Appendix C
Groundwater Resources and Yield In the Santa Clarita Valley

Appendix C
Groundwater Resources and Yield in the Santa Clarita Valley

Introduction

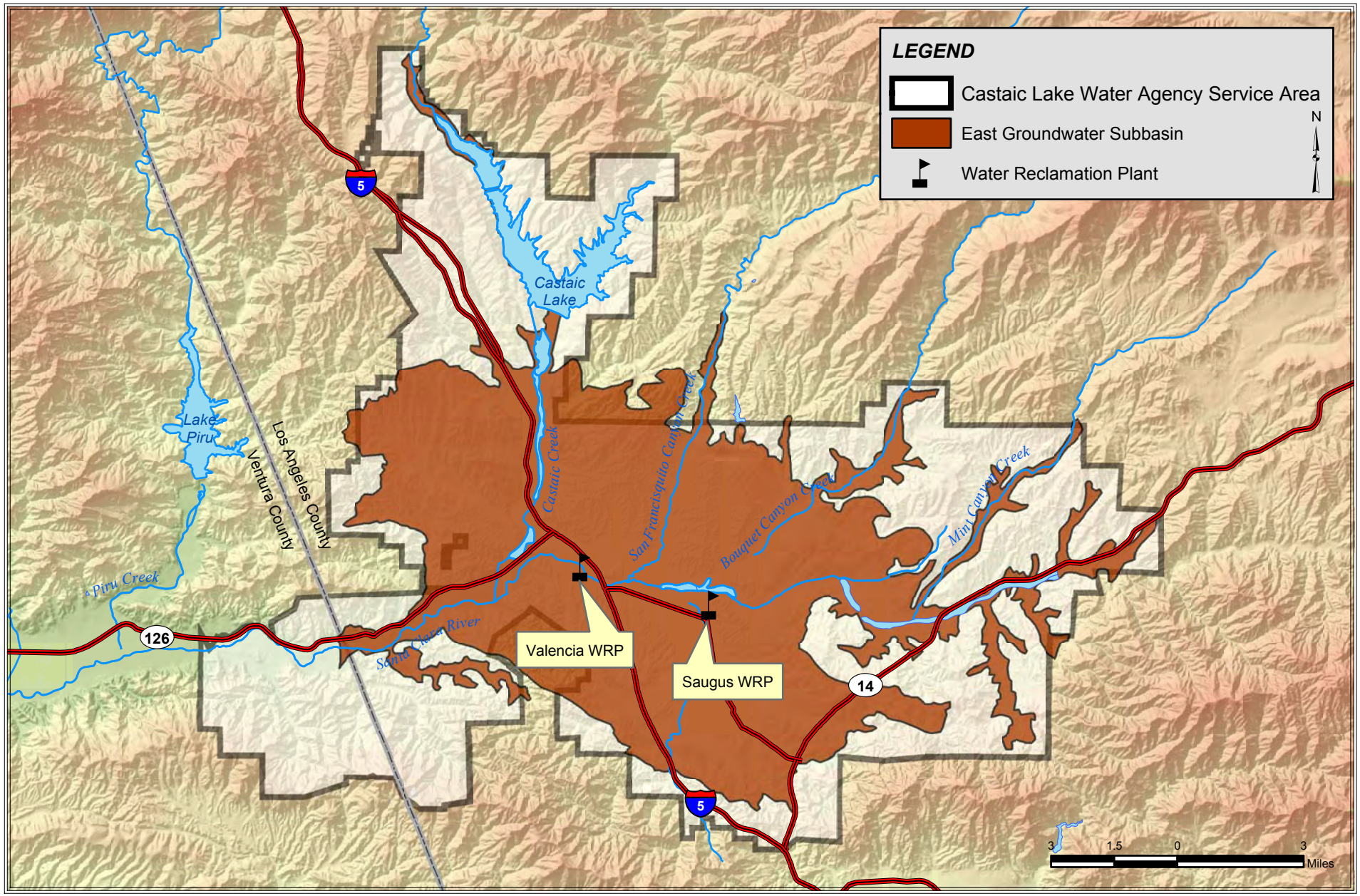
Beginning in the early part of the twentieth century, and continuing through the 1970s, local groundwater extracted from the two aquifers that comprise the local groundwater basin was the Santa Clarita Valley's sole source of water supply. Since 1980, local groundwater supplies have been supplemented with imported surface water from the State Water Project (SWP). In 2003, augmentation of those water supplies began with the initiation of deliveries from Castaic Lake Water Agency's (CLWA) recycled water system, which is anticipated to increase with time.

Santa Clara River Valley Groundwater Basin – East Subbasin

The groundwater basin generally beneath the Santa Clarita Valley, identified in the California Department of Water Resources' (DWR) Bulletin 118, 2003 Update as the Santa Clara River Valley Groundwater Basin, East Subbasin (Basin) (Basin No. 4-4.07), is comprised of two aquifer systems. The Alluvium generally underlies the Santa Clara River and its several tributaries and the Saugus Formation underlies practically the entire Upper Santa Clara River area. There are also some scattered outcrops of Terrace deposits in the Basin that likely contain limited amounts of groundwater; however, since these deposits are located in limited areas that are situated at elevations above the regional water table and are also of limited thickness, they are of no practical significance as aquifers and consequently have not been developed for any significant water supply. Figure C-1 illustrates the mapped extent of the Basin in DWR Bulletin 118 (2003), which approximately coincides with the outer extent of the Alluvium and Saugus Formation, and its relationship to the extent of the CLWA service area.

A 2001 Update Report on both the Alluvium and Saugus Formation Aquifers was completed by Richard C. Slade and Associates, Consulting Groundwater Geologists (Slade, 2002). That report updated the analyses and interpretation of hydrogeologic conditions from earlier reports (Slade, 1986 and 1988), including extensive detail on major aspects of the groundwater Basin. Notable parts of the 2001 Update Report includes:

- Description of the extensive additional data available since the original Alluvium and Saugus Formation reports were prepared in 1986 and 1988, respectively
- Organization of historic data into a Geographic Information System (GIS) database
- Description of the overall groundwater basin in conformance with that being mapped by the Department of Water Resources in Bulletin 118 (2003)



LUHDORFF & SCALMANINI
CONSULTING ENGINEERS

Figure C-1
Santa Clara River Valley
East Groundwater Subbasin

- Analysis of historical groundwater levels and production, and conclusions that there have been no conditions that would be illustrative of groundwater overdraft
- Suggestion that utilization of operational yield (as opposed to perennial yield) as a basis for managing groundwater production would be more applicable in this basin to reflect
- Fluctuating utilization of groundwater in conjunction with utilization of imported SWP water
- Conclusion that operational yield of the Alluvium is 30,000 to 40,000 acre-feet per year (afy) for wet and average/normal rainfall years, with an expected reduction into the range of 30,000 to 35,000 afy in dry years
- Conclusion that operational yield of the Saugus Formation would be in the range of 7,500 to 15,000 afy on a long-term basis, with short-term increases during dry periods into a range of 15,000 to 25,000 afy, and to 35,000 afy if dry year conditions continue

Groundwater Management Plan

As part of legislation authorizing CLWA to provide retail water service to individual municipal customers in addition to its ongoing wholesale water supply, Assembly Bill 134 (2001) included a requirement that CLWA prepare a groundwater management plan in accordance with the provisions of Water Code Section 10753, which was originally enacted by, and is commonly known as, Assembly Bill 3030. The general contents of CLWA's groundwater management plan were outlined in 2002, and a detailed plan was drafted and adopted in 2003 to satisfy the requirements of AB 134. The plan both complements and formalizes a number of existing water supply and water resource planning and management activities in CLWA's service area, which effectively encompasses the East Subbasin of the Santa Clara River Valley Groundwater Basin.

CLWA adopted the Groundwater Management Plan (GWMP) in December 2003. As part of the GWMP, four management objectives, or goals, were established for the Basin including: (1) development of an integrated surface water, groundwater, and recycled water supply to meet existing and projected demands for municipal, agricultural, and other water uses; (2) assessment of groundwater Basin conditions to determine a range of operational yield values that will make use of local groundwater conjunctively with supplemental SWP supplies and recycled water to avoid groundwater overdraft, (3) preservation of groundwater quality, including active characterization and solution of any groundwater contamination problems, and (4) preservation of interrelated surface water resources, which includes managing groundwater to not adversely impact surface and groundwater discharges or quality to downstream basin(s).

The adopted GWMP includes 14 elements that are intended to accomplish the Basin management objectives listed above. In summary, the plan elements include:

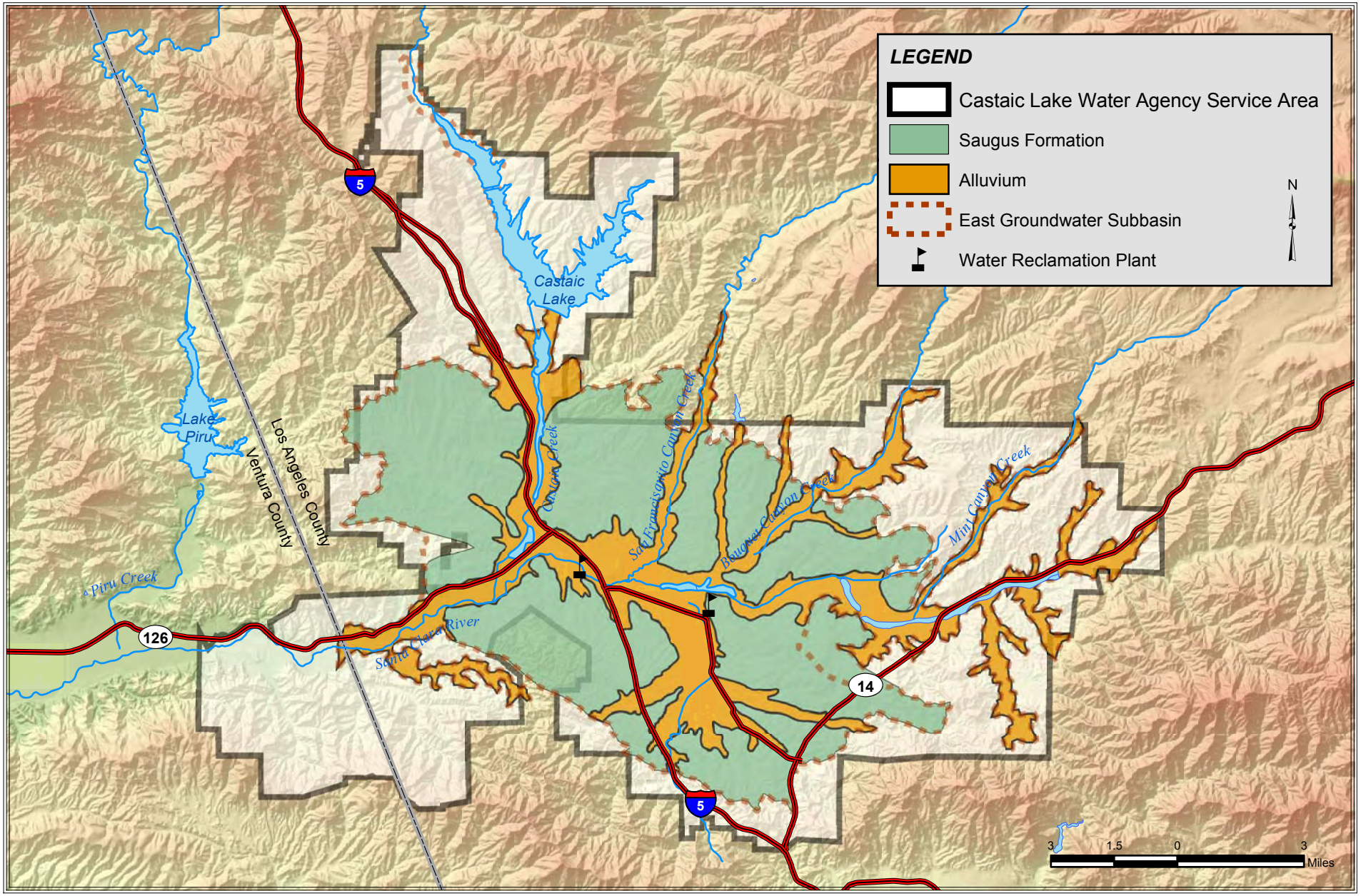
- Monitoring of groundwater levels, quality, production and subsidence
- Monitoring and management of surface water flows and quality
- Determination of Basin yield and avoidance of overdraft

- Development of regular and dry-year emergency water supply
- Continuation of conjunctive use operations
- Long-term salinity management
- Integration of recycled water
- Identification and mitigation of soil and groundwater contamination, including involvement with other local agencies in investigation, cleanup, and closure
- Development and continuation of local, state and federal agency relationships
- Groundwater management reports
- Continuation of public education and water conservation programs
- Identification and management of recharge areas and wellhead protection areas
- Identification of well construction, abandonment, and destruction policies
- Provisions to update the groundwater management plan

Alluvium – General

The Alluvial Aquifer system, of Quaternary to Holocene (recent) geologic age, consists primarily of stream channel and flood plain deposits of the Santa Clara River and its tributaries. The Alluvium is deepest along the center of the present river channel, with a maximum thickness of about 200 feet near the Saugus area. It thins toward the flanks of the adjoining hills and toward the eastern and western boundaries of the Basin and, in the tributaries, becomes a mere veneer in their upper reaches. The spatial extent of the Alluvium throughout the Basin is illustrated in Figure C-2.

Groundwater generally moves westward toward the outlet of the Basin, which is also the outlet of the Upper Santa Clara River Hydrologic Area. Thus, groundwater movement in the Alluvium beneath the tributaries is toward their confluence with the Santa Clara River and then westward in the Alluvium. From about Castaic Junction to Blue Cut, the Alluvium thins and narrows. This configuration forces groundwater to rise, keeping the depth to water at or close to the land surface. As discussed in more detail below, the general groundwater flow direction has remained unchanged whether groundwater levels are high or intermittently depressed. The San Gabriel and Holser faults traverse the Basin but neither fault measurably affects groundwater levels or flows in the Alluvium.

