Water-Resources Summary for Southern California, 1958

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By William C. Peterson

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ABSTRACT

Current water requirements for southern California are more than 2 million acre-feet per year. These requirements are being met by supplementing limited local water resources with imported water.

The average annual precipitation ranges from about 2 inches in parts of the desert to about 50 inches in the higher mountains, and there is a great variation in annual precipitation at any one place. The annual variation is not entirely random, in that the annual precipitation tends to follow a cyclic pattern made up of sequences of wet and dry periods. Records of the climatological year (July 1, 1957–June 30, 1958) indicate that precipitation was considerably above average, but the relative wetness does not necessarily forecast the abatement of the current dry period which began in 1944.

Runoff follows the same pattern of wet and dry periods that is shown by precipitation, but with even greater variability. Runoff for the 1957–58 water year at 15 selected gaging stations ranged from 0.42 to 24.0 inches, with departures from the average annual runoff for the 35-year base period. 1920–55, ranging from minus 76 to plus 290 percent. The average runoff of this group of gaging stations for the 1957–58 water year was 9.12 inches, a departure of plus 127 percent from the base mean and more than six times the average runoff for the 1956–57 water year. Average annual runoff for the 14-years dry period that began in 1944 ranged from 0.34 to 8.1 inches with an average departure of minus 32 percent from the base mean.

As a result of the current dry period that began in 1944, most of the reservoirs storing natural runoff were only partly full, and some were practically empty. The combined content of 12 representative reservoirs in September, 1958, was 42 percent of capacity.

The accelerated trend in ground-water depletion that also began in 1944 continued during the year in the desert areas. Elsewhere the above-average precipitation and runoff, together with the use of imported water in some areas, served to recharge ground-water basins sufficiently to stem the drastic decline of water levels observed in most observation wells during the current dry period.

The rapid increase in water requirements has accelerated the importation of water from the Colorado River from 20,000 acre-feet in 1944 to 597,000 acre-feet in 1957; about 535,000 acre-feet was imported from this source in 1958. During the same period, water imported from Owens Valley was almost equal to aqueduct capacity; about 335,000 acre-feet was imported from this source during 1958.

Runoff data for the 1956–57 water year from all currently published gaging-station records establish that year as one of the driest in recent years in southern California.

INTRODUCTION

This edition of water-resources summary for southern California is the 16th in a series issued annually since June 1944. Its main purpose is to present a brief analysis of those phases of local water supply associated with the work of the Geological Survey in southern California.

The first part of this summary deals with water resources for the water year ending September 30, 1958. It contains a brief analysis of annual precipitation, annual runoff (provisional) at selected gaging stations, water reserves in both surface and underground reservoirs, and imported water.

The second part gives, in detail, runoff for the preceding water year ending September 30, 1957. A period of about a year, beginning at the end of the water year, is usually required to complete computations of daily discharge for all the gaging stations. An additional 6 months to a year is required to process and present the data in published form in the annual Geological Survey water-supply papers. Consequently, this report represents the first opportunity to release data on magnitude of runoff for all gaging stations operated in southern California during the water year 1956–57.

Some information presented in this summary was included in previous editions. The repetition is made so that each edition will be complete and independent of the previous editions.

For the purpose of the summary, southern California is considered to be that part of the State extending southward from the Arroyo Grande basin, the Tehachapi Mountains, and the Inyo County line to the boundary with Mexico and extending inland from the Pacific

Coast to the Colorado River and the Nevada State line. The inland part of this 47,000-square-mile area is predominantly a desert, consequently, most of the population centers and agricultural areas of the region are concentrated in long narrow strip of coastal land. The chief exceptions are Antelope Valley in the Mojave Desert and Coachella and Imperial Valleys in the Colorado Desert. The area covered in this summary is shown in figure 1, and the detailed location of selected installations where data are collected is shown in figure 2.

Because of many desirable climatic and economic factors, the population growth of southern California has been phenomenal, probably the greatest in the United States. A population of about 300,000 in 1900 increased to about 5.7 million by 1950. About 80 percent of the population increase occurred in the three decades since 1920. Since 1950 the population growth has continued, and it is estimated that the present population of southern California is about 8.5 million.

