

**HYDROGEOLOGIC EVALUATION OF POTENTIAL
FOR RECHARGE AND WATER BANKING IN
THE PLEASANT VALLEY WATER DISTRICT**

**prepared for
PLEASANT VALLEY WATER DISTRICT
Coalinga, California**

**by
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February 2000

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February 29, 2000

Mr. Bob Viets, President
Pleasant Valley Water District
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Coalinga, California 92310

Re: Potential Recharge and Water
Banking Project

Dear Bob:

Submitted herewith is our report on the results of our hydrogeologic evaluation of the potential for recharge and water banking in the Pleasant Valley Water District. We appreciate the cooperation of well owners and Summers Engineering, Inc. in providing information for use in this evaluation.

Sincerely yours,


Kenneth D. Schmidt

KDS/sll

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HYDROGEOLOGIC EVALUATION OF POTENTIAL FOR RECHARGE AND WATER BANKING IN THE PLEASANT VALLEY WATER DISTRICT

INTRODUCTION

This evaluation focuses on hydrogeologic conditions in the Pleasant Valley Water District that are important in terms of implementing a recharge and water banking program. The District is located near Coalinga in Fresno County, California and has an irrigable area of about 32,000 acres. Pleasant Valley is bounded by Anticline Ridge on the north, the Jacalitos and Kreyenhagen Hills on the west, and the Guijarral and Kettleman Hills to the east. The major drainages all enter the valley from the west, and include Los Gatos Creek, Warthan Creek, Jacalitos Creek, and Zapato Chino Creek. Warthan Creek joins Los Gatos Creek near the east edge of Coalinga, and Jacalitos Creek joins Los Gatos Creek about four miles downstream to the east. Below the confluence with Jacalitos Creek, the drainage is termed the Arroyo Pasajero. The Arroyo Pasajero passes through the Pasajero Gap, between Anticline Ridge and the Guijarral Hills, and leaves Pleasant Valley. Zapato Chino Creek passes through the Polvadero Gap, between the Guijarral Hills and Kettleman Hills, and also leaves Pleasant Valley and joins the Arroyo Pasajero just upstream of I-5.

Lands in the District have been irrigated with well water since the 1920-1930's. Kahanovitz and Manning (1954) described the groundwater hydrology of Pleasant Valley, as part of early studies by Stanford University on the west side of the San Joaquin Valley. Their evaluation focused primarily on estimating the runoff and recharge in the valley and estimating groundwater overdraft. HydroDevelopment, Inc. (1967) evaluated sources of water for irrigation in Pleasant Valley for the Standard Oil Company. They discussed groundwater resources, the overdraft that was present, and alternative sources of water. HydroDevelopment, Inc. (1969) subsequently evaluated the chemical quality of deep groundwater in the valley, also for the Standard Oil Company. As part of that evaluation, a 3,300-foot deep test hole was done and water samples were collected at depth. Summers Engineering, Inc. prepared a Factual Report in April 1986, in which a potential distribution system to bring aqueduct water to the District was considered. This was part of an application for a California Department of Water Resources groundwater recharge facilities loan. Additional information on water resources in Pleasant Valley has become available during the past decade, associated with the Arroyo Pasajero flooding problem [California Dept. of Water Resources (1990 and 1993), and the U.S. Army Corps. of

Engineers (1999)].

The average annual rainfall at Coalinga has been about seven inches since 1972. The drainage area for the Arroyo Pasajero comprises about 513 square miles. The average annual runoff from the westerly drainages into Pleasant Valley has been estimated to be about 16,000 acre-feet. As of the mid-1950's, the annual pumpage was estimated to be about 50,000 acre-feet per year, and the groundwater in Pleasant Valley was being overdrafted. In recent years the amount of pumpage and the rate of water-level decline have decreased.

TOPSOILS

The U.S. Soils Conservation Service (2000, unpublished) mapped topsoil types in Pleasant Valley. Other than recent alluvium along stream channels, the topsoils can be grouped into loamy sand, sandy loam, loam, and clay loam. Loamy sand is generally the most permeable of these four types. One of the largest areas mapped as loamy sand is east of Highway 33 and West of Zapato Chino Creek, in parts of Sections 15, 16, 21, and 22 of T21S/R16E. Although the topsoils mapped as loamy sand or sandy loam are generally highly permeable within the upper several feet, the under-lying subsoils often contain silt loam layers of much lower permeability.

