Luhdorf & Scalmanini Technical Memorandum: Potential Capture of Perchlorate Contamination, Valencia Water Company Wells E14-E17
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Potential Capture of Perchlorate Contamination Valencia Water Company's Wells E14 – E17

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Introduction

As part of its water supply planning in accordance with the overall groundwater operating plan in the Santa Clarita Valley Groundwater Basin, East Subbasin, Valencia Water Company is in the process of installing four new municipal water supply wells in the western part of its overall service area, generally near the mouth of Castaic Creek Canyon. Those four wells are intended to augment Valencia's groundwater source capacity and, in general, provide municipal pumping capacity in that part of the overall basin that will replace a number of agricultural supply wells in the same area as the latter are abandoned in concert with general land development in the area.

In light of general concerns about perchlorate contamination in the groundwater basin, despite the fact that the focus of that concern is several miles to the east of the new Valencia wells, Valencia commissioned the work reported herein to investigate the risk of perchlorate contamination on its new wells. As a result, the analysis described below was undertaken to examine the potential capture of perchlorate-impacted groundwater by the new Valencia wells, and the results have been interpreted to conclude regarding risk of perchlorate capture at the new wells.

In summary, the approach to investigating potential capture of perchlorate-impacted groundwater by the new wells involved three sequential steps: identification of local and regional groundwater flow patterns in the Alluvium, the aquifer in which all four wells are completed; application of a single layer groundwater flow model to examine the capture zone of the four-well "well field" under planned operating conditions; and interpretation of potential capture of perchlorate via examination of the wells' theoretical independent capture zone relative to known occurrence of perchlorate and its mobility in the Alluvium. The latter step was subsequently augmented by considering other factors, such as the locations and magnitude of pumping between the new wells and the known occurrence of perchlorate, that affect the potential capture of perchlorate by the new wells. Ultimately, conclusion regarding the risk of perchlorate contamination at the new wells was drawn from a combination of the theoretical independent capture zone analysis and the other factors that affect the potential capture of known perchlorate in the basin.

Valencia Wells E14 – E17

Valencia's four new Alluvial wells are numbered E14 through E17. The locations of the new Valencia municipal wells are illustrated in Figure 1, which also shows other nearby wells.

As specified in Valencia's Water Supply Permit issued by the State Department of Health Services (DHS), Valencia's new municipal E wells are replacement wells for some of the nearby Newhall Land and Farming Company's agricultural E wells, e.g. Wells E, E2, E4 and E5, which are in the process of being permanently sealed and abandoned in accordance with the DHS Permit. As land development occurs in the general area of those wells, the need for irrigation water supply will progressively decrease and municipal water demands will correspondingly increase. Thus, in general, the new Valencia wells will generally produce water comparable to the historical production from the NLF wells, resulting in no substantial change in basin operation. Pumping from the basin will thus remain within the operating yield concept incorporated in the 2005 Urban Water Management Plan and analyzed in the 2005 Basin Yield Report.

The four new Valencia E wells are all generally similar in terms of aquifer completion and construction details. All four are completed solely in the Alluvium. All four well sites were explored via pilot hole drilling and logging to about 200 feet, and the four completed wells range in depth from 133 feet (Well E-15) to 170 feet (Well E-16). All four wells are similarly constructed with 18 inch nominal production casing from the ground surface to the top of a single perforated (louvered well screen) intake section. The depths of blank production casing range from 76 feet (Well E-14) to 92 feet (Well E-15). Louvered well screens range in length from 38 feet (Well E-14) to 63 feet (Well E-16). The bottom of the well intake sections ranges between depths of 114 feet (Well E-14) and 145 feet (Well E-16). All four wells have gravel envelopes extending from total depth to just above the top of the intake section, and are sealed above that depth, to the surface, with cement grout. Key well construction details for all four Valencia E wells are summarized in Table 1.

The four new Valencia E wells are intended to be equipped to pump between 1,000 and 1,400 gallons per minute (gpm). Three of the four wells (E-14 through 16) have comparable, high yields as indicated by their respective specific capacities (gpm per foot of drawdown) generally between about 62 and 66 gpm/ft. Well E-17, while still capable of its design capacity of 1,000 gpm, has a notably lower yield, about 34 gpm/ft. Well yield and design capacity details for all four wells are also summarized in Table 1.

At present, Valencia Well E-15 has been equipped with a permanent pump and appurtenant facilities to render it operational at its design capacity of 1,400 gpm. The other three wells have been approved by DHS for addition to Valencia's Water Supply Permit, but have not been equipped pending further development and associated increase in water demands.

