		Activity
June 30, 2000		Initial field inspection of wells.
July 5, 2000		Installation of transducers, start of pre-test Saugus Formation water level monitoring.
July 13, 2000		Start of initial attempt at injection into VWC 205.
July 19, 2000		Stopped initial injection test, reinstalled flow meter.
July 22 to 26, 2000		Drilling and construction of Alluvial Monitoring Well (AMW)
July 23, 2000		Drilling AMW
July 27, 2000		Restart of injection into VWC 205 at 500 gpm.
August 2, 2000		Raised injection rate in VWC 205 to approx. 800 gpm
August 8, 2000		Raised injection rate in VWC 205 to approx. 1100 gpm
August 16, 2000		End of injection phase of test, start of recovery period.
August 29, 2000		Start of VWC 205 constant rate discharge test at 2500 gpm.
September 9, 2000		End of VWC 205 constant rate discharge test, start of recovery period.
September 19, 2000		Conducted Flow Meter (Spinner) Log of VWC 205.
September 27, 2000		Conducted depth-discrete sampling in VWC 205.
October 3, 2000		Start of constant rate discharge test of VWC 201 at 2500 gpm.
October 13, 2000		End of constant rate discharge test in VWC 201, start of recovery period.
October 16, 2000		End of field phase of study.



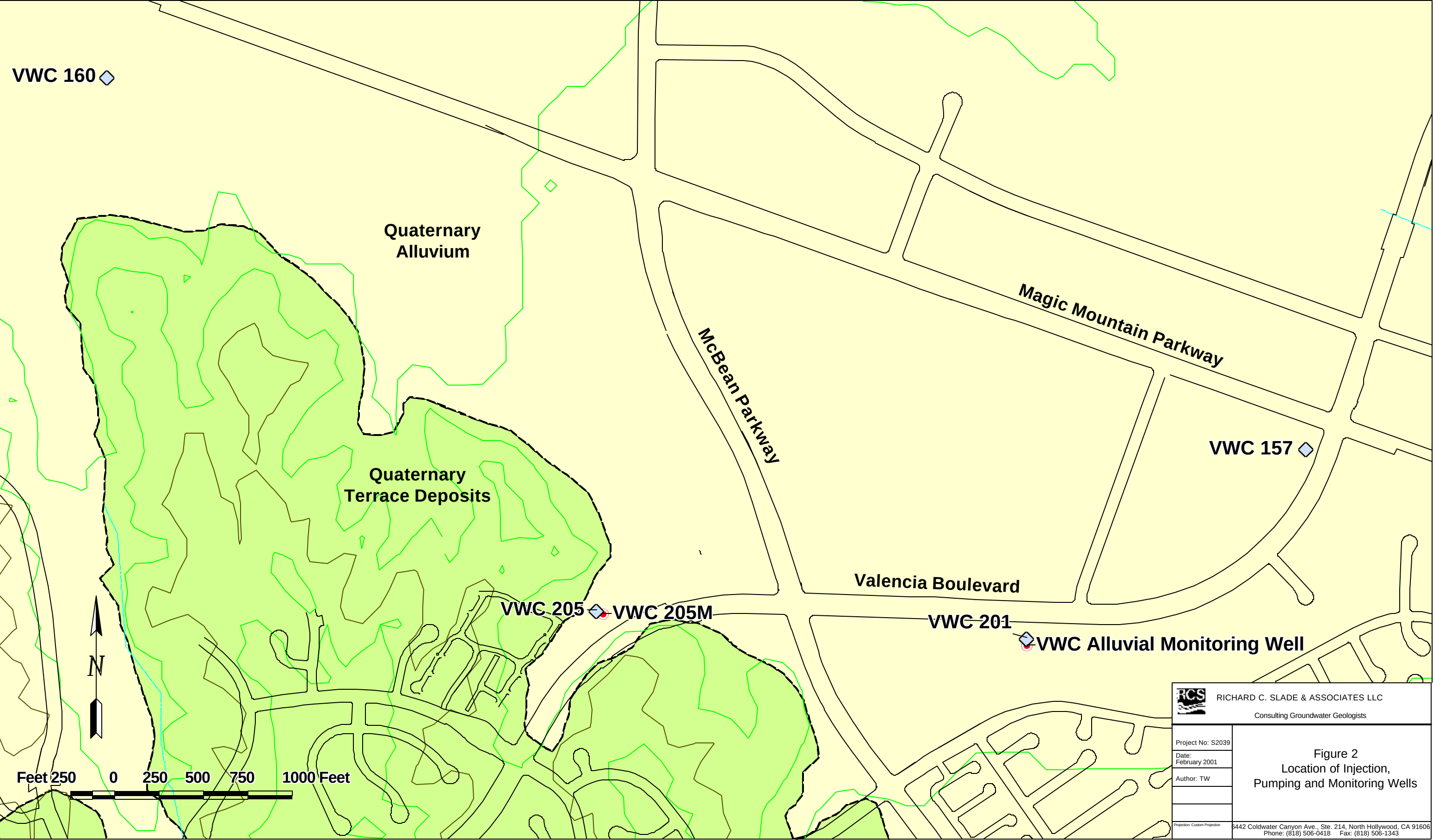
shows the position of other nearby Saugus Formation water wells that were not part of the study. Table 2 – Construction Data for Key Wells in Test – summarizes the total depths, cement seal depths, and perforated intervals for all of the wells used in this study.

Wells Utilized in Injection and Pumping Tests

VWC 205, a Saugus Formation water well that has not as yet been equipped with a permanent pump, was chosen as the injection well for this study. VWC 205 is located on the north side of Valencia Blvd., just west of McBean Parkway (refer to Figure 2). VWC 205 was constructed in 1999 to a total cased depth of 1956 ft bgs, with a cement sanitary seal extending from ground surface to 680 ft below ground surface (bgs). Perforated casing extends continuously in this well from 820 ft to 1936 ft bgs (for a total perforated length of 1116 ft), and consists of 18-inch diameter Roscoe Moss Full-Flo louvered casing with 0.050-inch slot size.

VWC 205M, a Saugus Formation monitoring well, is located approximately 40 ft southeast of VWC 205 (refer to Figure 2). Well 205M was constructed in 1999 to a total cased depth of 1956 ft bgs, with a cement sanitary seal extending from ground surface to 680 ft bgs. It was provided with 4-inch diameter steel casing with 0.050-inch machine-cut slots in the depth interval from 820 ft to 1936 ft bgs. Two 20-ft sections of blank casing were interspersed from 1504 to 1524 ft bgs and from 1685 to 1705 ft bgs (refer to Table 2). VWC 205M was used as a monitoring well throughout this study, with water levels being measured by means of a mini-Troll recording pressure transducer installed within the well casing, and by manual measurements taken with an electric tape sounder.

VWC 201, an active Saugus Formation water well, is located on the south side of Valencia Blvd., approximately 2,000 ft east of VWC 205 (refer to Figure 2). This well was constructed in 1989 to a total cased depth of 1685 ft bgs, with a cement sanitary seal extending from ground surface to 460 ft bgs. Perforated casing consists of 16 -inch diameter Roscoe Moss Full-Flo louvered casing with 0.080–inch slots interspersed with blank casing in the depth intervals between 540 ft to 1670 ft bgs (see Table 2). During the injection and pumping tests of



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February 2001

Author: TW

Projection: Custom Projection

Figure 2
Location of Injection,
Pumping and Monitoring Wells

6442 Coldwater Canyon Ave., Ste. 214, North Hollywood, CA 91606
Phone: (818) 506-0418 Fax: (818) 506-1343

TABLE 2

CONSTRUCTION DATA FOR KEY WELLS IN TEST

Well No.	Total Cased Depth (ft)	Cement Seal Depth (ft)	Depth of Perforation Intervals (ft)
157	2008	15	586 - 2008
160	2000	65	950 - 2000
201	1685	460	540 - 570 610 - 690 720 - 750 780 - 840 960 - 1000 1060 - 1160 1220 - 1300 1350 - 1380 1420 - 1490 1540 - 1670
205	1950	680	820 - 1930
205M (Saugus Fm. Monitoring Well)	1956	680	820 - 1504 1524 - 1685 1705 - 1936
AMW (alluvial monitoring well)	190	30	90 - 180



Phases One and Two of this project water levels were measured initially by means of a recording pressure transducer installed into the well casing via the temporarily disconnected discharge port. During the test pumping in Phase Three of this project, water levels were measured by electric tape sounder via a sounding port. VWC 201 was also subsequently test pumped in Phase Three of this project.

VWC 157, a Saugus Formation well currently on voluntary standby status, is located at the intersection of Magic Mountain Parkway, and Valencia Blvd., approximately 4,000 ft east of VWC 205 (refer to Figure 2). This well was constructed in 1962 to a total cased depth of 2008 ft bgs, with a cement sanitary seal extending from ground surface to 15 ft bgs. Perforated casing consists of 16 -inch diameter steel casing with knife-cut slots from 586 ft to 2008 ft bgs (see Table 2).

VWC 157 was used as a monitoring well throughout this project, with water levels measured by means of a pressure transducer installed in the well casing via the temporarily disconnected discharge port. The pressure transducer was connected at surface to a Hermit 2000 data logger. Water levels were also monitored using an electric tape sounder.

In order to monitor water levels in the Quaternary alluvium (Qal) in the vicinity of the Saugus Formation wells used during this test, an alluvial monitoring well (VWC AMW) was constructed between July 22 to 26, 2000. This new monitoring well is located approximately 40 ft south of VWC 201 (refer to Figure 2). The well has a total cased depth of 190 ft bgs (entirely within Qal), and a cement seal extending from ground surface to 30 ft bgs. Casing consists of 4-inch diameter Schedule 40 PVC with 0.050-inch machine cut slots extending from 90 to 180 ft bgs. Water levels were measured by means of a Solinst Levellogger recording pressure transducer installed directly into the well casing, and by periodic manual measurements using an electric tape sounder.



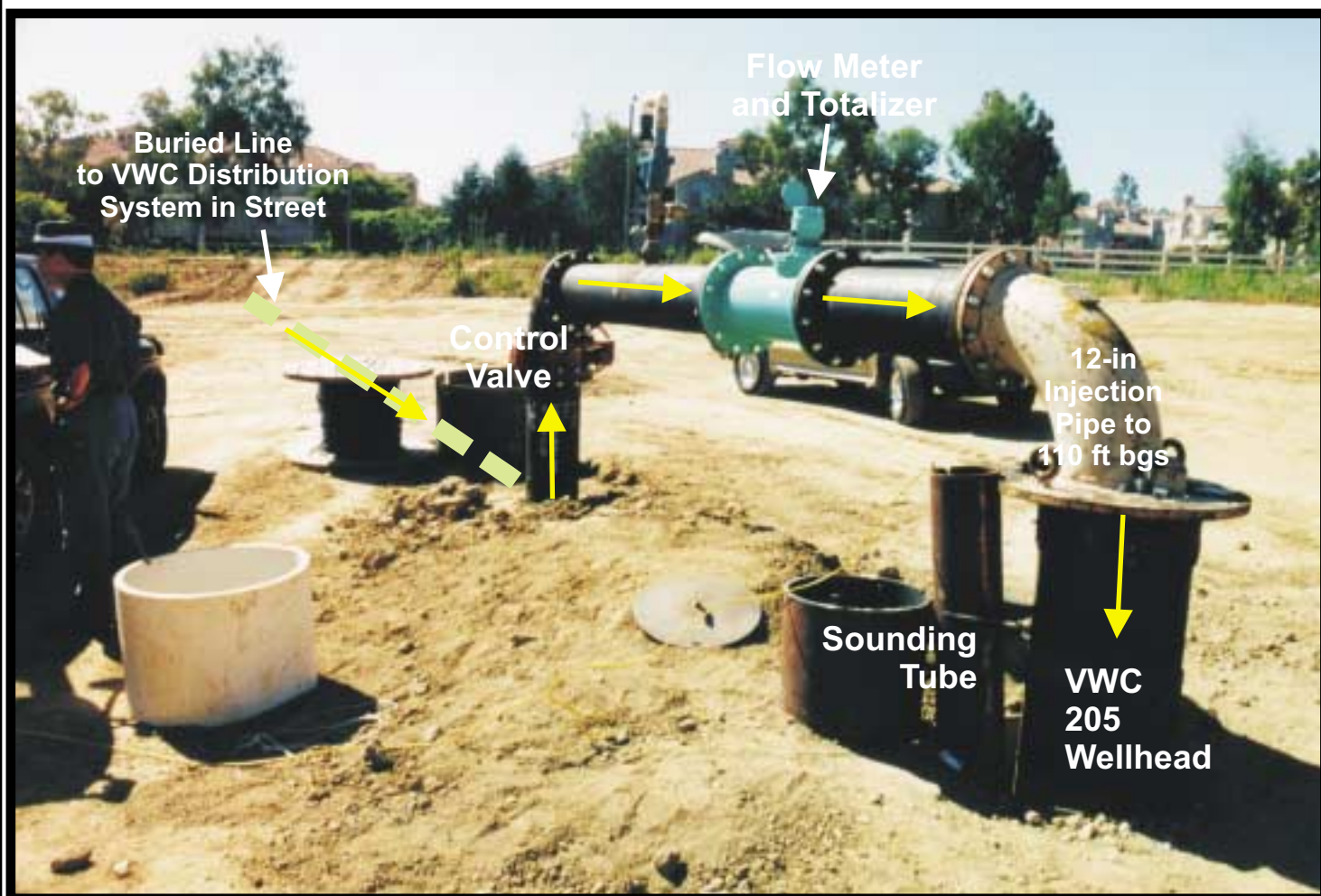
Water Level Monitoring Equipment

Water levels in the VWC 205 injection well were monitored using a mini-Troll recording pressure transducer that had been installed in the 3-inch diameter sounding tube of the well. Depending on the stage of the test, the transducer was programmed to record the water level at time intervals ranging from a few hundredths of a second during the initial stages of pumping, injection, or water level recovery, to a maximum of 30 minutes, at times when water levels were changing less rapidly.