SUBSURFACE GEOLOGIC CONDITIONS

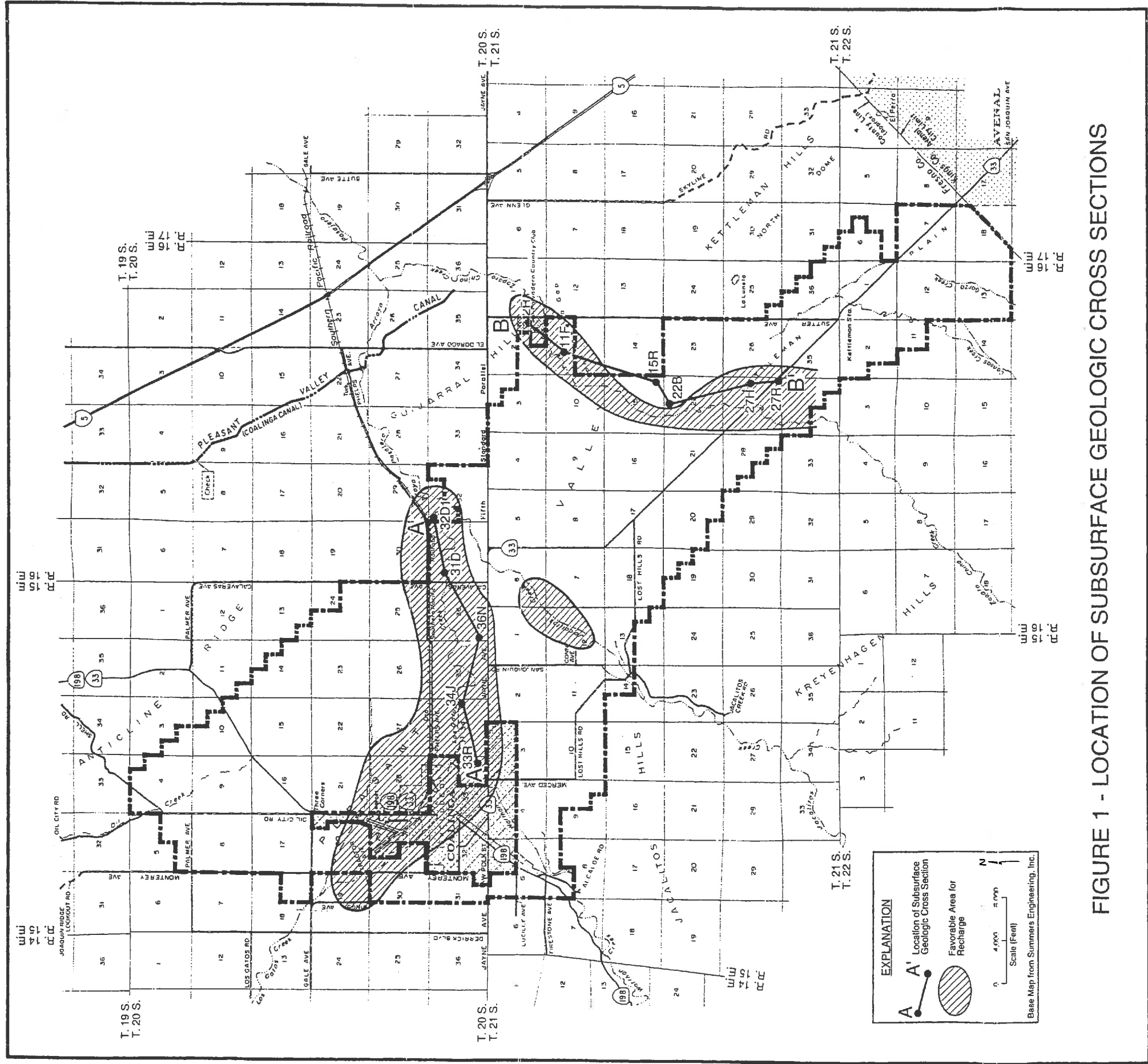
Non-marine upper Pliocene sedimentary rocks and Pleistocene and Recent alluvium are the most important deposits in terms of groundwater in Pleasant Valley. Most of the groundwater produced in Pleasant Valley is from poorly sorted sand, gravel, and cobbles that are interbedded with fine-grained layers, such as sandy clay, silt, and clay. Recent alluvium is present in the stream channels and is important in terms of recharge to the groundwater. Alluvium in Pleasant Valley is derived primarily from calcareous and gypsiferous sandstone, shale, and conglomerate from the tributary drainage area.

HydroDevelopment, Inc. (1969) presented a generalized east-west subsurface cross section through the central part of Pleasant Valley. This section indicated that the upper approximately 500 to 700 feet of deposits were primarily sands and gravels containing groundwater usable for irrigation. No significant laterally extensive confining beds were indicated to be present above a depth of about 1,000 feet.

As part of this evaluation, well drillers reports and electric logs were obtained for test holes and wells in the District. These logs provide a general indication of conditions below the topsoils. Based on the location of the Coalinga Canal,

which is the closest conveyance facility for water to be recharged, two subsurface cross sections were developed (Figure 1). One of these cross sections (A-A') is oriented from west to east along Los Gatos Creek, between Coalinga and Pasajero Gap. The other cross section (B-B') is oriented from north to south, generally along Zapato Chino Creek, between Highway 33 and the Polvadero Country Club. On each section, the main water-producing strata, fine-grained strata, and the water level are shown. Deposits above the water level and within the upper several hundred feet of the water level are most important in evaluating the potential for recharge. If fine-grained strata are present at shallow depth, particularly within the upper 50 feet, they can greatly hinder intentional recharge by basins.