Such a vast increase in population greatly intensifies the water problems in these arid and semiarid regions of limited water resources. It has been estimated that the water requirements for urban and agricultural purposes in the coastal areas were about 1.8 million acre-feet in 1950 and have been steadily increasing at a rate of about 40,000 acre-feet per year. As a result, providing water has been changed from a relatively simple problem to an extremely critical situation in many areas. Just how critical the situation is for any community depends largely upon the magnitude of the local groundwater reserves and the ability of the community to import water from outside the basin.

Southern California is forced to obtain its water supply from distant sources because its local water reserves are limited; as a result, it pays more for its water than any other area of comparable size in the United States.

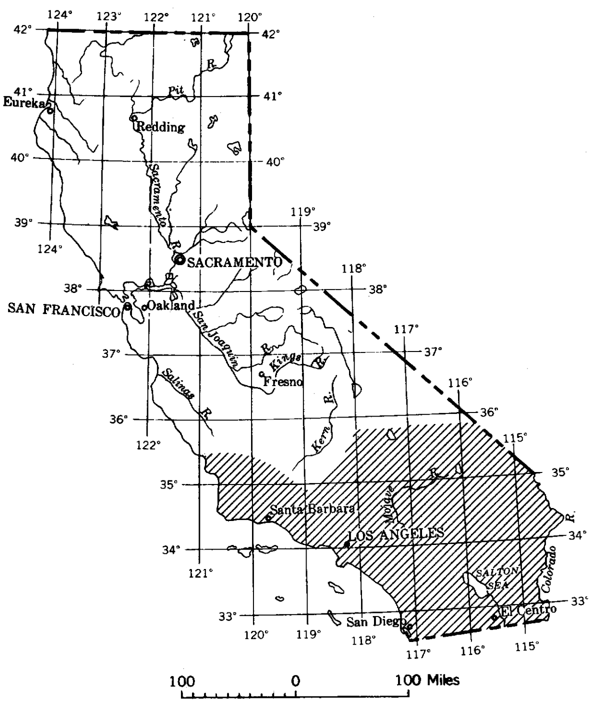

Figure 1.—Map showing area covered by this summary.

WATER RESOURCES FOR THE WATER YEAR 1957–58

PRECIPITATION

Very few areas in the United States have ranges in average annual precipitation that are as wide as those observed in southern California. Because of the effect of local physiographic features on the circulation of atmospheric moisture, the observed average annual precipitation ranges from about 2 inches at Bagdad in the Mojave Desert to more than 50 inches at Morse near Squirrel Inn in the San Bernardino Mountains.

The average annual precipitation of southern California, about 9.5 inches, is only about one-third of the national average of 30 inches; for not more than 2 percent of the area is equal to or larger than the national average. And more than 50 percent of southern California is arid, with an average annual precipitation of 5 inches or less.

Not only is there a great range in average annual precipitation, from place to place, but there is often an even greater variation in the annual precipitation at any one place. For example, the annual precipitation at Los Angeles for the climatological year, July 1 to June 30, has ranged from 5.59 inches, in 1898–99, to 38.18 inches, in 1883–84, the average being 15.07 inches for the 81-year period of record ending in 1958. At Indio, in the desert area of southern California, the annual precipitation has ranged from 0.40 inch in 1879–80, to 11.50 inches in 1939–40,