In addition to data automatically collected by the pressure transducers, water levels in VWC 205 and all other wells used in this study were measured periodically by hand using an electric tape water level sounder. Such hand monitoring was performed to provide an independent set of water level data, and to verify that the transducers were working correctly. In each case, the transducer water levels were found to correspond extremely well with the water levels measured manually using the electric tape sounder.

Injection Test Piping and Meters

Figure 3 – VWC 205 Injection Setup – illustrates the method by which water was directed from the VWC distribution system and injected into VWC 205. Injection water entered the well via a 12-inch diameter tube that had been temporarily installed inside the 18-inch diameter well casing of VWC 205 to a depth of approximately 110 ft bgs; this depth setting was approximately 20 ft below the pre-test static water level of approximately 90 ft bgs in this well. A valve installed along the aboveground portion of the injection piping controlled the rate of injection into the well. A flow meter equipped with a totalizer dial was initially installed just “downstream” from this valve in order to monitor and record injection rates and volumes. This flow meter was later moved to a position just “upstream” from the valve.



- Notes: 1. Yellow arrows indicate direction of flow of injection water.
2. Original flow meter position. Flow meter was subsequently placed in excavated section of underground piping between the street and the control valve

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FIGURE 3
VWC 205 Injection Test Setup

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Pre-Test Water Level Monitoring

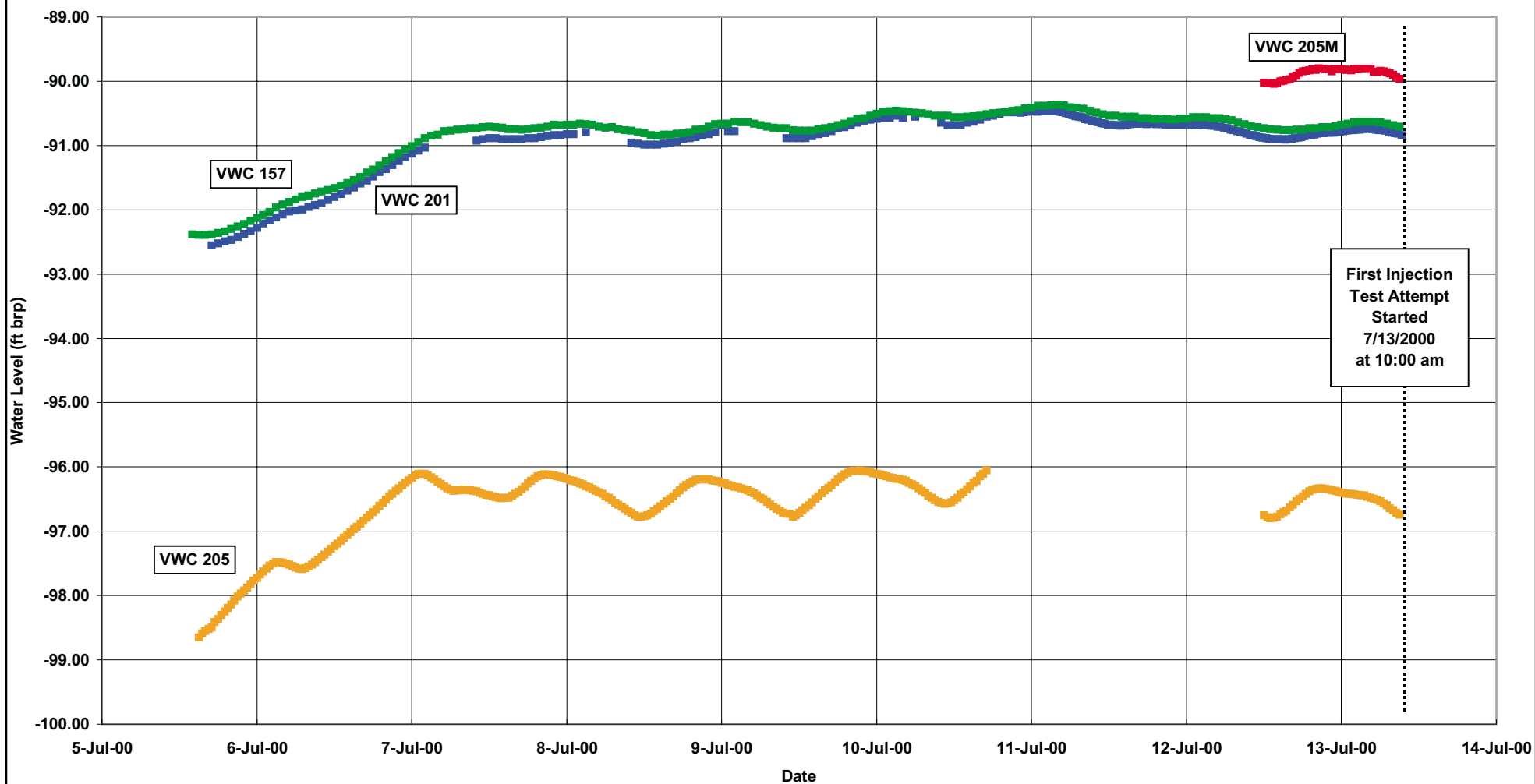
Pre-test monitoring of background (baseline) water levels commenced on July 5, 2000 by collecting manual measurements of static water levels in VWC 157, 201, 205 and 205M. Over the next several days, recording pressure transducers were installed in each of these Saugus Formation wells to collect a continuous record of the water level fluctuations experienced under pre-test conditions. Preprogrammed measurement intervals ranged from 15 to 60 minutes depending on the type of transducer in each well. Early problems with two of the transducers resulted in some minor gaps in the water level data collection records, and in the late start for monitoring in VWC 205M.

Figure 4 – Pre-Test Saugus Formation Water Levels – illustrates the results of the pre-test monitoring of these wells. As seen thereon, there was a slight 1.5 to 2.5 ft rise in water levels observed in VWC 201, 157 and 205 during the initial 36 hours of pre-test monitoring, and this probably represents recovery of the static water levels from earlier pumping of nearby Saugus Formation wells just prior to July 5, 2000.

By July 7 static water levels had essentially stabilized, with water level data from VWC 157, 201 and 205 all displaying a distinctive diurnal fluctuation in water levels ranging from 0.2 to 1.0 ft per day (see Figure 4). This seemingly natural variation cannot be correlated with pumping patterns for VWC 160, the only nearby actively pumping Saugus Formation well. Instead, the fluctuations appear to be due to tidal effects, which are often noted in semi-confined aquifers such as the Saugus Formation. No longer-term trends in static water levels were observed in any of the monitored Saugus Formation Wells.

Initial Injection Test Attempt

Following approximately eight days of pre-test monitoring, the initial injection of water into VWC 205 commenced at 10 am on July 13, 2000. The initial injection metered rate was approximately 500 gpm. This rate was calculated in the field by timing the change in flow meter





totalizer readings with a stopwatch for a period of two minutes, and then adjusting the control valve until the calculated injection rate was within ± 10 gpm of the desired rate. Frequent adjustments had to be made to the control valve over the course of the initial 500 gpm injection step in order to maintain the injection rate.

After injecting at a metered rate of approximately 500 gpm for a period of 7 days, the static water level had risen from a pre-test level of 95.4 ft below reference point (brp) to 89.1 ft brp, an increase of only 6.3 ft. This calculated to a specific capacity of approximately 60-gpm/ft of rise. The injection rate was increased to approximately 1000 gpm on July 18.

On July 19 it was determined that the rate of injection was not being accurately measured by the installed flow meter, and this initial injection test was halted. In order to correct this problem the flow meter was reinstalled in a new configuration "upstream" of the control valve prior to restarting the injection phase of the test.

Construction of Alluvial Monitoring Well

In order to measure possible effects on the water levels in the alluvium caused by injection and subsequent pumping from the Saugus Formation, a new alluvial monitoring well (VWC AMW) was constructed approximately 40 ft south of VWC 201. Drilling, construction and development of the 190 ft deep alluvial monitoring well took place from July 22 to 26, 2000 (refer to Table 1 for well construction details). A recording water level transducer was installed in this alluvial monitoring well on July 26.



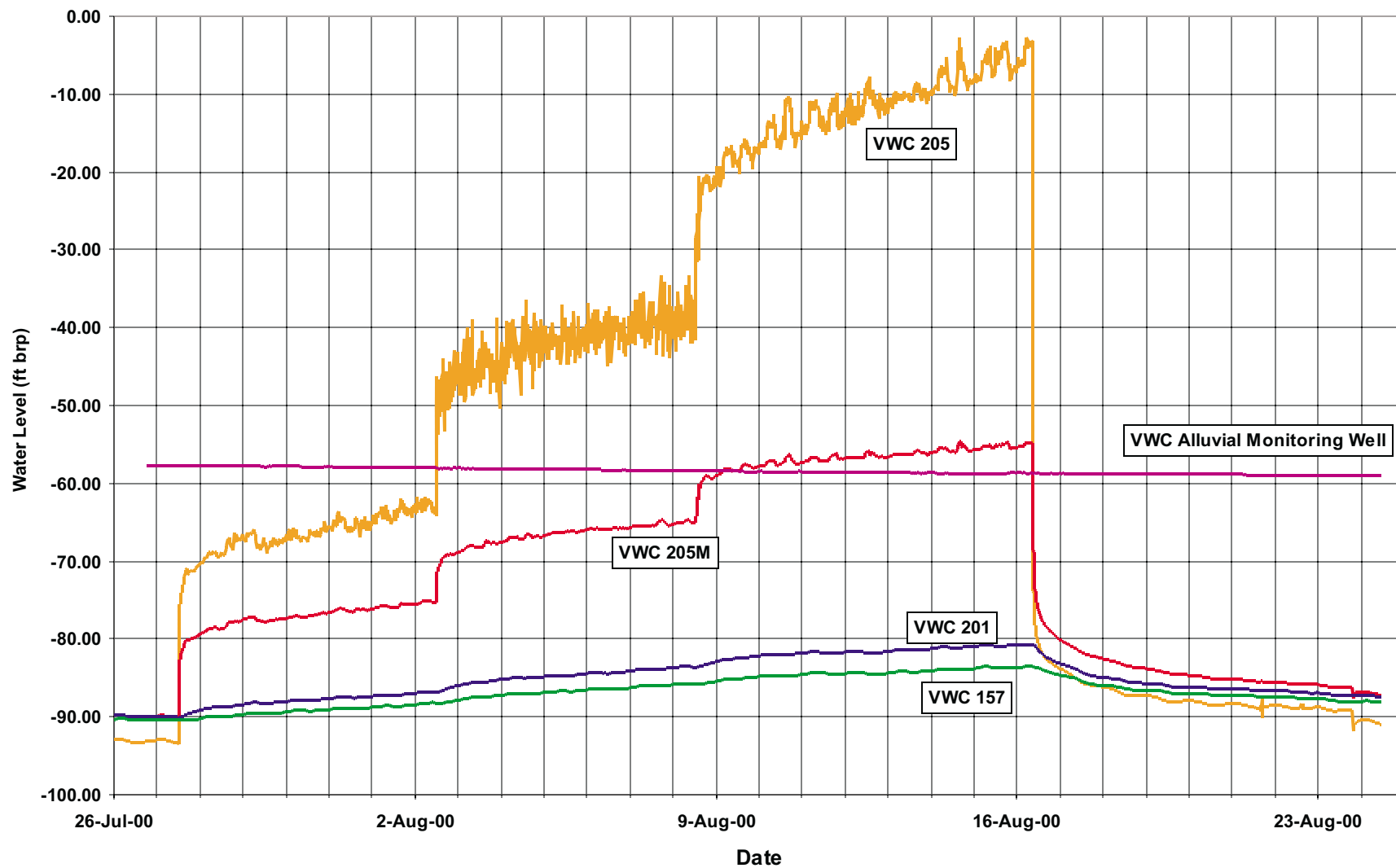
Phase One – VWC 205 Stepped-Rate Injection Test

Injection into VWC 205 recommenced at noon on July 27, 2000 at an initial step rate of approximately 500 gpm. This initial injection rate was increased to a second step rate of approximately 800 gpm on August 2, and again to a third step rate of approximately 1100 gpm on August 8. Continuous injection into VWC 205 continued until August 16, after which time water levels continued to be monitored until August 24. A total of 23,788,000 gallons (74 AF) of water were injected into VWC 205 during this first phase of testing.