Along Cross Section A-A' (Figure 2), sand, gravel, and cobbles are predominant within the upper 200 feet, except at the east edge of the section. At well 32D1, two significant clay layers are indicated between about 80 and 160 feet in depth. No extensive, continuous fine-grained layer was indicated above the December 1998 water level along this section. Subsurface geologic conditions along this section are generally indicated to be favorable for intentional recharge. The most favorable conditions along this section are indicated to be near Wells 34R,



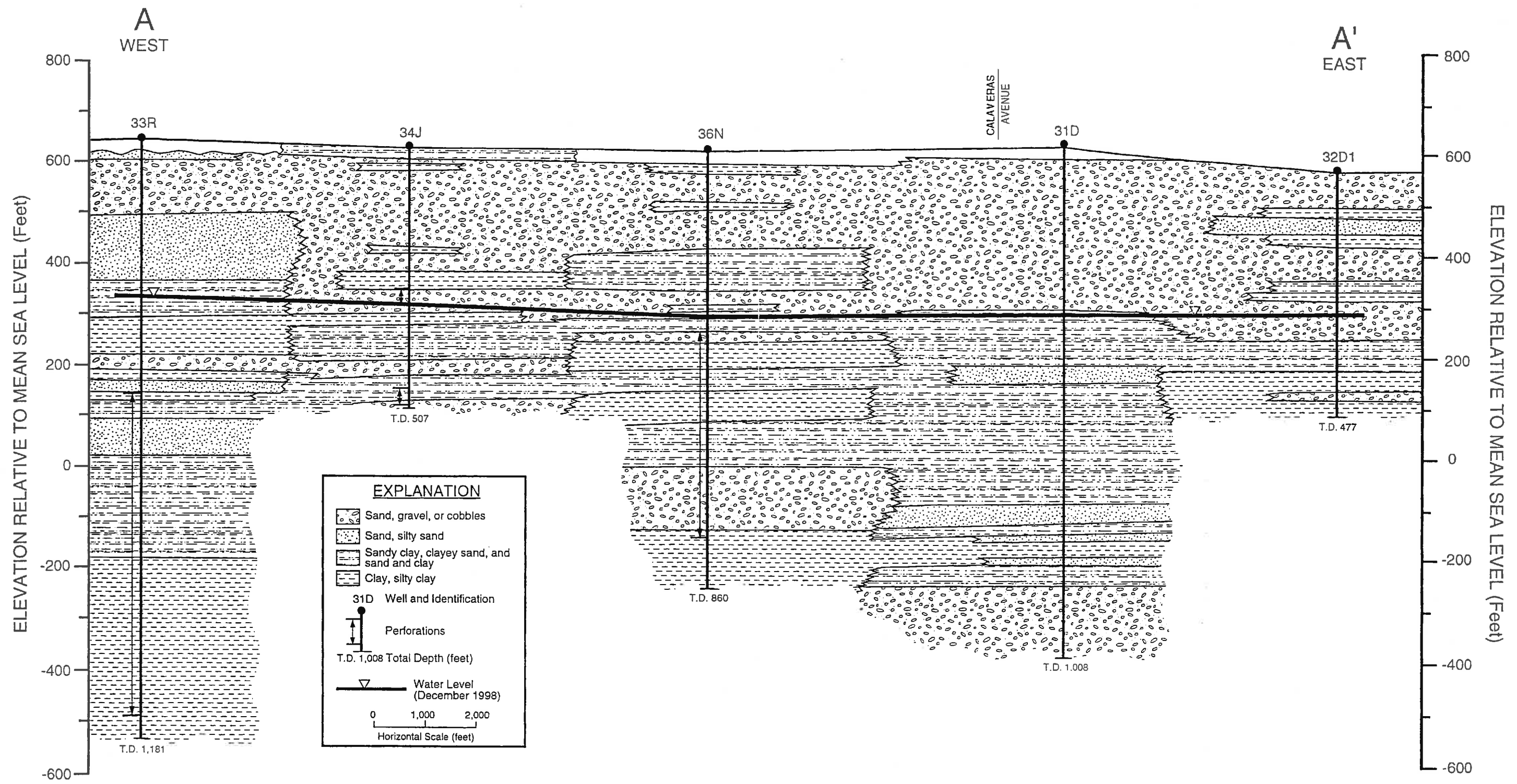
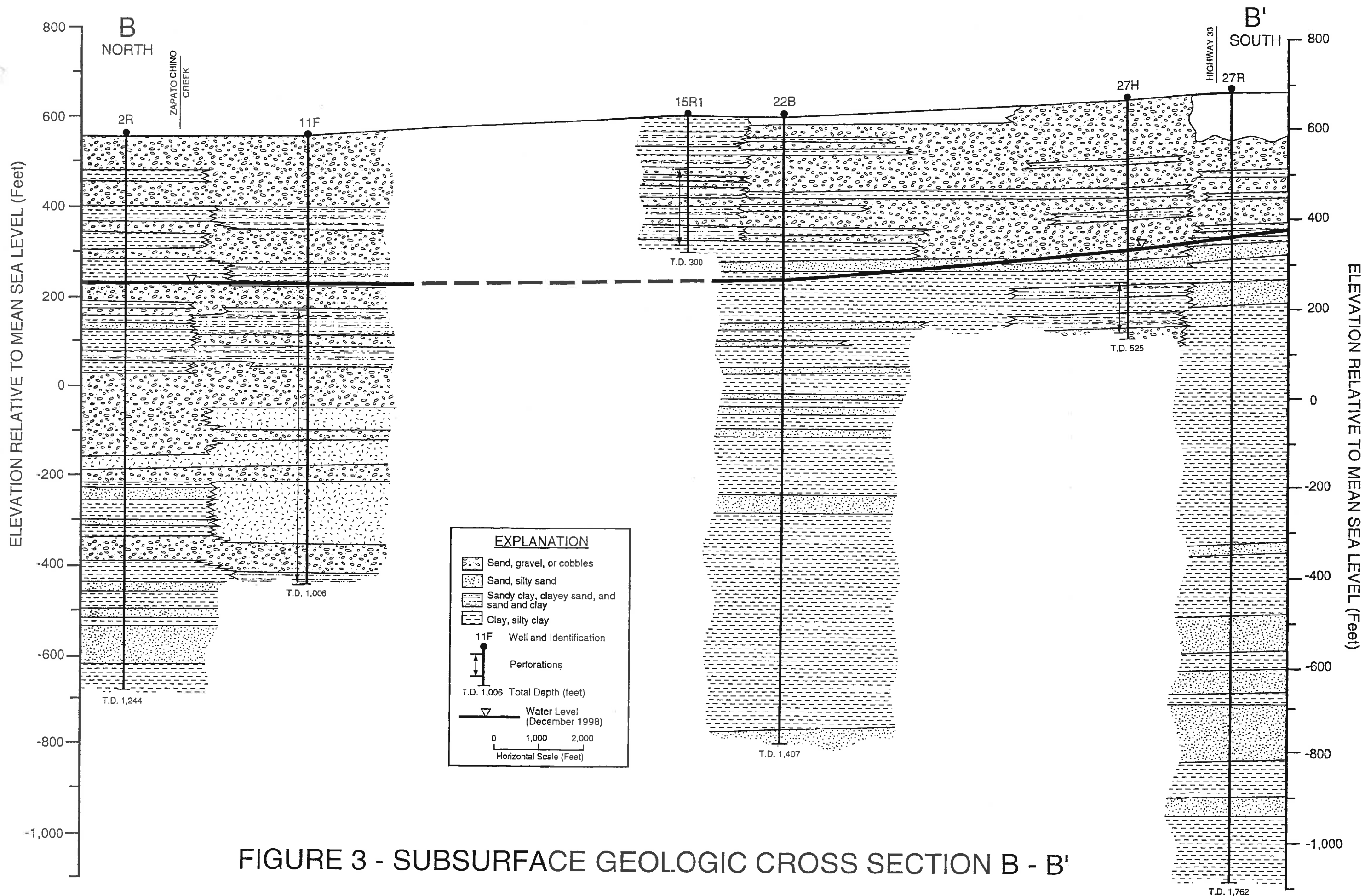