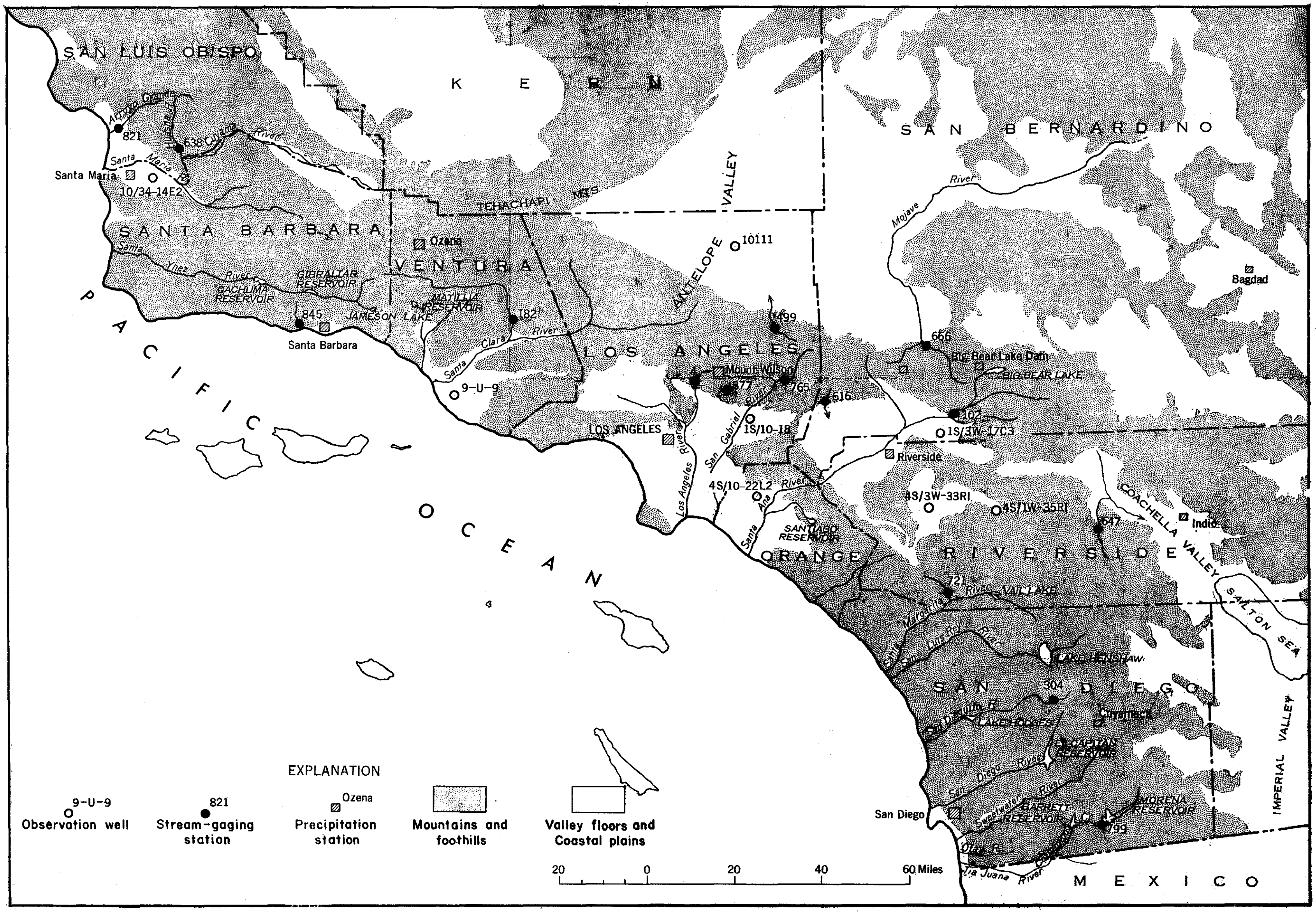

Figure 2.—Location of selected precipitation stations, stream-gaging stations, and observation wells.

