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State of California
The Resources Agency
DEPARTMENT OF WATER RESOURCES
Southern District

PLANNED UTILIZATION OF WATER RESOURCES IN ANTELOPE VALLEY

District Report

October 1980

Errata for

"Planned Utilization of Water Resources
in Antelope Valley"

On page 4, column 1, paragraph 4, last line, the figures within the parentheses should be (30°F to 40°F) rather than (63°F to 72°F).

On page 56, Table 19, last column, the final number should be 5,161,480 acre-feet rather than 1,161,480 acre-feet.

State of California
The Resources Agency
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Southern District

PLANNED UTILIZATION OF WATER RESOURCES IN ANTELOPE VALLEY

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District Report

October 1980

PWS-0184-0003

CONVERSION FACTORS

Metric to Customary System of Measurement

Quantity	Metric Unit	Multiply by	To get customary equivalent
Length	millimetres (mm)	0.03937	inches (in)
	centimetres (cm) for snow depth	0.3937	inches (in)
	metres (m)	3.2808	feet (ft)
	kilometres (km)	0.62139	miles (m)
Area	square millimetres (mm^2)	0.00155	square inches (in^2)
	square metres (m^2)	10.764	square feet (ft^2)
	hectares (ha)	2.4710	acres (ac)
	square kilometres (km^2)	0.3861	square miles (mi^2)
Volume	litres (l)	0.26417	gallons (gal)
	megalitres	0.26417	million gallons (10^6 gal)
	cubic metres (m^3)	35.315	cubic feet (ft^3)
	cubic metres (m^3)	1.308	cubic yards (yd^3)
	cubic metres (m^3)	0.0008107	acre-feet (ac-ft)
	cubic dekametres (dam^3)	0.8107	acre-feet (ac-ft)
	cubic hectometres (hm^3)	0.8107	thousands of acre-feet
	cubic kilometres (km^3)	0.8107	millions of acre-feet
Flow	cubic metres per second (m^3/s)	35.315	cubic feet per second (ft^3/s)
	litres per minute (l/min)	0.26417	gallons per minute (gal/min)
	litres per day (l/day)	0.26417	gallons per day)(gal/day)
	megalitres per day (Ml/day)	0.26417	million gallons per day (mgd)
	cubic metres per day (m^3/day)	0.0008107	acre-feet per day
Mass	kilograms (kg)	2.2046	pounds (lb)
	tonne (t)	1.1023	tons (short, 2,000 lb)
Velocity	metres per second (m/s)	3.2808	feet per second (ft/s)
Power	kilowatts (kW)	1.3405	horsepower (hp)
Pressure	kilopascals (kPa)	0.145054	pounds per square inch (psi)
	kilopascals (kPa)	0.33456	feet head of water
Specific capacity	litres per minute per metre drawdown	0.08052	gallons per minute per foot drawdown
Concentration	milligrams per litre (mg/l)	1.0	parts per million
Electrical conductivity	microsiemens per centimetre ($\mu S/cm$)	1.0	micromho per centimetre
Temperature	degrees Celsius (°C)	(1.8 × °C) + 32	degree Fahrenheit (°F)

PWS-0184-0004

FOREWORD

Heavy reliance on the local ground water supply is characteristic of many areas in Southern California. The Antelope Valley, which lies astride the Los Angeles, Kern, and San Bernardino County lines, is no exception. Currently, about 90 percent of the total water supply comes from the Valley's ground water basins. The remainder comes from the limited local surface water and reclaimed water and increasing amounts of imported water from the State Water Project. This heavy burden on the ground water basins has resulted in marked declines in ground water levels in the Valley.

At the same time, the choice of Palmdale in Antelope Valley as the site for a proposed major regional airport is expected to result in a significant increase in population.

Recognizing the need for local agencies to develop water resources management plans to cope with these two conditions, the Department of Water Resources in 1972 undertook a comprehensive investigation in cooperation with the County of Los Angeles and the United States Geological Survey to examine various alternative plans for meeting future water demands in the Valley.

The investigation entailed an inventory of the various sources of water supply, examination of factors influencing the demand, and evaluation of management alternatives for 1975-2020.

From this study, a "No-Change-in-Storage" plan is recommended, based on an evaluation of conditions that existed during the early part of 1980. Before a final water management plan is selected by local entities, however, a final assessment of the applicability of the recommended plan, in light of conditions that prevail at that time, should be made by major water users and organizations entrusted with water-related responsibilities. The leadership should be taken by the County Board of Supervisors, with ample opportunities provided for farmers, who are most significantly affected by any water management plan, to be heard.

To make possible implementation of a selected management plan with full cooperation from all concerned, a financial arrangement would be needed to make equitable distribution of both benefits and costs. The establishment of this arrangement should be based on a study to identify the benefited and the damaged and to formulate a plan for equitable distribution. Such a study would ensure that the selected management plan indeed represents a beneficial choice.

Jack J. Coe

Jack J. Coe, Chief
Southern District

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ACKNOWLEDGMENTS

The Antelope Valley Technical Advisory Committee was established at the commencement of the study in 1972 to provide guidance to the investigators. Composed of members directly involved with the future of the study area, it considered a number of significant issues which developed as the study progressed. Its member agencies and individuals who participated in the meeting were:

Los Angeles County Department of County Engineer
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Robert E. Lewis
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SUPPLEMENTAL DATA

The following Technical Information Records (TIRs) were prepared during the course of this study to document pertinent information derived from the investigation. Copies of the TIRs may be read in the Southern District office of the Department of Water Resources, 849 South Broadway, Los Angeles.

"A Preliminary Evaluation of Adequacy of Data for the Formulation of a Mathematical Water Quality Model of Antelope Valley", TIR 1335-6-A-1, 1975.

"A Preliminary Evaluation of Geologic Bases for the Selection of Spreading Grounds in the Antelope Valley Study Area", TIR 1335-6-A-2, 1976.

"A Preliminary Evaluation of Ground Water Quality Near Littlerock and Pearblossom in Antelope Valley", TIR 1335-6-A-3, 1976.

"A Preliminary Evaluation of Ground Water in Storage in the Antelope Valley Ground Water Model Area", TIR 1335-6-A-4, 1977.

"A Preliminary Evaluation of Ground Water Quality in the Antelope Valley", TIR 1335-6-A-5, 1979.

"A Preliminary Evaluation and Inventory of Water Supplies in the Antelope Valley", TIR 1335-6-B-1, 1978.

"A Preliminary Evaluation of Projections of Ground Water Levels Under Alternative Operating Conditions of the Antelope Valley Ground Water Basin", TIR 1335-6-C-1, 1977.

"A Preliminary Evaluation of Historical and Projected Water Demand, Antelope Valley", TIR 1335-6-C-2, 1977.

In addition, the U. S. Geological Survey has prepared a report to complete the earlier phase of the investigation. (See reference 40 in back of report.)

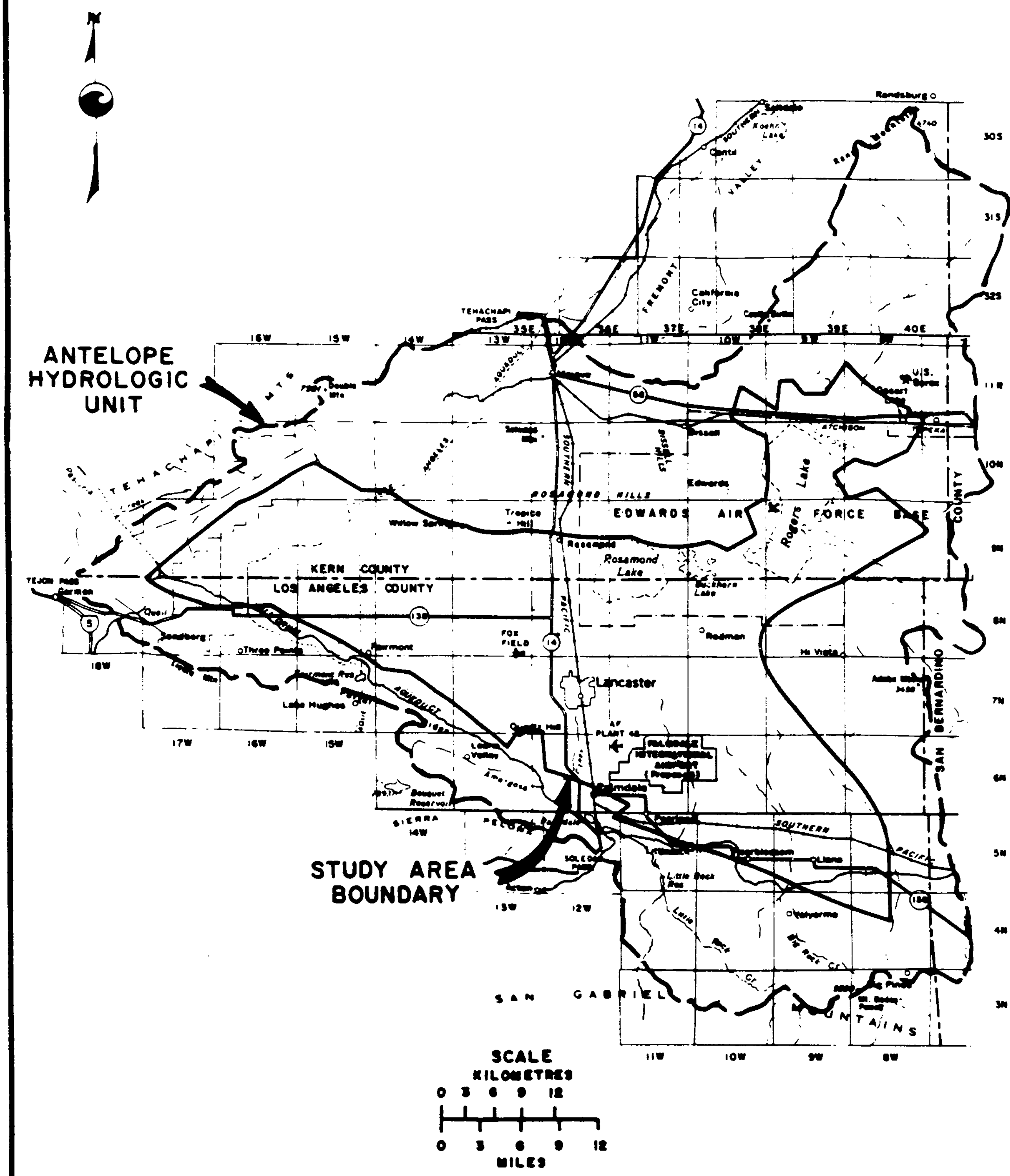


FIGURE 1 - STUDY AREA

DEPARTMENT OF WATER RESOURCES, SOUTHERN DISTRICT, 1980

PWS-0184-0012

I. INTRODUCTION AND SUMMARY

The Antelope Valley (Figure 1), which is one of the few remaining portions of Los Angeles County with large blocks of undeveloped level land, retains portions of the agricultural economy that once dominated the county. Location and climate have served to retard growth in the Antelope Valley, in comparison with the rapid growth which has characterized the coastal and near coastal areas. With the nearly complete urbanization of these areas, new urban development is spilling over into the Valley. The expanding aerospace industry and proposed international airport will accelerate this trend.

The arid climate of the Valley, although conducive to rapid crop growth, dictates a heavy reliance on ground water to satisfy the needs of both the agricultural and urban communities. Since 1900, when the initial steps were taken toward the full development of irrigated agriculture, ground water levels have consistently declined, especially in the heavy agricultural pumping area centered around Lancaster where as much as 60 metres (200 feet) of decline have been found. Increasing pump lifts, coupled with spreading urbanization and the high cost of imported water, will probably reduce the area farmed; however, agriculture will remain a basic part of the Valley's economy for some time to come.

Recognizing the need to prepare a feasible water resources management plan to ease the strain on the heavily burdened ground water supply, the California Department of Water Resources (DWR), the County of Los Angeles, and the U. S. Geological Survey (USGS) entered into a cooperative agreement to conduct an investigation of the Antelope Valley which was carried out in six phases. The last phase has been completed, and the results of the overall investigation are reported here. Details on the various aspects of the study are contained in a series of technical information records, copies of which are available in the Southern District office of DWR.

Objective of Investigation

The objective of this investigation was to formulate and evaluate alternatives for operating the Antelope Valley Ground Water Basin as part of a comprehensive water management plan. These alternatives, which were developed by DWR in close coordination with a technical advisory committee (TAC), can be used by the local agencies to ensure that future water demands can be met.