Figure 5 – Water Levels, VWC 205 Stepped Injection Test – shows the water levels in the injection and monitoring wells over the course of the injection test. Prior to recommencing injection on July 27, 2000, the static water level in VWC 205 was measured at a depth of 93.3 ft below reference point (brp) at the wellhead. At the end of each successive injection step rate, the maximum rise in water levels in VWC 205 was monitored at 29.9 ft (63.4 ft brp), 52.0 ft (41.3 ft brp) and 90.3 ft (3.0 ft brp) respectively. Specific capacities of injection calculated for each injection step rate were approximately 16.7, 15.7, and 12.2 gallons per minute per foot of water level rise (gpm/ft rise) respectively.

At the end of the 8-day water level “recovery” period following cessation of the Phase 1 injection, the water level in VWC 205 had “recovered” (technically, the water level declined) to a depth of 90.9 ft brp, approximately 3 ft higher than the static water level prior to the injection test. During this “recovery” period a temporary test pump was installed in VWC 205, but this work was not observed to affect water levels in the well.

Samples of groundwater were collected on a regular basis from actively pumping Saugus Formation Well VWC 160 (located to the north, see Figure 2), prior to and during the injection test in VWC 205. Well VWC 160 was being used as an active municipal-supply water well during this injection project. Water samples were also collected from the VWC distribution system in order to characterize the water being injected into VWC 205. All water samples were delivered by VWC personnel to a State-certified laboratory for analysis.



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FIGURE 5
Water Levels
VWC 205 Stepped Injection Test

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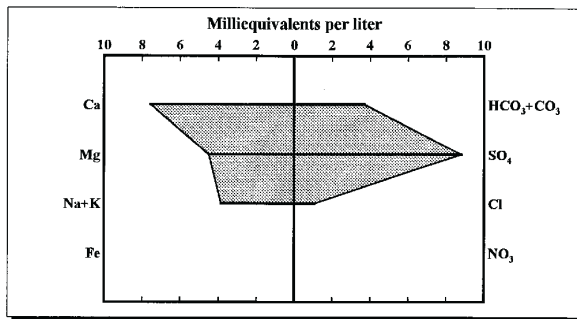


Stiff water quality pattern diagrams prepared from the results of the VWC 160 sampling program show that groundwater extracted from the Saugus Formation at this site has a calcium-sulfate (CaSO_4) character (refer to Figure 6 – VWC 160 Stiff Diagrams). Of the two samples collected prior to the commencement of the Phase One Injection Test, the sample collected on July 10, 2000 had a greater calcium sulfate content than the one collected on July 17, 2000. However, the next three samples, collected over the course of the injection test on July 31, August 8 and August 17, were extremely close in composition to the July 17 pre-injection sample. No discernable trends were observed in the composition of the groundwater extracted from the Saugus Formation at VWC 160 prior to and during injection of water into the Saugus Formation at VWC 205.

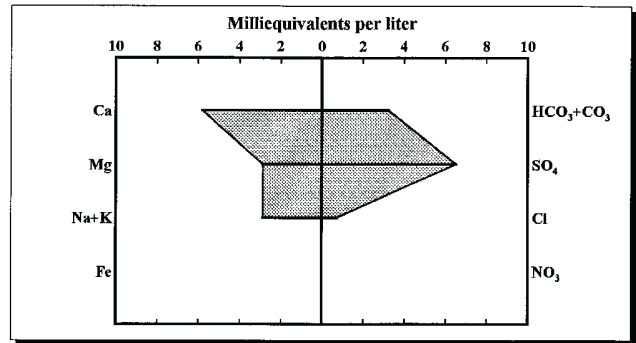
Phase 2 - VWC 205 Constant Rate Pumping Test

A temporary electric-powered test pump and discharge line were installed in VWC 205 between July 21 and 23, 2000. The pump was connected to a temporary onsite power panel that had been previously installed.

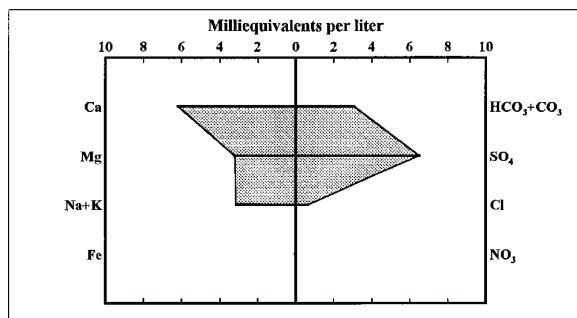
A 10-day constant rate pumping test of VWC 205 was then performed between August 29 and September 9, 2000. An electrical problem in the power panel resulted in the pump shutting down for approximately 24 hours between August 30 and 31. Once repaired, the electrical problems did not re-occur, and pumping was then continued on a constant basis until the end of the test on September 9. Recovery of the water levels was monitored until September 19, 2000. For the purposes of this report, the approximately 1520-minute-long interval of pumping prior to the unplanned pump shutdown is referred to as VWC 205 Pumping Test A, while the approximately 12,900 minute long period of pumping after the electrical problem was corrected is referred to as VWC 205 Pumping Test B. In general, only the results of the much longer Pumping Test B were used in calculating the various aquifer parameters that are discussed later in this report.



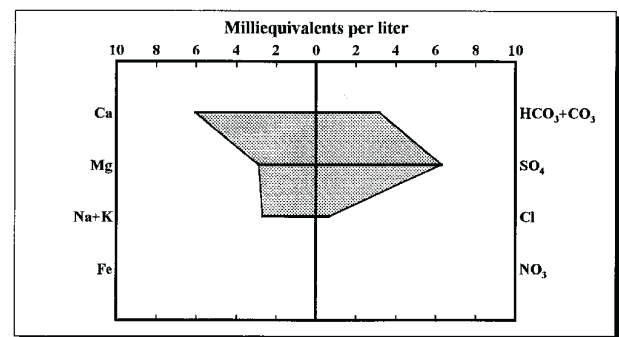
July 10, 2000



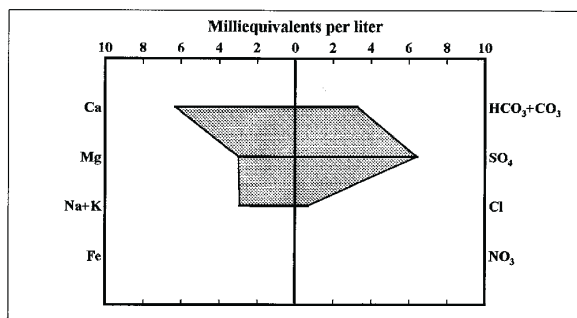
July 17, 2000



July 31, 2000



August 8, 2000



August 17, 2000

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FIGURE 6
VWC 160 STIFF DIAGRAMS

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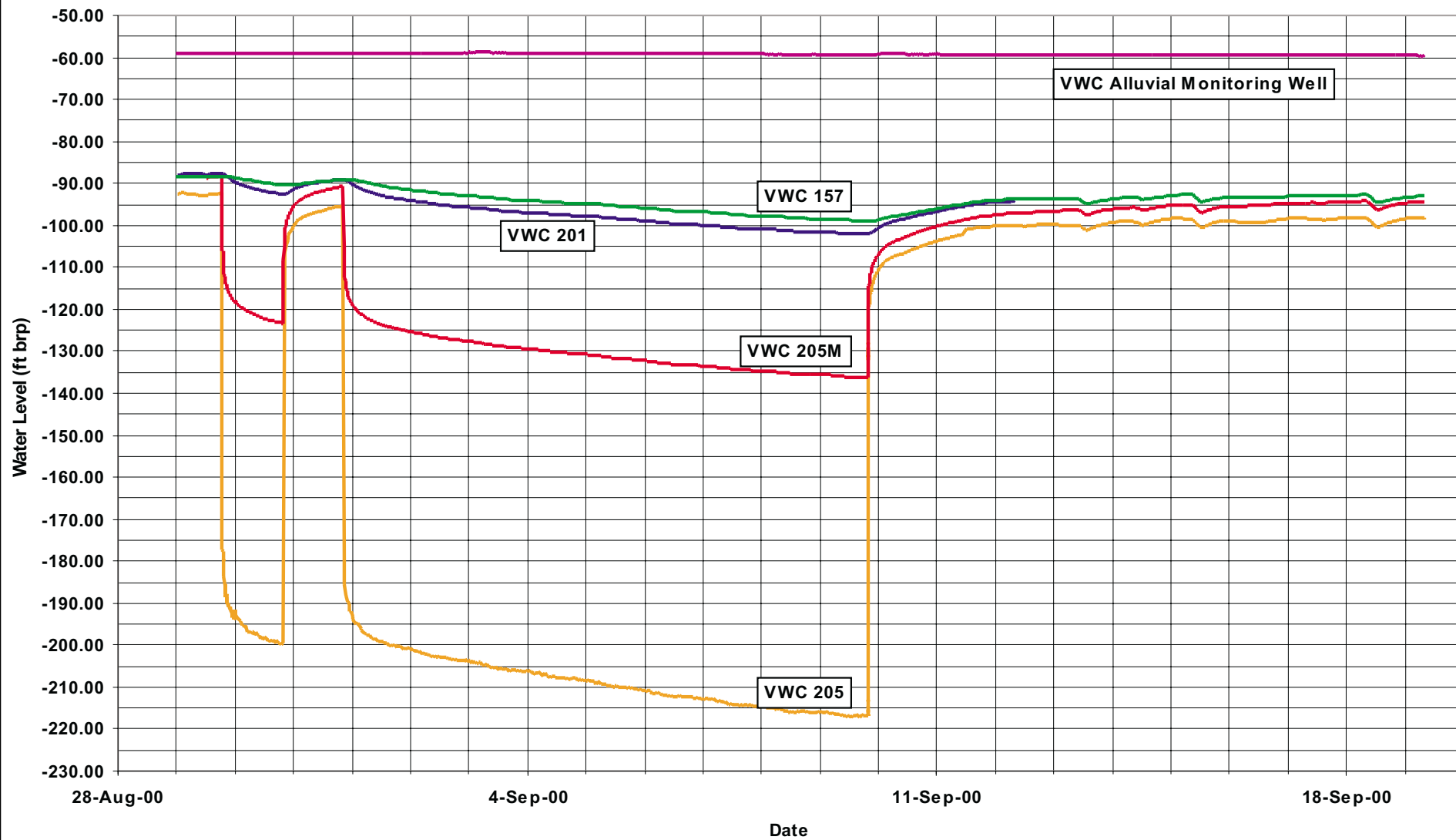
A total of approximately 33,003,000 gallons (101 AF) were pumped from VWC 205 at an average discharge rate of approximately 2300 gpm over the ten-day period from August 29 to September 9. This total amount of groundwater extracted from the Saugus Formation during the constant rate test (101 AF) exceeded the total amount previously injected into the Saugus Formation (74 AF) by approximately 27 AF.

Figure 7 – Water Levels, VWC 205 Constant Rate Discharge Test – shows the water levels in the pumping and monitoring wells over the course of this constant rate discharge test. The initial pre-test static water level in VWC 205 at the beginning of Pumping Test B was 95.5 ft brp. At the end of Pumping Test B, the pumping level was 216.6 ft brp, which calculates to a maximum water level drawdown of 121.1 ft. The specific capacity for this test was calculated to be 18.9 gpm/ft of drawdown (ddn).

At the end of the 10-day water level recovery period, the water level in VWC 205 had recovered to 98.39 feet, approximately 6 ft lower than the static level at the start of the test.

During the 10-day constant rate pumping test, a series of daily water quality samples were collected from the VWC 205 as the test proceeded in order to examine possible changes in groundwater chemistry as the water previously injected into the well was being extracted. Figure 8 – Stiff Diagrams, VWC 205 Constant Rate Test – illustrates the results of these analyses, while Figure 9 – Graph of Sulfate Concentration vs. Time During VWC 205 Pumping Test – shows the changing sulfate levels during the pumping test.