FIGURE 2 - SUBSURFACE GEOLOGIC CROSS SECTION A-A'

34J, and 31D.

Along most of Cross Section B-B' (Figure 3), sand, gravel, and cobbles are also predominant within the upper 200 feet. However, at Well 15R fine-grained deposits are predominant within the upper 120 feet. At Well 2R, a significant clay layer is present from about 80 to 100 feet in depth. At Well 22B, two clay layers are present within the upper 80 feet. Subsurface geologic conditions are generally indicated to be favorable for intentional recharge along the south part of the section (Wells 22B and 27R). Clay strata are predominant below a depth of about 750 feet and above a depth of about 1,200 feet along this section. No continuous, laterally extensive clay layers are indicated to be present above the water level along this section.

Although not included in this report, several other subsurface sections were developed, including along Jacalitos Creek. These sections generally indicate that subsurface conditions above the water level are not as favorable for intentional recharge at a distance of more than about one mile from the stream channels. That is, fine-grained deposits are common above the water table at more distant sites from these channels. Also, there is an area that is apparently suitable for intentional recharge along part of Jacalitos Creek.



Based on a review of available information in the District, the most favorable hydrogeologic areas for recharge were delineated, and these are shown on Figure 1. The largest extends from Coalinga to west of Pasajero Gap, and is located within about half a mile of the channel of Los Gatos Creek. North of Coalinga, this area includes several large abandoned gravel pits. A visual inspection of these pits was made in January 2000, and indicated that sand, gravel, and cobbles are predominant to a depth of at least 150 feet in this area. Fine-grained strata are scarce, and when present are thin and of limited areal extent. The second favorable hydrogeologic area extends along Zapato Chino Creek, from Highway 33 to near the Polvadero Country Club. The width of this favorable area is not as well known, but is likely similar to that along Los Gatos Creek. A third favorable area is along the upper part of Jacalitos Creek, but this area appears to be smaller than the other two. In terms of stream channel recharge, more information is needed on the silt content of the deposits in the stream channels.