Scope and Conduct of the Investigation

The three cooperating agencies agreed to share the cost of the investigation as follows: The County of Los Angeles and DWR each provided 35.9 percent of the funds and USGS, 28.2 percent. Involved was a resources and requirements survey of Antelope Valley, culminating in the development of plans for coordinated use of the various supplies available--ground water, imported State Water Project (SWP) water, local surface water, and reclaimed water. The study area (Figure 1) was chosen by the TAC to facilitate the creation of a ground water basin model by USGS. The time frame for the study was 1975-2020. The six phases of the study were:

Phase I. Collect geohydrologic data and develop mathematical ground water model.

Phase II. Develop the study program in cooperation with the TAC.

Phase III. Determine historical water use, update population projections, and cooperate with the TAC in selecting water demand projections to be used in analyzing the alternative plans developed.

Phase IV. Evaluate the local and imported water supplies available including an assessment of the probability of delivering SWP water to the Valley.

Phase V. Formulate areawide alternative plans for water management and, in cooperation with the TAC, select those plans to receive detailed analysis.

Phase VI. Analyze the selected alternatives.

Phase VII. Summarize and prepare the final report.

Basic data such as ground water levels were obtained from the cooperating agencies to estimate water demand, inventory water supplies, and examine the economic costs of the various alternatives. USGS conducted field studies and developed a finite-element mathematical model of the ground water basin. This model was used to examine the flow characteristics and response of basin ground water level elevations under the various pumping and recharge patterns imposed by the alternative plans. The economic evaluations of all plans, as well as consideration of land subsidence, flood hazards, and other environmental aspects of the plans, were done by DWR in concert with the TAC.

In this study, USGS has applied the term "conditions" to the various management plans developed. Thus, in this report, the terms "alternative plans" and "alternative operating conditions" are used interchangeably.

Area of Investigation

The Antelope Valley, a desert basin with internal drainage, is about 64 kilometres (40 miles) north of downtown Los Angeles, astride the Kern, Los Angeles, and San Bernardino County lines. Its more than 5 200 square kilometres (2,000 square miles) lie in the western Mojave Desert, between the Coast Ranges to the west and the Basin and Range Province to the east. It is isolated from the densely populated coastal areas to the south by the Transverse Ranges, which include the San Gabriel Mountains. The Tehachapi Mountains bordering to the northwest separate the Antelope Valley from the rich San Joaquin Valley. The Rosamond and Bissell Hills bound the Valley to the north; a series of granitic hills and buttes form the boundary to the east.

The study area (Figure 1) was defined by the USGS in an earlier phase of the investigation (40)*. It differs from the Antelope Hydrologic Unit used in past DWR reports in that it excludes much of the surface drainage north of the Rosamond Hills including the Mojave area. The two major communities are Lancaster, with a population of 45,625, and Palmdale, with a population of 10,417.** The bulk of the population lives in the Palmdale-Lancaster-Quartz Hill triangle. A small percentage lives in the Kern County towns of Rosamond, Edwards, and Boron.

The main avenues of approach to the Valley are through Soledad Pass (State Route 14) from the south, Tejon Pass (State Route 138) from the west, and Tehachapi Pass (State Route 58) from the northwest. The Valley is served by the Santa Fe and Southern Pacific railroads. The major airfields are William J. Fox Field, northwest of Lancaster, Palmdale International Airport at Air Force Plant 42, and Edwards Air Force Base. The Edwards

* Numbers in parentheses refer to reports listed in the back of the report.
** Los Angeles County Planning Commission estimates as of July 1, 1978.

SITE of proposed Palmdale International Airport is astride the Little Rock Creek wash. In the right foreground is the community of Littlerock.

runways are strictly for military traffic. The City of Los Angeles now plans to build a major regional airport to serve the north county at a site near the present Palmdale International Airport.

Geology

Antelope Valley is part of an untilted fault block lying between the San Andreas and Garlock faults, which intersect near the community of Gorman to the west. The surrounding highlands have been uplifted considerably in recent geologic times and have contributed a large quantity of eroded debris to the Valley floor.

Granitic and metamorphic rocks dominate the San Gabriel Mountains, which rise to 2 865 metres (9,399 feet) at Mt. Baden-Powell on the divide. The Tehachapi Mountains attain an elevation of 2 433 metres (7,981 feet) at Double Mountain.

The Valley floor is broken by remnant peaks protruding through the alluvium and locally termed buttes. Sedimentary deposits fill the basin to depths of as much as 2 400 metres (8,000 feet). (49). Older alluvium, which composes the bulk of the water-bearing deposits, is locally as much as 1 500 metres (5,000 feet) thick (40).

The elevation of the Valley floor ranges from about 910 metres (3,000 feet) along its borders down to 690 metres (2,270 feet) above sea level at Rosamond Dry Lake and 682 metres (2,237 feet) at Rogers Dry Lake.

Unlike other closed basins in the Mojave Desert, such as Searles Lake, Antelope Valley does not generally have saline waters with dissolved solids concentrations greater than 3 000 milligrams per litre (mg/L). The only indications of saline deposits are around Rogers Dry Lake, in the surface clay of Rosamond Dry Lake, and in the soil for several kilometres around its western and southern perimeter (38). This alkali presumably was deposited as ground water evaporated in this area.

The quality of water below the 610-metre (2,000-foot) depth penetrated by the deepest water wells is unknown. The existence of saline clays in the thick sedimentary deposits underlying the Antelope Valley other than around Rogers Dry Lake has been speculated upon; however, evidence from deep oil test holes has indicated no buried lakebeds (38).

Climate

The Antelope Valley has a semiarid desert climate with cool, moist winters and hot, dry summers. Lying in the rainshadow of the mountains, it receives less precipitation than the coastal regions of Southern California, which benefit from orographic rainfall on the windward slopes. About three-fourths of the annual precipitation falls from December through March. Precipitation generally increases with altitude, from less than 250 millimetres (10 inches) on the Valley floor to more than 1 000 millimetres (40 inches) in the higher elevations of the San Gabriel Mountains. The highest mean annual precipitation on the Valley floor is found in the west near Fairmont Reservoir with 380 millimetres (15 inches)--adequate for dry farming. Occasionally, during summer and fall, winds from the east will bring sudden thundershowers and high humidity from the Gulf of California.

The growing season in Antelope Valley averages 215 to 245 days (61), which is not as lengthy as that in the Imperial Valley, San Joaquin Valley, or coastal plains of Southern California.

There are about 350 good flying days per year at Edwards Air Force Base (45).

Isolated from the moderating influence of the ocean, the Valley has a climate that is more extreme than that found along the coast. Temperatures often exceed 38°C (100°F) during the summer and may drop below freezing in winter. They fluctuate as widely as 17° to 22°C (~~63~~°F to ~~72~~°F) in a single day.
30° 40°

Variable westerly winds prevail for most of the year in Antelope Valley.

The most damaging winds scour the Valley during spring and early summer when young alfalfa is vulnerable; Arizona cypress and other shrubs are therefore planted as windbreaks.

The Valley has an annual net atmospheric-water deficiency, which is characteristic of arid regions. During 1939-59, mean annual pan evaporation at Backus Ranch (T10N, R12W, Section 20), just north of the study area, was 2.90 metres (114 inches, or 9.5 feet), as measured by the U. S. Weather Bureau (2).

Agriculture and Industry

Agriculture in Antelope Valley is fairly diversified, with the emphasis on livestock and feed production. The poultry industry, although declining in recent years, is a major part of livestock production in the Valley. Some of the turkey and chicken breeding industry in Los Angeles County moved north to the Valley as the San Fernando Valley was urbanized.

Wheat and barley are dry-farmed in the western valley. These farms, which are heavily mechanized, average about 4.0 square kilometres (1,000 acres) in size (45). There was a surge in irrigated acreage when Antelope Valley-East Kern Water Agency (AVEK) introduced SWP water to the western Valley in 1972 at prices competitive with the costs of pumping ground water.

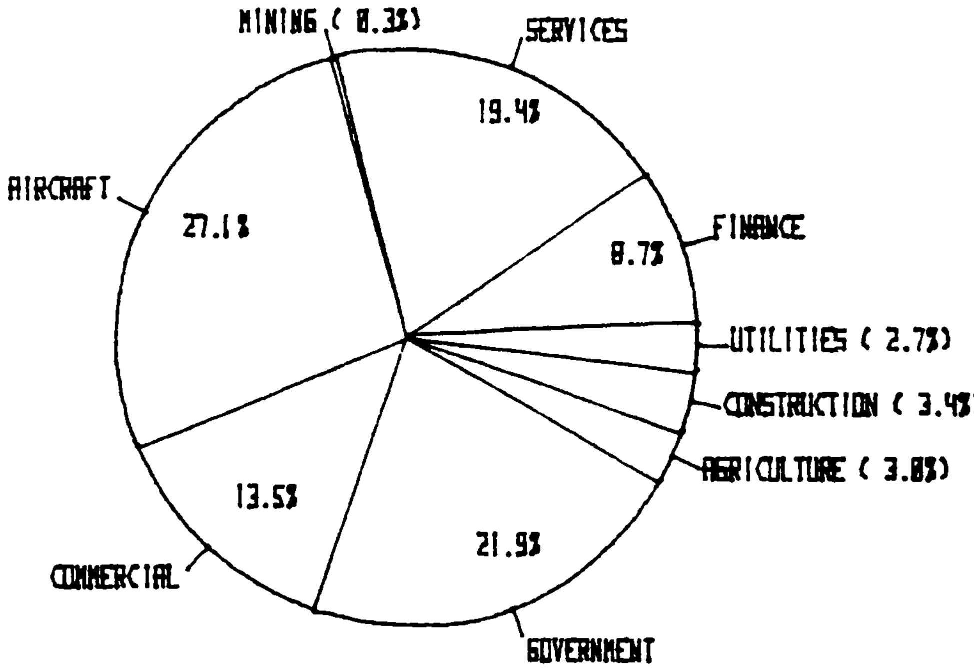
Irrigated agriculture is primarily concentrated in a band in the center of the study area, avoiding the alkaline clay of the lower Valley. Alfalfa is the main crop, often with five cuttings per year. The alfalfa hay is shipped to the Chino-Ontario dairies as well as fed to local stock. The hay market flourished during the past several years of drought because the Valley's irrigated farmlands were able to supply hay to cattlemen hurt by drought-stricken grasslands. Nonetheless, the amount of land in irrigated agriculture has generally been declining since the mid-1960s.

Manufacturing is the main economic activity in Antelope Valley. The aerospace industry, which constitutes the bulk of the manufacturing base, is concentrated in the Los Angeles County portion of the Valley. At Air Force Plant 42 near Palmdale are a number of civil aircraft production and testing facilities where much of the aircraft produced in Southern California is tested. A recent breakdown of employment in the Valley is shown in Figure 2.

FIGURE 2

ANTELOPE VALLEY EMPLOYMENT *

ACTON TO L. A. COUNTY LINE



TOTAL EMPLOYMENT

Agriculture	1,200	Services	7,788
Construction	1,380	Mining	125
Utilities & Transportation	1,084	Aircraft Manufacture	10,829
Finance, Banking, Real Estate, Insurance	3,500	Commercial	5,431
		Government	8,804

Total = 40,141

*Source: Antelope Valley Board of Trade, 1979. Figures apply to period ending 1978.

Edwards Air Force Base covers 1 200 square kilometres (300,000 acres), much of it within the northeastern part of the study area. Established by the Army as a bombing range in the 1930s, it was converted into a flight test center for military aircraft following World War II. There are now production facilities as well as sites for missile research located at Edwards.

Gold is no longer mined at Tropico in the Rosamond Hills, and the mining area is now operated as a tourist attraction. Borax is actively mined near Kramer. Rock and gravel quarrying is conducted in the southeastern part of the Valley along the mountainfront. Clay used for drilling mud formerly was mined from Rosamond and Rogers Dry Lakes.

Summary of Findings

Findings obtained in the Antelope Valley investigation include:

1. The population in Antelope Valley is projected to grow from 94,000 in 1975 to 320,000 by 2020; the amount of irrigated land cannot be reliably projected because of the drastic changes in energy and water costs.

2. Assuming that present trends continue, the projected annual water demand would rise from an estimated 238 000 cubic dekametres (192,600 acre-feet) in 1975 to 316 000 cubic dekametres (~~255,900~~ acre-feet) in the year 2020, an average growth rate of 1 800 cubic dekametres (1,500 acre-feet) per year. The increase in demand is expected to be derived solely from growth in municipal and industrial water use because agricultural use is predicted to remain at present levels for the duration of the study period.