Saugus Formation groundwater extracted at VWC 205 in the early stages of the constant rate discharge test has a calcium-bicarbonate (Ca-HCO_3) character similar to the calcium-bicarbonate water from the VWC distribution system that had been previously injected into the formation (refer to Figure 8). As the test progressed and more groundwater was extracted from the Saugus Formation, the water chemistry gradually and progressively changed to a calcium-sulfate (Ca-SO_4) character more typical of natural Saugus Formation groundwater (see Figure 8). As seen in Figure 9, this change was due primarily to an increase in sulfate (SO_4)



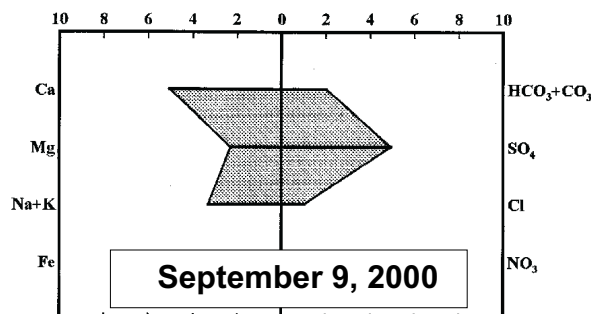
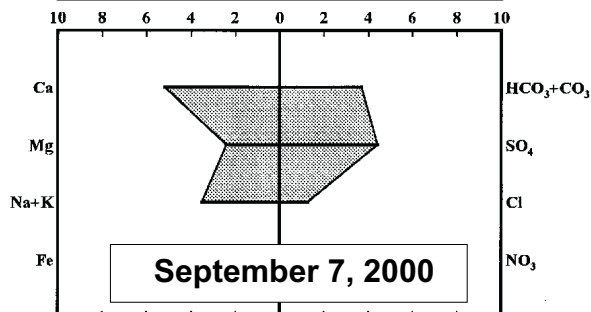
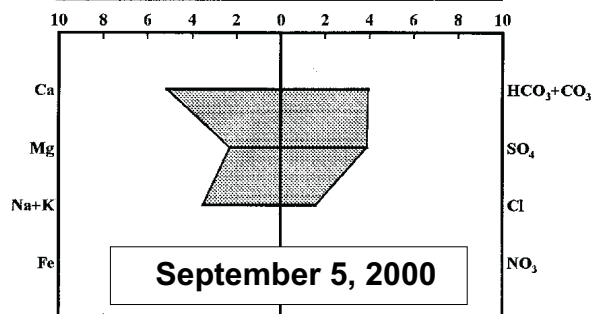
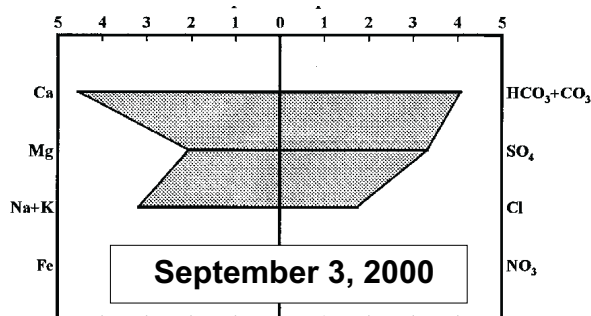
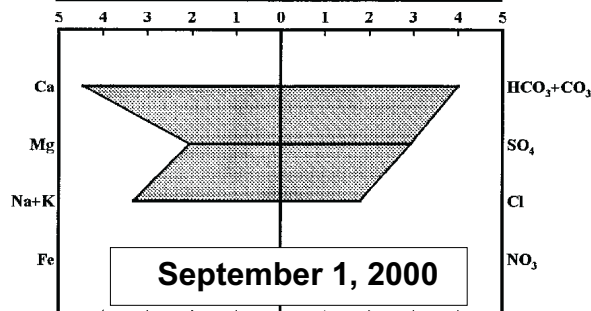
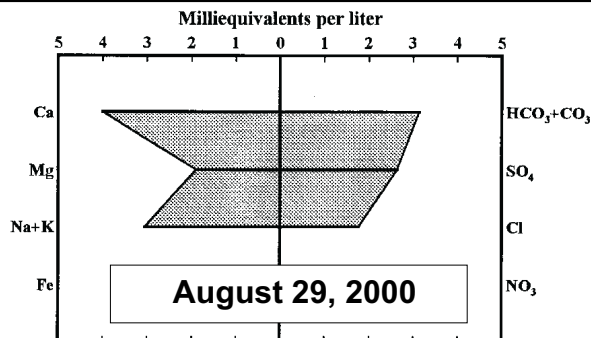
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FIGURE 7

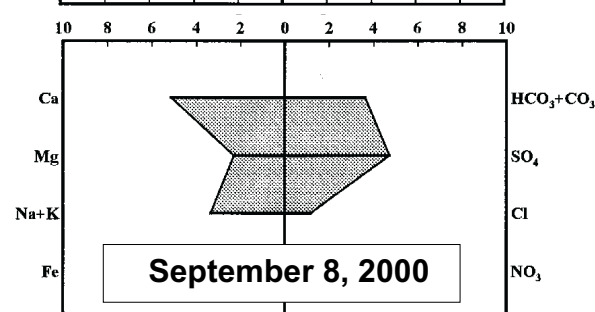
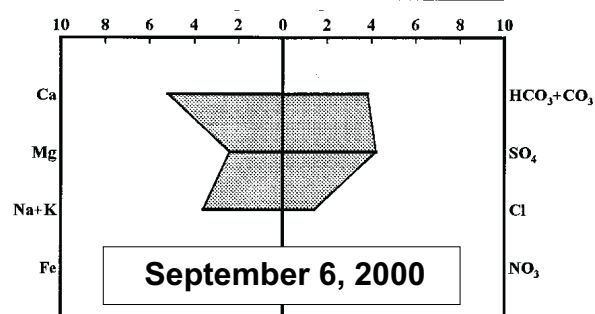
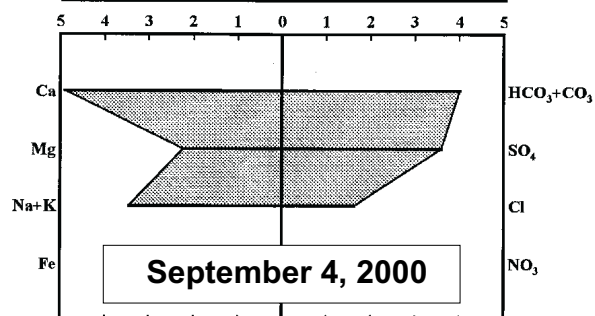
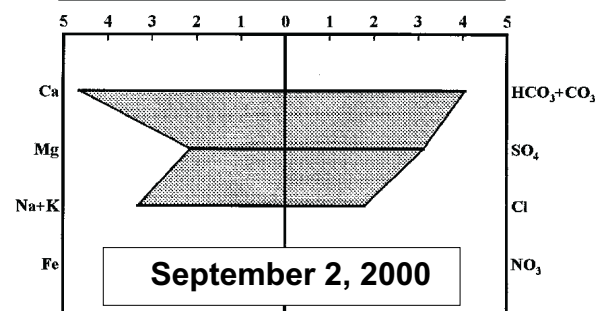
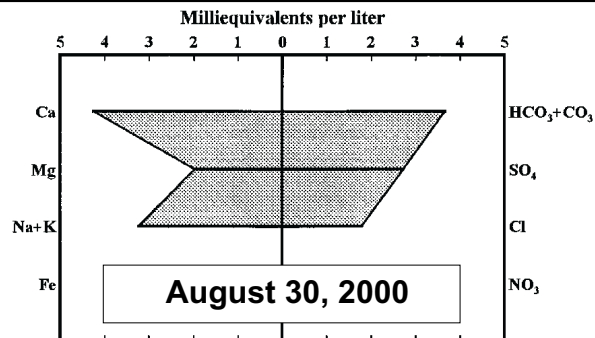
Water Levels
VWC 205 Constant Rate Discharge Test

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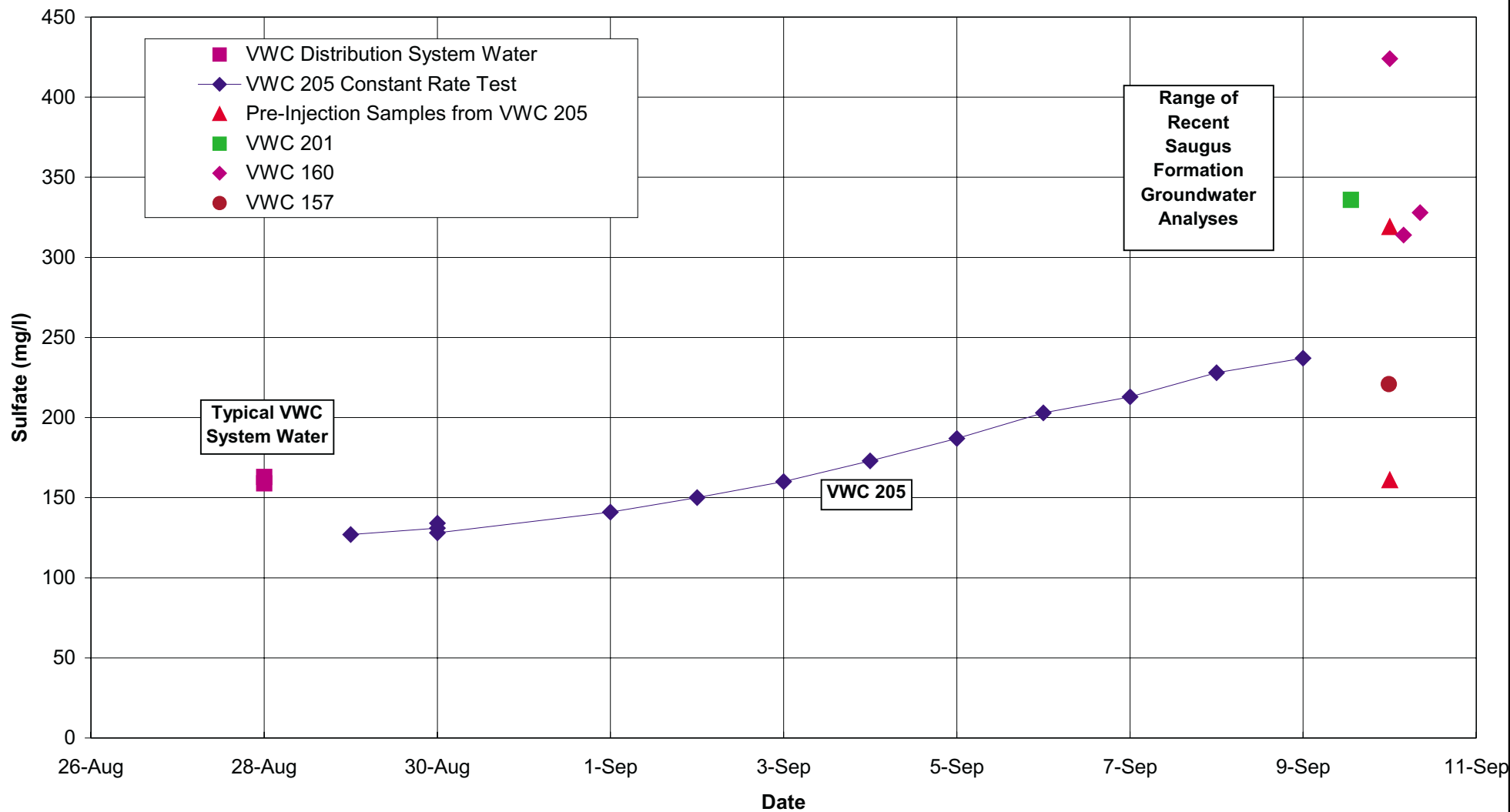


**Note
Change in
Graph
Scale from
September
4 to 5**



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**FIGURE 8
VWC 205 STIFF DIAGRAMS**



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FIGURE 9
Sulfate Concentrations
VWC 205 Constant Rate Discharge Test

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concentration, from 124 milligrams per liter (mg/l) on the first day of pumping (August 9, 2000) to 237 mg/l on the final day of pumping (September 9, 2000).

Although approximately 74 AF (an amount equivalent to that previously injected) had been pumped from VWC 205 by September 7, 2000, the chemistry of the extracted groundwater continued to evolve towards more typical Saugus Formation groundwater values until the end of the extraction period on September 9, 2000 (see Figure 8).