WATER LEVELS

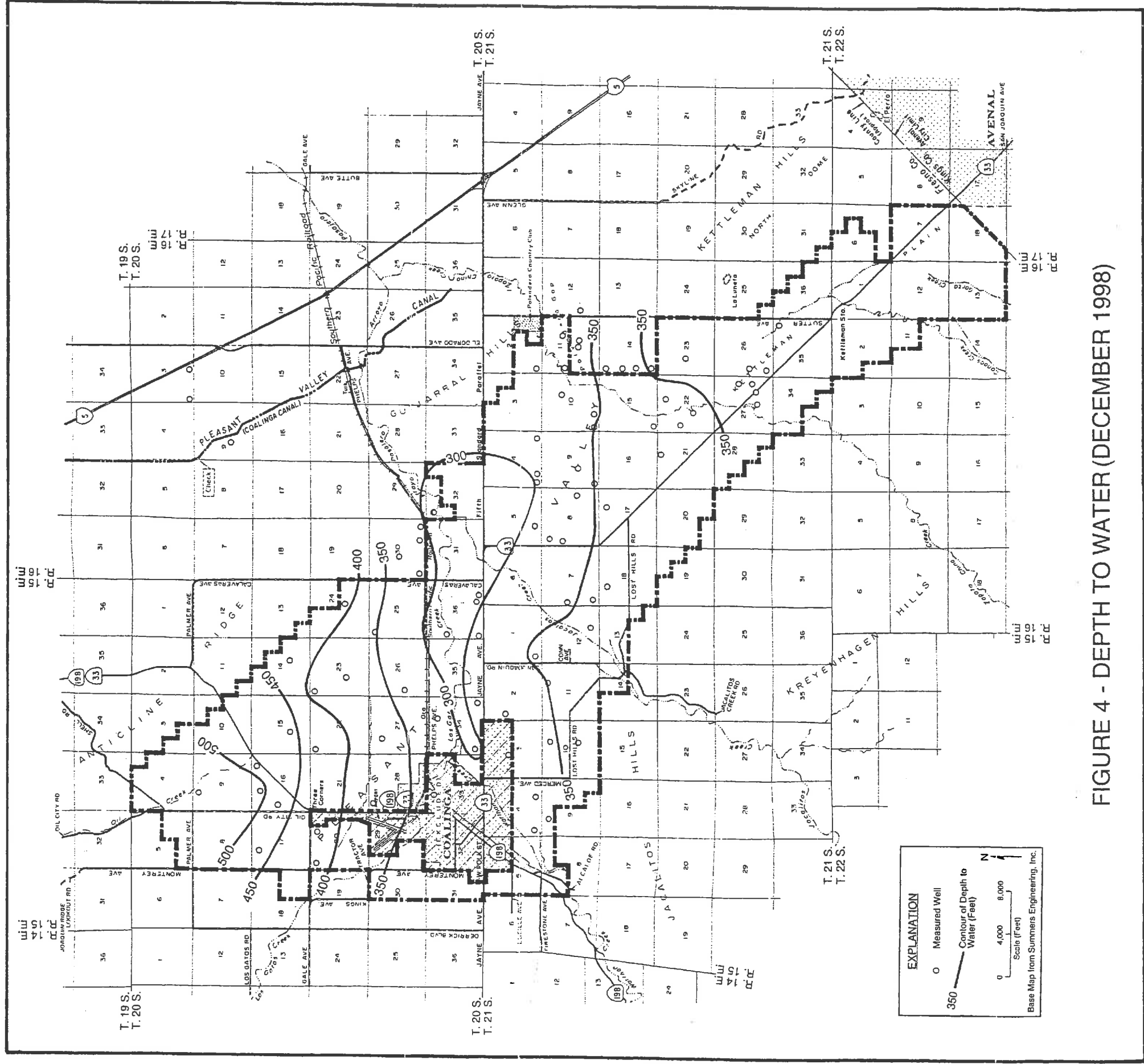
Water-level measurements for water supply wells in Pleasant Valley were obtained from the California Department of Water Resources, San Joaquin District, in Fresno.