3. Urban demand in the study area could be reduced significantly through institution of conservation measures. In a recent study, this reduction was estimated to be as much as 21 percent by 2000 and 23 percent by 2020. Under these projections, the per capita demand would drop from the present 950 litres (250 gallons) per capita per day to 746 litres (197 gallons) per day by 2000 and to 730 litres (193 gallons) per day by the year 2020. Therefore, the adjusted total water demand in Antelope Valley would rise to 290 000 cubic dekametres (235,400 acre-feet) rather than 316 000 cubic dekametres (255,900 acre-feet), by the end of the study period in 2020.

4. In 1975, the Antelope Valley's sources of supply were ground water (92.8 percent of the total), imported water from the SWP (4.5 percent), local surface runoff (2.1 percent), and reclaimed water (0.6 percent), to make up a total 237 580 cubic (192,600 acre-feet).

5. In 1976, 1 540 cubic dekametres (1,250 acre-feet) of reclaimed water was used beneficially for irrigation and recreation. Los Angeles County Sanitation Districts are planning to provide an additional 2 800 cubic dekametres (2,200 acre-feet) annually of waste water from District 14 Water Reclamation Plant near Lancaster, currently discharged to ponds, to an alfalfa ranch to the west.

6. Little Rock and Big Rock Creeks provide approximately 5 060 cubic dekametres (4,100 acre-feet) of local surface water supply annually. One element of this supply network, Little Rock Dam, which now stores 1 233 cubic dekametres (1,000 acre-feet), is currently being investigated by DWR Safety of Dams Division with respect to its safety. The removal of this dam would increase the amount of flood runoff in Little Rock and Big

SAME VIEW IN 1936 AND 1979, looking northeast across the Valley and the community of Palmdale. Major changes include increased development along old Sierra Highway (in middle of both photos), completion of new freeway (lower left in lower photo), and construction of major facilities at Air Force Plant 42, such as the Lockheed plant (upper left in lower photo).

Rock Creeks, posing a threat to facilities in the floodplain.

7. In Antelope Valley, there are three major contractors for State Water Project water: the largest, AVEK, had an entitlement of 43 170 cubic dekametres (35,000 acre-feet) in 1975, which will increase to a maximum of 170 720 cubic dekametres (138,400 acre-feet) in 1991; Littlerock Creek Irrigation District, with 640 cubic dekametres (520 acre-feet) in 1975 rising to 2 840 cubic dekametres (2,300 acre-feet) in 1991; and Palmdale Water District, whose entitlement increases from 6 880 (5,580 acre-feet) in 1975 to 21 340 cubic dekametres (17,300 acre-feet) in 1991.

8. The Antelope Valley ground water basin is subdivided by faults and other physical features into West Antelope, Neenach, Buttes, Finger Buttes, Lancaster, Pearland, and North Muroc subbasins. However, knowledge of the basin is incomplete.

   The largest subbasin, Lancaster, is the only one composed of a two-aquifer system, the principal (upper) aquifer and the deep (lower) aquifer. The aquifers are separated by a series of layers which are mostly clay. In 1975, the principal aquifer supplied 213 200 cubic dekametres (172,800 acre-feet) and the confined deep aquifer 7 200 cubic dekametres (5,900 acre-feet) of water to the Valley.

9. The total ground-water storage capacity of Antelope Valley is estimated to be 84 million cubic dekametres (68 million acre-feet). In 1975, the amount of fresh water estimated to be in storage was 68 million cubic dekametres (55 million acre-feet).

10. Approximately 16 million cubic dekametres (13 million acre-feet) of storage was above the water table, a large part of which is available for future recharge operations. Because the average annual precipitation is less than 250 millimetres (10 inches) on the Valley floor, direct rainfall does not contribute recharge to the ground water basin. Natural recharge is derived largely from streamflow and near surface percolation whose source is precipitation in the surrounding mountains. Mean annual recharge to the basin is estimated to be 50 200 cubic dekametres (40,700 acre-feet).

11. The ground water is generally of good quality, with total dissolved solids (TDS) concentrations less than 500 mg/L. The water is characteristically calcium bicarbonate near the source mountains tending toward sodium bicarbonate in the north. The water from the deep aquifer tends to be sodium bicarbonate in character.

    Water with TDS concentration of 1 000 mg/L or more is found in the North Muroc Subbasin, around the borders of the Lancaster Subbasin, and in shallow wells scattered through the basin.

12. The sampling of wells has led to the discovery of elevated nitrate concentrations around the orchards of Littlerock and Quartz Hill.

13. From the evaluation of the various management alternatives (which covered options ranging from total reliance on ground water to meet demands to recharge of the basin with imported water to restore historic water levels) the following results were found:

    a. Use of the ground water model indicated that the Maximum Pumping Plan (Condition 4), which places total reliance on ground water for supply, will result in an average basinwide decline of 24 metres (78 feet) of water level elevation by 2020. The plan to recharge the basin and restore historic water levels, Maximum Recharge Plan (Condition 6), would yield a rise of 35.2 metres (115.5 feet) by 2020. Between these two conditions, the No-Change-in-Storage Plan (Condition 5) and the Full Entitlement Plan (Condition 7) would tend to stabilize ground water levels.

b. The estimated total energy consumption for 1975 to 2020 would range from 6.9 billion kilowatthours (kWh) under the Maximum Pumping Plan (Condition 4) to 57.5 billion kWh under the Maximum Recharge Plan (Condition 6). For the No-Change-in-Storage Plan (Condition 5), it would be 23 billion kWh and for the Full Entitlement Plan (Condition 7), 24.3 billion kWh.

c. Comparing the present worth of net costs (at 6 percent interest) for each alternative (including costs of ground water, imported water, and spreading program minus the savings in pumping costs after 2020), reveals costs which range from $268.3 million for the Maximum Pumping Plan (Condition 4) to a maximum $699.4 million for the Maximum Recharge Plan (Condition 6). For the No-Change-in-Storage Plan (Condition 5), the cost would be $364.8 million and for the Full Entitlement Plan (Condition 7), $391.0 million.

d. A model simulating the change in ground water quality in Antelope Valley cannot, at this time, be developed because of insufficient data.

14. Under most of the alternative plans, the amount of land under cultivation is likely to diminish, assuming that imported water costs assessed to agricultural users are on a par with the rates applied to municipal and industrial users. A possible exception might be the Maximum Recharge Plan (Condition 6) under which ground water levels would be restored to historic levels--allowing farmers to operate with smaller pumping lifts. (For the study, it was assumed that the area devoted to agriculture will remain at the 1975 level for the duration of the study period.)

Conclusions

Based on the findings made in this study, the following conclusions were drawn:

1. If the management objective is to arrive at a least-cost plan, maximum use of ground water would be the selection; however, to stabilize ground water levels as soon as possible, the coordinated use of ground water and SWP water would be necessary.

2. When the new Palmdale Airport is built, the expected resulting increase in population will generate additional waste water available for reclaiming. Reclaimed water use for agriculture will continue to rise with the increased future production of waste water if the Los Angeles County Sanitation Districts continue to provide it at a price competitive with the cost of pumping ground water.

3. Effects of flood flows in Little Rock and Big Rock Creeks as a result of the removal of Little Rock Dam could be mitigated

by constructing percolation ponds and improving spreading grounds.

4. Effective water conservation measures will reduce the cost of operation as well as total energy consumption in the Antelope Valley.

5. Closer monitoring of water quality is needed in problem areas such as Littlerock and Quartz Hill. In this regard, the Regional Water Quality Control Board, Lahontan Region, has specific objectives of an adequate surveillance and monitoring program to locate and identify sources of water pollution that pose an acute, accumulative or chronic threat to the environment.

6. Additional geohydrologic information would be needed for formulation of a water quality model. For example, the extent of deep percolation of water from the ground surface to the principal and deep aquifers must be determined. The degree of interconnection between the principal and deep aquifers must also be defined.

Recommendations

Based on the preceding conclusions, the following recommendations are made in concert with the TAC:

1. The No-Change-in-Storage Plan (Condition 5) be the plan implemented by the local agencies to provide maximum ensurance of a long-term reliable supply of water for the Antelope Valley. This plan is feasible provided that adequate SWP water is made available. Although this plan uses more energy and has a higher cost than the Maximum Pumping Plan (Condition 4), the advantage is that it halts the decline of ground water levels in the Valley while supplying the users with good quality SWP water.

2. Before a final plan is selected, an assessment be made of applicability of the plan to current conditions. The leadership should be taken by the County Board of Supervisors, with input from farmers and other agencies entrusted with water management responsibilities. Establishment of an additional water agency is not needed.

3. Urban water conservation measures be instituted where possible as a means of reducing water and energy demand, thus delaying the need for additional SWP facilities.

4. The present policy of encouraging appropriate use of reclaimed water as more reclaimed water becomes available be continued.

5. Floodplain management principles be employed to mitigate possible flooding in the floodplain and improve ground water recharge in the upper reaches of Little Rock and Big Rock Washes.

6. To defend against the sudden onset of future water quality problems, the representatives from participating agencies develop a plan to continue the program for data collection and analysis. As a part of this monitoring program, provisions should be made for pooling data for more detailed study such as time-series analysis. In portions of the Valley that are not regularly monitored, yet in which significant water quality changes may be occurring, the system of monitoring certain key wells should be developed. Whenever additional geohydrologic and geochemical information become available, the data should be analyzed. Also the water quality control plan for the Lahontan Region should be considered in future water quality studies.

II. WATER DEMAND AND SUPPLIES

In conducting the investigation, consideration was given first to examining the factors influencing demand, then to inventorying the various sources of water supplies to meet that demand.

Water Demand

The major demands for water in Antelope Valley are for agricultural and municipal and industrial uses. The water demand for recreational purposes is comparatively insignificant.

Historically, municipal and industrial use has been small. Palmdale, Lancaster, Littlerock, and other communities were founded to serve the local farmers. The railroad was the major industry, connecting Valley farmers with the major markets. Since World War II, however, economic growth has been independent of farming, reflecting the expansion of military and civilian aerospace activities, as well as the substantial growth in Southern California as a whole.

The construction of Palmdale International Airport will have a significant impact on future growth rates; the Los Angeles City Department of Airports is planning to build the airport in the early 1980s. Most of the land, at a cost of $80 million, has already been purchased by the City of Los Angeles. Although it has been scaled down to an airport capable of handling 12-15 million annual passengers from the originally envisioned 70 million annual passengers, it will increase the level of development in the Valley by attracting subsidiary industries and people.

The uncertainty and disagreement regarding the Valley's future growth make inevitable the publication of conflicting population projections and irrigated land estimates by various State and local agencies.

Projections

From among several projections of irrigated land for Antelope Valley made by various agencies, the TAC selected the projection of the Los Angeles County Planning Commission (Figure 3).

There has been a steady decline in agricultural land since the 1950s as a result of urban encroachment, increasing water costs, and rising land values. This decline halted in 1972 and the land under tillage has even risen slightly as the result of rising crop prices and the delivery by AVEK of imported water to agricultural users in the western portion of the Valley at prices competitive with the cost of pumping ground water. The availability of imported water to agricultural users is expected to drop sharply after 1983 when the renewal of SWP energy contracts sharply increases the cost of SWP water.

With consideration of this uncertainty in predicting future events, the TAC elected to assume that the cultivated land in the Valley will remain at about 142 000 hectares (35,000 acres) for the projection period of this study. This assumption was a reasonable one when it was made at the time the study was conducted. However, both the cost of energy and prices of agricultural products could significantly affect agriculture; therefore, continual updating is needed to develop an appropriate projection.