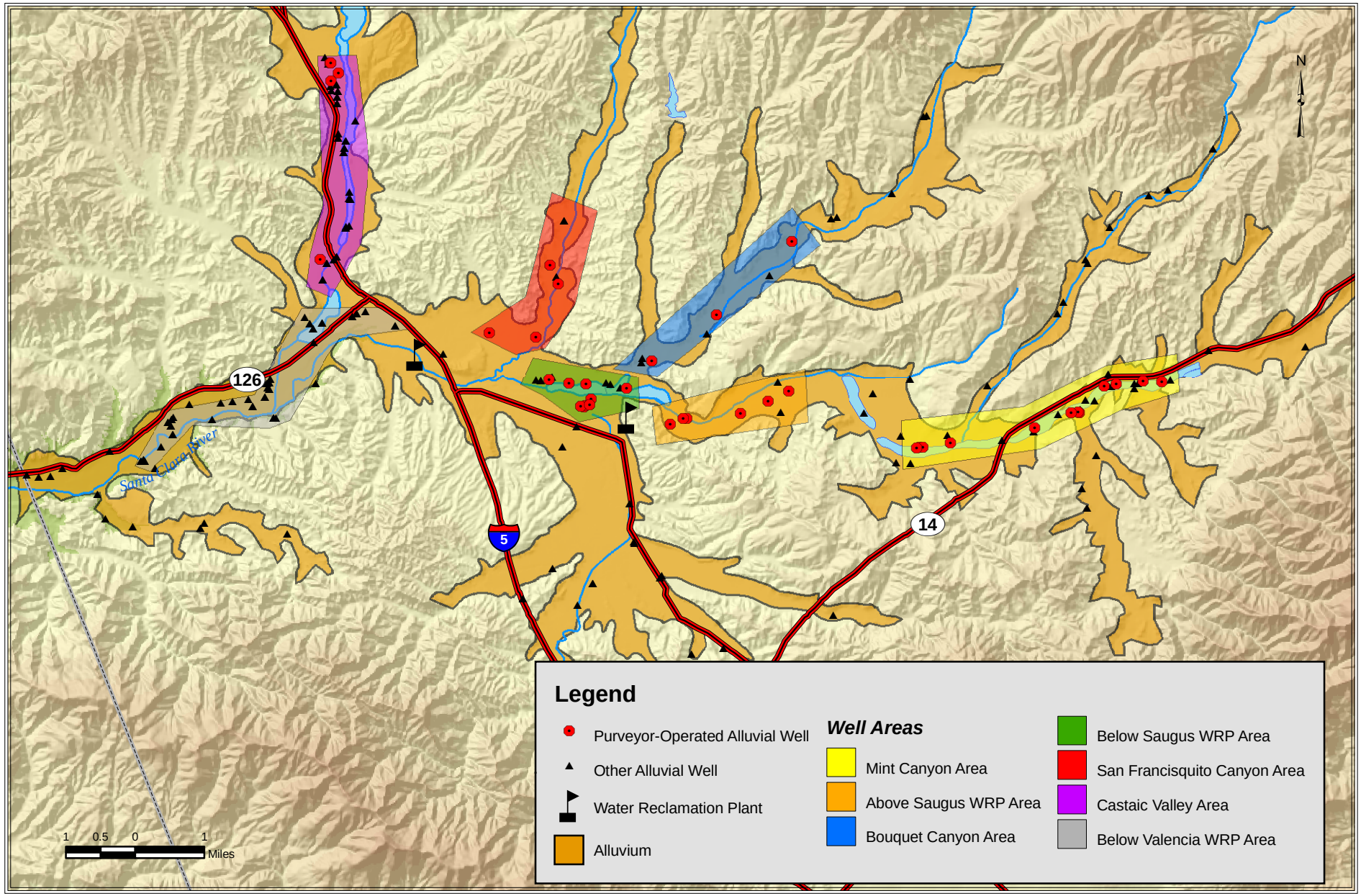


LUHDORFF & SCALMANINI
CONSULTING ENGINEERS

Figure C-2
Alluvial and Saugus Formations
Santa Clara River Valley East Groundwater Subbasin

Alluvial wells are distributed throughout the basin along the Santa Clara River and its southwest draining tributaries. Figure C-3 illustrates the location of the wells operated by retail water purveyors and other known Alluvial wells in the Basin. The Alluvium is the most permeable of the local aquifer units. Based on well yields and aquifer testing, estimated transmissivity values of 50,000 to 500,000 gallons per day per foot have been reported for the Alluvium, with the higher values where the Alluvium is thickest in the center of the Valley and generally west of Bouquet Canyon. The amount of groundwater in storage in the Alluvium can vary because of the effects of recharge, discharge, and pumping from the aquifer. The maximum storage capacity of the Alluvium has been estimated to be 240,000 acre-feet (af).

Consistent with the 2001 Update Report (Slade, 2002), the current management practice of the local retail water purveyors is to continue a groundwater operating plan that generally results in total Alluvial pumping in the range of 30,000 to 40,000 afy, slightly reduced to 30,000 to 35,000 afy in dry periods. This operating plan maximizes use of the Alluvium because of the aquifer's ability to store and produce good quality water on a perennial basis, and because the Alluvium is capable of rapid recovery of water levels and storage in wet periods. As with many groundwater basins, it is possible to intermittently exceed the long-term average yield for one or more years without long-term adverse effects. In the eastern part of the Alluvial Aquifer system, pumping during dry periods results in intermittently lower water levels in that portion of the aquifer. However, management of pumping during dry periods limits the lowering of water levels, and normal-to-wet period recharge results in a rapid return of groundwater levels to historic highs. Historical groundwater data collected from the Alluvium over many hydrologic cycles provides assurance that groundwater elevations return to normal in average or wet years following periods during which the groundwater elevations have declined. In addition, high rainfall totals in only one to two years generally will cause water levels within the Alluvium to rise quickly and by a relatively large amount. Such water level response to rainfall is a significant characteristic of permeable, porous, alluvial aquifer systems that occur within large watersheds.



LUHDORFF & SCALMANINI
CONSULTING ENGINEERS

Figure C-3
Alluvial Well Locations
Santa Clara River Valley, East Groundwater Subbasin

Alluvium – Historical and Current Conditions

Total pumpage from the Alluvium in 2004 was about 33,800 af, of which about 56 percent (19,000 af) was for municipal water supply, and the balance, about 44 percent (14,800 af), was for agriculture and other (minor) miscellaneous uses.

Alluvial pumpage has been recorded intermittently since the mid-1940s, and consistently since 1980. When pumpage records are unavailable (e.g., in the 1970s), data has been approximated to obtain a continuous historic record (Figure C-4). Alluvial pumpage from private wells, estimated to be at most 500 afy, has been included in the total Alluvial pumpage. Since the inception of SWP deliveries to CLWA in 1980, total pumpage from the Alluvium has ranged from a low of about 20,000 afy (in 1983) to slightly more than 43,000 afy (in 1999). Agricultural pumpage remained stable from the mid-1940's through about 1960, generally ranging from 33,000 to 37,000 afy, with annual pumpage as high as 41,000 af. From 1960 through the late 1970's, agricultural pumpage declined in a nearly linear trend, and has fluctuated slightly since then, between approximately 10,000 and 16,000 afy. As agricultural pumpage declined, municipal pumpage from the Alluvium increased from less than 4,000 afy in the 1950s to approximately 17,000 af in 1980. Beginning in 1980 with the importation of SWP water, municipal pumpage from the Alluvium declined to about 12,500 afy and remained stable throughout the 1980's. Municipal pumpage has subsequently increased to the current range of approximately 20,000 to 25,000 afy. Overall, there has been a change in municipal/agricultural pumping distribution since 1980, toward a slightly higher fraction for municipal water supply (from about 50 percent to nearly 60 percent of Alluvial pumpage), which reflects the general land use changes in the Valley.

The most recent analysis of the Alluvium (Slade, 2002) suggested that the operational yield of the Alluvium is 30,000 to 40,000 afy in average/normal and wet years, with a reduction to 30,000 to 35,000 afy in dry years. On a long-term basis since the importation of SWP water, total Alluvial pumpage has been about 30,500 afy (31,300 af in years with less than average precipitation, and 29,400 af in years with greater than average precipitation). These amounts are at the lower end of the range of operational yield of the Alluvium.

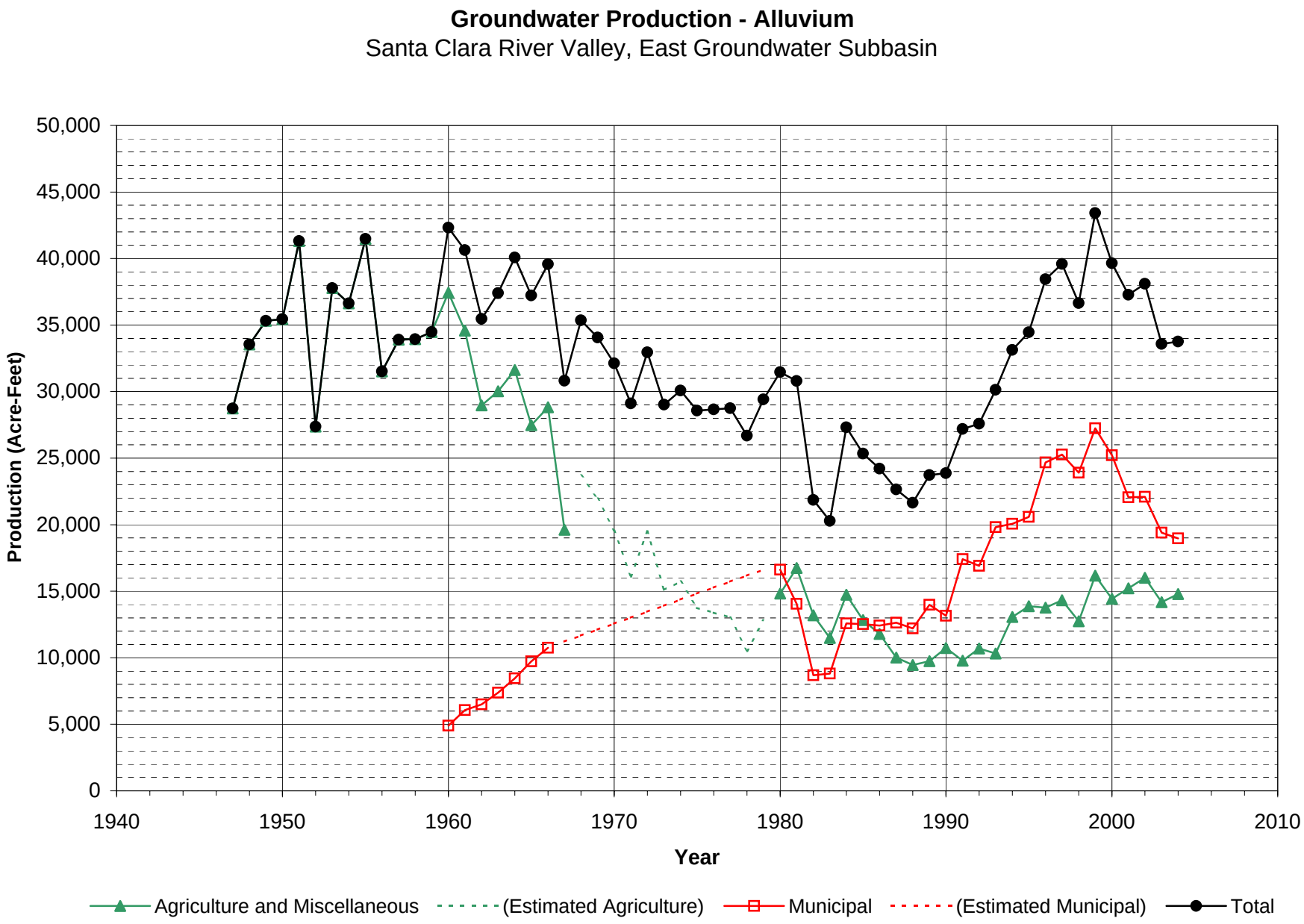

Groundwater Production - Alluvium
Santa Clara River Valley, East Groundwater Subbasin
Production (Acre-Feet)
50,000
45,000
40,000
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
1940
1950
1960
1970
1980
1990
2000
2010
Year
Agriculture and Miscellaneous
(Estimated Agriculture)
Municipal
(Estimated Municipal)
Total

Figure C-4

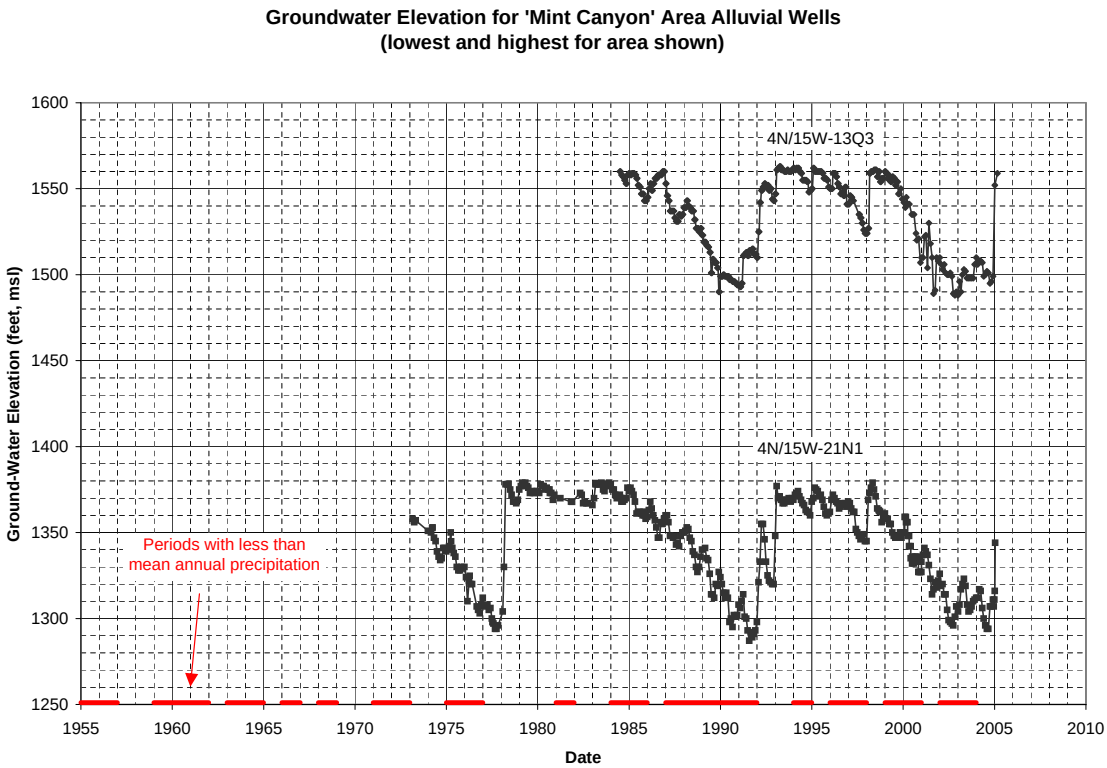
Groundwater levels in various parts of the Basin have historically exhibited different responses to both pumpage and climatic fluctuations. During the last 20 to 30 years, in essentially all the alluvial portions of the Basin, groundwater levels have fluctuated from near the ground surface when the Basin is full, to as much as 100 feet lower when the Basin is pumped during intermittent dry periods of reduced recharge. Figure C-3 groups the Alluvial wells into areas with similar groundwater level fluctuations. Figures C-5 and C-6 present historical groundwater levels organized into hydrograph form (groundwater elevation vs. time) for four of these areas in the Basin. The other areas shown in Figure C-3 exhibit groundwater level responses similar to those in these four areas.