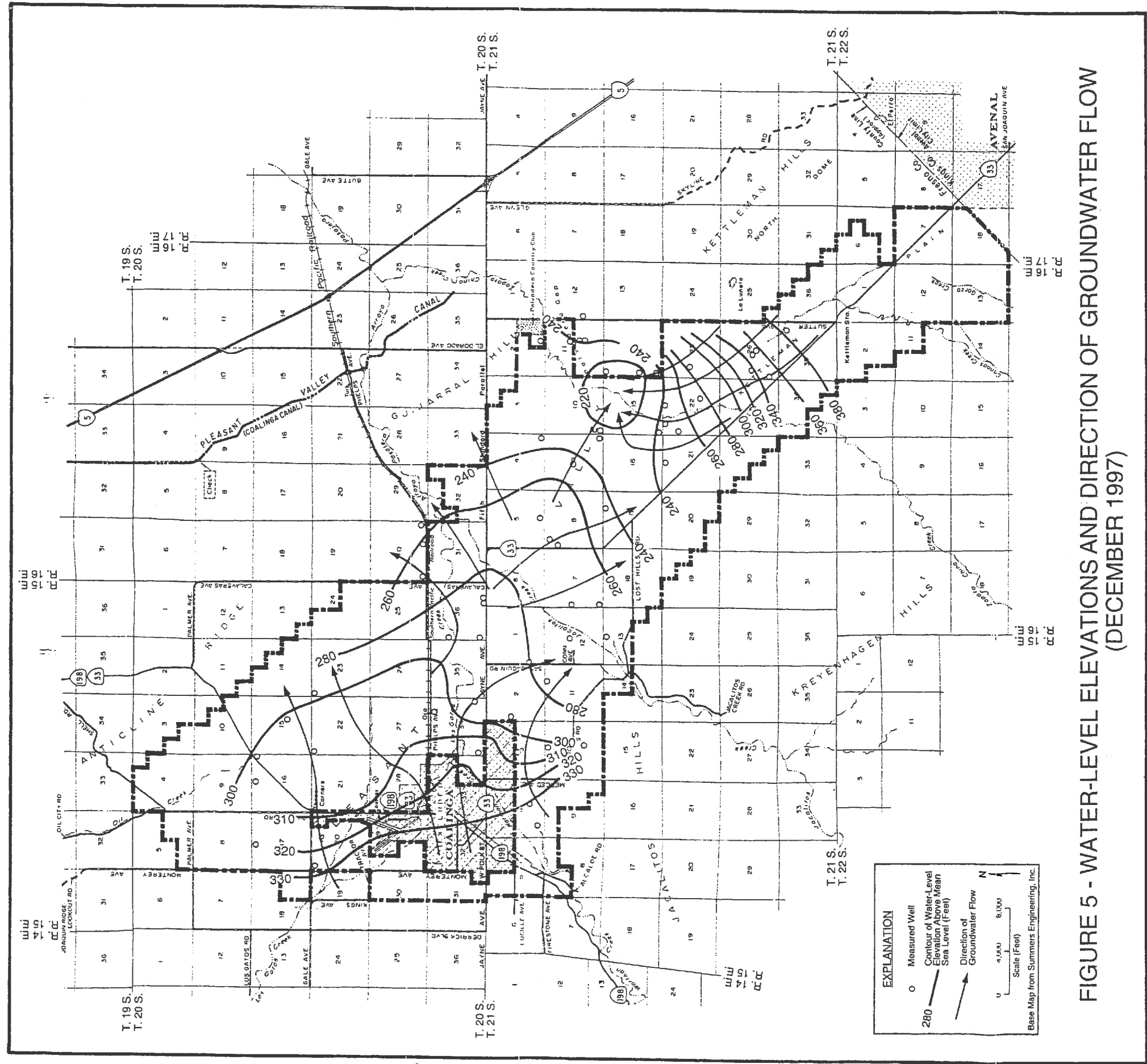
Depth to Water

Figure 4 shows depth-to-water contours for December 1998. Depth to water was less than 300 feet in a relatively small area, generally along Los Gatos Creek, between Coalinga and the Guijarral Hills. North of this area, depth to water increased to more than 500 feet north of the easterly extension of Los Gatos Road. Depth to water in most of the area south of Jayne Avenue ranged from about 300 to 370 feet. Some wells have anomalously shallow water levels compared to other wells in the vicinity. These shallower levels are commonly about 20 to 80 feet shallower than levels in other wells in the vicinity. DWR records indicate that most of these wells are less than 500 feet deep. This suggests that the shallowest groundwater level may be up to about 80 feet shallower than the water levels in nearby deep water supply wells. Further evaluation of the shallowest groundwater should be done as part of future hydrogeologic studies, if the project is feasible from the economic and environmental aspects.

Water-Level Elevations and Direction of Groundwater Flow

Under natural conditions, groundwater generally flowed easterly and exited Pleasant Valley through Pasajero and Polvadero Gaps. Figure 5 shows water-level elevations for December 1997.





The highest water-level elevations were to the southeast near Kettleman Station, where they exceeded 380 feet above mean sea level. Water-level elevations exceeded 330 feet beneath the central part of Coalinga and the large abandoned gravel pits north of the City. The lowest water-level elevations were in a cone of depression southwest of Polvadero Gap, where they were less than 220 feet. North of Jayne Avenue, the direction of groundwater flow was primarily to the east or east-northeast. In the south part of the valley, the direction of groundwater flow was as to the northwest and then toward the pumping depression southwest of Polvadero Gap. Water-level elevation contours in the area near Polvadero Gap indicate a westerly direction of groundwater flow, into Pleasant Valley. West of Pasajero Gap, a northeasterly direction of groundwater flow is indicated, but no measurements were available for December 1997 near the gap.

Water-Level Changes

Long-term water-level records extending back about 40 years are available for a number of wells in Pleasant Valley. A review of these measurements generally indicates greater rates of decline in deep wells that are more distant from sources of recharge, such as Los Gatos Creek, than in wells closer to these sources. Summers

Engineering, Inc. (1986) indicated that the average rate of water-level decline between 1964 and the early 1980's was about 4.8 feet per year. The water level has declined an average of about four feet per year during the past four decades. The rate of decline has decreased in the last 15 years, since the Factual Report was prepared. This is primarily due to a reduction in groundwater pumpage.

WELL PRODUCTION AND AQUIFER CHARACTERISTICS

PG&E pump tests are available for a number of irrigation wells in Pleasant Valley. Pumping rates for most of these wells range from about 600 to 1,100 gpm. The specific capacities (pumping rate divided by drawdown) of most of the wells range from about 10 to 40 gpm per foot. Aquifer tests are not known to have been conducted in Pleasant Valley to allow determination of transmissivity and storage coefficient. The average specific yield of the alluvial deposits below the water table has been estimated to be about 10 percent. However, the specific yield of the coarse-grained deposits within the upper several hundred feet of the land surface is estimated to be about 20 percent. Summers Engineering (1986) estimated that there was a storage space of about 800,000 acre-feet above a depth of about 200 feet in Pleasant Valley as of the mid-

1980's. This was based on a specific yield of 10 percent. However, use of a larger storage coefficient (20 percent as opposed to 10 percent), which is considered more reasonable, would double this amount.