From among several projections of population made by various agencies, the most optimistic is given in the 1973

FIGURE 3

HISTORIC AND PROJECTED IRRIGATED ACREAGE
ANTELOPE VALLEY

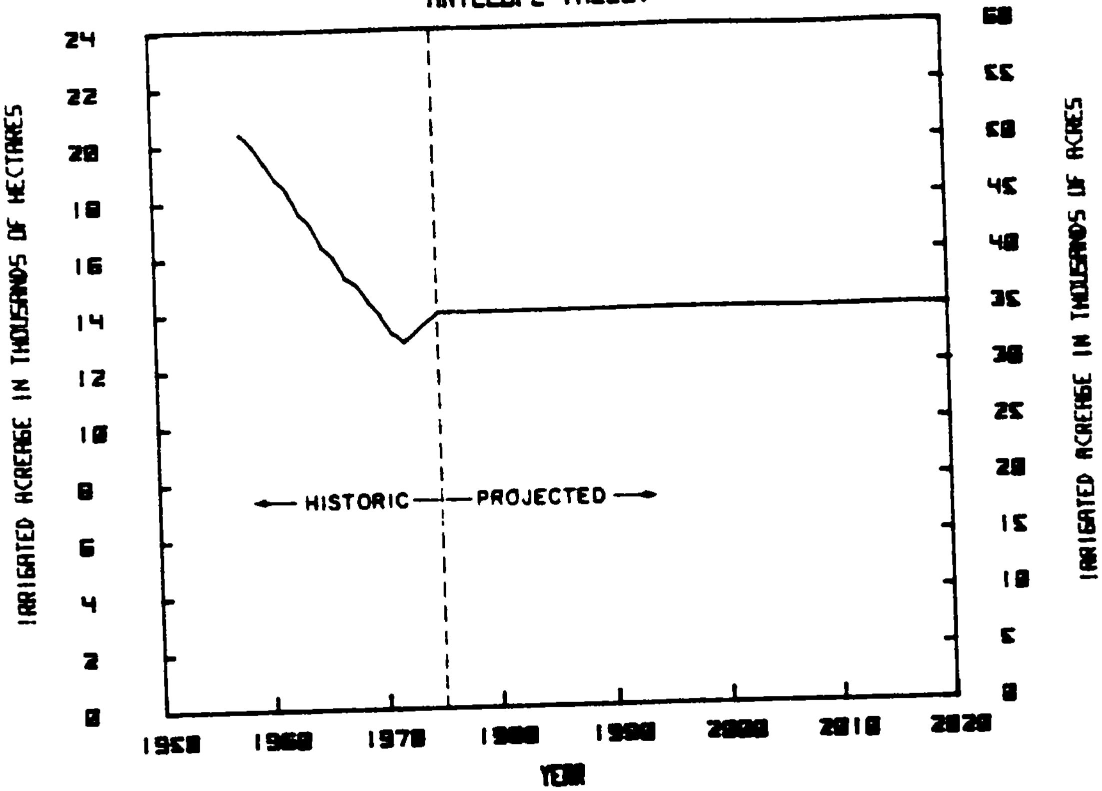
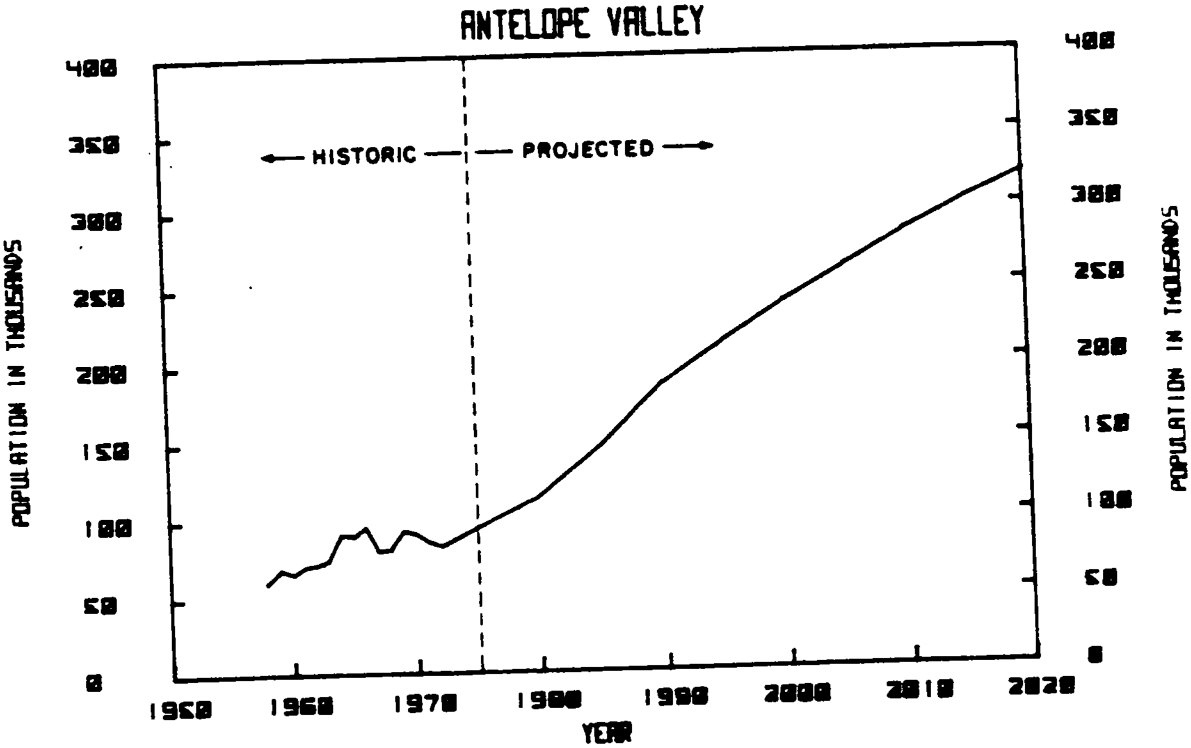


FIGURE 4

HISTORIC AND PROJECTED POPULATION
ANTELOPE VALLEY



Water Quality Control Plan--a projection, developed by the Department of Finance and DWR. Projected is a Valley population of 476,000 by year 2000. The lowest growth rate is given in the 1974 Department of Finance E-O projection under which Antelope Valley is estimated to have a population of 106,000 in 2000. The Los Angeles County Planning Commission has projected a population of 230,000 in the Antelope Valley by 2000.

The Planning Commission's population projections were selected, with adjustments to include the Kern County portion of the Valley and the impact of the proposed Palmdale International Airport. Both the historic and projected populations are shown in Figure 4. The extension of the projection to year 2020 was based on the analyses made on the Kern County Planning Commission's 1976 update.

On the basis of these projections, future water demand was estimated by using an urban unit water consumption rate of 0.95 cubic metre (250 gallons) per capita per day and an irrigation water use factor of 1.45 metres (4.75 feet). Both unit use factors were assumed to remain constant throughout the study period. The projected water demand is illustrated in Figure 5 as an extension of the historic demand.

The total water demand in 1975 was 238 000 cubic dekametres (192,600 acre-feet) and comprised two parts: an agricultural demand of 205 000 cubic dekametres (166,300 acre-feet) and a municipal and industrial demand of 33 000 cubic dekametres (26,300 acre-feet).

Factors That Could Change Projections

Several factors could change these projections:

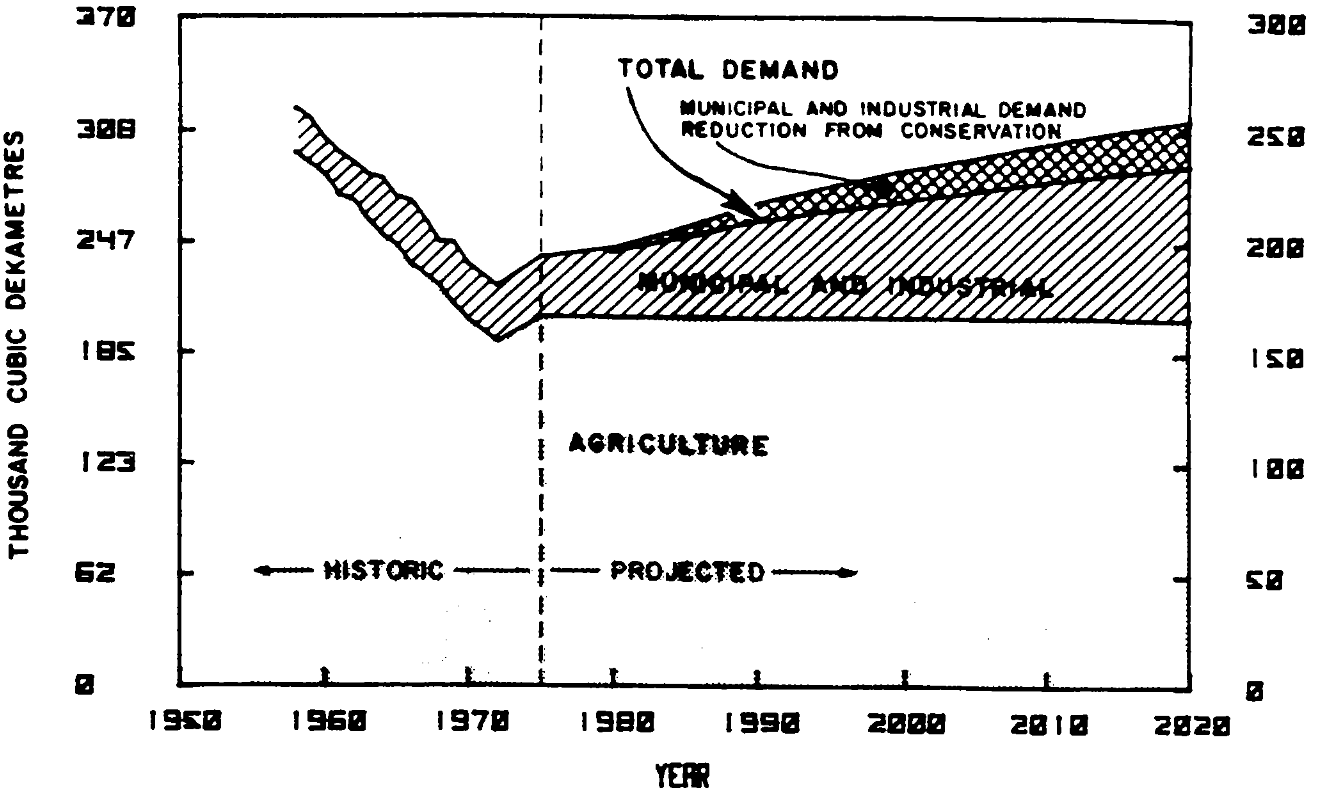
- Improved irrigation methods and urban water conservation efforts could reduce the projected demands for both agricultural and urban uses. Some possible means of encouraging reduction of water use include the institution of one or more of the following measures:

  1. Install water meters on every pump and home connection, providing a means of assessing costs according to use.
  2. Raise the price of water, including adding surcharges on peak use. A corollary would be to raise the rates selectively to discourage certain types of uses such as irrigation.
  3. Encourage the conversion from high water-consuming crops to lower water-consuming crops.
  4. Encourage the change to more water-efficient equipment, using selective taxation or laws.
  5. Continue to educate water users to water conservation.
  6. Ration water and deny it to certain uses.

  The chief crops, alfalfa and pasture, are both sprinkler- and border-irrigated. Water use may be reduced by encouraging the use of more scientifically precise management of irrigation which may reduce the agricultural water demand in the Valley. Although these measures may not effect true saving of water loss in the atmosphere or to a body of unusable water, they could postpone the need for facilities to import water from external sources and reduce energy consumption.

- If the growth rate induced by the construction of the airport and by spillover from the Coastal Plain exceeds the county's projected rate, the projections made for future municipal and industrial demand

FIGURE 5
HISTORIC AND PROJECTED WATER DEMAND
ANTELOPE VALLEY



would be low, possibly resulting in the planning of inadequate facilities for the distribution of water supplies.

- On the other hand, the projections made for agricultural water use may be high because of the ongoing displacement of agriculture by soaring land values and the concomitant property taxes, as well as by rising energy costs for pumping ground water.

- Even in the absence of the airport, the diminishing area of inexpensive real estate within the Coastal Plain is pressing developers and manufacturers to look to the interior of Los Angeles County for expansion. The Santa Clara River Valley is already being engulfed by the spillover from the Los Angeles Basin. The relatively long distances from the Coastal Plain to Antelope Valley have, until now, served to isolate the area, but future advances in commuting systems would serve to increase the population in the Valley.

Effect of Water Conservation on Total Demand

The potential reduction in the municipal and industrial water demand of the Antelope Valley by means of mandated and voluntary conservation measures is shown in Table 1 for the period 1980-2020. The reduction of demand is expected from a combination of factors including: the mandated reduction of line pressures and flow rates; requirements that new household appliances be water efficient; more efficient exterior use including the introduction of low-water demand plants; and lower industrial use as older, less water-efficient equipment is replaced.