The 'Mint Canyon' area is located at the far eastern end of the Basin along the Santa Clara River. In this area, the Alluvium is shallower than in the western parts of the Basin; consequently, the area has historically exhibited the most dramatic responses to climatic fluctuations. The 'Above Saugus WRP' and 'Bouquet Canyon' areas generally exhibit groundwater level responses that are similar to those in the 'Mint Canyon' area.

The 'Below Saugus WRP' area is located along the Santa Clara River immediately downstream of the Saugus Water Reclamation Plant (WRP). This area has shown a dramatic increase in groundwater levels (30 to 60 feet) since the 1960s. The area now receives recharge from the treated wastewater discharged from the Saugus WRP to the Santa Clara River, and is located in one of the thickest areas of the Alluvium. The 'Below Saugus WRP' area exhibits groundwater level responses to climatic fluctuations, but these responses are much smaller than those further east in the Basin. The 'San Francisquito Canyon' area generally exhibits groundwater level responses that are similar to those in the 'Below Saugus WRP' area.

The 'Castaic Valley' area is located along Castaic Creek below Castaic Lake. Groundwater levels in this area have remained fairly constant, with slight responses to climatic fluctuations, since the 1950s.

The 'Below Valencia' WRP area is located along the Santa Clara River downstream of the Valencia WRP, and receives recharge from the treated wastewater discharged from the Valencia WRP to the Santa Clara River. Groundwater levels in this area exhibit slight, if any, response to climatic fluctuations, and have remained fairly constant since the 1950s.


Groundwater Elevation for 'Mint Canyon' Area Alluvial Wells
(lowest and highest for area shown)
Ground-Water Elevation (feet, msl)
Date
4N/15W-13Q3
4N/15W-21N1
Periods with less than
mean annual precipitation
1600
1550
1500
1450
1400
1350
1300
1250
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010

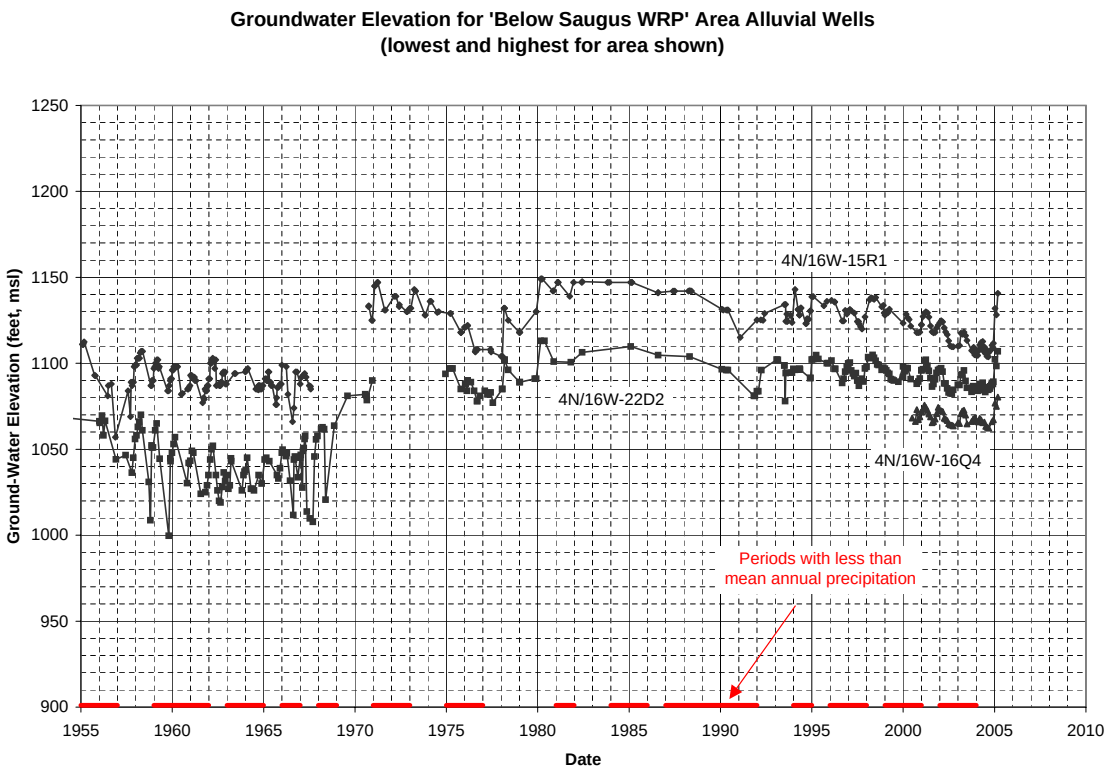
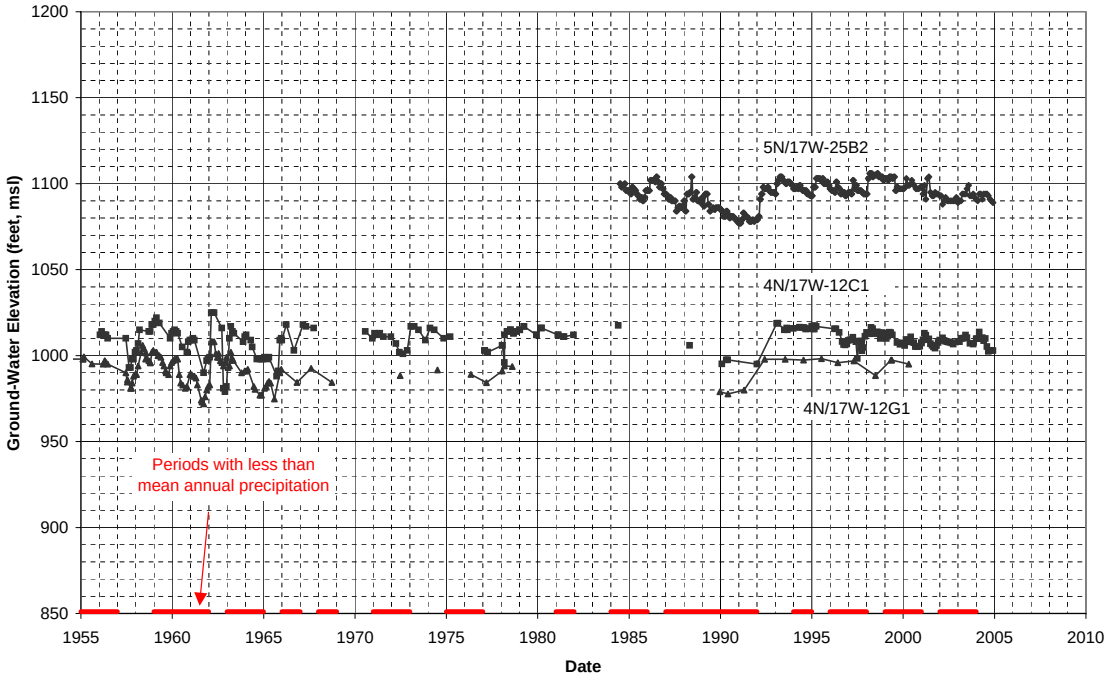

Groundwater Elevation for 'Below Saugus WRP' Area Alluvial Wells
(lowest and highest for area shown)
Ground-Water Elevation (feet, msl)
Date
4N/16W-15R1
4N/16W-22D2
4N/16W-16Q4
Periods with less than
mean annual precipitation
1250
1200
1150
1100
1050
1000
950
900
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010

Figure C-5

Groundwater Elevation for 'Castaic Valley' Area Alluvial Wells
(lowest and highest for area shown)



Groundwater Elevation for 'Below Valencia WRP' Area Alluvial Wells
(lowest and highest for area shown)

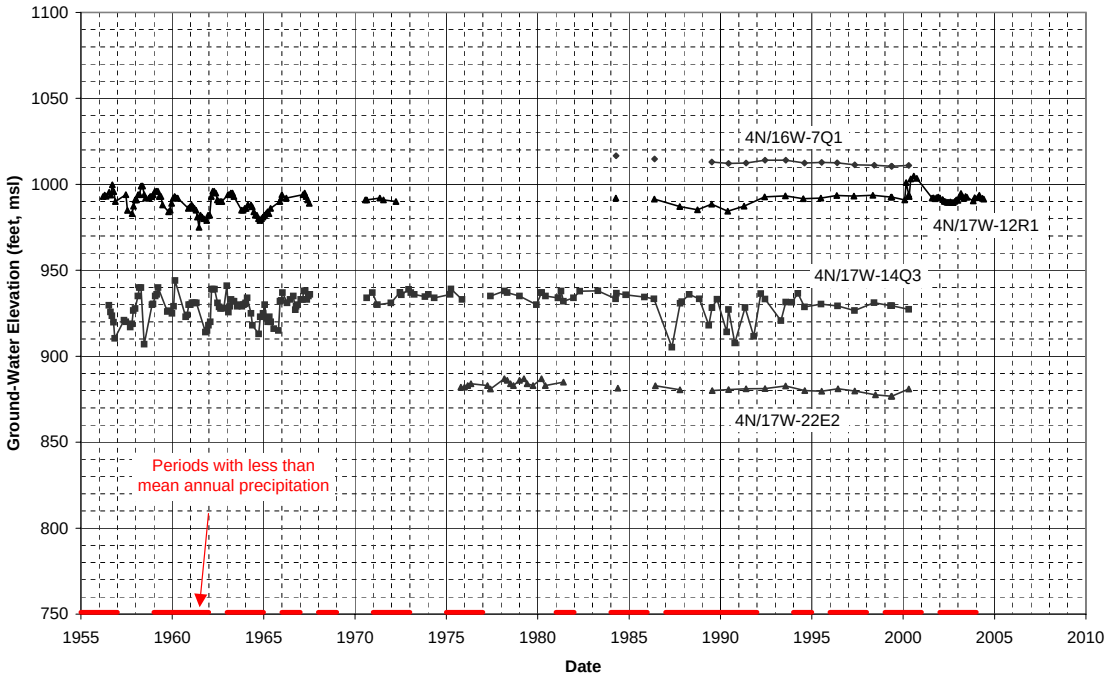
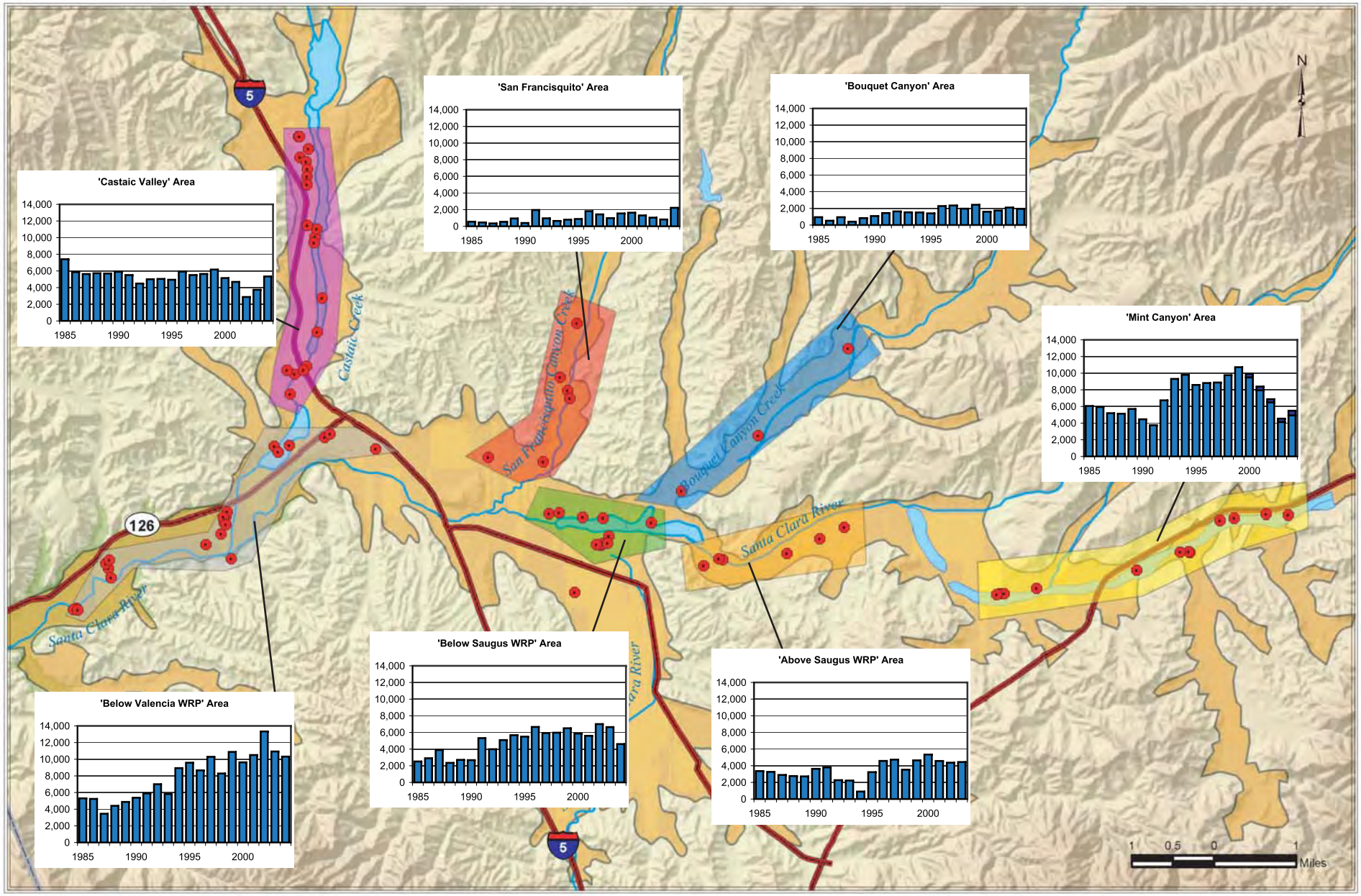


Figure C-6

Groundwater fluctuations in the 'Mint Canyon' area (illustrated in Figure C-5) represent the most substantial intermittent changes in the Basin. As described and discussed above, the Alluvium has historically experienced a number of alternating wet and dry hydrologic conditions during which groundwater level declines are followed by returns to historic highs. Since the Alluvium is thinner to the east, the resulting groundwater fluctuations are most dramatic in this area, up to 75 to 100 feet. When water levels are low, well yields and pumping capacities in this area can be impacted. The affected retail water purveyors respond by decreasing pumping and increasing use of Saugus Formation and imported SWP supplies. The purveyors also shift a fraction of the Alluvial pumpage that would normally be supplied by 'Mint Canyon' area wells to areas further west, where well yields and pumping capacities remain fairly constant because of smaller groundwater level fluctuations. As shown in Figure C-7, the purveyors have decreased the percent of total Alluvial pumpage from the 'Mint Canyon' area steadily beginning in 2000, and have offset these decreases by increasing pumpage in the 'Below Saugus WRP' and 'Below Valencia WRP' areas. This allows the purveyors to maximize the available supply from the Alluvium during dry periods to best meet demand. In spite of the current period of below average precipitation, groundwater levels in the 'Mint Canyon' area have ceased to decline in the last two years. This is illustrative of the purveyors' integrated use of surface water and groundwater to maintain local groundwater resources within their overall yield.