SOURCES OF RECHARGE AND DISCHARGE

Kahanovitz and Manning (1954) concluded that the main source of recharge to groundwater in the valley was from streamflow seepage. They used estimates of precipitation and runoff to estimate the average annual groundwater recharge to be about 16,000 acre-feet. The primary source of groundwater discharge in the valley is by pumping wells, although some ground-water may flow out through Pasajero Gap. Due to the lowered water levels in Pleasant Valley, some groundwater now flows into the valley through Polvadero Gap. The annual pumpage in the valley was estimated to be about 50,000 acre-feet in the early 1950's. Summers Engineering, Inc. (1986) estimated the annual pumpage to be about 54,000 acre-feet as of the mid-1980's. The present annual pumpage is believed to be about 20,000 to 30,000 acre-feet.

GROUNDWATER QUALITY

The quality of groundwater is important for recovery of stored water in a water banking project. Recharged water will mix to some

extent with native groundwater. The recovered water would thus be a mixture of these two sources of water. Groundwater in much of Pleasant Valley is of moderate to high salinity and has high concentrations of sodium and sulfate. Total dissolved solids (TDS) concentrations in water from most wells ranged from about 1,000 to 3,000 mg/l and averaged about 1,500 mg/l in 1954. Boron concentrations ranged from about 1 to 5 mg/l, and were between 1.5 and 2.0 mg/l in water from most of the sampled wells at that time. Because the valley essentially comprises a closed groundwater basin where groundwater is pumped for irrigation, it is expected that the groundwater salinity would eventually increase in the absence of importation of lower salinity water. This is due to concentration of salts by evapotranspiration in the deep percolation.

HydroDevelopment, Inc. (1967) indicated that the TDS of the groundwater above a depth of about 1,000 feet ranged from about 1,000 to 1,800 mg/l, whereas deeper groundwater had TDS concentrations ranging from 1,800 to more than 3,000 mg/l. However, below a depth of about 2,000 feet, groundwater was present with a TDS of only about 1,000 mg/l, based on the results of a deep test hole done for the Standard Oil Company.

The historical chemical analyses in the DWR database were obtained for well water in Pleasant Valley. The lowest salinity

groundwater (less than about 1,000 mg/l of TDS) in the 1950's was along the upper reach of Jacalitos Creek (in Section 12 of T21S/R15E and Section 7 of T21S/R16E), and along the upper reaches of Zapato Chino Creek, south of the easterly extension of Merced Avenue.

Chemical analyses are available for water from two wells near Los Gatos and Jacalitos Creek that were sampled in 1991 and for other wells located farther south that were sampled in April 1997 (Table 1). Electrical conductivities ranged from 1,300 to 2,700 micromhos per centimeter at 25°C. Except for one well (Section 6), values ranged from 1,300 to 2,100 micromhos. The lowest values were generally for the southernmost wells. Boron concentrations ranged from 0.2 to 2.0 mg/l. Chloride concentrations ranged from about 60 to 220 mg/l, and except for the two northerly wells, ranged from about 60 to 140 mg/l.

Chemical analyses are available for water from five irrigation wells in the vicinity of Zapato Chino Creek that were sampled in April 1997 (Table 2). Electrical conductivities ranged from 980 to 1,400 micromhos. Except for one well, values ranged from 980 to 1,100 micromhos. The lowest values were for two wells (22B and 22L) relatively close to the creek. Boron concentrations ranged from 0.4 to 0.5 mg/l. Chloride concentrations ranged from 30 to

TABLE 1 - CHEMICAL ANALYSES OF WATER FROM
WELLS IN LOS GATOS CREEK - JACALITOS CREEK AREA

<u>Constituent (mg/l)</u>	<u>T20S/R15E</u>		<u>T21S/R16E</u>		<u>17E</u>
	<u>Sec 36</u>	<u>Sec 6</u>	<u>9H</u>	<u>9N</u>	<u>17B</u>
Calcium	122	124	180	126	94
Magnesium	79	75	118	71	58
Sodium	246	253	239	200	184
Bicarbonate	226	275	116	153	201
Chloride	135	220	142	78	64
Nitrate	20	35	4	4	6
Boron	9	0.2	0.6	0.7	0.7
pH	7.6	7.8	7.5	7.5	7.4
Electrical Conductivity (micromhos/cm @25°C)	2,100	2,700	1,900	1,600	1,700
Date	8/91	1/91	5/97	4/97	4/97
Samples analyzed by Dellavalle Laboratory, Inc.					

TABLE 2 - CHEMICAL ANALYSES OF WATER FROM
WELLS IN ZAPATO CHINO CREEK AREA (T21S/R16E)

<u>Constituent (mg/l)</u>	<u>14D</u>	<u>14E</u>	<u>22B</u>	<u>22L</u>	<u>26B</u>
Calcium	116	72	74	72	86
Magnesium	80	46	49	52	47
Sodium	152	145	131	120	166
Bicarbonate	146	159	195	201	171
Chloride	78	39	32	32	32
Nitrate	2	2	13	9	4
Boron	0.5	0.5	0.5	0.7	0.5
pH	7.5	7.7	7.7	7.7	7.7
Electrical Conductivity (micromhos/cm @25°C)	1,400	1,100	1,000	980	1,100

Water samples collected on April 14, 1997 and analyzed by Dellavalle Laboratory, Inc.