TABLE I
ANTELOPE VALLEY
REDUCTION IN WATER DEMAND THROUGH MANDATED AND
SELF-IMPOSED WATER USE REDUCTION MEASURES
In acre-feet

	Potential reduction, in acre-feet				
	1980	1990	2000	2010	2020
Interior					
New construction	140	2,840	5,440	7,500	9,100
Rehabilitation/Replacement	0	1,260	2,920	3,100	3,200
Retrofit	650	500	350	300	300
Subtotal	790	4,600	8,710	10,900	12,600
Exterior Use*					
More efficient irrigation and elimination of conspicuous overwatering and waste	800	1,100	1,400	1,600	1,800
Expanded use of low-water demand plants	0	770	1,440	2,000	2,500
Pressure reduction	0	600	750	900	1,000
Subtotal	800	2,470	3,590	4,500	5,300
Leak Detection and Repair*					
Utility distribution system to household and other consumer	0	500	1,300	1,600	1,800
Industrial	150	460	600	700	800
Total reduction	1,740	8,030	14,200	17,700	20,500
Total demand - no reduction					
acre-feet	31,640	51,800	66,500	79,100	89,600
gallons per capita per day	250	250	250	250	250
Total demand - with reduction					
acre-feet	29,900	43,770	52,300	61,400	69,100
gallons per capita per day	236	209	197	194	193
% Reduction	5%	16%	21%	22%	23%

*Some of this water percolates to usable ground water basins

In this investigation, initiated in 1972, the projections of water demands, analyses of ground water levels, and cost analyses of each alternative plan were completed prior to the time when conservation was to be considered a serious management factor. Partly as a result of the financial difficulties of the cooperating agencies, no recalculation was made of water levels and costs of alternatives taking conservation into consideration. It may be noted that the relative merits of the alternative plans will not be materially changed because the impact of water conservation on the demand for each alternative was identical. The estimated water demand reduction, however, is reflected in Figure 5. The present goal of the State is to obtain a reduction of 15 percent in the per capita use of water for urban uses. However, studies made by the Land and Water Use Unit of the Southern District of DWR indicate that an estimated 21 percent reduction in the Antelope

TABLE I
REDUCTION IN MUNICIPAL AND INDUSTRIAL DEMAND
THROUGH MANDATED AND SELF-IMPOSED WATER USE
REDUCTION MEASURES
In cubic dekametres

	Potential reduction, in cubic dekametres				
	1980	1990	2000	2010	2020
Interior					
New construction	170	3 500	6 710	9 250	11 220
Rehabilitation/Replacement	0	1 550	3 600	3 820	3 950
Retrofit	800	620	430	370	370
Subtotal	970	5 670	10 740	13 440	15 540
Exterior Use*					
More efficient irrigation and elimination of conspicuous overwatering and waste	990	1 360	1 730	1 970	2 220
Expanded use of low-water demand plants	0	950	1 780	2 470	3 080
Pressure reduction	0	740	920	1 110	1 230
Subtotal	990	3 050	4 430	5 550	6 530
Leak Detection and Repair*					
Utility distribution system to household and other consumer	0	620	1 600	1 970	2 220
Industrial	190	570	740	860	990
Total reduction	2 150	9 910	17 510	21 820	25 280
Total demand - no reduction					
cubic dekametres	39 030	63 970	82 020	97 570	110 520
litres per capita per day	950	950	950	950	950
Total demand - with reduction					
cubic dekametres	36 880	54 060	64 510	75 750	85 240
litres per capita per day	893	791	746	734	730
% Reduction	5%	16%	21%	22%	23%

*Some of this water percolates to ground water basins and becomes usable.

Valley can be achieved using various water conservation techniques, which is the reduction used in the study. The potential for conservation in agricultural water use is considered to be minor.

Water Supplies

To meet the demand, four sources of water are available: local surface water, ground water, water imported by the SWP, and reclaimed water (Figure 6). As shown in Figure 7, ground water represented 92.8 percent of the total applied water demand in 1975. Water imported by the SWP represents a small, but growing portion of the total supply. Surface and reclaimed water supply growth rates are essentially static and they are minor components of the total supply.

Local Surface Water

The major tributary watersheds to the Antelope Valley are the San Gabriel and Tehachapi Mountains. The San Gabriels provide more runoff because they are both higher and more exposed to the moist southwesterly winds off the Pacific. Figures 8-10 show the rainfall characteristics at selected stations in the Valley. Fairmont and Palmdale, located at the base of the mountains, were recipients of higher totals than Lancaster, located just a few kilometres north. These historic records show a few unusually wet years interspersed between many years with sub-par rainfall.

The mean annual runoff is estimated to be 50 200 cubic dekametres (40,700 acre-feet). More than half is supplied by two streams: Little Rock and Big Rock Creeks (40). Other streams from the San Gabriel Mountains have a combined mean annual flow of about 11 600 cubic dekametres (9,400 acre-feet) per year. Streams in the Tehachapi Mountains provide about 9 500 cubic dekametres (7,700 acre-feet) per year (Figure 11).

Precipitation runoff and spring flow emerging from the mountains converge toward the playas. Streamflow normally infiltrates into the pervious alluvial fans or evaporates within several

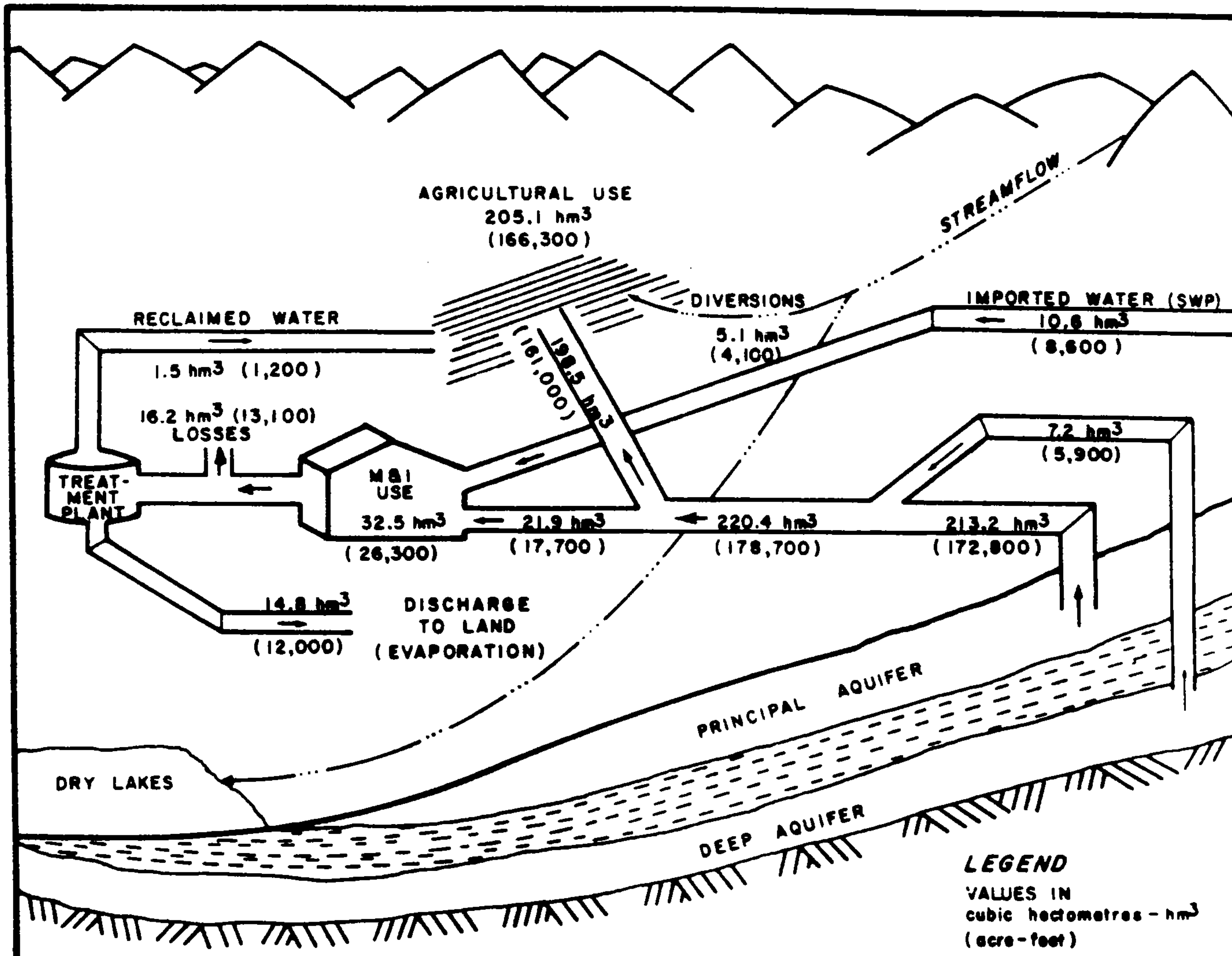
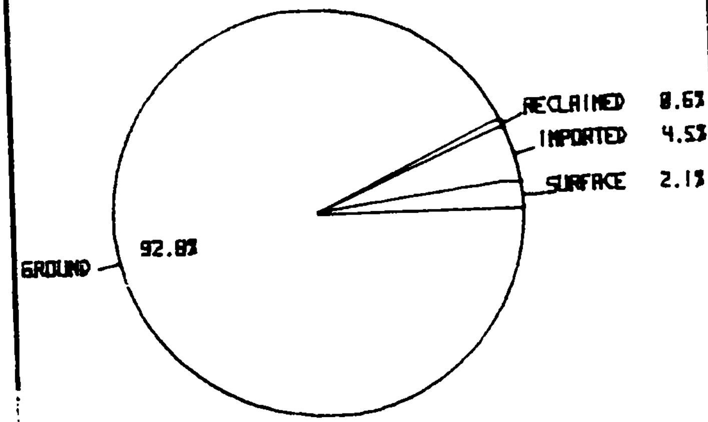


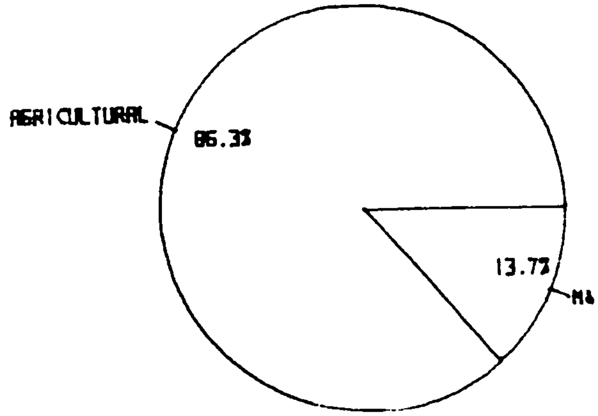
FIGURE 6 - WATER SUPPLY USED IN STUDY AREA IN 1975

COMPONENTS OF WATER SUPPLY IN 1975*



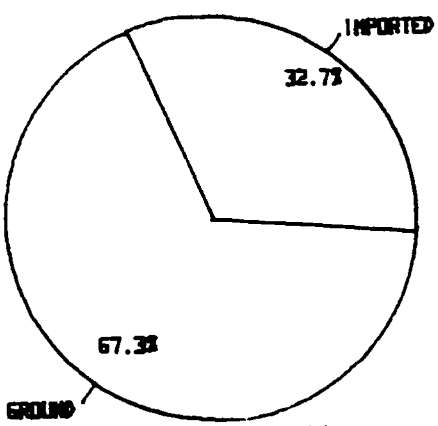
	Cubic dekametres	Acre-feet
Surface diversions	5 060	4,100
Imported water	10 610	8,600
Reclaimed water	1 480	1,200
Ground water	220 430	178,700
Total	237 580	192,600

AGRICULTURAL AND M&I DEMAND IN 1975



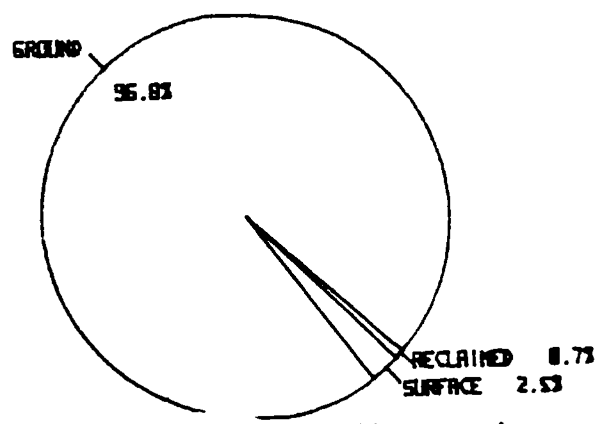
	Cubic dekametres	Acre-feet
Agricultural demand	205 140	166,300
Municipal and industrial demand	32 440	26,300
Total	237 580	192,600

SOURCES OF MUNICIPAL & INDUSTRIAL WATER IN 1975



	Cubic dekametres	Acre-feet
Imported water	10 610	8,600
Ground water	21 830	17,700
Total	32 440	26 300