Table 1
Design and Construction Features
Valencia Water Company Wells E14-E17

	Well			
	E14	**E15**	**E16**	**E17**
Test Hole/Pilot Hole Depth (ft.)	191	200	200	194
Production Borehole Depth (ft.)	150	180	184	160
Well Depth (ft.)	135	160	170	150
Well Diameter (ft.)	18	18	18	18
Well Casing Depth (ft.)	0-76 114-135	0-92 133-160	0-82 145-170	0-81 121-150
Well Screen Depth (ft.)	76-114	92-133	82-145	81-121
Design Capacity (gpm)	1,200	1,400	1,200	1,000
Specific Capacity (gpm/ft.)	65.9	62	61.8	34.1

Groundwater Flow

There is no known occurrence of perchlorate contamination in the Alluvium anywhere near the new Valencia E wells. Consequently, it is illogical to think that the E wells, regardless of design capacity or future operation, would induce the movement, or capture, of perchlorate-contaminated groundwater as a result of their pumping. However, to examine what might theoretically be captured by the new Valencia E wells, consideration was given to the limited detection of perchlorate in the Alluvium, about five miles east of those wells, and the general movement of groundwater in the Alluvium, both regionally and locally near the E wells.

In the Alluvium, groundwater flow is generally recognized to be aligned with the Santa Clara River and its tributaries. For the most part, groundwater levels west of Bouquet Canyon remain relatively constant over time, suggesting that both the direction and rate of groundwater flow do not vary widely in that part of the aquifer system. East of Bouquet Canyon, the Alluvium has experienced groundwater level fluctuations of varying magnitudes, generally increasing to the east, through wet and dry periods. Examination of the fluctuations suggests that the overall flow direction has remained westerly and southwesterly beneath the Santa Clara River and its main tributaries respectively, although the rate of groundwater flow has fluctuated as groundwater levels have changed.

More specifically for purposes of this analysis, groundwater flow in the vicinity of the Valencia E wells, and upgradient from the vicinity of the E wells to the area where perchlorate has been detected in the Alluvium, was examined by preparing contour maps of equal groundwater elevation for both wet and dry climatic conditions, i.e. high and low groundwater levels. The resultant contour maps are illustrated in Figures 2 and 3. Unaffected by local groundwater level drawdown directly attributable to pumping operations, groundwater flow directions in the Alluvium, in both wet and dry periods, are generally westerly beneath the Santa Clara River from the vicinity of Bouquet Canyon where the only two Alluvial production wells ever impacted by perchlorate are located. Near the E wells themselves, there is a confluence of groundwater flow, with some southerly inflow beneath Castaic Creek joining the predominant westerly to southwesterly groundwater flow at the mouth of the Castaic Creek Canyon and its confluence with the main Santa Clara River Valley. The hydraulic gradient in both wet and dry periods is approximately 30 feet per mile. The lack of significant differences in groundwater flow directions and hydraulic gradients between the wet and dry periods is consistent with the generally stable groundwater level conditions in the westerly portion of the overall groundwater basin, west of the mouth of Bouquet Canyon.

Considering the locations of the E wells relative to the surrounding groundwater flow directions, a component of flow into the E wells can be expected to be from the upgradient easterly direction. Further considering the confluence of groundwater flow from the north (Castaic Canyon) with the regional flow from the east, it is also likely that a component of flow into the E wells will be from the upgradient northerly direction. Of course, pumping operations at the wells themselves will locally alter the gradient and associated flow directions, potentially resulting in inflow to the wells from cross-gradient and downgradient directions.

Capture Zone Simulation

The nature of drawdown around one or more pumped wells, and the resultant impact on local groundwater flow, i.e. "capture" of groundwater by the well(s), is directly affected by several factors related to the well(s) and the aquifer in which they are completed. Well parameters include pumping capacity and duration of pumping cycles (time). Aquifer parameters include hydraulic conductivity, transmissivity, and storage coefficient of the aquifer materials. Design capacities for all four E wells are listed in Table 1; in summary, they are 1,000 to 1,400 gpm. Pumping cycles for all the Valencia wells are variable as water requirements fluctuate through the year. During peak demand periods, some wells can operate as much as all day, or slightly longer. However, for all Valencia wells as a group, long-term average pumping cycles are about 8 hours per day. For the conservative analytical purposes described herein, drawdown due to pumping of the new Valencia E wells and the associated capture zone formation were based on hypothetical continuous pumping equivalent to intermittent pumping for an average of 8 hours per day. The duration of such hypothetical continuous pumping can be widely varied as a function of other water supply considerations. In light of other perchlorate-related activities in the Valley, with recognition of the plans to start construction later in 2006 for perchlorate control and extraction from the Saugus Formation, the theoretical capture associated with assumed continuous pumping of the E wells was analyzed for a two year period.