Depending on the period of available data, all the hydrographs of groundwater levels in the Alluvium show the same general picture: recent (last 30 years) groundwater levels have exhibited historic highs; in some locations, there are intermittent dry-period declines (and an associated use of some groundwater from storage) followed by wet-period recoveries (and associated natural refilling of storage space). On a long-term basis, the Alluvium shows no signs of water level-related overdraft (i.e., no trend toward decreasing water levels and storage). Since there is no evidence of any historic or recent trend toward permanent groundwater level or storage decline, pumpage from the Alluvium has been, and continues to be, within the operational yield of that aquifer.

As previously mentioned, it is possible to intermittently pump the aquifer by exceeding its average yield for one or more years without long-term impacts. This utilizes some water from storage in the aquifer, and is evidenced by lowered groundwater levels, which subsequently recover during periods of reduced pumpage or higher than average precipitation. Records of groundwater levels, pumpage and precipitation suggest that declines and subsequent rises in groundwater levels are influenced more by fluctuations in the availability of water for recharge than by pumpage. When less water is available for recharge, during periods of lower than average precipitation and streamflow, groundwater levels decline even when pumpage remains



LUHDORFF & SCALMANINI
CONSULTING ENGINEERS

Figure C-7
Annual Groundwater Production from Alluvium by Area (Acre-feet)
Santa Clara River Valley, East Groundwater Subbasin

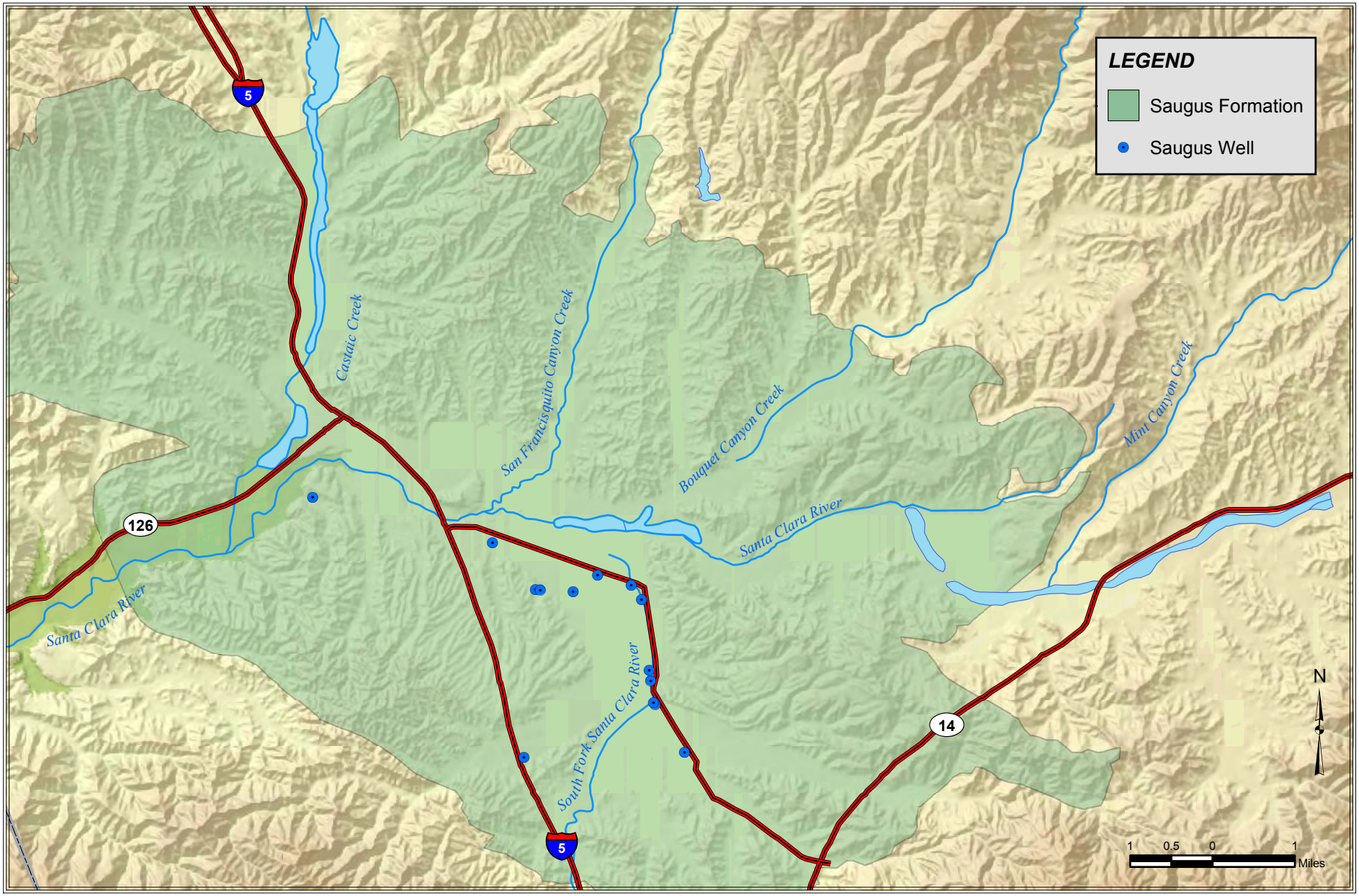
constant. Conversely, when an abundance of water is available for recharge because of wet conditions, pumpage can increase significantly without affecting groundwater levels. Overall, long-term experience with Alluvial Aquifer response to pumping in the ranges now considered to be its operational yield shows that such ranges can be considered reliable components of future supply. Recently completed numerical groundwater flow modeling, discussed in detail below, has been used to project Alluvial Aquifer response to the same ranges of pumping over multiple decades of varying hydrologic conditions; groundwater levels are projected to essentially repeat what has historically occurred since the importation of supplemental SWP water.

Saugus Formation – General

The Saugus Formation, of Pliocene to Pleistocene geologic age, has traditionally been divided into two stratigraphic units: the lowermost, geologically older Sunshine Ranch Member, which is of mixed marine to terrestrial (non-marine) origin; and the overlying, or upper, portion of the Formation which is entirely terrestrial in origin. The Sunshine Ranch Member of the Saugus Formation has a maximum thickness of about 3,000 to 3,500 feet in the central part of the Valley; however, due to its marine origin and fine-grained nature, it is not considered to be a viable source of groundwater for municipal or other water supply. Above the Sunshine Ranch Member, the upper portion of the Saugus Formation is coarser grained, consisting mainly of lenticular beds of sandstone and conglomerate that are interbedded with lesser amounts of sandy mudstone, which were deposited in stream channels, flood plains, and alluvial fans by one or more ancestral drainage systems in the Valley. The sand and gravel units that represent aquifer materials in the upper part of the Saugus Formation are generally located between depths of about 300 and 2,500 feet. The spatial extent of the Saugus Formation throughout the Basin is illustrated on Figure C-8.

The Saugus Formation is much thicker and more spatially extensive throughout the Basin when compared to the Alluvium. It is also significant in terms of groundwater storage and individual well capacity. However, the Saugus Formation has typically lower values of transmissivity, in the range of 80,000 to 160,000 gpd/ft, with the higher values in the upper portions of the Formation. The storage capacity of the Saugus has most recently been estimated to be 1.65 million af between depths of 300 feet and approximately 2,500 feet (to the base of the Saugus, or to the base of fresh water if shallower than 2,500 feet). Groundwater in the Saugus Formation generally moves north along the South Fork of the Santa Clara River, towards the Santa Clara River and the outlet of the Basin. Saugus wells operated by the retail water purveyors (shown in Figure C-8) are located in the southern portion of the Basin, south of the Santa Clara River.

For long-term planning purposes, the operating plan includes pumping from the Saugus in the range of 7,500 to 15,000 afy in average/normal years, a conservative estimate in light of historical estimates of potential recharge to the Saugus complemented by observations of high groundwater levels in the overlying Alluvium over the last 30 years. The operating plan also



LUHDORFF & SCALMANINI
CONSULTING ENGINEERS

Figure C-8
Saugus Well Locations
Santa Clara River Valley, East Groundwater Subbasin

includes planned dry-year pumping of 15,000 to 35,000 afy for one to three consecutive dry years, when shortages to other water supplies could occur. Such high pumping would be followed by periods of lower pumpage (7,500 to 15,000 afy in average/normal years as noted above) to allow recharge to recover water levels and storage in the Saugus. Maintaining the substantial volume of water in the Saugus Formation is an important strategy to help provide water supplies in the Valley during dry periods.

Saugus Formation – Historical and Current Conditions

Total pumpage from the Saugus Formation in 2004 was 6,500 af, of which most (5,700 af) was for municipal water supply, and the balance (800 af) was for agricultural and other (minor) uses. Historically, groundwater pumpage from the Saugus peaked in the early 1990s and then declined steadily. Pumpage has remained generally stable, at an average of about 4,600 afy, since 1998.

Historical pumpage records for the Saugus Formation are limited prior to 1980, but suggest that pumpage from the Saugus was minimal at that time. When pumpage records are unavailable, data have been approximated to obtain a continuous historic record (Figure C-9). The records indicate that there was almost no pumping from the Saugus prior to 1960 (about 100 af in most years, beginning in 1948), and that some increased pumping for agricultural water supply (about 900 af) began in about 1962. The largest amount of agricultural pumping from the Saugus was during the mid-1960s, when annual pumpage was about 3,000 af. Agricultural pumping from the Saugus declined to near zero by the late 1970s, but has generally ranged from 500 to 1,000 afy since 1982. Municipal pumping records from the Saugus are incomplete prior to 1980. There was no Saugus pumpage for municipal supply in the early 1960s. Despite the lack of pre-1980 records, post-1980 data suggests that municipal pumping from the Saugus began in the 1970s, and reached nearly 5,000 afy by 1980-81.

The first historical investigation of the Saugus (Slade, 1988) suggested that the recharge potential of the Saugus was in the range of 11,000 to 22,000 afy, depending on precipitation and groundwater levels in the partially overlying Alluvium. Recent updating of that original work (Slade, 2002) suggested that the operational yield of the Saugus Formation is in the range of 7,500 to 15,000 afy in average years, with an increase to as much as 35,000 afy in multiple dry year periods. On a long-term average basis since the importation of SWP water, total pumpage from the Saugus Formation has ranged from a low of about 3,700 afy (in 1999) to a high of nearly 15,000 afy (in 1991); average pumpage from 1980 to present has been about 6,700 afy. These numbers are at the lower end of the estimated range of the operational yield of the Saugus Formation.

Unlike the Alluvium, which has an abundance of wells with extensive water level records, the water level data for the Saugus Formation is limited by the distribution of the wells in this Formation and the periods of record. The wells that do have water level records extending back

Groundwater Production - Saugus Formation
Santa Clara River Valley, East Groundwater Subbasin