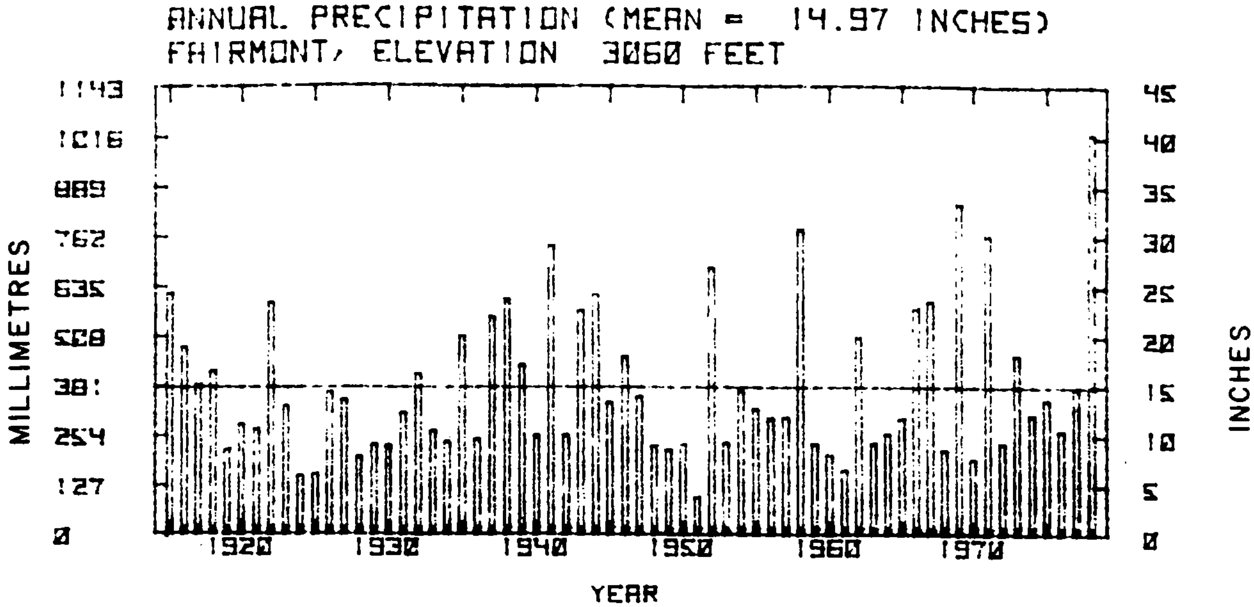
SOURCES OF AGRICULTURAL WATER IN 1975*



	Cubic dekametres	Acre-feet
Surface water	5 060	4,100
Reclaimed water	1 480	1,200
Ground water	198 600	161,000
Total	205 140	166,300

*Does not include SWP water (above entitlements) used for agriculture—less than 400 acre-feet (about 400 cubic dekametres).

FIGURE 7 - BREAKDOWN OF SUPPLIES USED IN 1975



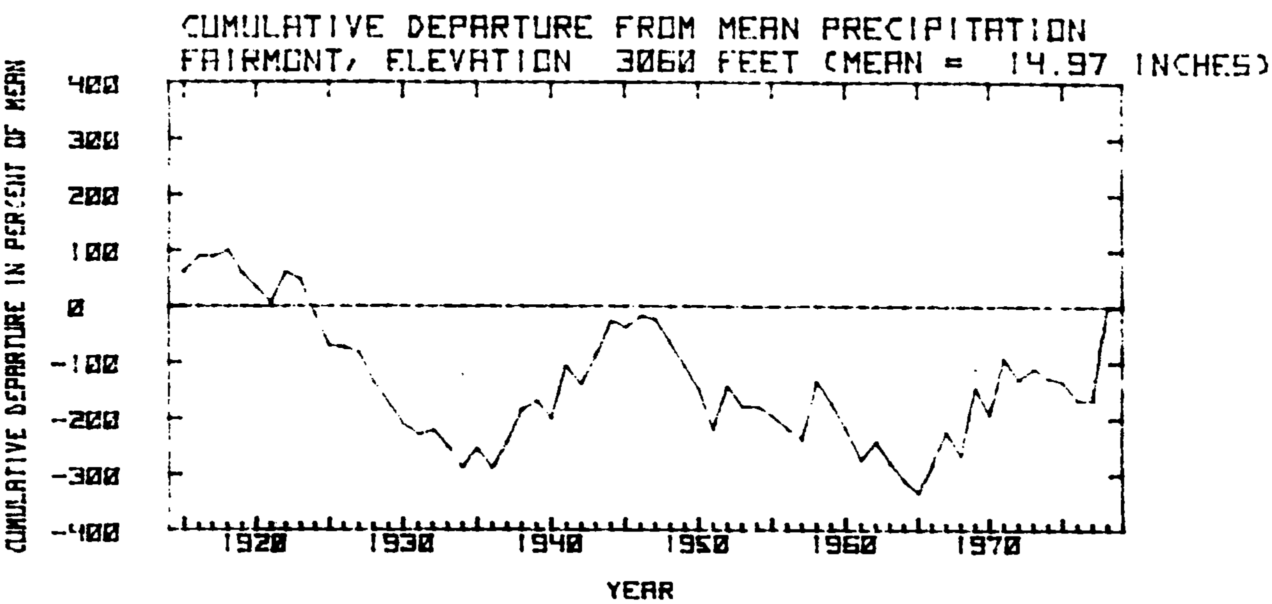
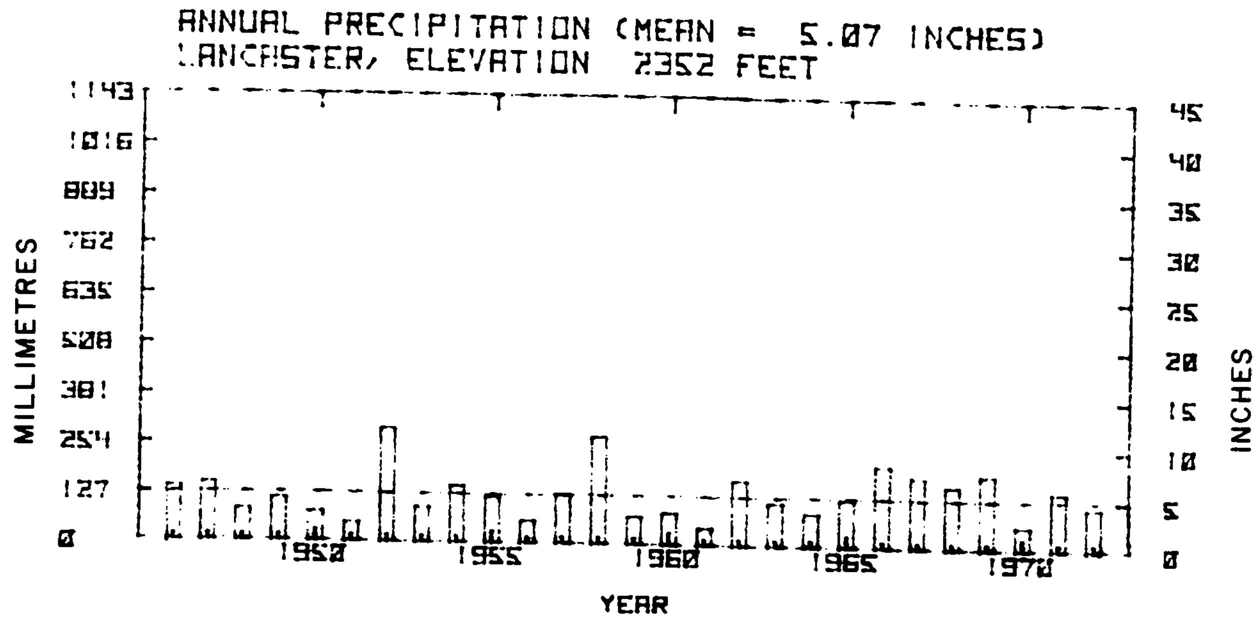


FIGURE 8 - PRECIPITATION SUMMARY: FAIRMONT RESERVOIR



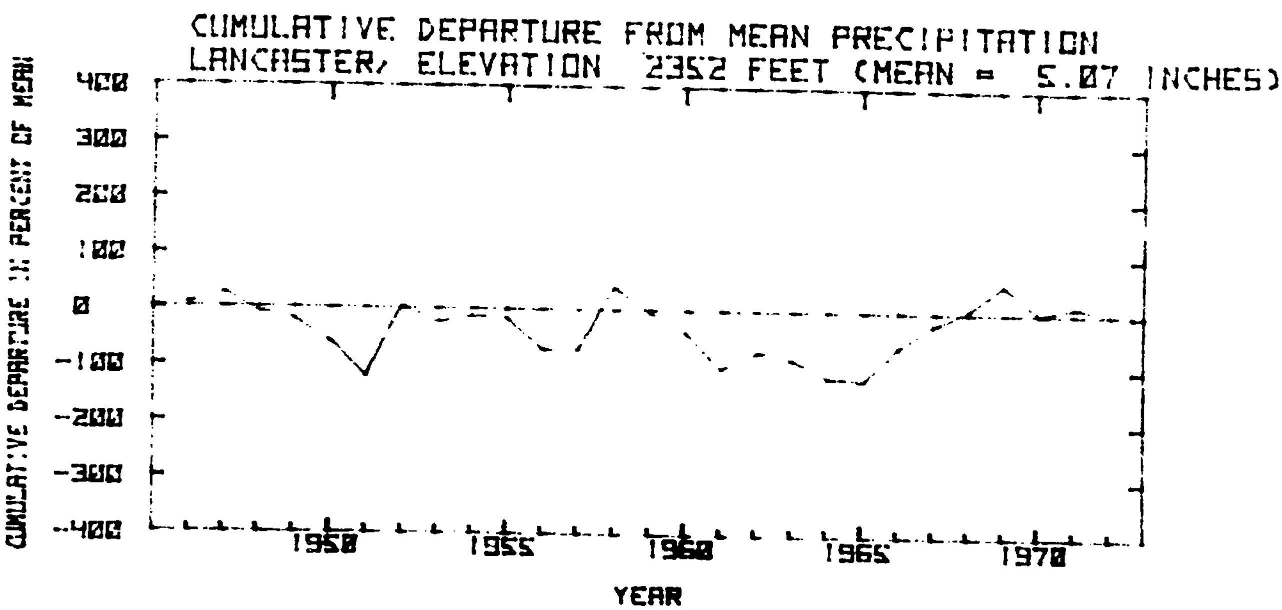
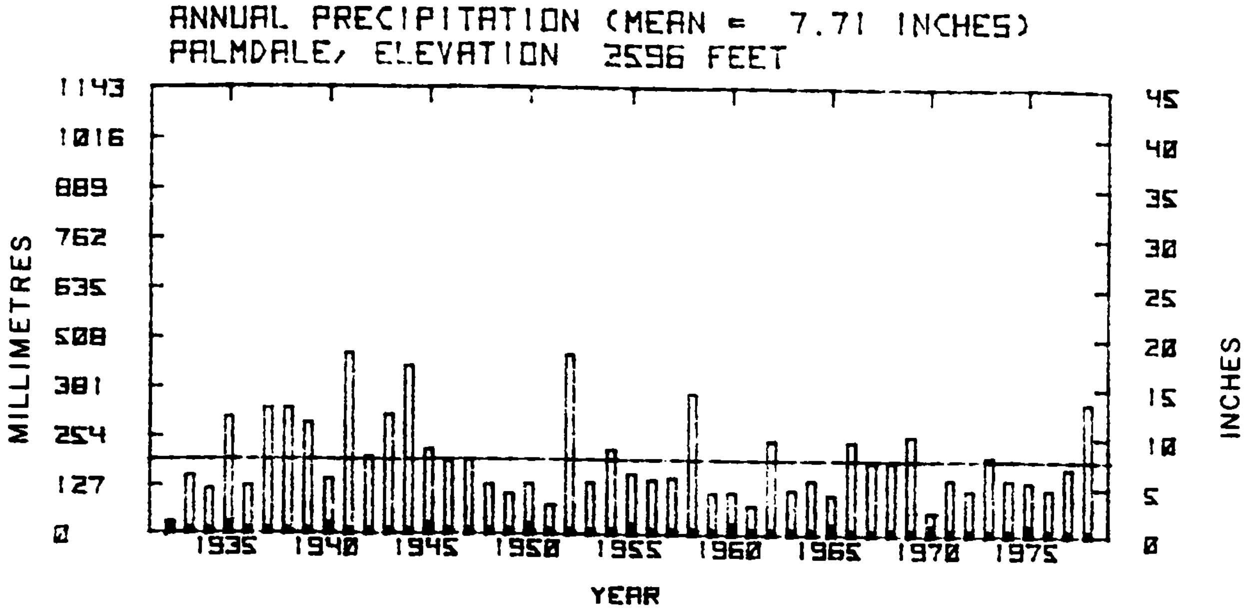