In selecting the two year period for theoretical independent capture zone analysis, it should be recognized that there is no absolute nexus between the planned construction of perchlorate containment facilities in the Saugus Formation and any significant change in the Alluvial aquifer that would further protect the E wells. While previous analyses of Saugus containment have included a small component of containment-type capture of Alluvial groundwater, that ultimate effect will be a small incremental addition to the nature of "containment" that results from the regular operation of numerous high capacity Alluvial wells between the E wells and the limited detection of perchlorate in the Alluvium. The capture zone analysis described herein is theoretical and independent in the sense that it purposely ignores the containment and capture effects of all intervening pumping between the E wells and the area of perchlorate detection in the Alluvium. The two year capture zone time period was simply utilized to conservatively examine the potential capture of perchlorate in spite of the actual operation of intervening wells, through a time period until some additional control of migration would be added to the rest of ongoing Alluvial pumping.

A final comment on the two year time period selection is to recognize that, again ignoring the effects of all other Alluvial pumping, in particular the "containment" effects of intervening pumping between the E wells and the historical detection of perchlorate in the Alluvium, the capture zone of the new E wells could theoretically be extended incrementally farther upgradient by simply extending the simulated time period. Ultimately, a scenario could be crafted to show theoretical "capture" of groundwater from an area where perchlorate has been detected. However, such an interpretation would be unrealistic in light of a combination of actual pumping practices and natural processes in the aquifer system as discussed below. In summary, the two-year theoretical independent capture zone is presented for theoretical, conservative illustration purposes; however, it should not be interpreted as the probable real capture zone of the E wells for the collection of reasons discussed below.

Based on interpretation of aquifer tests, and consistent with hydraulic aquifer characteristics used in the recently completed numerical groundwater flow model of the basin, a theoretical, independent capture zone analysis was conducted using a steady-state, single-layer numerical flow model of the Alluvium. The model incorporated specific yield (storage coefficient) and hydraulic conductivity values consistent with the recently completed basin-wide groundwater flow model developed by CH2M Hill. The steady-state model incorporated a specific yield value of 0.1, hydraulic conductivity values that ranged from 105 to 550 feet per day, and transmissivity values that ranged from 200,000 to 600,000 gpd/ft. The model was calibrated to the contours of equal groundwater elevations in the Alluvium presented in the 2004 CH2M Hill regional flow model report. Assumptions incorporated into the model included no change in aquifer storage, which is supported by a review of Alluvium groundwater elevations and the minimal amount of storage change over the past several decades.

As discussed above, the theoretical, independent capture zone analysis simulated the extent of the E Wells capture of groundwater flow over a two-year period. In addition to the conservative nature of the capture zone analysis that ignored all other pumping and related capture or "containment", the E well analysis was further conservative in that it assumed actual operation of all those wells, at their design capacities of 1,000 to 1,400 gpm, when in reality only one of the wells is currently equipped and operational, and the other three wells are not scheduled to become operational until water requirements increase.

Based on a combination of the aquifer characteristics and equivalent full time pumping for two years as described above, assuming all four Valencia E wells are operational, the theoretical independent capture zone for the new Valencia E wells would primarily extend upgradient in two directions: up to about 13,000 feet, or about 2.5 miles, northerly and easterly. The extent and shape of the integrated capture zones of all four E wells is illustrated in Figure 4. The outer bounds of the integrated individual capture zones of the individual wells are illustrated; each individual well's capture zone is a narrower, elongated zone, parallel to the overall integrated capture zone as illustrated in Figure 4.

Perchlorate Contamination in the Alluvium

The overall issue of perchlorate contamination of groundwater in the Santa Clarita Valley has primarily impacted the Saugus Formation, where four municipal wells have been out of service due to perchlorate since 1997. The Alluvium, on the other hand, has been impacted to a notably lesser extent. From the perspective of impacted municipal water supply wells, Santa Clarita Water Division's Stadium well was the first and, for a long time, the only Alluvial well impacted by perchlorate. The Stadium well is located on the south side of the Santa Clara River, upstream of its confluences with Bouquet Canyon and the South Fork of the Santa Clara River. The Stadium well is also located adjacent to the Northern Alluvium area on and immediately adjacent to the northern-most part of the Whittaker-Bermite site. The initial detection of perchlorate in that well was 5.9 g/l in 2002. The Stadium well has been removed from municipal service since the initial detection of perchlorate.