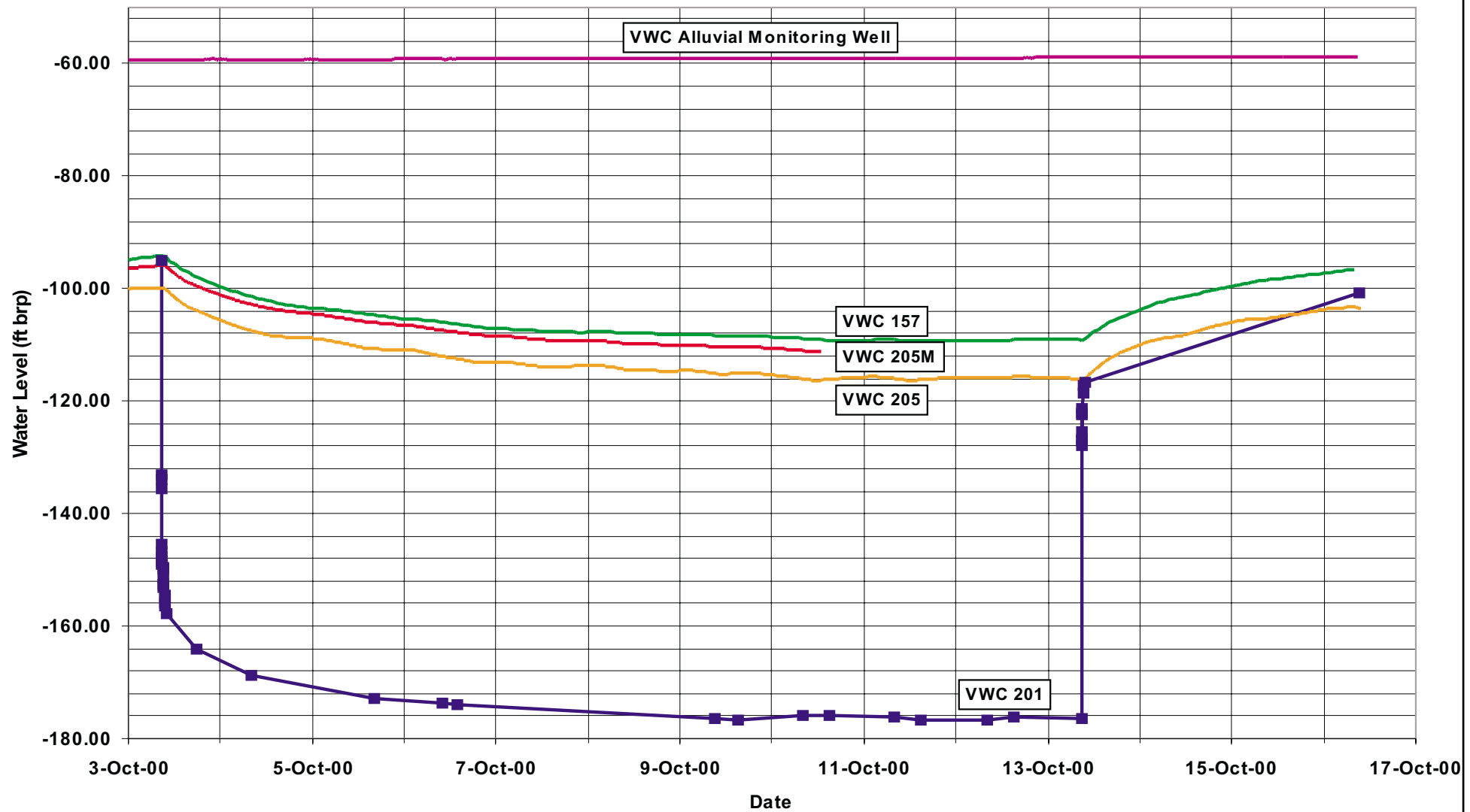
Phase 3 - VWC 201 Constant Rate Pumping Test

A ten-day constant rate pumping test of VWC 201 was conducted between October 3 and October 13, 2000. Recovery of water levels was monitored until October 16. For this test, VWC 201 was pumped continuously at an average rate of approximately 2400 gpm; a total of approximately 107 AF of groundwater were produced during the test. All water levels recorded for VWC 201 were measured using an electric tape sounder inserted into the sounding tube.

Figure 10 – Water Levels, VWC 201 Constant Rate Discharge Test – shows the water levels in the pumping and monitoring wells over the course of this constant rate discharge test. The initial static water level in VWC 201 was 94.9 ft brp just prior to commencement of pumping. By the end of the constant rate pumping test, the water level in this well had declined to 176.3 ft brp, thus revealing a total water level drawdown of 81.4 ft. The specific capacity for the test was calculated to be 30.0 gpm/ft ddn.

At the end of the subsequent 3-day water level recovery period, the water level in VWC 201 had recovered to 100.9 ft brp, approximately 6 ft lower than at the start of the test.

The static water level in the adjacent Alluvial Monitoring well was monitored continuously every 30 minutes by a recording pressure transducer from July 26 to October 16, 2000. This record is shown in Figure 11 - Static Water Levels in VWC Alluvial Monitoring Well. Manual water level measurements taken periodically with an electric tape sounder were consistently within



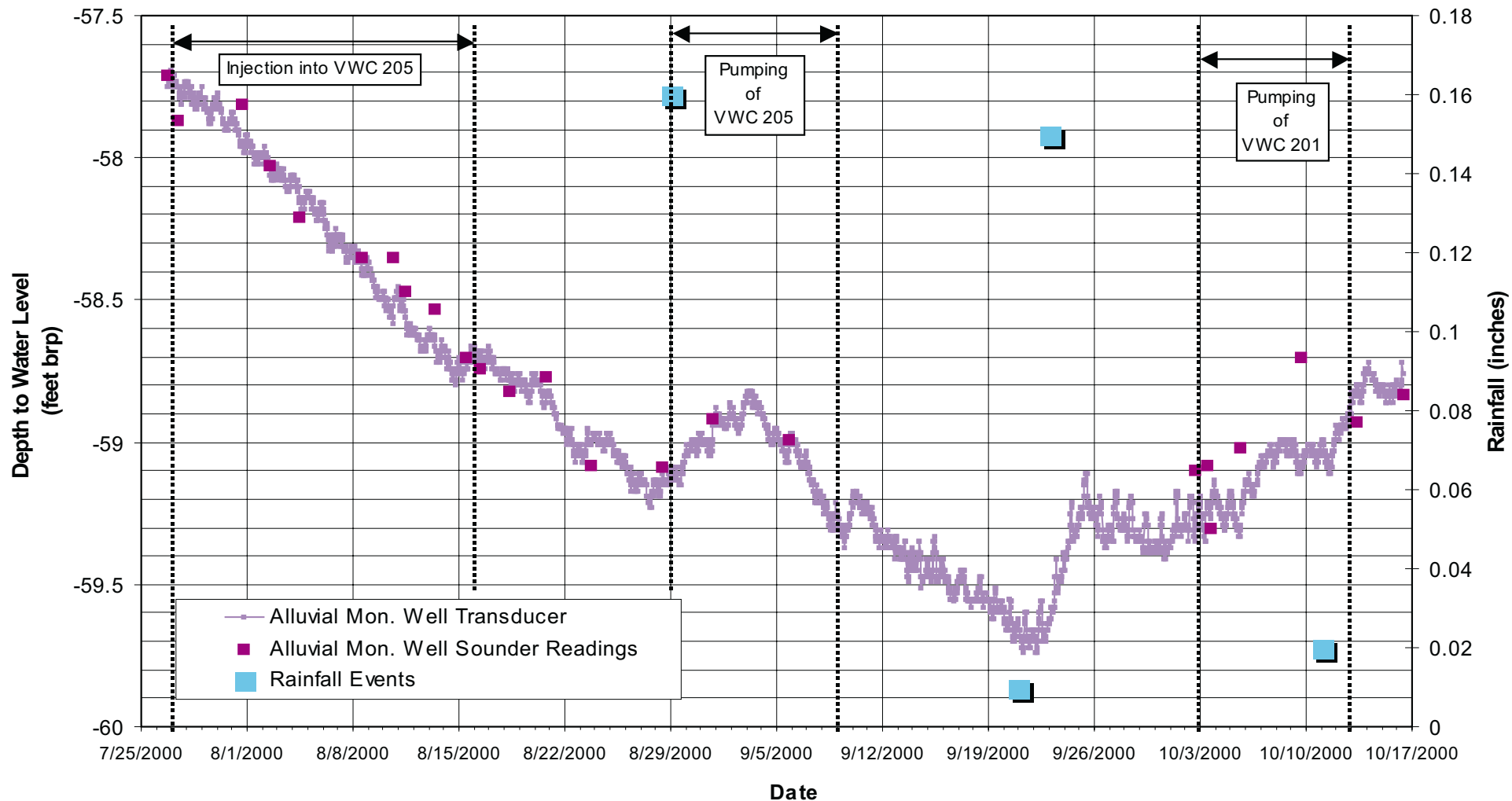
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FIGURE 10

Water Levels
VWC 201 Constant Rate Discharge Test

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FIGURE 11
Static Water Levels
VWC Alluvial Monitoring Well

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0.10 inches of the transducer reading. Static water levels in the Alluvial Monitoring well rose and fell over the three-month course of this study, with a maximum variation of approximately 2 ft. A net drop in the static water level of approximately 1 ft was recorded between July 26 and October 16, 2000. Over this time period, a total of 0.34 inches of rain was recorded at the California Department of Forestry Saugus gage, located approximately 1.8 miles east of VWC 157. There was no discernible change in the water level in the Alluvial Monitoring well in response to any of the recorded rainfall events.

Figure 11 also shows the timing of injection into and pumping from the Saugus Formation at VWC 205 and 201 in relation to the water level record in the Alluvial Monitoring well. These injection and pumping events appear to have had no discernable effect on water levels in the Alluvial Monitoring Well. Figure 12 – Detailed Water Levels, VWC 201 Constant Rate Discharge Test – provides a more detailed graph of water level records during the constant rate discharge test of VWC 201. While VWC 201 experienced a total water level drawdown of approximately 81 ft by the end of the 10-day constant rate pumping test, the static water level in the adjacent Alluvial Monitoring well actually rose from 59.3 ft brp to 58.8 ft brp (0.5 ft) during the same period.

VWC 205 Flow Meter Survey and Depth Discrete Groundwater Sampling

A flow meter (spinner log) survey of VWC 205 was performed on September 19, 2000. The objective of this task was to determine the amount of groundwater flowing into the well from various screened depths within this Saugus Formation water well as it was being pumped. Table 3 – Estimate of Flow from Zones in VWC 205 – summarizes the results of this survey.

The most important result of the flow meter survey is that groundwater is produced by the well throughout its entire perforated length (from 820 to 1930 ft bgs). Although the greatest production comes from two specific zones, the first between 820 to 960 ft brp (34.3% of flow) and the second between 1570 to 1700 ft brp (22.6% of flow), the remainder of the groundwater production is distributed fairly evenly over the rest of the perforated intervals in the well. The flow meter data conclusively demonstrates that the entire thickness of the Saugus Formation at this