FIGURE 9 - PRECIPITATION SUMMARY: LANCASTER



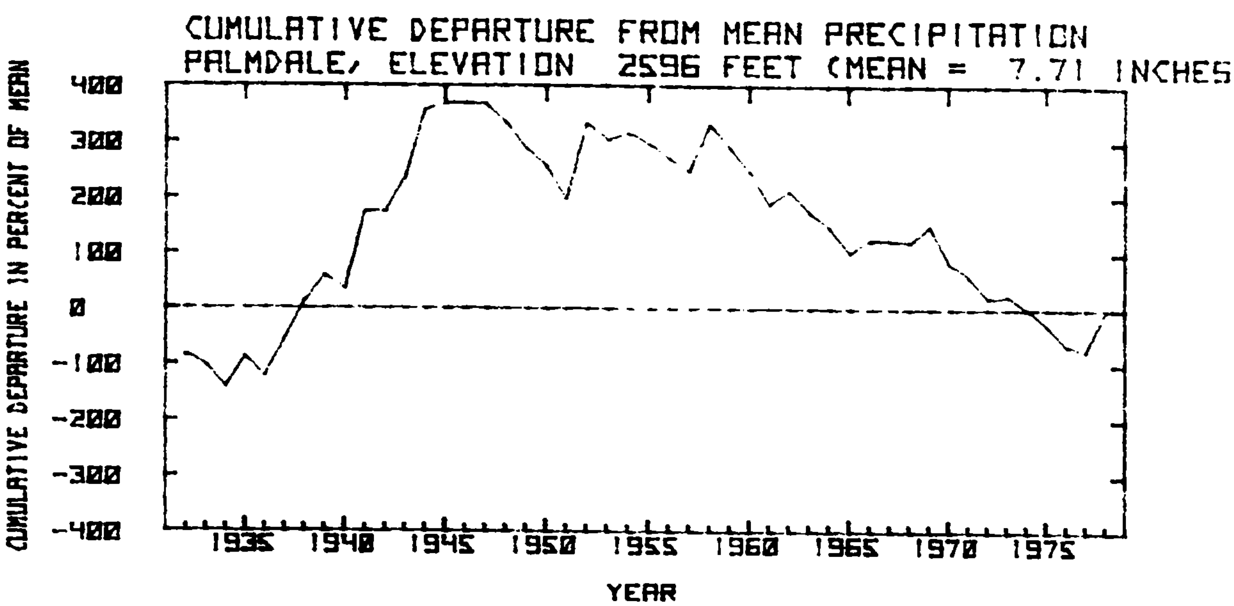
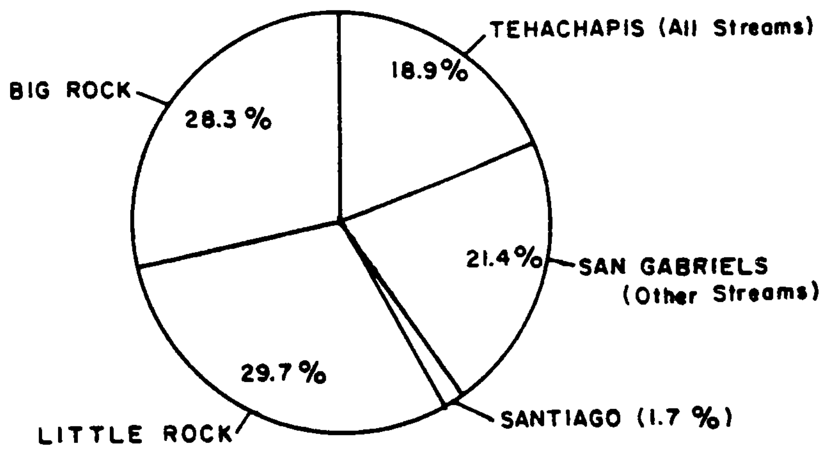


FIGURE 10 - PRECIPITATION SUMMARY: PALMDALE

PWS-0184-0033

FIGURE II

MEAN ANNUAL RUNOFF FROM ANTELOPE VALLEY STREAMS*
WITHIN THE STUDY AREA



Drainage basin	Area		Mean annual runoff	
	In square kilometres	In square miles	In cubic dekametres	In acre-feet
San Gabriel Mountains				
Big Rock Creek	60	23	14 200	11 500
Little Rock Creek	127	49	14 900	12,100
Santiago Creek	28	11	900	700
Other Streams**	451	174	10 700	8,700
Tehachapi Mountains				
All Streams**	332	128	9 500	7,700
Total	998	385	50 200	40,700

*From reference 37
**Estimated runoff

PWS-0184-0034

kilometres of the base of the mountains. Flow rarely reaches the playas except during extremely wet winters or after major storms. That water reaching the impermeable playas is also lost to evaporation.

The flow of Little Rock Creek, impounded by 38-metre (124-foot) high Little Rock Dam, is about equally divided between the Littlerock Creek Irrigation District and the Palmdale Water District. They have exclusive rights to the flow.

Littlerock Creek Irrigation District also obtains water from the Cienega well in the San Andreas fault about 3 kilometres (2 miles) below Little Rock Dam, tapping the near-surface flow of Little Rock Creek. Approximately 1 200 to 2 500 cubic dekametres (1,000 to 2,000 acre-feet) of water are annually delivered from the reservoir to local orchards by Littlerock Creek Irrigation District.

The Palmdale Water District diverts about 1 400 cubic dekametres (1,100 acre-feet) annually from Little Rock Reservoir into a ditch terminating at Palmdale Lake, which is now used only for recreation. Palmdale Dam was rebuilt in 1966 to comply with earthquake standards, anticipating the delivery of water from the SWP.

Three ranches, Mountain Brook, Valyermo, and Pallett, have rights to a minimum of 0.35 cubic metre (12.5 cubic feet) per second from Big Rock Creek. In 1973-74, they diverted 3 700 cubic dekametres (3,000 acre-feet). The remaining normal flow is either diverted by downstream users or percolates to ground water.

Although the amount of surface water used by small communities and individuals living in the mountains is unknown, it is believed to be small. Table 2 lists the major existing impoundments in Antelope Valley.

The chemical quality of runoff is good, as the analysis of water from Little Rock and Big Rock Creeks demonstrates. (See Table 3.)

The discharge of wastes into surface waters is prohibited above elevation

TABLE 2
EXISTING STORAGE FACILITIES FOR LOCAL SURFACE WATER IN ANTELOPE VALLEY

Reservoir	Year completed	Owner and-or operating agency	Source of water	Maximum storage, cubic dekametres (acre-feet)
Fairmont*	1912	City of Los Angeles	Los Angeles Aqueduct	9 260 (7,507)
Palmdale	1891 Rebuilt 1966	Palmdale Water District	Little Rock Creek	5 230 (4,240)
Little Rock	1924	Littlerock Creek Irrigation District and Palmdale Water District	Little Rock Creek	5 300 (4,300)**
Pearblossom Spilling Basin	1970	Department of Water Resources	State Water Project	130 (106)

*Tentatively scheduled to be taken out of operation in 1982 because of a fault running through main dam. To be replaced by reservoir with 1/10 present storage at adjacent site.

**Actual capacity is less than 3 080 cubic dekametres (2,500 acre-feet) because of silt deposition. Storage limited to elevation 984 metres (3,228 feet) by Division of Safety of Dams, DWR, reducing active storage to about 1 233 cubic dekametres (1,000 acre-feet).

TABLE 3
RANGE AND AVERAGE CONCENTRATIONS OF CHEMICAL CONSTITUENTS OF SURFACE FLOWS OF LITTLE ROCK AND BIG ROCK CREEKS
In milligrams per litre

Constituent	Big Rock Creek 1951-1963*		Little Rock Creek 1951-1963*		1971**
	Range	Average	Range	Average	
Calcium	36 – 79	57	20 – 59	38	31
Magnesium	15 – 36	23	1 – 15	11	10
Sodium	9 – 28	19	9 – 48	21	15
Potassium	3 – 7	4	2 – 5	3	3
Carbonate	0 – 14	1	0 – 14	2	0
Bicarbonate	171 – 267	214	106 – 224	178	153
Chloride	0 – 23	5	2 – 10	6	5
Sulfate	22 – 187	88	9 – 66	31	19
Nitrate	0 – 12.6	6	0 – 3.5	0.6	0.7
Fluoride	0 – 0.9	0.3	0.1 – 0.7	0.3	0.2
Boron	0 – 0.5	0.15	0 – 0.5	0.08	0.05
TDS	232 – 456	350	140 – 345	240	172
Total hardness	170 – 297	236	83 – 180	141	119

*From reference 19
**Sampling conducted at Little Rock Reservoir

1 070 metres (3,500 feet) to protect beneficial uses of water. Septic tank pumpings and chemical toilet wastes must be discharged to a sewage treatment plant, if one capable of handling such wastes is available in the regional service area. (33)

Ground Water

Numerous faults slice across Antelope Valley, some acting as partial barriers to ground water movement. For example, water level discontinuities of up to 91 metres (300 feet) are found along the Randsburg-Mojave fault in the western part of the Valley. These fault systems, the locations of which are either known or inferred from water levels in wells (40), serve to divide the Antelope Valley ground water basin into subbasins. These are: Lancaster, Buttes, Pearland, Neenach, West Antelope, Finger Buttes, and North Muroc Subbasins (Figure 12).

The two major aquifers, the principal and the deep, are separated by a series of thick, discontinuous layers of lacustrine clay deposits, which serve as a confining bed. A rough outline of that portion of the Valley underlain by this confining bed is shown in Figure 12. Cross sections through the ground water basin are shown in Figure 13.

The unconfined principal aquifer, which overlies the confining bed, supplies most of the water pumped in Antelope Valley. This aquifer extends through all subbasins except North Muroc (Figure 12).

The deep aquifer underlies the North Muroc Subbasin and most of the Lancaster

Subbasin (Figure 12). The deep aquifer is generally unconfined in two areas: north and east of Rogers Lake in North Muroc Subbasin and in the Lancaster Subbasin east of Little Buttes. Most of the deep aquifer underlies the clay aquitard.

In Lancaster Subbasin, numerous clay lenses are found in the principal aquifer. Water levels in wells show semiperched water above these clay lenses.

Water in Storage. The estimated total storage capacity of the ground water basin is 84 million cubic dekametres (68 million acre-feet) (24). The storage capacity is determined for depths ranging from 6 metres (20 feet) below ground surface (to avoid problems associated with a high water table) to the base of the water-bearing sediments. The amount of available ground water storage capacity above the water table and below a 6-metre depth from ground surface, was estimated to be 16 million cubic dekametres (13 million acre-feet) in 1975 (24). Therefore, the total amount of ground water in storage, from the water table to the base of the water-bearing sediments, was an estimated 68 million cubic dekametres (55 million acre-feet) in 1975 (24). Depths-to-water ranged from less than 15 metres (50 feet) at various points along the base of the San Gabriel Mountains and near Rosamond Lake to more than 120 metres (400 feet) at well 6N/11W-19E5 near Palmdale.

Water levels have been declining in the Antelope Valley since the 1920s (Figure 14). In parts of Lancaster Subbasin, ground water elevations have receded more than 60 metres (200 feet) (40). Rates of fall are as much as 1.2 metres (4 feet) per year near Lancaster (40). Partly responsible for these large drops are lowered pressures in confined aquifers tapped by some wells. Figure 15 shows the ground water level elevations in 1974.

Water Quality. The overall quality of Antelope Valley ground water is currently good, posing few problems for agricultural and municipal and industrial uses. Total dissolved solids (TDS) concentrations generally are under 500 mg/L. Deteriorating water quality in local areas probably results from the recirculation of irrigation return where pumping depressions or other conditions inhibit the movement of ground water (28).

Ground water in Antelope Valley has always been of good quality, with the exception of certain areas paralleling faults and in the northern portion of North Muroc Subbasin, which is affected by the Kramer borate deposits.

Altalfa, the major crop, has affected ground water quality only slightly since its introduction to the Valley; as a nitrogen-fixing plant, it does not require as heavy an application of easily leached nitrogen fertilizer as orchard crops. Some areas planted in orchards show fairly steadily increasing nitrate and TDS concentrations. At certain wells near the orchards of Littlerock and Quartz Hill, nitrates exceed 45 mg/L, probably as a result of irrigation return waters which have leached fertilizer from the soil.

The best quality ground water, with TDS concentrations under 500 mg/L, is found in the southern and western sections of the Valley, where natural recharge is greatest. Ground water is calcium or sodium bicarbonate in character in this portion of the Valley compared to sodium bicarbonate and sodium chloride in the northern half of North Muroc Subbasin. The poorest water, with TDS concentrations of 1 000 mg/L or more can be found in: (1) the North Muroc Subbasin, (2) around the borders of the Lancaster Subbasin, and (3) shallow wells scattered throughout the Valley.