The only other detection of perchlorate in an Alluvial water supply well was in March and April 2005 when Valencia's Well Q2 was found to have low concentrations of perchlorate. Well Q2 is located on the north side of the Santa Clara River, on the west side of its confluence with Bouquet Creek. Initial detection and confirmation sampling of Well Q2 ranged between 9.8 and 11 g/l. After confirmation of perchlorate in April, Valencia temporarily removed the well from service and proceeded with a fast-track permitting and construction program to install wellhead treatment and return the well to service. That work was completed in September and Well Q2 has been in service, with wellhead treatment, since October 2005. Since then, however, the only indications of perchlorate at Well Q2 have been below the analytical detection limit of 4 g/l.

In addition to the limited detection of perchlorate in two municipal supply wells as described above, off-site investigation of perchlorate associated with the Whittaker-Bermite site has identified low concentrations (less than 10 g/l) in shallow Alluvium near Valencia's Pardee well field (Wells N, N7 and N8). Those detections have all been from sampling of shallow groundwater, above 50 feet and also above the intake (screened) sections of those wells. Despite those detections, however, there has been no detection of perchlorate in the nearby, deeper completed production wells.

Whittaker-Bermite has recently initiated actions to pump a production well, and to also extract from several small monitoring wells, as part of perchlorate containment efforts in the Northern Alluvium. The extracted water will be treated for perchlorate removal and then discharged to the Santa Clara River system. These pump and treat activities are intended to subsequently expand as necessary the remediation of perchlorate contamination in the Alluvium, immediately upgradient of the Stadium well, and also upgradient of the other municipal production wells in the vicinity of the Whittaker-Bermite site.

Potential Capture of Perchlorate by Valencia's E Wells

As illustrated in Figure 4, the theoretical independent capture zone of Valencia's new E wells, after an equivalent two year period of continuous pumping of all four wells, would extend toward the area where perchlorate has been detected in two Alluvial water supply wells (Stadium and Q2). However, the capture zone would not extend as far as any historical detection of perchlorate in the Alluvium, whether in production wells or as part of the off-site investigation of the Whittaker-Bermite site. Literal interpretation of the extent of the capture zone and the known detection of perchlorate would be that the E wells can be expected to not capture perchlorate-contaminated groundwater over the time period of analysis, which includes the period of construction and initial operation of facilities to contain and extract perchlorate from the Saugus Formation. However, as discussed above, such an expectation can be interpreted two ways: that the E wells are thus not a risk or, conversely, that the E wells could be at risk if the capture zone analysis were simply extended for sufficient time to encounter areas of perchlorate detection. As also discussed above, the planned containment and extraction of perchlorate in the Saugus Formation is expected to have a small effect on the Alluvium, but not to the extent that it will sufficiently contain perchlorate that downgradient wells can be considered to be protected. Thus, it could be reasoned that the capture zone should be analyzed for a longer pumping period, i.e. beyond the two years related to construction of the Saugus containment facilities. In simple summary, given the nature of groundwater flow direction and the hydraulic properties of the Alluvial aquifer, it is possible to model sets of conditions that would result in theoretical "capture" of groundwater from the area where perchlorate has been detected in the Alluvium. However, recognizing that such a result could be simulated, it should also be recognized that, for the reasons discussed below, such a result should not be interpreted to conclude that the E wells are at risk. In fact, it is logical to conclude, again for the reasons discussed below, that the E wells are likely not at risk.

Upgradient of the E wells in the direction of perchlorate detection in the Alluvium are several high capacity production wells, all of which are artificially removed from the simulated capture zone analysis, but all of which represent actual pumping locations that provide a combination of containment in the aquifer and potential capture of perchlorate if it were to mobilize that far from where it has been detected. For reference with regard to mobility, as discussed above, sampling of shallow portions of the Alluvium near the Pardee well field has detected low concentrations of perchlorate, but the nearby production wells have not detected any perchlorate. Ongoing pumping for water supply since the initial detections of perchlorate (in the Saugus Formation in 1997 and in the Alluvium in 2002) have resulted in only one additional Alluvial production well impact: Valencia's Well Q2 which was briefly impacted but has not detected perchlorate since it was equipped with wellhead treatment and returned to service in October 2005. All other

Alluvial wells between the Whittaker-Bermite site and the E wells have not been impacted despite closer proximity to detected perchlorate and regular water supply pumping for at least four years since perchlorate was first encountered.