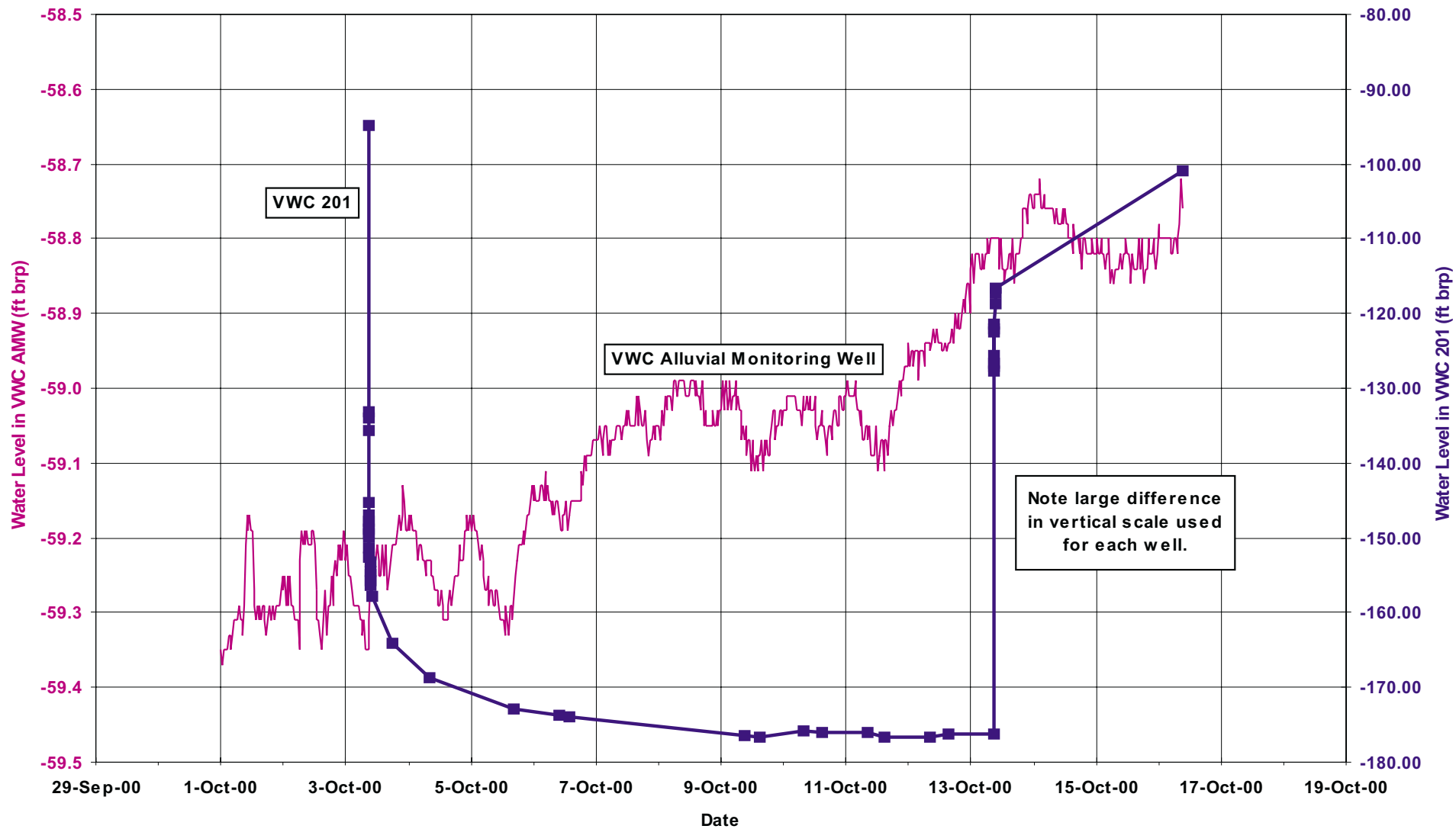


Table 3
ESTIMATE OF FLOW FROM ZONES IN VWC 205

INITIAL FLOW METER READING (gals):				61920500		
FINAL FLOW METER READING (gals):				62229150		
TIME OF FLOW PERIOD (min):				137		
CALCULATED FLOW RATE (GPM):				2253		
STOP COUNT ANALYSIS						
Depth (ft bgs)	Number of Counts (cps)	Depth Interval (ft,bgs)	Length of Depth Interval (ft)	CPS Per Interval	Interval Flow (%)	Interval Flow (gpm)
1930	0	*	*	*	*	*
1800	7	1800 to 1930	130	7	9.6	216
1700	8.5	1700 to 1800	100	1.5	2.1	46
1570	25	1570 to 1700	130	16.5	22.6	509
1500	26	1500 to 1570	70	1	1.4	31
1375	30	1375 to 1500	125	4	5.5	123
1310	36	1310 to 1375	65	6	8.2	185
1200	38	1200 to 1310	110	2	2.7	62
1100	42	1100 to 1200	100	4	5.5	123
960	48	960 to 1100	140	6	8.2	185
860	63	860 to 960	100	15	20.5	463
820	73	820 to 860	40	10	13.7	309
TOTALS>			1110	73	100.0	2253



well (to a depth of at least 1930 ft) is capable of both providing groundwater to wells and accepting water via injection.

A depth-discrete series of groundwater samples were also collected from VWC 205 on September 26. The objective of this task was to collect data on potential changes in water chemistry with depth, within the portion of the Saugus Formation that has been screened in VWC 205.

Six discrete zones were sampled within the well, the details of which are summarized in Table 4 – Results of Depth-Discrete Sampling of VWC 205. The overall results generally agree with existing water chemistry data for the Saugus Formation. Specifically, the groundwater water has: a calcium to sodium-sulfate character; moderately high total dissolved solids (TDS values of 504 to 661 mg/l); low nitrate (4.78 to 8.6 mg/l); and moderately high iron (0.072 to 1.27 mg/l).

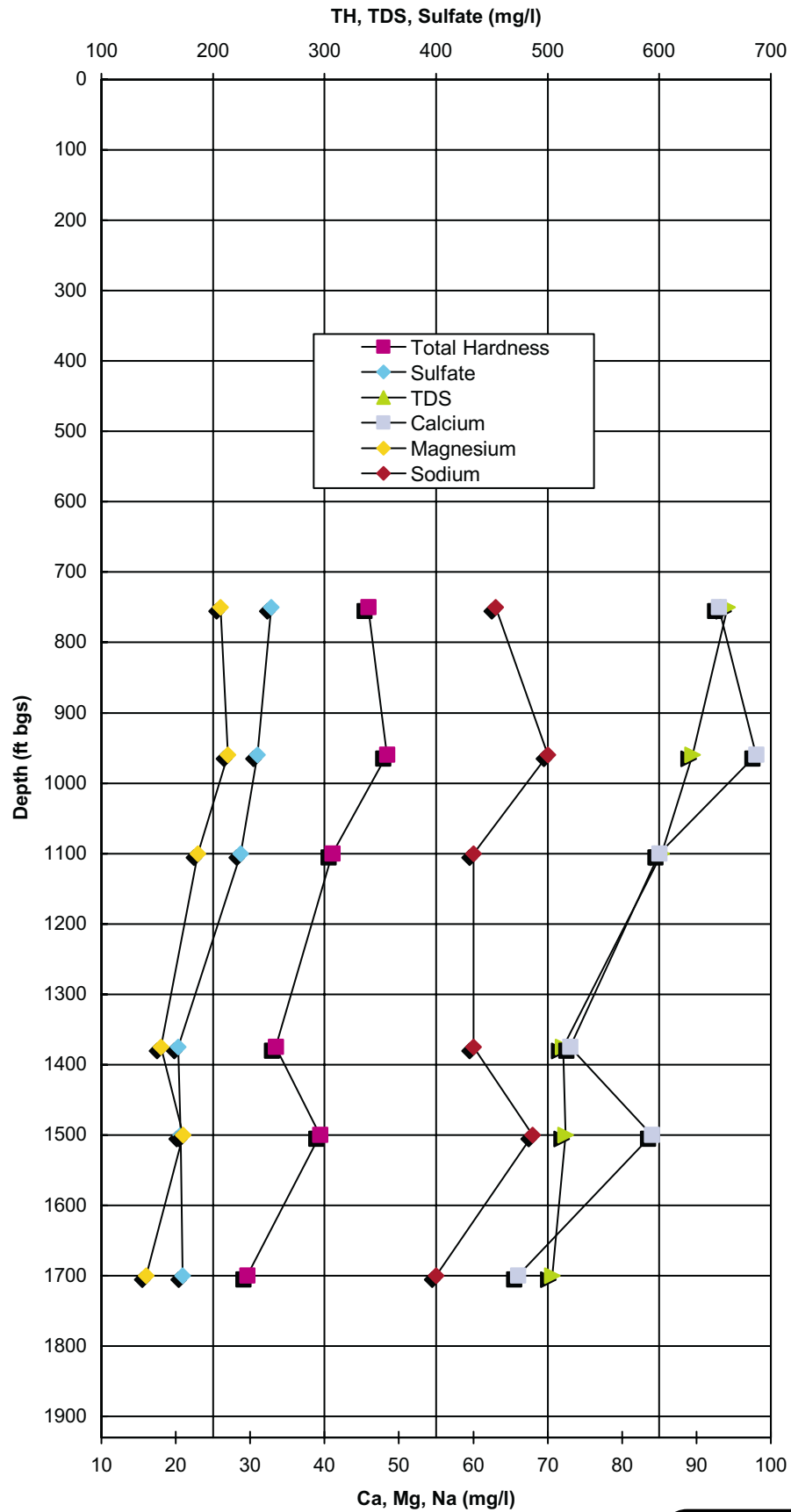
An interesting aspect of the laboratory results is the apparent presence of a vertical chemical gradient within the Saugus Formation, with the concentration of virtually all dissolved constituents showing a generally consistent decrease with *increasing* depth of sampling (see Figure 13 – Plot of Water Quality vs. Depth, VWC 205). These new data appear to corroborate a similar improvement in water quality with depth that was observed in 1990 in a series of depth-discrete zone samples taken during construction of the Newhall County Water District Saugus Formation Well No. 13. It should be noted that VWC 205 penetrates only the upper and geologically younger one-third of the total Saugus Formation thickness at that site, and these results provide no information as to water quality in the older underlying beds near the base of the Saugus Formation.

Analyses of Results of Injection and Pumping Tests

A number of different well and aquifer parameters, including specific capacity, transmissivity and storativity, were calculated from the results of the injection and pumping tests carried out during this study. These parameters help to characterize the hydrogeologic characteristics of

Table 4
Results of Depth-Discete Sampling of VWC 205

Depth ft	1700	1500	1375	1100	960	750
Total Hardness	231	296	256	307	356	339
Ca	66	84	73	85	98	93
Mg	16	21	18	23	27	26
Na	55	68	60	60	70	63
K	2.6	3.4	2.8	2.7	3.1	2.9
Alkalinity	153	161	163	170	170	175
Hydroxide	0	0	0	0	0	0
Carbonate	0	0	0	0	0	0
Bicarbonate	187	196	199	207	207	214
Sulfate	173	171	169	225	240	252
Chloride	25	28	29	30	30	33
Nitrite as NO ₂	<1	<1	<1	<1	<1	<1
Nitrate as NO ₃	4.9	4.7	5.2	6.4	6.8	8.6
Fluoride	0.18	0.21	0.23	0.27	0.28	0.27
Orthophosphate	<1	<1	<1	<1	<1	<1
Bromide	0.11	0.12	0.12	0.15	0.15	0.15
pH	7.64	7.67	7.62	7.58	7.52	7.52
Specific Conductance	744	784	755	858	908	920
TDS	504	516	514	602	630	661
Color	10	5	5	<5	<5	10
Odor						
Turbidity	9	7	5	4	2	12
Al	9	11	9	11	<5	<5
As	<2	<2	<2	<2	<2	<2
B						
Ba	53	53	49	48	44	43
Be	<1	<1	<1	<1	<1	<1
Cd	2	<1	<1	<1	<1	<1
Co	<1	<1	<1	<1	<1	<1
Cr	2	3	<1	2	1	1
Cu	6	<1	<1	<1	<1	<1
Fe	376	482	125	276	72	1273
La	<1	<1	<1	<1	<1	<1
Mn	5	5	1	3	2	13
Mo	1	0	1	2	1	2
Ni	78	20	13	5	10	6
P	58	40	25	71	40	114
Pb	<20	<20	<20	<20	<20	<20
Sb	<100	<100	<100	<100	<100	<100
Se	<100	<100	<100	<100	<100	<100
Sr	<100	<100	<100	<100	<100	<100
V	15	18	14	10	13	11
Zn	500	495	182	406	33	84



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FIGURE 13

Water Quality vs Depth
VWC 205

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the Saugus Formation, and allow for greater control of planned water balance calculations and groundwater models.

Specific Capacity

The specific capacity of a well during a pumping test is the discharge rate of the well divided by the total water level drawdown created in that well during the pumping test, and is expressed as gallons per minute per foot of water level drawdown (gpm/ft ddn). The specific capacity of a well in which injection is occurring is a similar value, but is calculated by dividing the injection rate by the total water level rise during an injection test; it is expressed here as gpm per foot of water level rise (gpm/ft rise). Both parameters are affected by both aquifer characteristics and well design and construction, and are commonly used as a measure of a well's efficiency.