Quality variations between the principal and deep aquifers are difficult to discern because the current practice of gravel-packing wells encourages water

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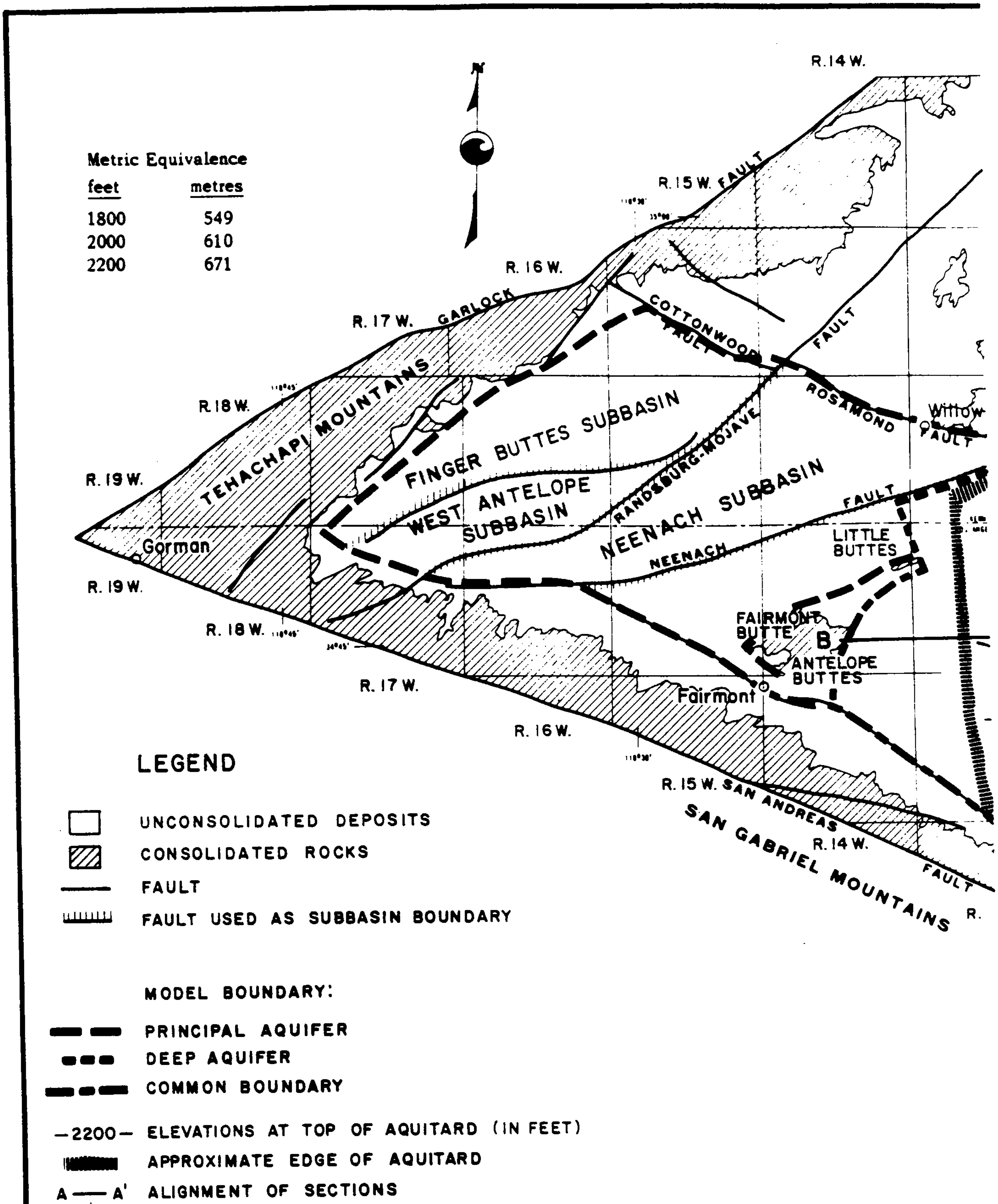
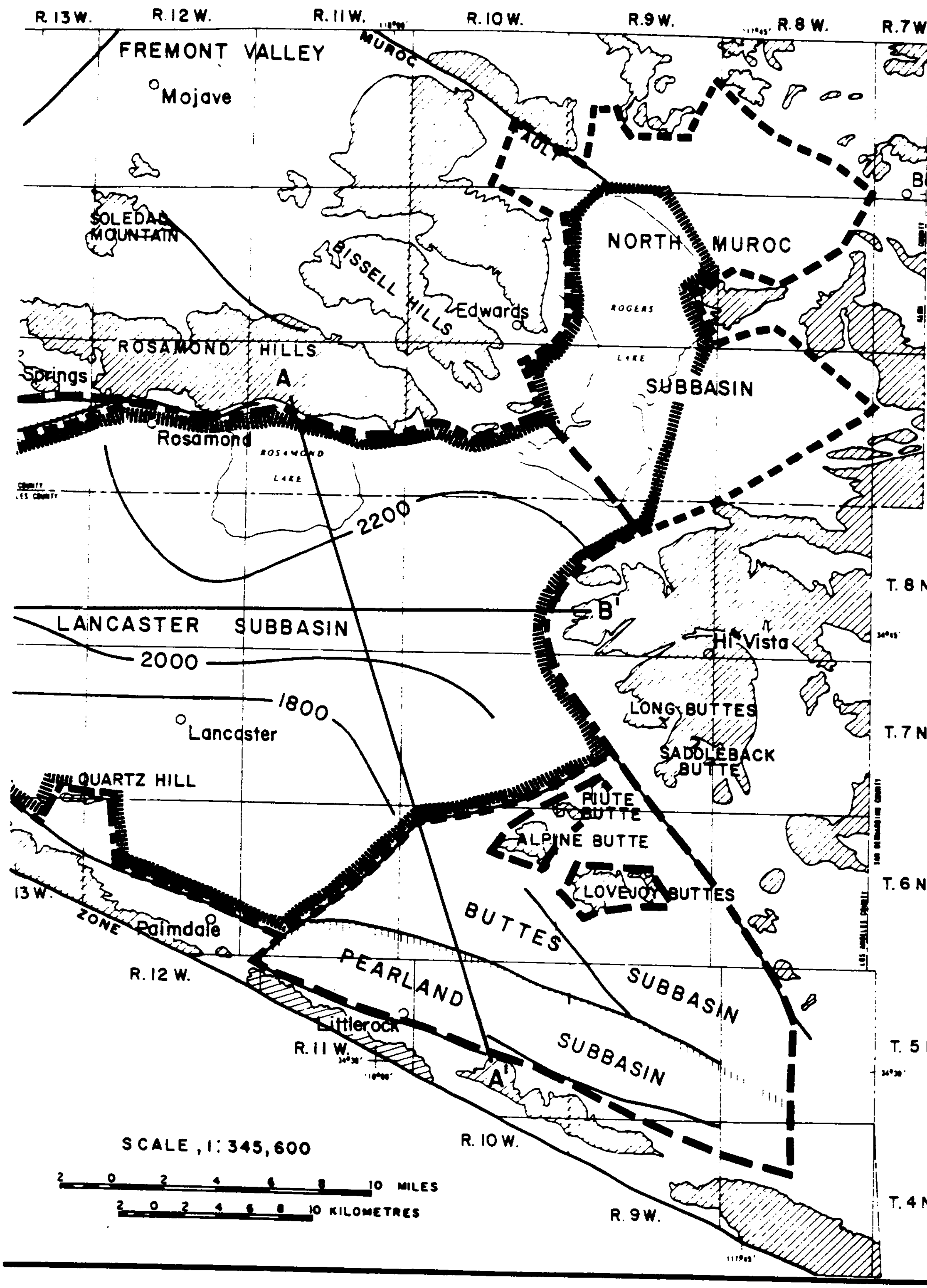

Metric Equivalence
feet metres
1800 549
2000 610
2200 671
R.14 W.
R.15 W.
R.16 W.
R.17 W.
R.18 W.
R.19 W.
GARLOCK FAULT
COTTONWOOD FAULT
ROSAMOND FAULT
FAULT
RANDSBURG-MOJAVE
TEHACHAPI MOUNTAINS
FINGER BUTTES SUBBASIN
WEST ANTELOPE SUBBASIN
NEENACH SUBBASIN
NEENACH FAULT
Willow
Gorman
LITTLE BUTTES
FAIRMONT BUTTE
B
ANTELOPE BUTTES
Fairmont
SAN ANDREAS FAULT
SAN GABRIEL MOUNTAINS
R.
LEGEND
UNCONSOLIDATED DEPOSITS
CONSOLIDATED ROCKS
FAULT
FAULT USED AS SUBBASIN BOUNDARY
MODEL BOUNDARY:
PRINCIPAL AQUIFER
DEEP AQUIFER
COMMON BOUNDARY
—2200— ELEVATIONS AT TOP OF AQUITARD (IN FEET)
APPROXIMATE EDGE OF AQUITARD
A —— A' ALIGNMENT OF SECTIONS

FIGURE 12



GENERALIZED GEOLOGY

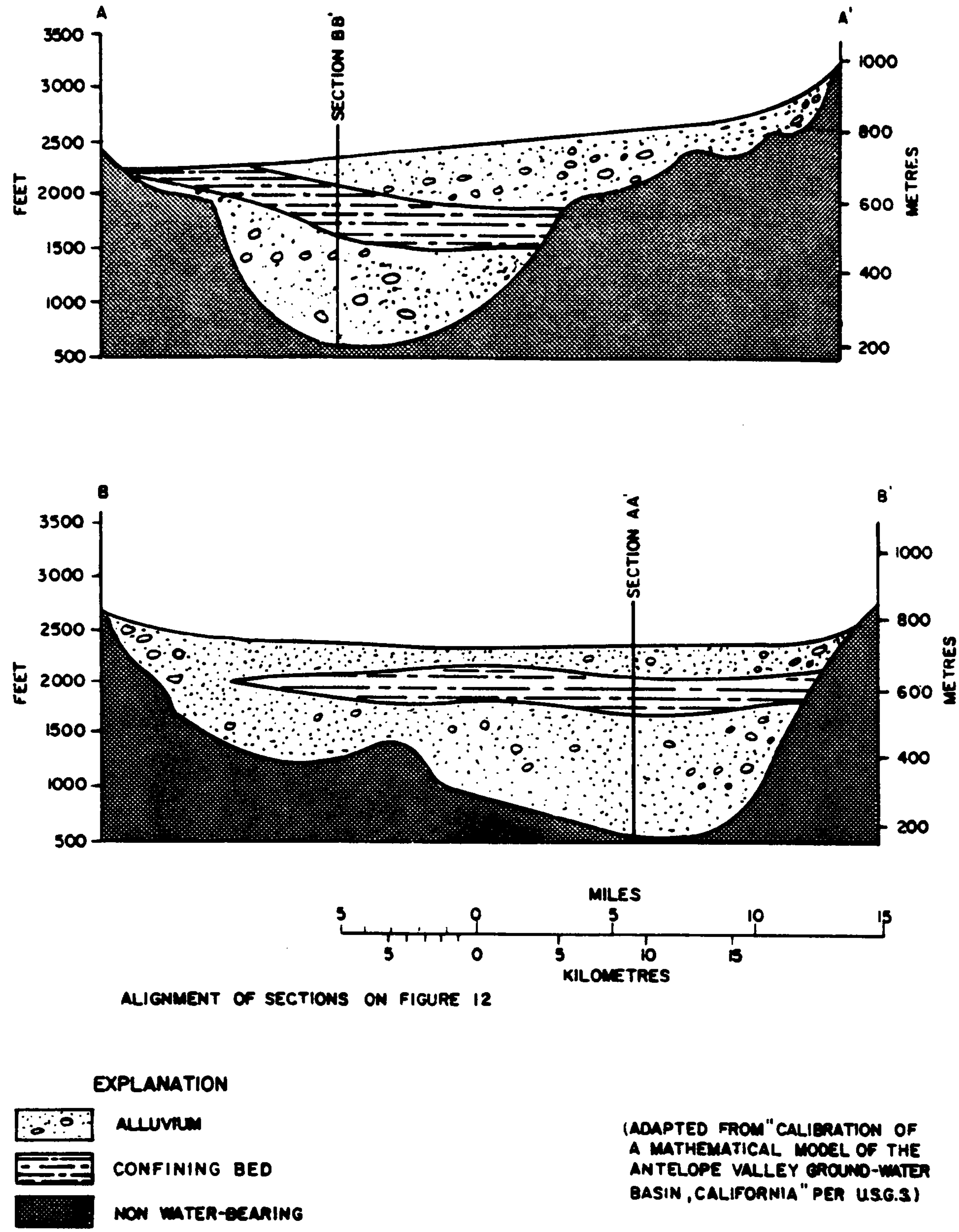


FIGURE 13 – GEOLOGIC SECTIONS THROUGH THE GROUND WATER BASIN