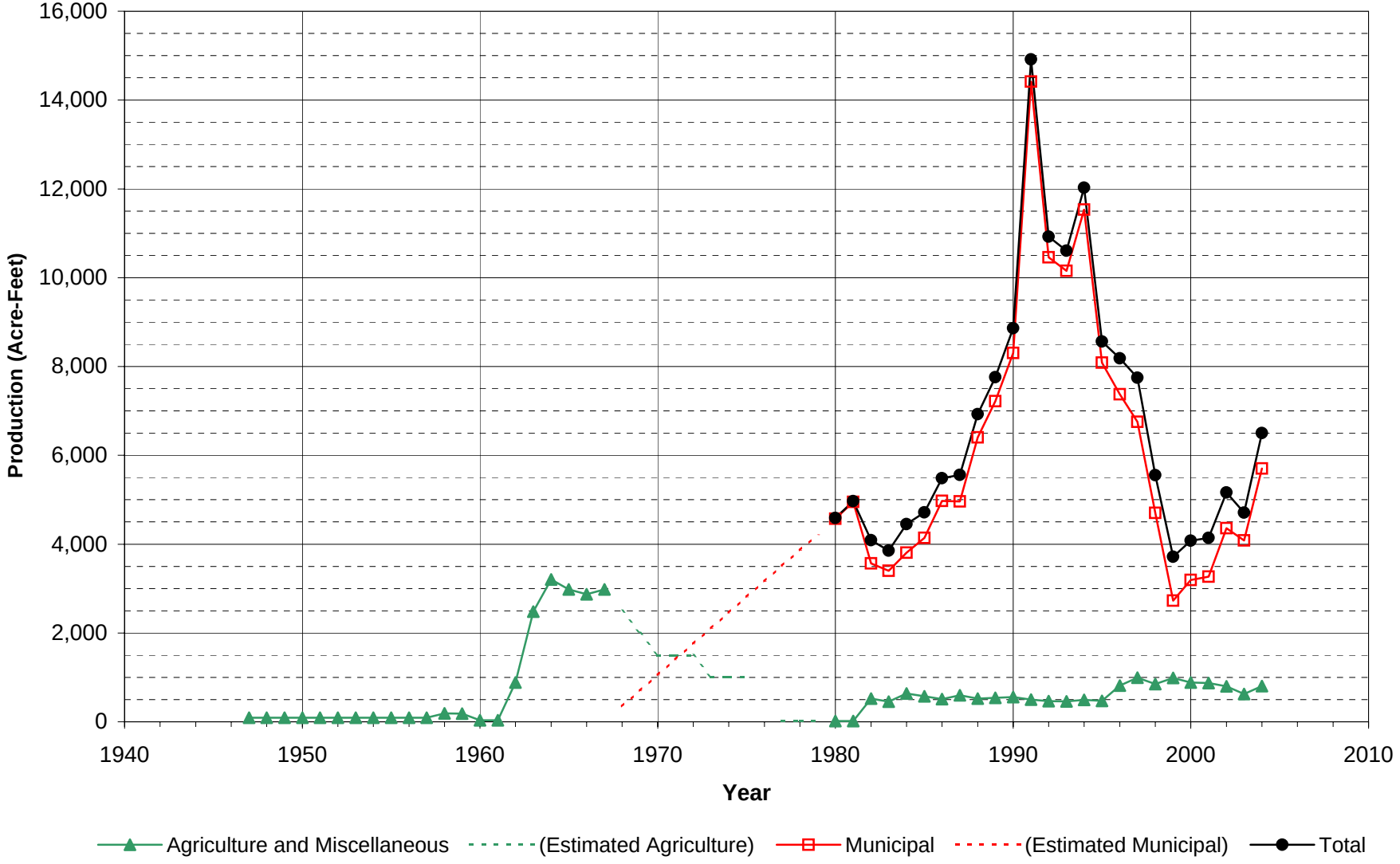


Figure C-9

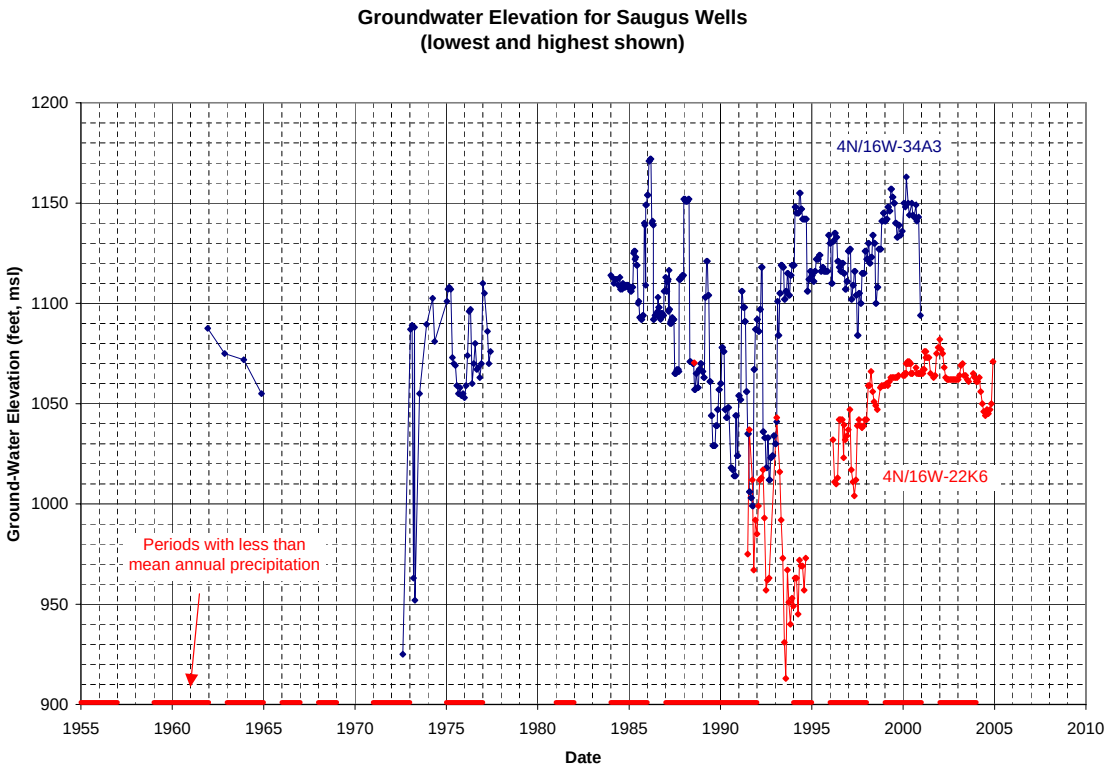
to the mid-1960s indicate that groundwater levels in the Saugus Formation were highest in the mid-1980s and are currently higher than they were in the mid-1960s (Figure C-10). Based on these data, there is no evidence of any historic or recent trend toward permanent water level or storage decline.

Records of groundwater levels, pumpage and precipitation suggest that declines and subsequent rises in groundwater levels in the Saugus Formation are more influenced by pumpage than by climatic fluctuations. Water levels in wells in the Saugus Formation are highly dependent on pumping in the respective wells. As opposed to the Alluvium, where pumpage is fairly evenly distributed among a number of wells in a given area, there are fewer active wells in the Saugus Formation. Consequently, pumping at one well can create a localized pumping depression that is evident in groundwater level hydrographs. Water levels in the Saugus Formation also exhibit stronger seasonal pumping fluctuations over a year than in the Alluvium (generally more than 20 feet in active Saugus wells, as opposed to generally less than ten feet in Alluvial wells). These responses to pumping are characteristic of the lower transmissivity of the Saugus Formation.

During the period from 1985 through 1991, which experienced consecutive years of lower than average precipitation (with one average year in the middle), pumpage from the Saugus increased from 4,700 afy to nearly 15,000 afy, and groundwater levels declined more than 100 feet in some cases. The subsequent rise in water levels at an individual well depended on pumping at that well. For example (as illustrated on Figure C-10), pumping of Saugus wells declined dramatically beginning between 1993 and 1995, and water levels in individual wells subsequently rose when pumping decreased. Since 1999, water levels in the Saugus have been stable and have exhibited very slight, if any, response to current less-than-average precipitation. A slight pumping depression is evident around active wells. Water levels in the Saugus remain at or above historic levels, and there is no trend toward a sustained decline in Saugus water levels or storage that would be indicative of overdraft.

Consistent with the 2001 Update Report (Slade, 2002), the current management practice of the retail water purveyors is to preserve the Saugus Formation so this supply is available during drought periods, when Alluvial groundwater and SWP supplies are anticipated to decrease. The period of increased pumpage during the late 1980s and early 1990s is a good example of this management strategy. Most notably, in 1991, when SWP deliveries were substantially reduced, increased pumpage from the Saugus made up almost half of the decrease in SWP deliveries. This increased Saugus pumpage resulted in a short-term decline in water levels reflecting the use of stored water. However, the water levels subsequently rose when pumping was reduced, reflecting recovery of groundwater storage in the Saugus Formation.

As with the Alluvial aquifer as introduced above, the response of the Saugus Formation to pumping in the operational yield ranges has been projected by use of a recently completed numerical groundwater flow model. Results of those projections, discussed in detail below,


Groundwater Elevation for Saugus Wells
(lowest and highest shown)
Ground-Water Elevation (feet, msl)
Date
4N/16W-34A3
4N/16W-22K6
Periods with less than
mean annual precipitation
1200
1150
1100
1050
1000
950
900
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010

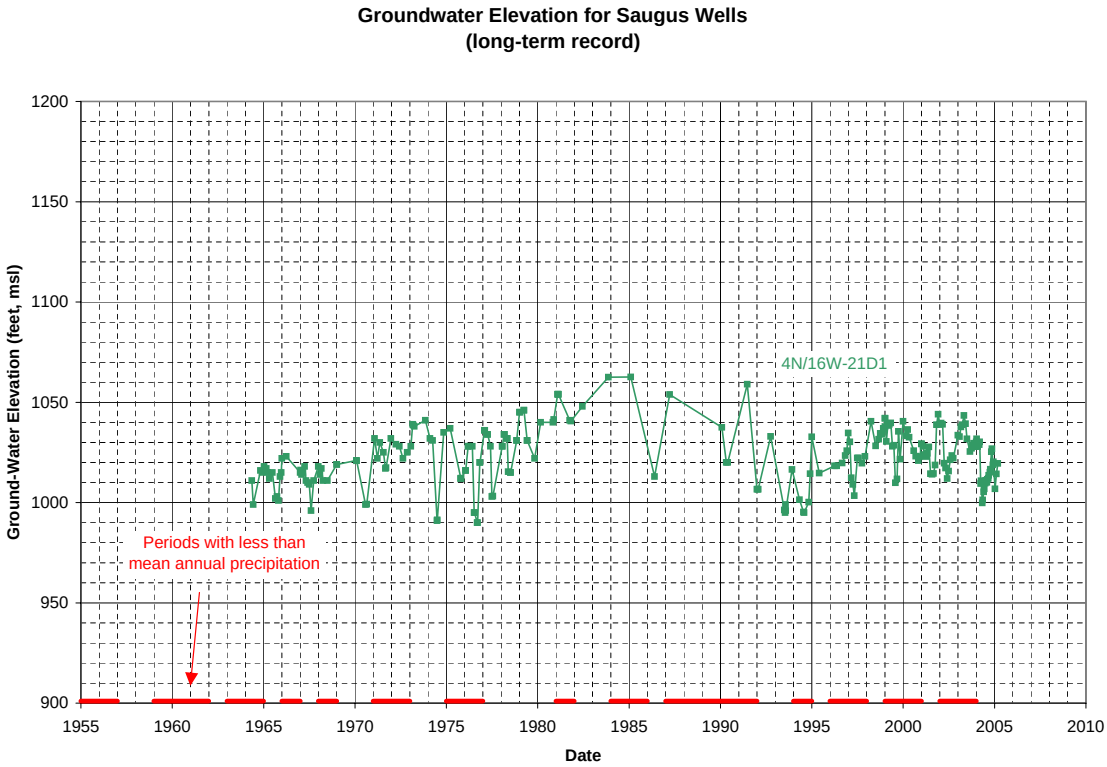

Groundwater Elevation for Saugus Wells
(long-term record)
Ground-Water Elevation (feet, msl)
Date
4N/16W-21D1
Periods with less than
mean annual precipitation
1200
1150
1100
1050
1000
950
900
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010

Figure C-10

show that fluctuations in pumping over multiple decades of varying hydrologic conditions will cause fluctuations in groundwater levels similar to what has historically occurred. Short-term declines during dry periods when Saugus pumping is temporarily increased are followed by recovery of water levels when pumping is reduced during wet/normal periods. The lack of any projected permanent decline in Saugus groundwater levels supports the reliability of the Saugus Formation as a long-term water supply at the capacities included in its operational yield.

Sustainability of Groundwater Supplies

Alluvial Aquifer – Based in part on historical operating experience, complemented by recent groundwater modeling work as described herein, it is planned that the Alluvial Aquifer can supply water on a long-term sustainable basis in the overall range of 30,000 to 40,000 afy, with a probable reduction in dry years to a range of 30,000 to 35,000 afy. Both of those ranges include about 15,000 afy of Alluvial pumping for current agricultural water uses and about 500 afy for small private water supply. The dry year reduction is a result of practical constraints in the eastern part of the Basin where lowered groundwater levels in dry periods have the effect of reducing pumping capacities in that shallower portion of the aquifer.

Until recently, the long-term renewability of Alluvial groundwater was empirically determined from approximately 60 years of recorded experience as previously described: long-term stability in groundwater levels and storage, with some dry period fluctuations in the eastern part of the Basin, over a historical range of Alluvial pumpage from as low as about 20,000 afy to as high as about 43,000 afy. Over the last couple of years, those empirical observations have been complemented by the development and application of a numerical groundwater flow model, has been used to predict aquifer response to the planned operating ranges of pumping. The numerical groundwater flow model has also been used to analyze the control of contaminant migration under selected pumping conditions that would restore, with treatment, pumping capacity that has been inactivated due to perchlorate contamination detected in some wells in the Basin.

To examine the yield of the Alluvium or, in other words, the sustainability of Alluvium on a renewable basis, the groundwater flow model was used to examine long-term projected response of the aquifer to pumping for municipal and agricultural uses in the 30,000 to 40,000 afy range under average/normal and wet conditions, and in the 30,000 to 35,000 afy range under locally dry conditions. To examine the response of the entire aquifer system, the model also incorporated pumping from the Saugus Formation in accordance with the normal (7,500-15,000 afy) and dry year (15,000-35,000 afy) operating plan for that aquifer. The model was run over a 78 year hydrologic period which was selected from actual historical hydrology (i.e., precipitation) to examine a number of hydrologic conditions that would be expected to affect both groundwater pumping and groundwater recharge. The selected 78-year simulation period was assembled from an assumed recurrence of 1980 to 2003 conditions, followed by an assumed

recurrence of 1950 to 2003 conditions. The 78-year period was analyzed to define both local hydrologic conditions (normal vs. dry), which affect the rate of pumping from the Alluvium, and hydrologic conditions that affect SWP operations, which in turn affect the rate of pumping from the Saugus. The resultant simulated pumping cycles included the distribution of pumping around the Basin for each of the existing wells, for normal and dry years respectively, shown in Tables C-1 and C-2.

The resultant pumping cycles are summarized as follows:

- Twenty-four years of dry year Alluvial pumping at 30,000 to 35,000 afy
- One drought of four consecutive dry years of Alluvial pumping at 30,000 to 35,000 afy
- Two droughts of three consecutive dry years each, with Alluvial pumping at 30,000 to 35,000 afy
- Three selected years with assigned dry-year Alluvial pumping despite near-normal or above-normal rainfall because each selected year was preceded by a multi-year drought
- Eighteen years of dry-year pumping from the Saugus, or an average of one dry year approximately every four years
- Two droughts lasting three years, plus (in both cases) a dry year that occurs two years before the beginning of each three-year drought and another dry year that begins one year after each three-year drought has ended; Saugus pumping was increased into the 15,000 to 35,000 afy range in all those years
- Two droughts lasting two years; Saugus pumping was increased into the 15,000 to 25,000 afy range in those years
- Sixty years of normal-year Saugus pumping, 7,500 to 15,000 afy

Simulated Alluvial aquifer response to the preceding range of hydrologic conditions and pumping stresses was essentially a long-term repeat of the historical conditions that have resulted from similar pumping over the last several decades. The resultant response consisted of (1) generally constant groundwater levels in the middle to western portion of the Alluvium, and fluctuating groundwater levels in the eastern portion of the Alluvium as a function of wet and dry hydrologic conditions, (2) variations in recharge that directly correlate with wet and dry hydrologic conditions, and (3) no long-term decline in groundwater levels or storage. Examples of projected groundwater levels and storage in various parts of the basin are illustrated in Figures C-11 through C-15. Based on the combination of actual experience with Alluvial aquifer pumping at capacities similar to those planned for the future and the resultant sustainability (recharge) of groundwater levels and storage, complemented by modeled projections of aquifer response to planned pumping rates that also show no depletion of groundwater, the Alluvial Aquifer is considered a sustainable water supply source to meet the Alluvial portion of the operating plan for the groundwater Basin.