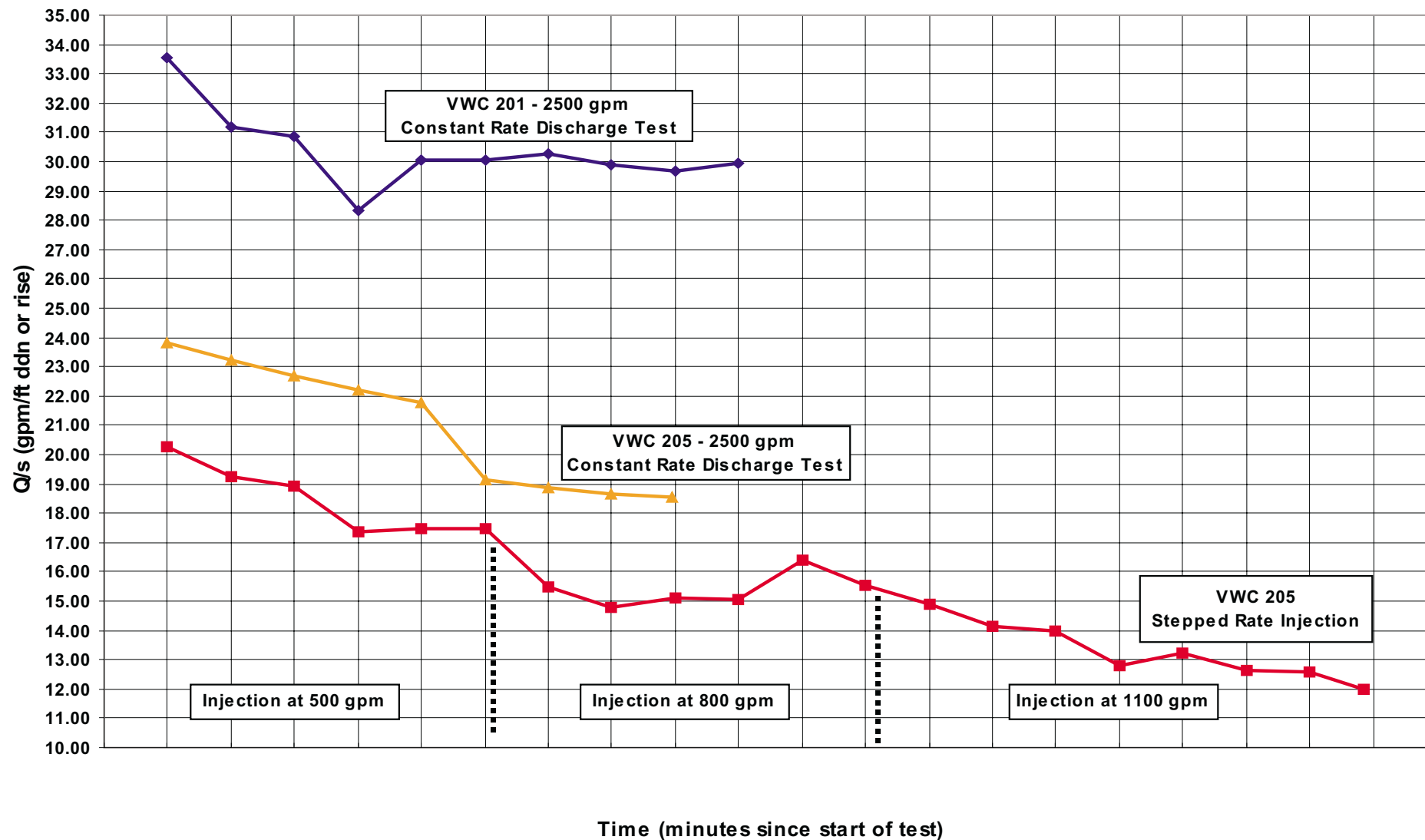
Historically known specific capacity values for Saugus Formation wells are typically on the order of 10 to 70 gpm/ft ddn. Values calculated from the results of pumping tests for this project for both VWC 205 (20.4 gpm/ft ddn) and VWC 201 (29.9 gpm/ft ddn) are toward the lower end of the typical range for Saugus Formation wells in the region.

Specific capacity values calculated for VWC 205 during injection are somewhat lower than those calculated for pumping conditions. Values of 16.5, 15.8 and 12.2 gpm/ft rise were calculated for injection rates of approximately 500, 800 and 1100 gpm respectively (refer to Table 5 – Specific Capacity Data, Q/s). These lower specific capacities of injection may reflect the fact that: a) wells are generally more efficient for extracting groundwater than for injecting it, and b) there is a greater general tendency for wells to become clogged during injection than during pumping.

Figure 14 – Specific Capacities During Injection in VWC 205 – illustrates the trend of decreasing specific capacity with increased injection rates observed during the injection test of VWC 205. This may be due to a number of factors, including progressive clogging of the injection well and the surrounding aquifer by entrained air and/or sediment, as well as a loss of well

Table 5
Specific Capacity Data (Q/s)

Time from start of test (min)	Pumping/Injection Rate (gpm)	Drawdown/Rise in Water Level (ft)	Specific Capacity (gpm/day/ft)
Well 205 Post-Construction Pumping Test (1999)			
900	3394.0	147.6	23.0
Well 205 Injection Test			
Step 1 approx. 500 gpm			
1440	496.7	24.5	20.3
2880	488.2	25.4	19.3
4320	487.9	25.8	18.9
5760	485.7	28.0	17.4
7200	502.6	28.7	17.5
8640	504.2	29.9	16.9
Q/s at end of Step 1	499.1	29.9	16.7
Step 2 approx. 800 gpm			
10080	777.8	50.2	15.5
11520	811.1	54.9	14.8
12960	819.4	54.2	15.1
14400	821.6	54.6	15.0
15840	864.0	52.8	16.4
17280	807.2	52.0	15.5
Q/s at end of Step 2	816.0	52.0	15.7
Step 3 approx. 1100 gpm			
18720	1104.6	74.3	14.9
20160	1103.7	78.2	14.1
21600	1108.3	79.3	14.0
23040	1084.5	84.8	12.8
24480	1093.5	82.5	13.3
25920	1064.1	84.2	12.6
27360	1100.7	87.5	12.6
28601	1082.7	90.3	12.0
Q/s at end of Step 3	1097.3	90.3	12.2
Well 205 Pumping Test B (after pump restart)			
1440	2510.9	105.4	23.8
2880	2510.9	108.2	23.2
4320	2510.9	110.7	22.7
5760	2510.9	113.1	22.2
7200	2510.9	115.2	21.8
8640	2248.8	117.4	19.2
10080	2248.8	119.1	18.9
11520	2248.8	120.6	18.6
12900	2248.8	121.3	18.5
Q/s for Pumping Test B	2272.7	121.3	18.7
Q/s for Entire Aquifer Test	2278.5	124.6	18.3
(includes Test A, 1440 minutes prior to pump shutdown due to electrical problems)			
Well 201 Pumping Test			
1440	2477.1	73.8	33.6
2880	2432.2	78.0	31.2
4320	2432.2	78.8	30.9
5760	2241.0	79.1	28.3
7200	2452.0	81.5	30.1
8640	2452.0	81.5	30.1
10080	2447.3	80.9	30.3
11520	2428.2	81.2	29.9
12960	2422.4	81.7	29.7
14400	2435.1	81.4	29.9
Q/s for Entire Aquifer Test	2438.5	81.4	30.0



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FIGURE 14
Specific Capacity (Q/s)
During Injection & Pumping Tests

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efficiency due to turbulent flow which may have developed within the gravel pack and areas of the Saugus Formation near the well casing at higher injection rates.

Temporary clogging of an injection well is a normal consequence of injection under both testing and operational scenarios. A routine maintenance procedure for operational injection wells involves pumping or back flushing the well periodically to remove fine sediment and entrained air that may have built up in the perforations and gravel pack.

Transmissivity and Storativity

Transmissivity is a measure of the ability of an aquifer to transmit water to a pumping well, or to accept water from an injection well. It is expressed in units of gallons per day per foot of aquifer width (gpd/ft). Storativity is a measure of the volume of water released to a pumping well, or accepted by an injection well for a given volume of aquifer materials. Storativity is dimensionless and has no units. Both transmissivity and storativity values were calculated from measured water level drawdown (or rise) in the non-pumping observations wells used during the various tests. The calculations were carried out using the software program Aqtesolv, using the automatic curve fitting procedure.

Table 6 – Transmissivity & Storativity Data – summarizes the various aquifer parameters calculated from the test data. For the stepped injection test of VWC 205, the Theis Step Test solution provided the best fit with the observed data. For the pumping tests of VWC 201 and 205, it was found that the Hantush-Jacob solution for a leaky confined aquifer provided the best fit for the observed data. This suggests that there may be a minor degree of connection between the Saugus Formation and the overlying alluvium, although this degree of connection was not enough to result in measurable water level declines in the alluvium while pumping from a nearby Saugus Formation well during this project. Even in a semi-confined aquifer such as the Saugus Formation, there may be a limited amount of vertical permeability and therefore groundwater flow, but it is likely to be at least an order of magnitude less than the horizontal permeability and corresponding horizontal groundwater flow.

Table 6
Transmissivity & Storativity Calculations
Saugus Formation Injection Study

Test	Transmissivity (gal/day/ft)	Storativity
VWC 205 Injection Test (21 days injecting + 9 days recovery)	Theis Step Test Solution (pumping & recovery)	
Composite	40,670	1.09E-03
205M (40 ft)	41,370	8.88E-04
201 (2400 ft)	50,450	7.56E-04
157 (4100 ft)	54,880	6.45E-04
VWC 205 Injection Test (21 days injecting + 9 days recovery)	Theis Solution (recovery only)	
205M (40 ft)	47,240	6.20E-01
201 (2400 ft)	74,530	4.72E-01
157 (4100 ft)	96,500	3.54E-01
VWC 205 Pumping Test B (9 days pumping + 10 days recovery)	Hantush-Jacob Solution for a Leaky Aquitard	
Composite	75,950	1.28E-03
205M (40 ft)	78,910	9.48E-04
201 (2400 ft)	76,410	1.37E-03
157 (4100 ft)	65,880	1.36E-03
VWC 201 Pumping Test (10 days pumping + 2 days recovery)	Hantush-Jacob Solution for a Leaky Aquitard	
Composite	65,100	5.75E-04
157 (1900 ft)	44,230	1.17E-03
205M (2360 ft)	57,210	8.49E-04
205 (2400 ft)	47,890	6.75E-04

Note: Solutions refer to the best-fit Aqtesolv solutions to the pumping or injection data.



Calculated transmissivity data ranged from approximately 41,000 to 55,000 gallons per day per foot of aquifer (gpd/ft) for the injection test in VWC 205, from 66,000 to 76,000 gpd/ft for the pumping test of VWC 205, and from 44,000 to 65,000 gpd/ft for the pumping test of VWC 201. These values are in good general agreement with data from prior testing of Saugus Formation water wells. The slightly lower transmissivity values for the injection test may reflect decreased well efficiency as a result of clogging or turbulent flow during injection.

Storativity values calculated from the aquifer test data ranged from 10^{-3} to 10^{-4} , which is also in good general agreement with previous data. Such values are representative of confined or semi-confined aquifer systems.

Static water levels in the three monitored Saugus Formation wells declined slightly over the course of this study (July 5 to October 16, 2000). During that time period, the static water level in VWC 205 declined by 4.8 ft, the static water level in VWC 157 declined by 4.2 ft, and the static water level in VWC 201 declined by 1.6 ft. As with water levels in the alluvium, static water levels in the Saugus Formation also typically experience a natural decline each year during the late summer and early autumn as pumping extraction proceeds in the absence of rainfall recharge. The effects, if any, of the injection and pumping tests on static water levels in the Saugus Formation are indistinguishable from this natural variation.

Evaluation of Saugus Formation Continuity

As part of our evaluation of the subsurface continuity of the Saugus Formation, we reviewed and constructed detailed electric log (E-log) correlations from approximately 150 oil wells and water wells in the region. Based on these detailed correlations, a number of sand/gravel units and silt/clay units were identified and correlated from one well location to another. Because these stratigraphic units were consistently recognizable on electric logs of oil wells and water wells from one well to another, the continuity of these units in an east to west direction across the Santa Clarita Valley is thus demonstrated.



One of these key correlated stratigraphic units is here informally designated as the Santa Clarita Aquifer Zone. Based on our correlations, we have prepared Tables 7, 8 and 9 – Depth to Key Electric Log Marker Beds, in – Water Wells, - Oil Wells Between Faults, and – Oil Wells South of Holser Fault, respectively. These tables list the depth below ground surface to the top of the Santa Clarita Aquifer Zone as identified on E-logs in: all Saugus Formation water wells for which E-logs exist (Table 7); in oil wells located between the San Gabriel fault and the Holser fault (Table 8; see also general locations of these faults on Figure 1); and in oil wells located south of the Holser fault (Table 9).

It is noteworthy that existing Saugus Formation wells, depending on location, produce groundwater from Saugus Formation strata that lie both above and below the Santa Clarita Aquifer Zone. Figure 15 – Type Electric Log and Santa Clarita Aquifer Zone, VWC 205M – shows a typical E-log (i.e. the type E-log) for the Saugus Formation from VWC 205M, the 1956-foot deep Saugus Formation groundwater monitoring well that lies approximately 35 ft from VWC 205. Shown on this type E-log is the top of the Santa Clarita Aquifer Zone. It is noteworthy that approximately 10% of the 2253-gpm pumping rate during the spinner log survey of VWC 205 was derived from perforated zones in the lower part of the Santa Clarita Aquifer Zone, and down to the 1953-ft deep total casing depth in this well. Geologically, this Santa Clarita Aquifer Zone lies stratigraphically within the younger (upper) portion of the Saugus Formation in the region.