The Alluvial production wells between the E wells and the area of detected perchlorate can be considered in three groups, progressively farther from the E wells: the S well field (Wells S6, S7, and S8); the Pardee well field (Wells N, N7 and N8); and Well Q2. Collectively, all those wells have a total pumping capacity of nearly 13,500 gpm, or nearly three times the total design capacity of the E well field. The S well field has existing pumping capacity of 6,000 gpm; the Pardee well field has existing pumping capacity of 6,250 gpm; and Well Q2 is equipped to pump and treat 1,200 gpm. Collectively and as individual wells or groups of wells, those various wells represent significant local pumping locations that provide a form of "containment", if perchlorate were to migrate to any of those areas, against further downgradient movement; and they represent significant extraction rates that would also extract perchlorate, again if it were to migrate to any of those areas. As described above, Well Q2 is already equipped to treat any perchlorate if it were to re-impact that well. The other intervening wells are not equipped with wellhead treatment; however, as is also the case at the E wells, all are designed with wellhead space and provisions for installation of treatment facilities, as was rapidly done at Well Q2 when perchlorate was detected, to enable their continued operation for perchlorate containment and extraction if they are impacted. Thus, the collective intervening wells represent a real pumping scenario that, in effect, produces pumping interruptions of the independent, theoretical capture zone of the E wells described and illustrated above.

In light of all the preceding, it can be concluded that, while a theoretical capture zone can be simulated to show that, with sufficient extended pumping, the new Valencia E wells might "capture" groundwater from areas where perchlorate has been detected in the Alluvium, such a capture zone analysis would necessarily be overly theoretical and conservative because it ignored the intervening effects of numerous other high capacity pumping. It also ignored the actual observations that have shown no detection of perchlorate in all but one of those intervening wells after at least four years of regular pumping operations since initial detection of perchlorate in the Alluvium. The presence of those wells, combined with the existing wellhead treatment at one of them and the provisions for installation of treatment at all the others if ever necessary, represents significant containment of potential perchlorate migration toward the E wells, again assuming perchlorate first migrates as far as the intervening wells. Thus, it can be concluded that the E wells are not at risk of capturing perchlorate from areas in the overall Alluvial aquifer system where it has previously been detected.

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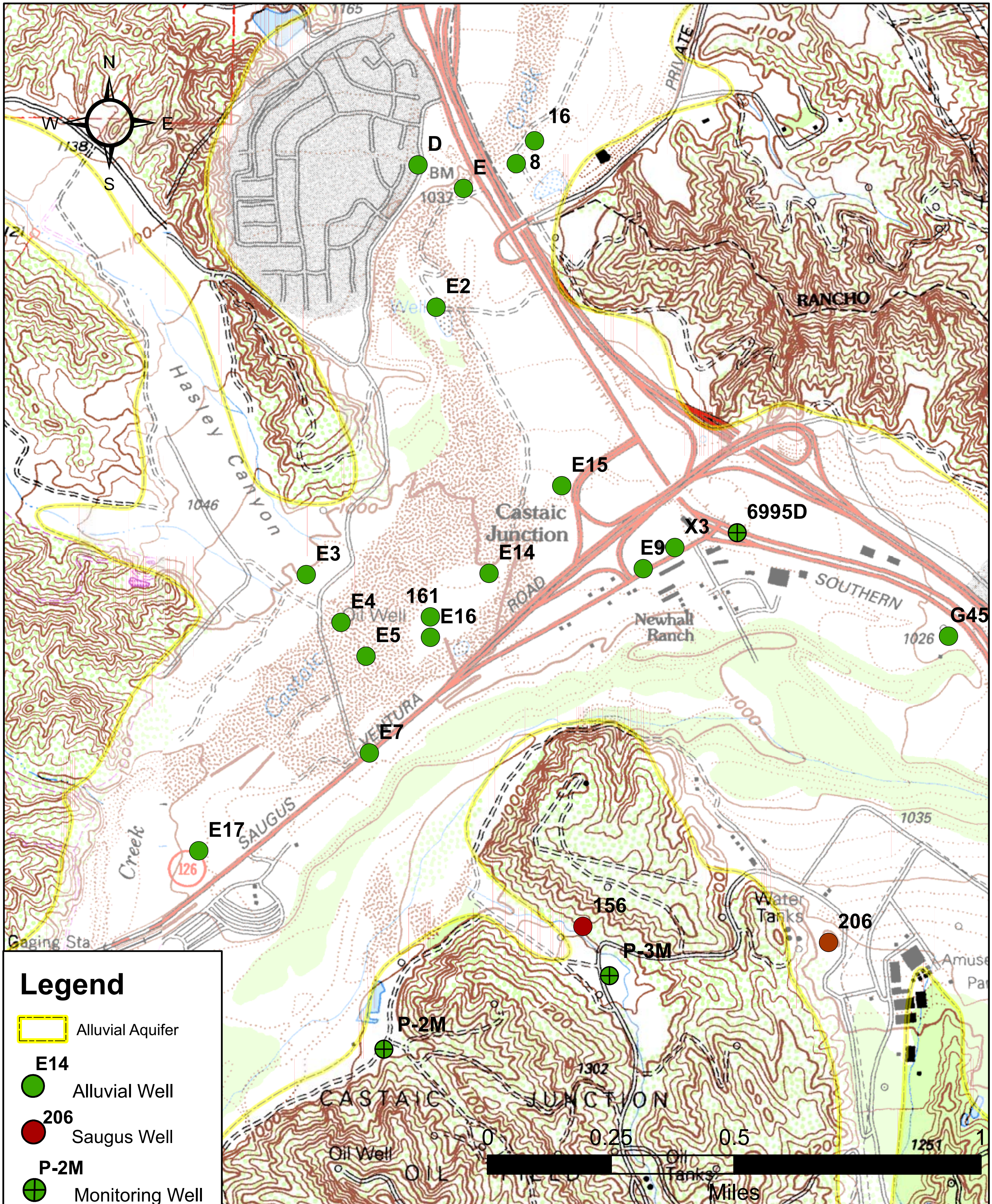