TABLE C-1

Recent and Simulated Future Annual Groundwater Pumping Volumes from the Alluvial Aquifer

Analysis of Groundwater Basin Yield, Upper Santa Clara River Groundwater Basin, East Subbasin, Los Angeles County, California

		Historical Pumping			UWMP Pumping	
Well Name	**Location[a]**	**2001**	**2002**	**2003**	**Normal Years**	**Dry Years**
NCWD-Castaic 1	Castaic Valley	345	385	561	385	345
NCWD-Castaic 2	Castaic Valley	166	0	123	166	125
NCWD-Castaic 3	Castaic Valley	0	0	0	0	0
NCWD-Castaic 4	Castaic Valley	100	47	56	100	45
NCWD-Pinetree 1	Mint Canyon	164	0	0	164	0
NCWD-Pinetree 2	Mint Canyon	0	0	0	0	0
NCWD-Pinetree 3	Mint Canyon	566	544	525	545	525
NCWD-Pinetree 4	Mint Canyon	300	5	0	300	0
NCWD Total		**1,641**	**981**	**1,265**	**1,660**	**1,040**
NLF-161	Downstream of Valencia WRP	496	485	2,021	485	485
NLF-B10	Downstream of Valencia WRP	1,240	534	344	344	344
NLF-B11	Downstream of Valencia WRP	205	232	271	232	232
NLF-B5	Downstream of Valencia WRP	1,680	2,280	1,582	1,582	1,582
NLF-B6	Downstream of Valencia WRP	1,312	2,175	1,766	1,766	1,766
NLF-B7	Downstream of Valencia WRP	474	584	402	584	584
NLF-C	Downstream of Valencia WRP	1,319	1,720	1,373	1,373	1,373
NLF-C3	Downstream of Valencia WRP	93	192	186	192	192
NLF-C4	Downstream of Valencia WRP	1,028	809	764	809	809
NLF-C5	Downstream of Valencia WRP	680	850	622	850	850
NLF-C6	Downstream of Valencia WRP	231	241	108	241	241
NLF-C7	Downstream of Valencia WRP	741	866	443	866	866
NLF-C8	Downstream of Valencia WRP	293	594	408	594	594
NLF-E	Castaic Valley	1,691	16	28	16	16
NLF-E2	Castaic Valley	141	55	14	55	55
NLF-E4	Downstream of Valencia WRP	0	0	0	0	0
NLF-E5	Downstream of Valencia WRP	172	679	537	679	679
NLF-E9	Downstream of Valencia WRP	238	814	47	814	814
NLF-G45	Downstream of Valencia WRP	291	283	60	283	283
NLF-W4	San Francisquito Canyon[b]	46	1	0	0	0
NLF-W5	San Francisquito Canyon	276	104	23	107	107
NLF-X3	Downstream of Valencia WRP	12	0	0	0	0
NLF Total		**12,659**	**13,514**	**10,999**	**11,872**	**11,872**
SCWD-Clark	Bouquet Canyon	696	782	712	782	700
SCWD-Guida	Bouquet Canyon	1,047	1,320	1,230	1,320	1,230
SCWD-Honby	Above Saugus WRP	721	696	874	696	870
SCWD-Lost Canyon 2	Mint Canyon	741	730	644	741	640
SCWD-Lost Canyon 2A	Mint Canyon	1,034	905	593	1,034	590
SCWD-Mitchell #5A	Mint Canyon	407	143	19	0	0
SCWD-Mitchell #5B	Mint Canyon	0	150	0	557	0
SCWD-N. Oaks Central	Mint Canyon	822	1,646	1,641	822	1,640
SCWD-N. Oaks East	Mint Canyon	1,234	448	485	1,234	485
SCWD-N. Oaks West	Mint Canyon	898	1,123	31	898	0
SCWD-Sand Canyon	Mint Canyon	930	705	195	930	195
SCWD-Sierra	Mint Canyon	846	87	0	846	0
SCWD-Stadium	Above Saugus WRP	565	778	0	800	800
SCWD Total		**9,941**	**9,513**	**6,424**	**10,660**	**7,150**

TABLE C-1

Recent and Simulated Future Annual Groundwater Pumping Volumes from the Alluvial Aquifer

Analysis of Groundwater Basin Yield, Upper Santa Clara River Groundwater Basin, East Subbasin, Los Angeles County, California

		Historical Pumping			UWMP Pumping	
Well Name	**Location[a]**	**2001**	**2002**	**2003**	**Normal Years**	**Dry Years**
VWC-D	Castaic Valley	645	772	687	690	690
VWC-I	San Francisquito Canyon	0	0	0	0	0
VWC-K2	Downstream of Saugus WRP[c]	669	955	364	0	0
VWC-L2	Downstream of Saugus WRP[d]	349	490	71	0	0
VWC-N	Downstream of Saugus WRP	591	700	622	620	620
VWC-N3	Downstream of Saugus WRP[e]	226	857	255	0	0
VWC-N4	Downstream of Saugus WRP[f]	458	909	248	0	0
VWC-N7	Downstream of Saugus WRP				1,160	1,160
VWC-N8	Downstream of Saugus WRP				1,160	1,160
VWC-Q2	Downstream of Saugus WRP	923	1,167	1,451	985	985
VWC-S6	Downstream of Saugus WRP	1,490	1,320	2,134	865	865
VWC-S7	Downstream of Saugus WRP	564	419	1,095	865	865
VWC-S8	Downstream of Saugus WRP	327	190	409	865	865
VWC-T2	Above Saugus WRP	900	696	1,014	460	460
VWC-T4	Above Saugus WRP	690	831	799	460	460
VWC-U3	Above Saugus WRP[g]	956	572	823	0	0
VWC-U4	Above Saugus WRP	942	796	934	935	935
VWC-U6	Above Saugus WRP	0	0	0	825	825
VWC-W10	San Francisquito Canyon	182	0		0	0
VWC-W11	San Francisquito Canyon	806	939	764	600	600
VWC-W6	San Francisquito Canyon[h]	0	0	36	865	865
VWC-W9	San Francisquito Canyon				350	350
VWC Total		**10,718**	**11,613**	**11,706**	**11,705**	**11,705**
Robinson Ranch	Mint Canyon				932	400
WHR (All Wells)	Castaic Valley	1,604	1,602	2,273	1,600	1,600
Total Alluvial Aquifer Pumping		**36,563**	**37,223**	**32,667**	**38,429**	**33,767**

[a]See Figure 2-4 for well locations.

[b]Former well NLF-W4 was located approximately 900 feet west of existing production well VWC-11.

[c]Former well VWC-K2 was located approximately 210 feet south of existing production well VWC-N7.

[d]Former well VWC-L2 was located approximately 150 feet southeast of existing production well VWC-N7.

[e]Former well VWC-N3 was located approximately 440 feet northeast of existing production well VWC-N8.

[f]Former well VWC-N4 was located approximately 430 feet southeast of existing production well VWC-N8.

[g]Former well VWC-U3 was located approximately 2,300 feet northeast of existing production well VWC-U4.

[h]Former well VWC-W6 was located approximately 575 feet northeast of existing production well VWC-11.

Notes:

All pumping volumes are listed in AF/yr. Blank entries for historical pumping indicate that the well did not exist at that time.

Wells that are not listed are assumed to not be pumping in the future.

NLF = Newhall Land & Farming Company

UWMP = Urban Water Management Plan

VWC = Valencia Water Company

WHR = Wayside Honor Rancho, whose wells are owned by the Los Angeles County Waterworks District No. 36

TABLE C-2

Simulated Annual Groundwater Pumping from the Saugus Formation for the 78-year Simulation

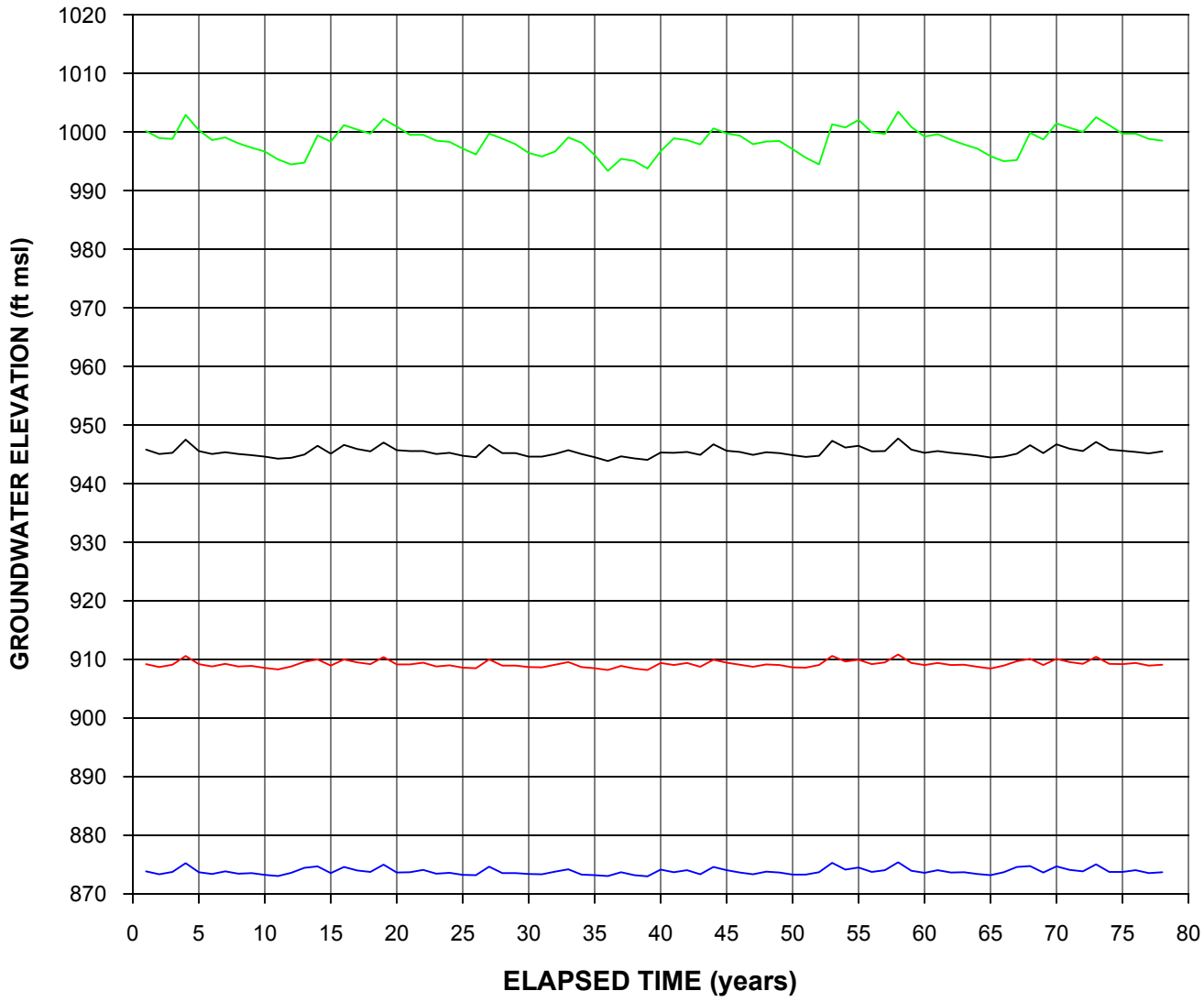
Analysis of Groundwater Basin Yield, Upper Santa Clara River Groundwater Basin, East Subbasin, Los Angeles County, California

Owner	Well Name	Normal Years	Dry Year 1	Dry Year 2	Dry Year 3
NCWD	11	811	811	811	811
	12	1,315	2,044	2,044	2,044
	13	1,315	2,044	2,044	2,044
Total Pumping (NCWD)		**3,441**	**4,899**	**4,899**	**4,899**
NLF	156	369	369	369	369
Total Pumping (NLF)		**369**	**369**	**369**	**369**
SCWC	Saugus1	1,772	1,772	1,772	1,772
	Saugus2	1,772	1,772	1,772	1,772
Total Pumping (SCWC)		**3,544**	**3,544**	**3,544**	**3,544**
VWC	159	50	50	50	50
	160 (Municipal)	500	830	830	830
	160 (Valencia Country Club)	500	500	500	500
	201	100	100	3,577	3,577
	205	1,000	2,734	3,827	3,827
	206	1,175	2,734	3,500	3,500
Total Pumping (VWC)		**3,325**	**6,948**	**12,284**	**12,284**
To Be Determined	Future #1	0	0	3,250	3,250
	Future #2	0	0	0	3,250
	Future #3	0	0	0	3,250
	Future #4	0	0	0	3,250
Total Pumping (Future)		**0**	**0**	**3,250**	**13,000**
Total Saugus Formation Pumping		**10,679**	**15,760**	**24,346**	**34,096**

Notes:

All pumping volumes are listed in acre-feet.

Wells VWC-157 and NCWD-7, 8, 9, and 10 are assumed to no longer operate in the future.



LEGEND

- LACFCD-6968
- NLF-TOPCO1
- NLF-C6
- LACFCD-6995D

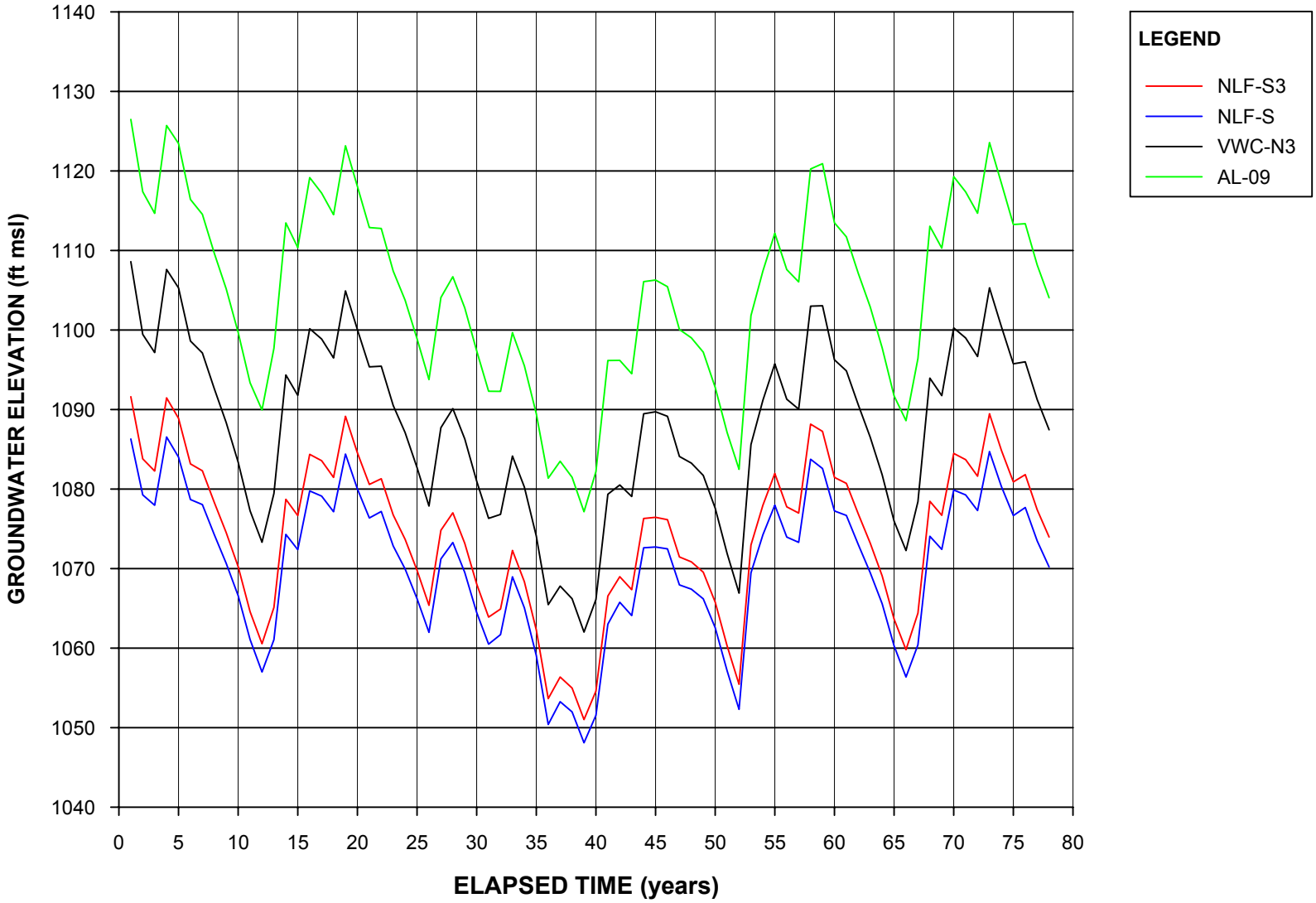
NOTE:

1. SEE FIGURE 2-4 FOR LOCATIONS OF WELLS. WELL NLF-TOPCO1 IS LOCATED 210 feet SOUTHWEST OF WELL NLF-B11.

FIGURE C-11
SIMULATED AVERAGE ANNUAL GROUNDWATER ELEVATIONS IN THE ALLUVIAL AQUIFER WEST OF INTERSTATE 5
ANALYSIS OF GROUNDWATER BASIN YIELD
UPPER SANTA CLARA RIVER GROUNDWATER BASIN
EAST SUBBASIN, LOS ANGELES COUNTY, CALIFORNIA

178973-366.GRF

CH2MHILL



NOTES:

1. AL09 IS A CLUSTER OF OBSERVATION WELLS LOCATED 845 feet SOUTHWEST OF PRODUCTION WELL VWC-Q2.

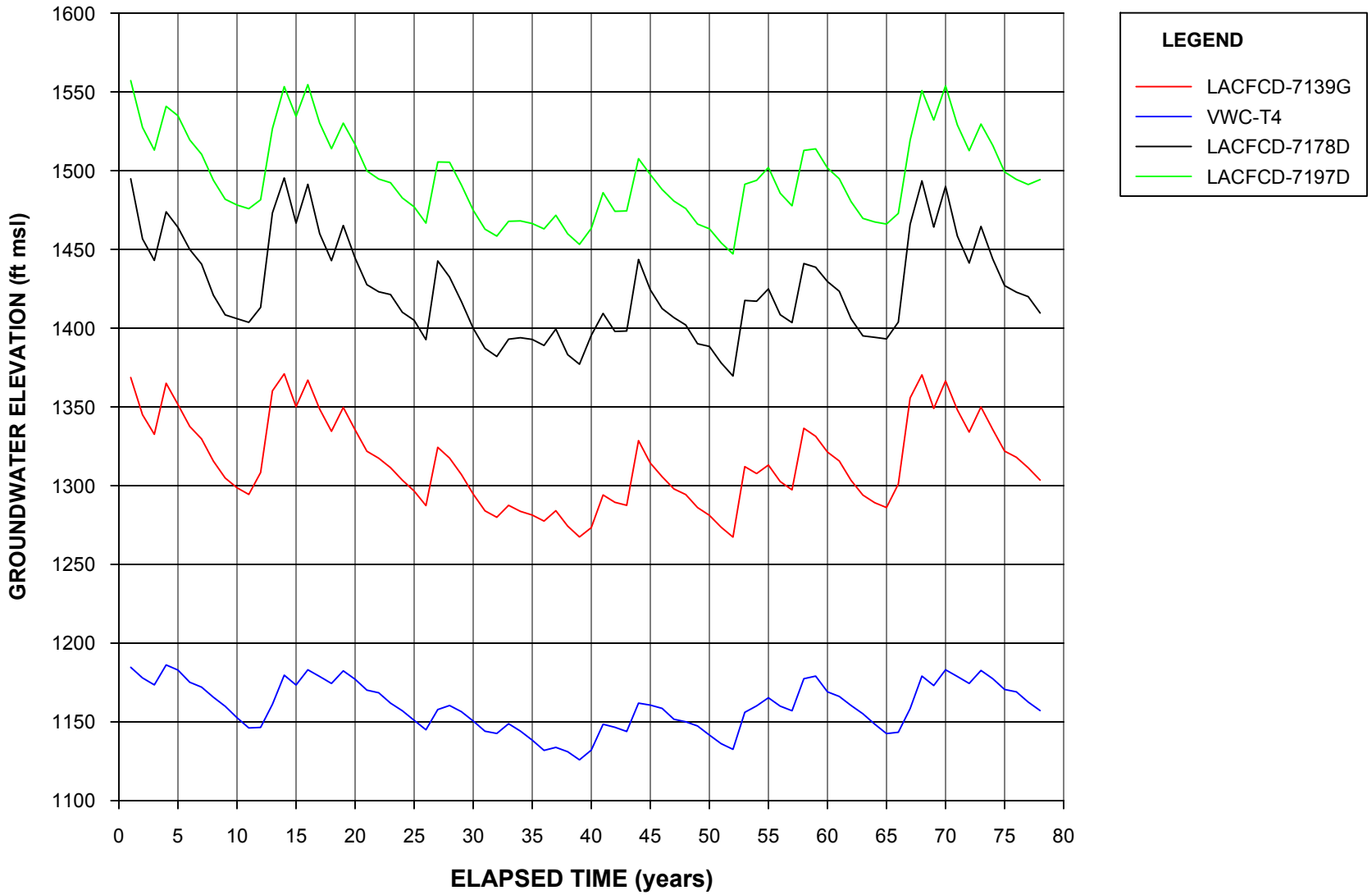
2. THE REMAINING HYDROGRAPHS REPRESENT FORMER ALLUVIAL AQUIFER WELLS THAT HAVE BEEN ABANDONED AND THEREFORE ARE NOT PUMPED IN THE MODEL SIMULATIONS. RELATIVE TO EXISTING WELLS SHOWN ON FIGURE 2-4, THESE FORMER WELLS WERE LOCATED AS FOLLOWS:

   – WELL NLF-S3 WAS LOCATED 305 feet EAST OF WELL VWC-S6
   – WELL NLF-S WAS LOCATED 940 feet SOUTHWEST OF WELL VWC-S6
   – WELL VWC-N3 WAS LOCATED 435 feet NORTHEAST OF WELL VWC-N8

FIGURE C-12
SIMULATED AVERAGE ANNUAL GROUNDWATER ELEVATIONS IN THE ALLUVIAL AQUIFER EAST OF INTERSTATE 5
ANALYSIS OF GROUNDWATER BASIN YIELD
UPPER SANTA CLARA RIVER GROUNDWATER BASIN
EAST SUBBASIN, LOS ANGELES COUNTY, CALIFORNIA

CH2MHILL

178973-367.GRF



NOTES:

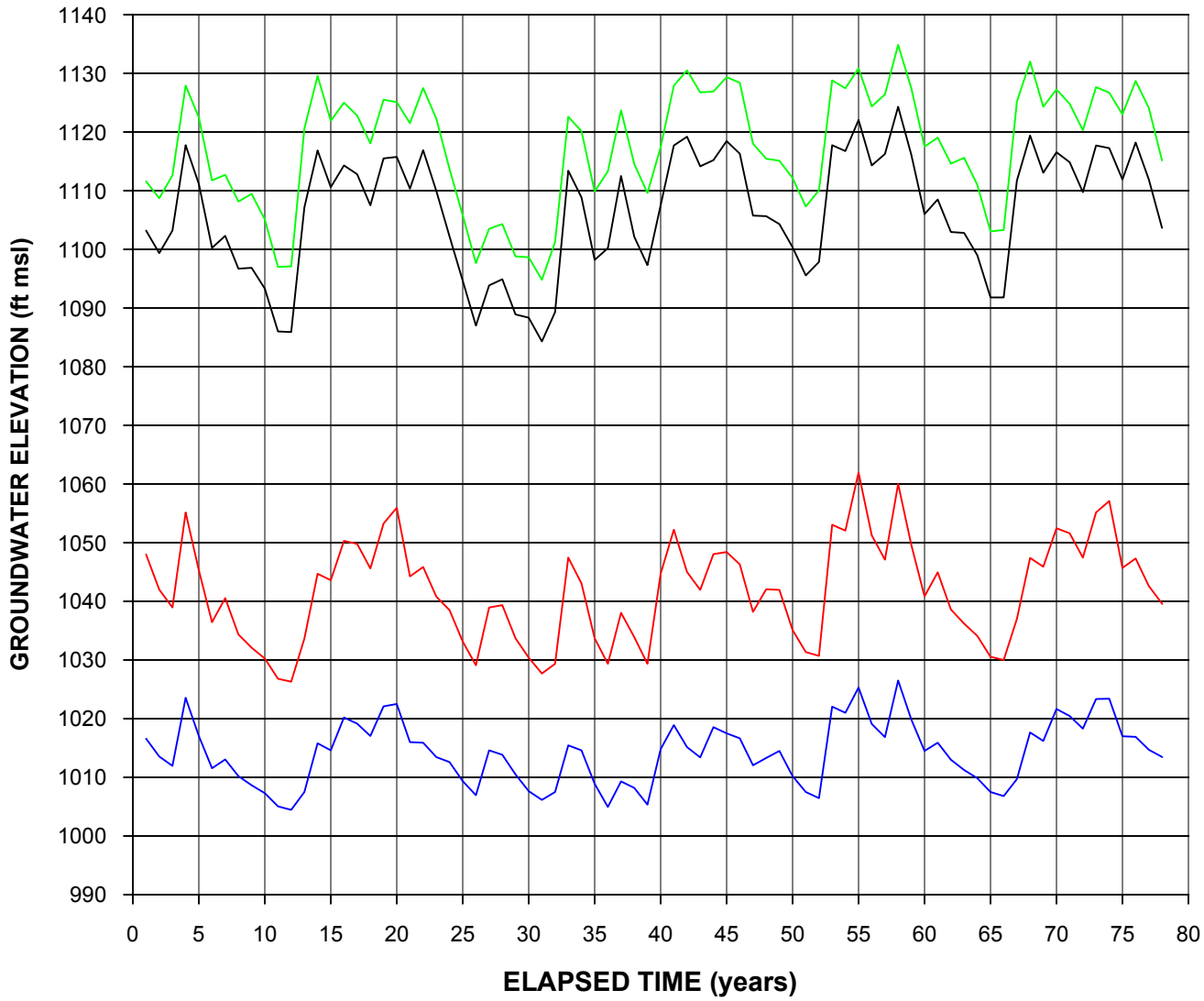
1. SEE FIGURE 2-4 FOR LOCATIONS OF WELLS.
2. LOWEST HISTORICAL GROUNDWATER ELEVATION FOR VWC- T4 = 1101 ft msl; ALLUVIUM BOTTOM ELEVATION ~1050 TO 1065 ft msl.
3. LOWEST HISTORICAL GROUNDWATER ELEVATION FOR LACFCD-7139G = 1289 ft msl; ALLUVIUM BOTTOM ELEVATION ~1256 ft msl OR LOWER.
4. LOWEST HISTORICAL GROUNDWATER ELEVATION FOR LACFCD-7178D = 1463 ft msl; ALLUVIUM BOTTOM ELEVATION ~1398 TO 1425 ft msl.
5. LOWEST HISTORICAL GROUNDWATER ELEVATION FOR LACFCD-7197D = 1474 ft msl; ALLUVIUM BOTTOM ELEVATION ~1423 TO 1447 ft msl.

FIGURE C-13
SIMULATED AVERAGE ANNUAL GROUNDWATER ELEVATIONS IN THE ALLUVIAL AQUIFER IN SOLEDAD CANYON

ANALYSIS OF GROUNDWATER BASIN YIELD
UPPER SANTA CLARA RIVER GROUNDWATER BASIN
EAST SUBBASIN, LOS ANGELES COUNTY, CALIFORNIA

178973-368.GRF

CH2MHILL



LEGEND

- LACFCD-6993A
- VWC-D
- LACFCD-6981D
- LACFCD-6980E

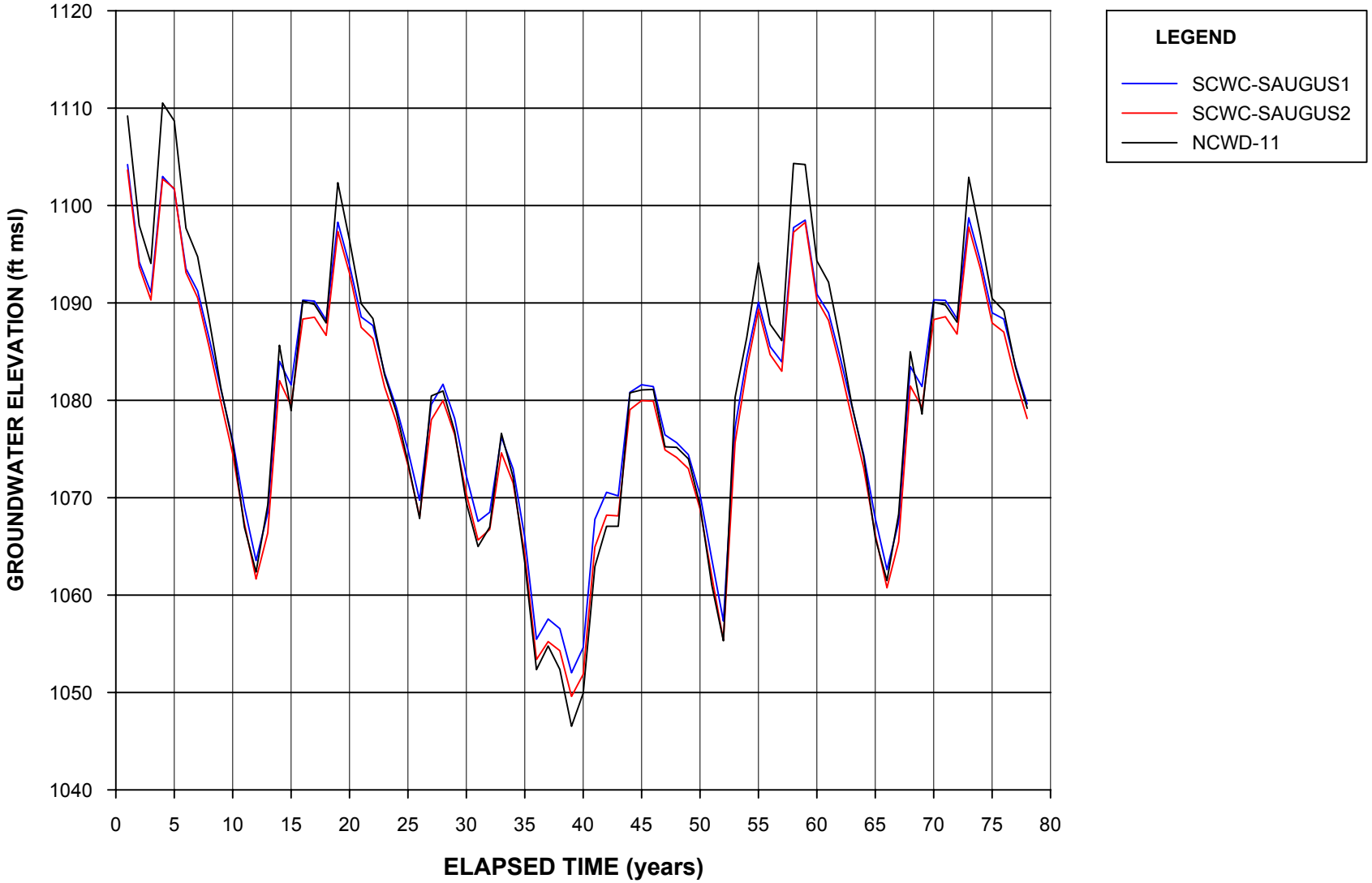
NOTE:

1. SEE FIGURE 2-4 FOR LOCATIONS OF WELLS.

FIGURE C-14
SIMULATED AVERAGE ANNUAL GROUNDWATER ELEVATIONS IN THE ALLUVIAL AQUIFER ALONG CASTAIC CREEK
ANALYSIS OF GROUNDWATER BASIN YIELD
UPPER SANTA CLARA RIVER GROUNDWATER BASIN
EAST SUBBASIN, LOS ANGELES COUNTY, CALIFORNIA

178973-369.GRF

CH2MHILL



NOTES:

1. SEE FIGURE 2-4 FOR LOCATIONS OF WELLS.

2. THESE WELLS ARE CONSTRUCTED IN THE SAUGUS FORMATION AND ARE NOT OPEN TO THE ALLUVIAL AQUIFER. THE SIMULATED HYDROGRAPHS AT THESE WELL LOCATIONS ARE FOR GROUNDWATER LEVELS IN THE ALLUVIAL AQUIFER, ABOVE THE OPEN INTERVALS OF THESE WELLS.

FIGURE C-15
SIMULATED AVERAGE ANNUAL GROUNDWATER ELEVATIONS IN THE ALLUVIAL AQUIFER ALONG THE SOUTH FORK SANTA CLARA RIVER
ANALYSIS OF GROUNDWATER BASIN YIELD
UPPER SANTA CLARA RIVER GROUNDWATER BASIN
EAST SUBBASIN, LOS ANGELES COUNTY, CALIFORNIA

CH2MHILL

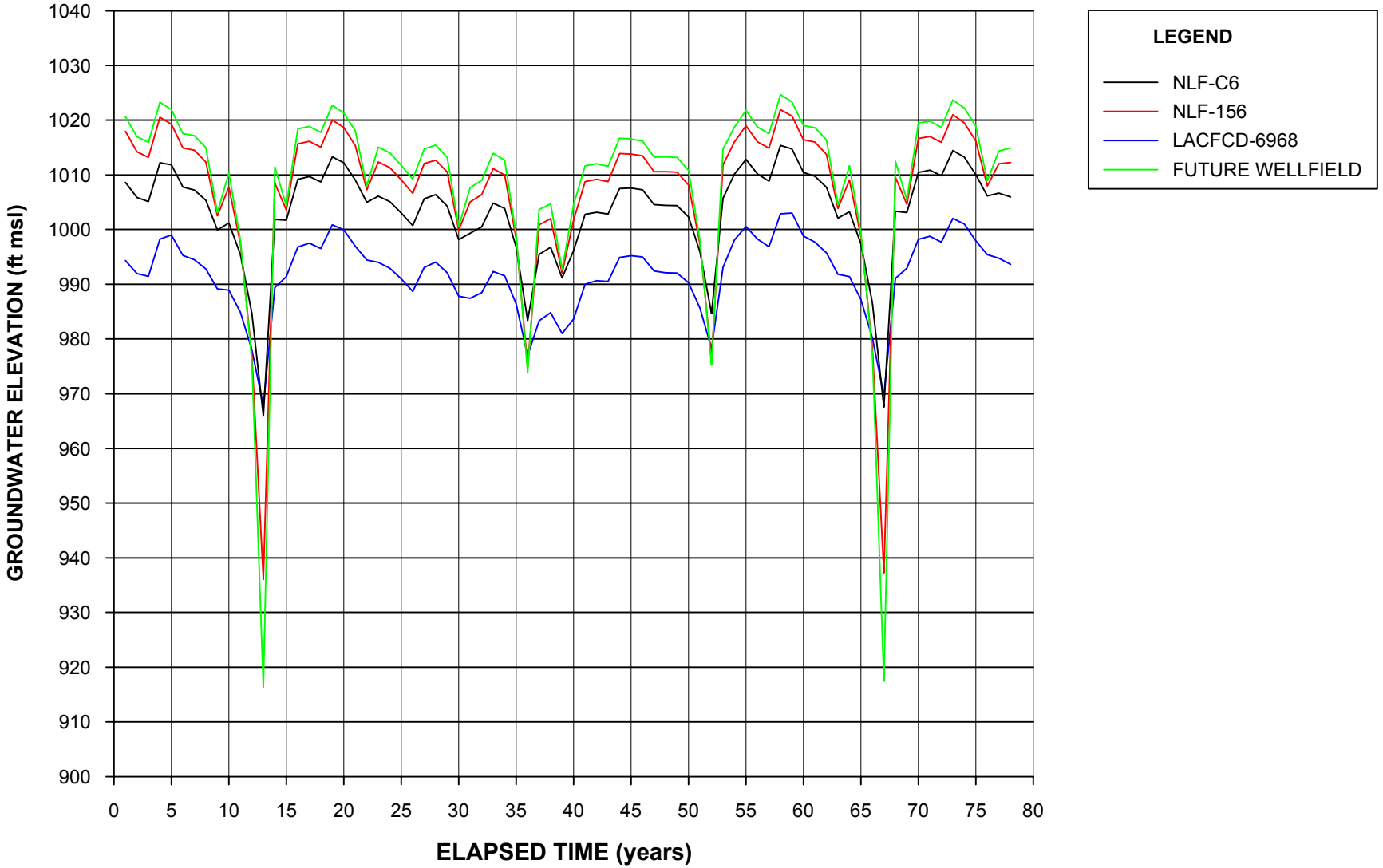
178973-370.GRF

Saugus Formation – Based partially on historical operating experience, complemented by extensive recent testing and groundwater modeling work as described herein, it is planned that the Saugus Formation aquifer can supply water on a long-term sustainable basis in a normal range of 7,500 to 15,000 afy, with intermittent increases to 25,000 to 35,000 af in multiple dry years. The dry-year increases result from limited historical observation, now complemented by modeled projections, that a small amount of the large groundwater storage in the Saugus Formation can be pumped over a relatively short (dry) period, followed by recharge (replenishment) of that storage during a subsequent wet to normal period when pumping would be reduced.

Until recently, the long-term sustainability of Saugus groundwater was empirically determined from limited historical experience. The historical record shows fairly low annual pumping in most years, with one four-year period of increased pumping up to about 15,000 afy, that produced no long-term depletion of the substantial groundwater storage in the Saugus. As with the Alluvium, those empirical observations have now been complemented by the development and application of the numerical groundwater flow model. The model has been used to examine aquifer response to the operating plan for pumping from both the Alluvium and the Saugus, and to examine the effectiveness of pumping for both contaminant extraction and control of contaminant migration within the Saugus Formation.

To examine the yield of the Saugus Formation or, in other words, its sustainability on a renewable basis, the groundwater flow model was used to examine long-term projected response to pumping from both the Alluvium and the Saugus, over the 78-year period of hydrologic conditions to introduce alternating wet and dry periods as have historically occurred. The pumping simulated in the model was in accordance with the operating plan for the Basin. For the Saugus, simulated pumpage included the planned restoration of recent historic pumping from the perchlorate-impacted wells. That pumping was analyzed to assess, in addition to the overall recharge of the Saugus, the effectiveness of controlling the migration of perchlorate by extracting and treating contaminated water close to the source of contamination.

Simulated Saugus Formation response to the ranges of pumping under assumed recurrent historical hydrologic conditions was consistent with actual experience under smaller pumping rates. The response consisted of (1) short-term declines in groundwater levels and storage near pumped wells during dry-period pumping, (2) rapid recovery of groundwater levels and storage after cessation of dry-period pumping, and (3) no long-term decreases or depletion of groundwater levels or storage. Examples of projected groundwater levels and storage around the planned Saugus pumping areas are illustrated in Figures C-16 and C-17. The combination of actual experience with Saugus pumping and recharge up to about 15,000 afy, now complemented by modeled projections of aquifer response that show long-term utility of the Saugus at 7,500 to 15,000 afy in normal years and rapid recovery from higher pumping rates during intermittent dry periods, shows that the Saugus Formation can be considered a sustainable water supply source to meet the Saugus portion of the operating plan for the groundwater Basin.



NOTES:

1. SEE FIGURE 2-4 FOR LOCATIONS OF WELLS.

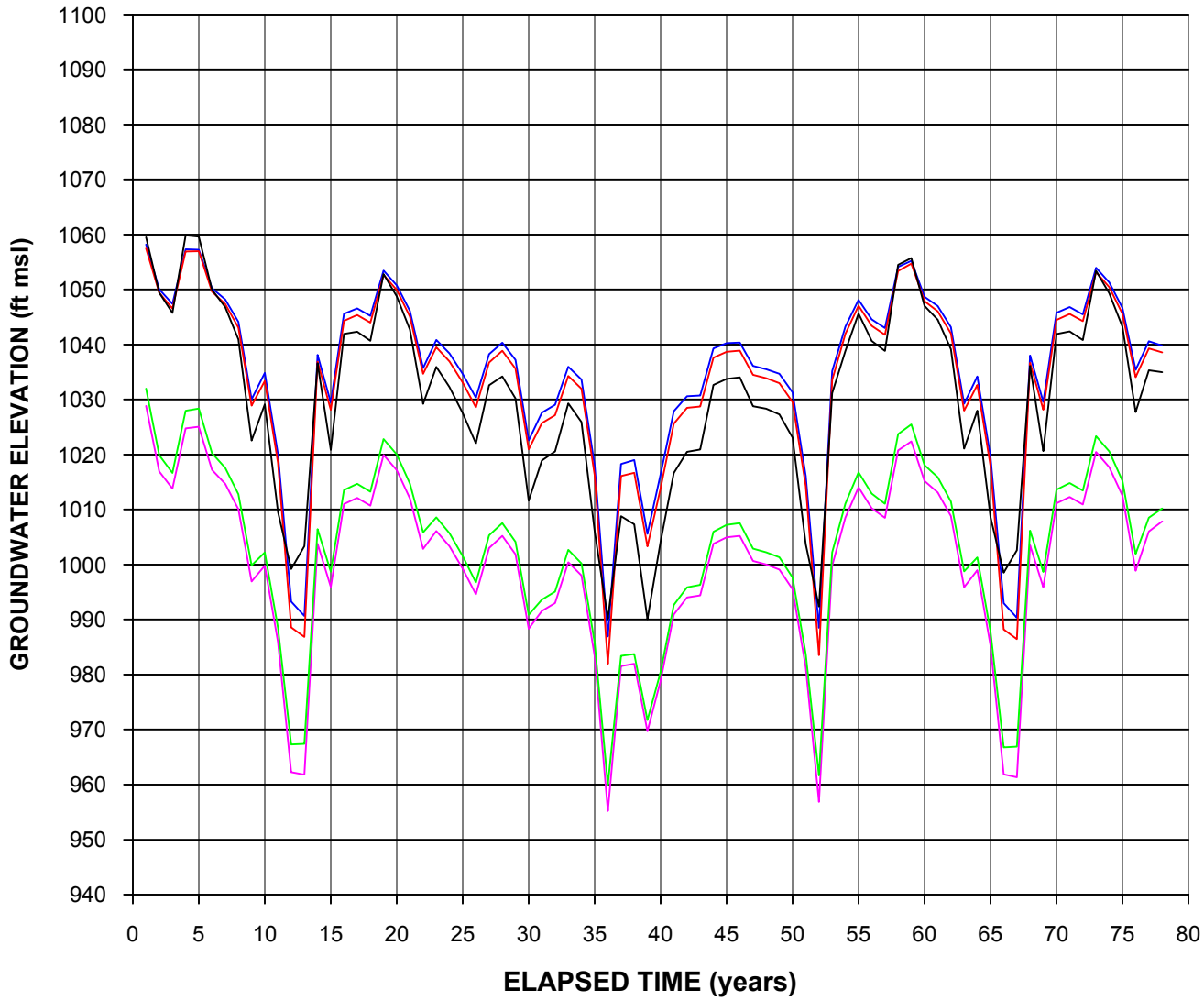
2. WELLS NLF-C6 AND LACFCD-6968 ARE CONSTRUCTED IN THE ALLUVIAL AQUIFER AND ARE NOT OPEN TO THE SAUGUS FORMATION. THE SIMULATED HYDROGRAPHS SHOWN AT THESE WELL LOCATIONS ARE FOR GROUNDWATER LEVELS IN THE SAUGUS FORMATION, BELOW THE OPEN INTERVALS OF THESE WELLS.

3. THE SIMULATED HYDROGRAPH FOR THE FUTURE WELLFIELD IS FOR A MODEL NODE WITH NO ASSIGNED PUMPING, LOCATED INSIDE THE WELLFIELD NEAR VWC-206.

FIGURE C-16
SIMULATED AVERAGE ANNUAL GROUNDWATER ELEVATIONS IN THE SAUGUS FORMATION WEST OF INTERSTATE 5
ANALYSIS OF GROUNDWATER BASIN YIELD
UPPER SANTA CLARA RIVER GROUNDWATER BASIN
EAST SUBBASIN, LOS ANGELES COUNTY, CALIFORNIA

CH2MHILL

178973-371.GRF



LEGEND

- VCW-157
- MP-5
- NCWD-11
- SCWC-SAUGUS1
- SCWC-SAUGUS2

NOTE:

1. SEE FIGURE 2-4 FOR LOCATIONS OF WELLS.

FIGURE C-17
SIMULATED AVERAGE ANNUAL GROUNDWATER ELEVATIONS IN THE SAUGUS FORMATION EAST OF INTERSTATE 5

ANALYSIS OF GROUNDWATER BASIN YIELD
UPPER SANTA CLARA RIVER GROUNDWATER BASIN
EAST SUBBASIN, LOS ANGELES COUNTY, CALIFORNIA

178973-372.GRF

CH2MHILL