80 mg/l. These analyses confirm that better quality groundwater is present along Zapato Chino Creek.

In terms of implementing a water banking project, the largest area of relatively low salinity groundwater is along Zapato Chino Creek, except near and southwest of Polvadero Gap, where the salinity is higher. This could be important if water was to be recharged and stored in the valley, and then repumped into the aqueduct, because of the mixing with native groundwater that would occur.

GROUNDWATER RECHARGE

Direct recharge in abandoned gravel pits is possible without any excavation. Intentional recharge may also be possible in stream channels without any excavation. However, on the adjacent higher land, excavation of the uppermost soils would likely be necessary in most areas. Soil borings are necessary in specific areas to evaluate the thickness of deposits that would need to be excavated, if this is necessary.

The most favorable hydrogeologic areas for recharge are indicated to be within about a mile of the major stream channels in the area. Except in the channels or abandoned gravel pits, some topsoils would probably have to be excavated in order to practice

high-rate recharge (i.e., infiltration rates in the range of one-half foot per day or greater). There appears to be substantial recharge potential in the large, deep, abandoned gravel pits north of Coalinga and along Los Gatos Creek. Other favorable areas are along Zapato Chino Creek, and the upper part of Jacalitos Creek. Silt deposits in the stream channel may limit infiltration rates, and should be investigated.

There is considerable underground storage space in the valley. This is presently estimated to be more than one million acre-feet. Intentionally recharged groundwater should essentially stay in Pleasant Valley until recovered, as long as recharge is practiced more than several miles west of Pasajero Gap and more than several miles south of Polvadero Gap. If too much water is stored too close to these gaps, some of the recharged water could move out of the Pleasant Valley groundwater basin.

Recharge by stream-channel infiltration and in some of the abandoned gravel pits appears hydrogeologically feasible. For abandoned gravel pits, recharge rates of at least 2 to 4 feet per day are considered possible. For each 100 acres of pit, at least about 200 to 400 acre-feet per day, or 6,000 to 12,000 acre-feet per month, could be recharged. It may be possible to recharge in

a larger area of pits, and also to achieve even higher infiltration rates.

For stream channel recharge, infiltration rates of about one to two feet per day may be obtainable. Temporary levees or T-bars would likely be used. For a channel area of about 100 acres, about 100 to 200 acre-feet per day, or 3,000 to 6,000 acre-feet per month, could be recharged. It may be possible to recharge in a larger area of the channel. As discussed, silt deposited by natural streamflow could reduce infiltration rates in these channels, and this should be further evaluated.

Except for the abandoned gravel pits, soil borings are necessary to confirm subsurface conditions, particularly within the upper 50 feet or so of deposits. Once favorable areas are found based on these borings, pilot infiltration tests, using at least a quarter-acre or larger pond, should be conducted for several months in order to determine long-term infiltration rates. In order to evaluate stream channel sites, more information on the silt and clay in the channels should be obtained.

CONCLUSIONS AND RECOMMENDATIONS

Subsurface geologic conditions in Pleasant Valley are

favorable for implementation of a recharge and/or water banking project. Coarse-grained alluvial deposits are predominant within the uppermost several hundred feet. The most favorable areas are indicated to be located within about one mile of the stream channels, particularly along Los Gatos Creek, Zapato Chino Creek, and part of Jacalitos Creek. Depth to water is more than 300 feet in most of the area and water levels have declined about four feet per year since 1960. Groundwater quality is a limitation for a water banking project, unless the recovered water can be pumped somewhere besides into the California Aqueduct. Total dissolved solids (TDS) concentrations in the groundwater in the valley average over 1,500 mg/l. However, an area of lower TDS concentrations in groundwater (less than 1,000 mg/l) is present along the upper reaches of Zapato Chino Creek. When water is recharged and subsequently recovered, the quality of recovered water will be a mixture of the recharged water and native groundwater. Based on decades of experience with projects in similar settings, the mixture would probably be less than 50 percent recharged water and more than 50 percent native groundwater on the short-term (i.e., up to 5 to 10 years). On the long-term (more than 10 years), the mixture would probably be more than 70 percent recharged water and 30 percent native groundwater. This

mixing of recharged water with native groundwater does not mean that any recharged water would be lost to Pleasant Valley.

Yields of at least 1,000 gpm are considered attainable for recovery wells. However, in some areas, such as near the abandoned gravel pits, it may be possible to develop dual-cased or flow-path wells to tap shallower strata that became saturated due to recharge. In this case, well yields in excess of 2,000 gpm could probably be attained. Higher specific yields can likely be obtained from wells tapping shallower saturated strata that have been recharged, compared to existing wells.

Once the water source for a project is evaluated further, and if the project appears economically and environmentally feasible, then the next phase of hydrogeologic studies should be commenced. This would involve soil borings if stream-channel or basin recharge appears feasible, and pilot infiltration tests in the abandoned gravel pits, if this appears feasible. Also, the silt content in the stream channel deposits should be evaluated.

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