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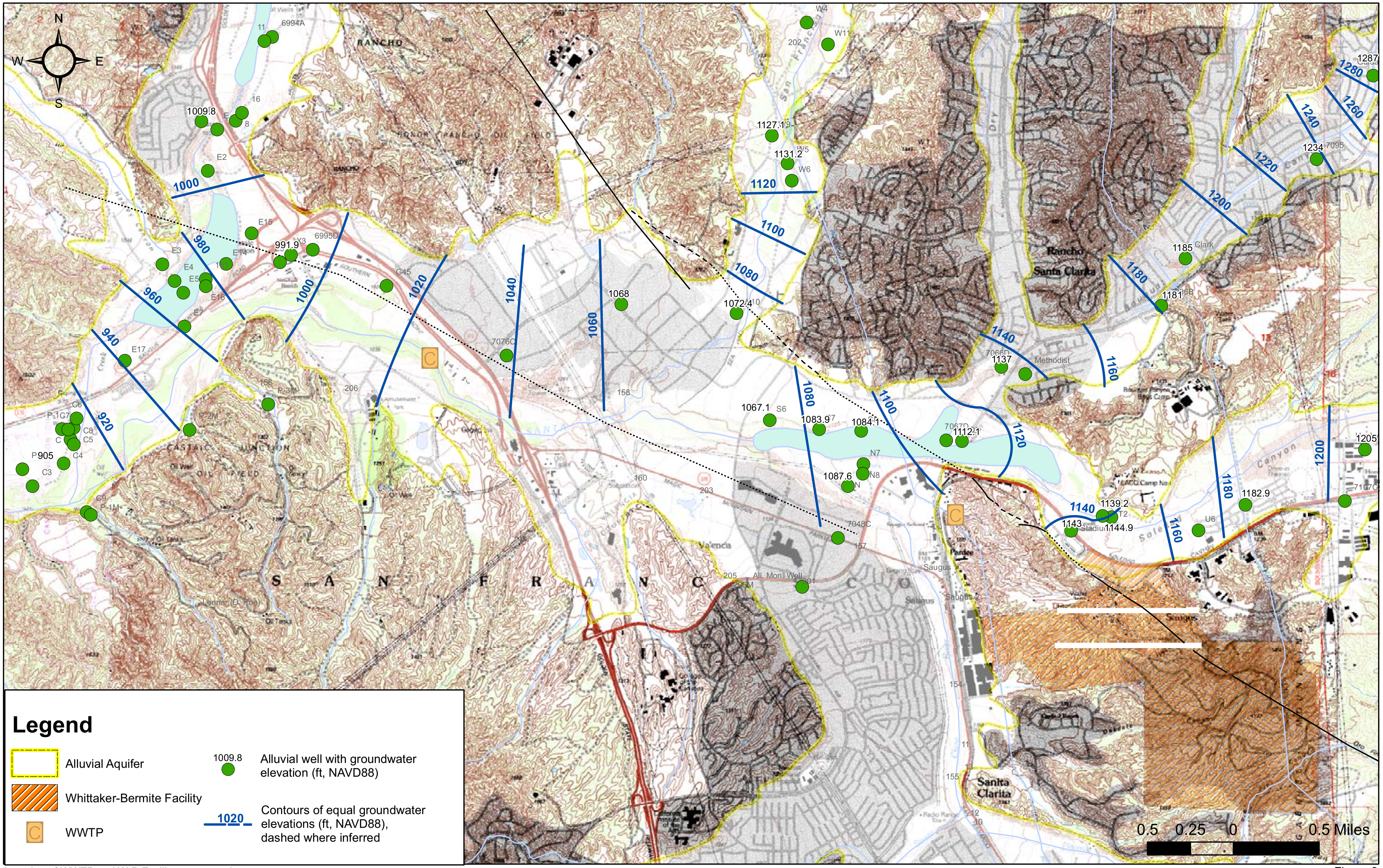
Figure 1
Well Location Map