General Considerations for Siting and Design of New Saugus Formation Injection and Recovery Wells

Although detailed siting and design criteria for specific new Saugus Formation injection and recovery wells are beyond the scope of this study, the following general criteria are provided:

1. New Saugus Formation injection and recovery wells should be sited in areas that contain both thick accumulations of Saugus Formation sediments, and thick total Saugus Formation sand and gravel accumulations. The locations of the relatively thick accu-

TABLE 7
DEPTH TO TOP OF SANTA CLARITA AQUIFER ZONE

Well No.	Casing Depth (ft)	Depths of Perforation Intervals (ft)	Depth to Top of Santa Clarita Aquifer Zone (ft)
NCWD Wells			
No. 9	675	311-674	Eroded off
No. 11	1136	200-1075	1070
No. 12	1340	485-1280	796
No. 13	1410	420 - 630	910
SCWC Wells			
No. SF-1	1640	490-520 570-630 710-810 890-1000 1020-1080 1130-1190 1290-1330 1400-1620	1452
No. SF-2	1592	490-495 515-555 585-725 824-883 923-983 1043-1103 1212-1251 1310-1591	1370
VWC Wells			
No. 154	Destroyed	29 - 1003	1110
No. 155	Destroyed	108 - 1468	945
No. 156	1805	320 - 1800	1325
No. 157	2008	586-2008	1636
No. 158	Destroyed	740 - 1605	2030 (est.)
No. 159	1950	662 - 1900	1016
No. 160	2000	950-2000	1550
No. 201	1685	540 - 570 610 - 690 720 - 750 780 - 840 960 - 1000 1060 - 1160 1220 - 1300 1350 - 1380 1420 - 1490 1540 - 1670	1610
No. 203	Not completed		1545
No. 205-MW	1956	820 - 1504 1524 - 1685 1705 - 1936	1765
Private Wells			
Smiser #3		? - 780	Eroded off
Poe		600 - 2030	230

TABLE 8
DEPTH TO TOP OF SANTA CLARITA AQUIFER ZONE
OIL WELLS - Between Faults

Well Name	Location	Depth to Top of Santa Clarita Aquifer Zone (ft)
NL&F #74	18Ja-4N-16W	2810
Newhall #F1	7Pa-4N-16W	2780
NL&F #1	16Ka-4N-16W	1380
Magic Mountain #1	17Ka-4N-16W	2297
Newhall #C-5	7Ga-4N-16W	1470
Wayside Unit #30	7Fa-4N-16W	980
NL&F #75	18Ha-4N-16W	2872
Honor Rancho (NCT-1) #25	8Ca-4N-16W	810
NL&F #E-1	17Fa-4N-16W	2510
Wayside Honor Farm #1	1Qa-4N-17W	570
NL&F #C-1	1La-4N-17W	540
Good #1	2Ha-4N-17W	830
McGillivrae #2	2Na-4N-17W	580
Mable Strawn #5	3Qa-4N-17W	490
Newhall #D-2	12Ma-4N-17W	1540

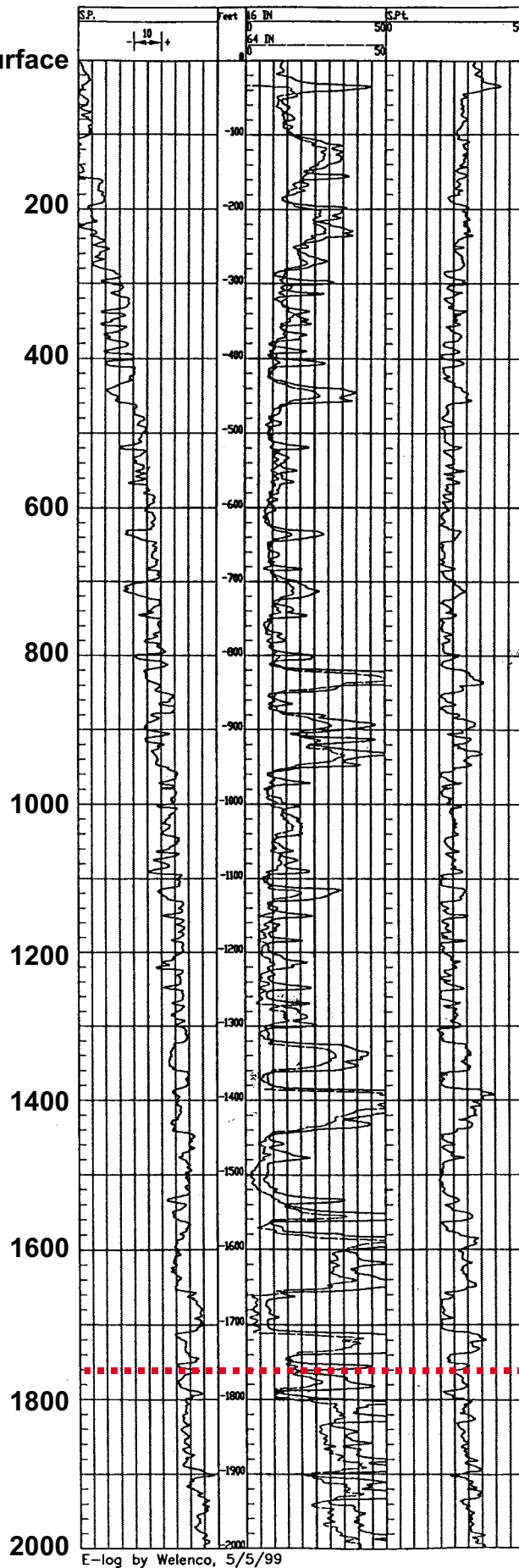
TABLE 9
DEPTH TO TOP OF SANTA CLARITA AQUIFER ZONE
OIL WELLS, South of Holser Fault

Well Name	Location	Depth to Top of Santa Clarita Aquifer Zone (ft)
Eagle Oil - Bishop #2	2Db-3N-16W	Estimate 390
Newhall Community #1-1	2Ma-3N-16W	Top 40 ft, eroded off
La Salle #44-1	3Na-3N-16W	Eroded off
Happy Valley Unit #1	3Ab-3N-16W	Estimate 220
Bermite #1	25Ea-4N-16W	370
Circle J #2 R/D	26Ha-4N-16W	1090
Circle J #1	26Qa-4N-16W	931
NL&F #5-3	34Qa-4N-16W	887
H&M #1	27Ha-4N-16W	1055
Newhall #E-1	22Qa-4N-16W	1420
NL&F #5-1	34La-4N-16W	1230
NL&F #E-1	33Ka-4N-16W	1260
NL&F #48-21	21Pa-4N-16W	1730
NL&F #37	27La-4N-16W	1120
NL&F #13-1	28La-4N-16W	1510
NL&F #2	28Ma-4N-16W	1985
NL&F #1	29Da-4N-16W	2195
NL&F Valencia #2	20Ma-4N-16W	1822
NL&F #44	19Ja-4N-16W	1424
NL&F #20	19Ea-4N-16W	1030
NL&F #24	19Ma-4N-16W	Estimate 650
NL&F #59	18Na-4N-16W	1462
NL&F #74	18Ja-4N-16W	2490
NL&F #37	19Ka-4N-16W	1290
NL&F #68	14Ja-4N-17W	Est. 120, cut out by Qal
NL&F #9	14Qa-4N-17W	Eroded off
NL&F #1	14Ea-4N-17W	Eroded off
NL&F #2	14Pa-4N-17W	Eroded off
NL&F #54	23Ea-4N-17W	Eroded off
Trifield #1	22Ka-4N-17W	Eroded off
NL&F #64	13Qa-4N-17W	1060
NL&F #12	24Ca-4N-17W	340
NL&F #53	24Ma-4N-17W	Est. 450
NL&F #70	14Ga-4N-17W	Eroded off
NL&F #67	13Ma-4N-17W	Est. 470
NCS #1	25Aa-4N-17W	Est. 120
NL&F #12-2	13Fa-4N-17W	770
NC #1	25Ha-4N-17W	Eroded off
NL&F #8	24Fa-4N-17W	Est. 50
NL&F #11	24Ka-4N-17W	70
RDF #62-3	27Da-4N-17W	Spud in Qal above Pico

Depth (ft)

VWC 205M

Ground Surface



**Top of Santa Clarita
Aquifer Zone at 1765 ft bgs**

RICHARD C. SLADE & ASSOCIATES LLC
CONSULTING GROUNDWATER GEOLOGISTS

FIGURE 15

Type Electric Log and
Santa Clarita Aquifer Zone
VWC 205M

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mulations of sand and gravel zones are provided as a figure in the report appended to this document.

2. The lowermost, older zones of the Saugus Formation, including the Sunshine Ranch Member, are not considered prospective for new wells, because they are finer-grained and of relatively low permeability. They also tend also to have poorer-quality groundwater (Slade, 1988).
3. Areas north of, and immediately adjacent to the San Gabriel fault zone, are not recommended for siting new Saugus Formation injection and recovery wells. These areas lack thick accumulations of sand and gravel layers that are common in other portions of the Saugus Formation. Instead, sediments in these areas comprise the finer-grained, lower permeability Sunshine Ranch Member of the Saugus Formation.
4. New injection and recovery wells should not be sited within the boundaries of known oilfields that may have current or historic oil production from the Saugus Formation.
5. Selected sites must permit the legally mandated setbacks from sewers, storm drains and other potential and/or known sources of contamination. It will also be necessary to maintain a sufficient distance from existing privately owned Saugus Formation wells to minimize the potential for mutual water level drawdown interference between wells.
6. The specific design of the wells will depend on whether they are to be used for both injection and recovery, or as dedicated injection or recovery wells. All new wells should be equipped with cement sanitary seals to a minimum depth of 250 ft.



Conclusions of this Project

Based on our hydrogeologic analyses of data acquired during the injection and pumping tests conducted on existing Saugus Formation water wells in the area, we submit the following conclusions:

1. The data from this study demonstrate that it is hydrogeologically feasible to inject and recover significant volumes of water from the Saugus Formation. The formation readily accepted water from the injection well, and subsequently yielded a comparable amount of water to a pumping well. Local mounding or depression of nearby static water levels (piezometric or pressure levels) due to injection or pumping quickly returned to near pre-test levels once injection or pumping ceased.
2. Injection into, and pumping from the Saugus Formation in wells used for this project had no measurable effect on water levels in the overlying alluvial aquifer system, as measured in the Alluvial Monitoring Well situated 40 ft from Saugus Formation well VWC 201.
3. Static water levels in the three monitored Saugus Formation wells declined slightly (2 to 5 ft) over the course of this study (July 5 to October 16, 2000). As with water levels in the alluvium, static water levels in the Saugus Formation also typically experience a normal decline each year during the late summer and early autumn due to ongoing pumping and reduced rainfall recharge during this period. The effects, if any, of the injection and pumping tests on static water levels in the Saugus Formation are indistinguishable from this natural variation.
4. Historically known specific capacity values calculated from pumping tests conducted in Saugus Formation wells are typically on the order of 10 to 70 gpm/ft ddn. Values calculated from the results of pumping tests for this project for both VWC 205 (20.4 gpm/ft ddn) and VWC 201 (29.9 gpm/ft ddn) are toward the lower end of the typical range for Saugus Formation wells in the region.



5. Specific capacity of injection values calculated for VWC 205 during the injection test are somewhat lower than those calculated for pumping conditions. Values of 16.5, 15.8 and 12.2 gpm/ft rise were calculated for injection rates of approximately 500, 800 and 1100 gpm respectively. These lower specific capacities of injection may reflect the fact that: a) wells are generally more efficient for extracting groundwater than for injecting it, and b) there is a greater general tendency for wells to become clogged during injection than during pumping. The trend of decreasing specific capacity with increased injection rates observed during the injection test of VWC 205 may also be due to a number of factors, including progressive clogging of the injection well and the surrounding aquifer by entrained air and/or sediment.
6. Calculated transmissivity data ranged from approximately 41,000 to 55,000 gallons per day per foot of aquifer (gpd/ft) for the injection test in VWC 205, from 66,000 to 76,000 gpd/ft for the pumping test of VWC 205, and from 44,000 to 65,000 gpd/ft for the pumping test of VWC 201. These values are in good general agreement with data from prior testing of Saugus Formation water wells. The slightly lower transmissivity values for the injection test may reflect decreased well efficiency during injection, and/or clogging of the well screens and gravel pack. Clogging of injection wells is normal, and is dealt with routinely by periodic pumping of the affected well.
7. Storativity values calculated from the aquifer test data ranged from 10^{-3} to 10^{-4} , which is also in good general agreement with previous data. Such values are representative of confined to semi-confined aquifer systems like the Saugus Formation.
8. Flow meter data for VWC 205 clearly show that groundwater was produced from the well throughout its entire perforated interval (820 ft to 1930 ft bgs). Two depth zones (820 ft to 960 ft, and 1570 ft to 1700 ft bgs) produced nearly 57% of the total flow rate during the pumping test, while the remainder of the total flow was fairly evenly distributed throughout the balance of the perforated zones in the well. These data conclusively demonstrate that



the Saugus Formation aquifer system is capable of: yielding groundwater in useable quantities and acceptable quality for municipal-supply purposes, down to tested depths of at least 1930 ft, and; accepting water via injection down to tested depths of at least 1930 ft.

9. Detailed correlations of electric logs from all Saugus Formation wells and from a large number of wildcat oil wells reveal that several different key marker beds can be consistently recognized on electric logs from well to well in an east to west direction across the Santa Clarita Valley. Hence, correlation of these several marker beds clearly demonstrates the lateral continuity of Saugus Formation strata in the subsurface.
10. Although general considerations for the siting and design of new Saugus Formation injection/pumping wells are proposed, further site-specific study is required to refine specific details as to the siting and design of future injection and recovery wells, and the optimum rates of injection and recovery at each new selected well site.

Very truly yours,
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