Location of WWTP and W-B Facility are approximate.

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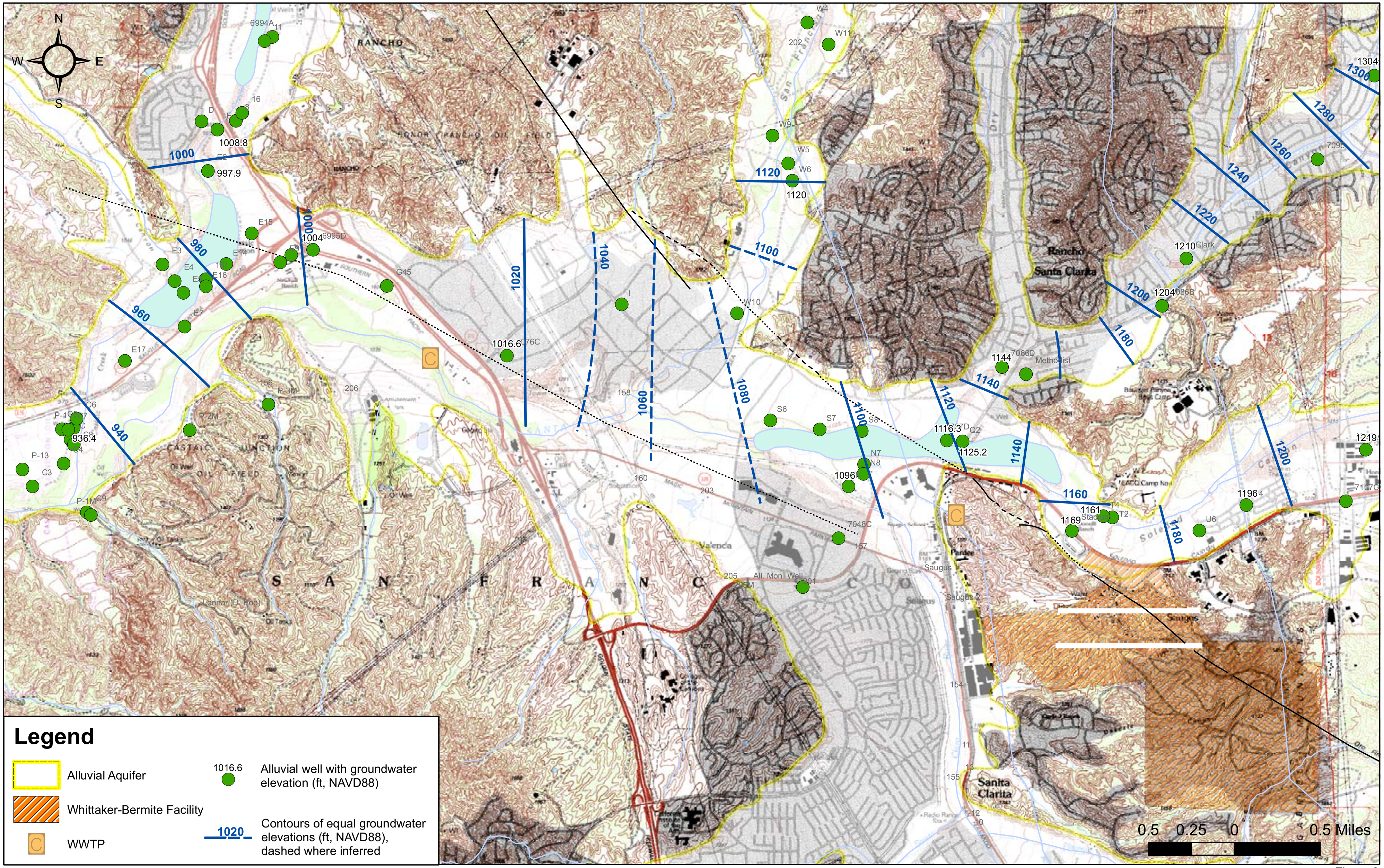
Figure 3
Contours of Equal Groundwater Elevation in Alluvium
Wet Period, Spring 2004



Legend

- Alluvial Aquifer
- Whittaker-Bermite Facility
- WWTP
- 1016.6 Alluvial well with groundwater elevation (ft, NAVD88)
- 1020 Contours of equal groundwater elevations (ft, NAVD88), dashed where inferred

Location of WWTP and W-B Facility are approximate.

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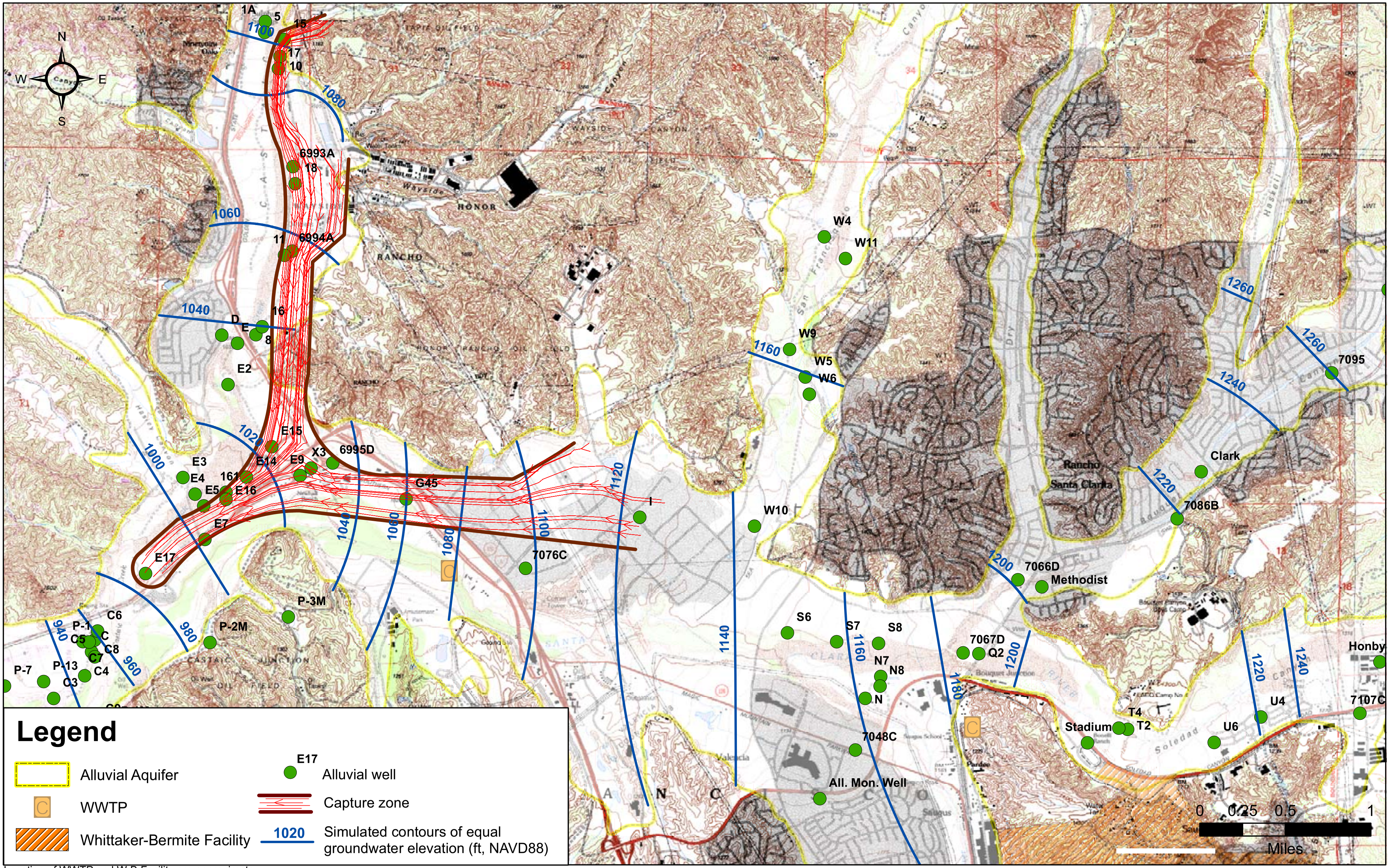
Figure 2
Contours of Equal Groundwater Elevation in Alluvium
Dry Period, Spring 1992



Location of WWTP and W-B Facility are approximate.

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Figure 4
Valencia E Well Capture Zone
Two-Year Groundwater Travel Time Simulation