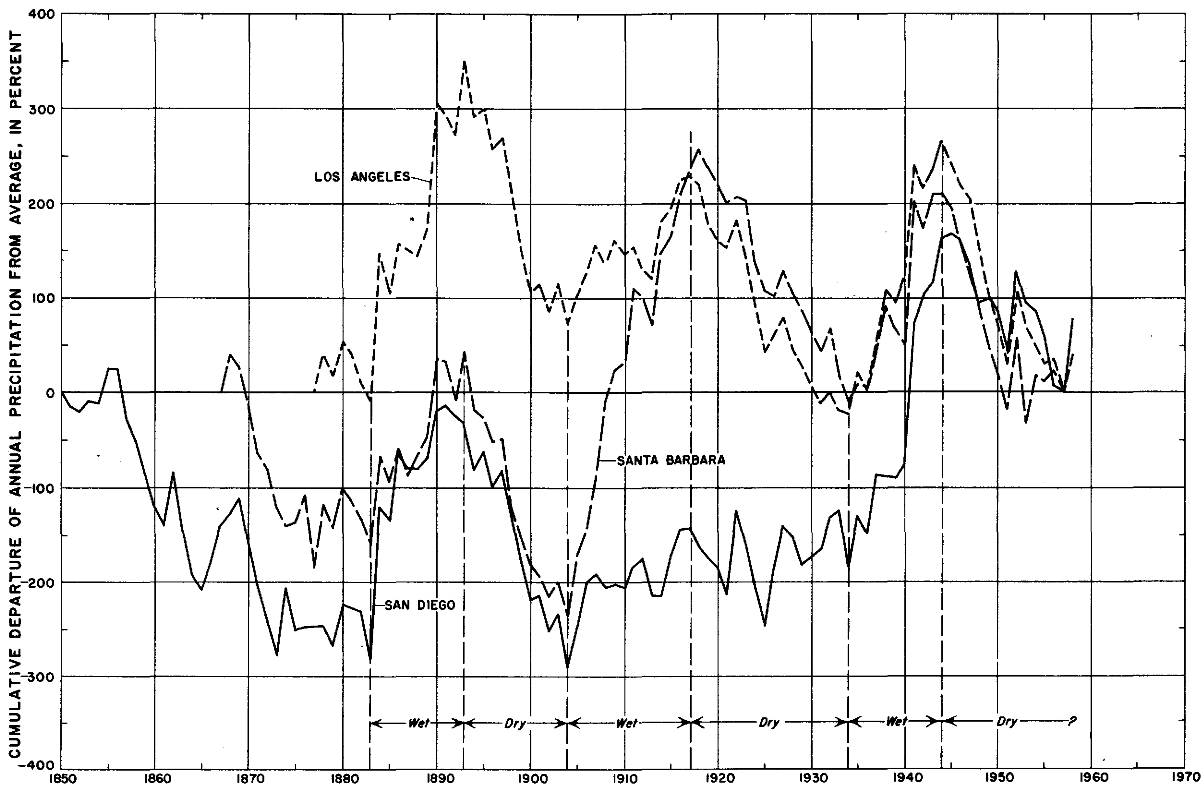

Figure 3.—Cumulative departure of annual precipitation, 1850–1958.

and averaged 3.18 inches for an 80-year period of record ending in 1958.

The variation in annual precipitation is not entirely random as it occurs in extended sequences of wet and dry years that tend to define an irregular cyclic pattern—a series of wet years alternating with a series of dry years—in the time distribution of the precipitation. This distribution in time is most pronounced on the coastal side of the mountains and least defined in the arid desert regions.

Possibly the longest existing record of these wet and dry periods is to be found in the relative widths of annual tree rings in certain types of trees growing in the mountains of southern California. Schulman[1] has been able to measure the annual tree-ring growth in big-cone spruce for the 560-year period of 1385 to 1944. These records indicate a definite cyclic pattern of wet and dry periods, with the average length of dry periods being 14.5 years and wet periods, 12.5 years, making an average cyclic period of 27 years. Not all the individual years within a wet period are wet, but the wet years predominate; conversely, not all the individual years within a dry period are dry, but the dry years predominate.

One of the methods used for determining wet and dry periods is that of cumulative departures. Figure 3 shows the cumulative departures of annual precipitation at Santa Barbara, Los Angeles, and San Diego in percent from the average annual precipitation. Each of the three average annual values is for the period of record up to and including the climatological year 1957—58. Consequently, upward trends on this graph represent wet periods and downward trends represent dry periods.

The observed annual precipitation for 1958 (climatological year, July 1 to June 30) at these stations is given in table 1, together with that for 7 other selected sites that measure the precipitation in the major physiographic features of the area. Many of the longest and most complete records in the region have been collected at these stations, and they are intended to serve as general indices of precipitation throughout southern California.

[1] Schulman, Edmund, 1947, Tree-ring hydrology in southern California: Univ. Ariz., Lab. of Tree-ring Research, Bull. 4.

Table 1.—Precipitation for the climatological year July 1, 1957-June 30, 1958, and the average annual precipitation for the dry period 1944-58 at selected precipitation stations.

Physiographic type and station	Period of record		Precipitation for 1957-58		Average annual precipitation for 1844-58 dry period	
	Length (years)	Average annual precipitation (inches)	Inches	Departure from average (percent)	Inches	Departure from average (percent)
Coastal and Plain:						
San Diego WB Airport	108	9.98	13.90	+39	9.06	-9
Los Angeles WB City	81	15.07	21.13	+40	12.58	-17
Santa Barbara	91	18.07	31.94	+77	16.23	-10
Santa Maria	68	13.96	24.21	+73	11.55	-17
Valley:						
Riverside Fire Station 3	77	11.16	15.00	+34	9.48	-15
Mountain:						
Cuyamaca	71	38.47	48.18	+25	34.10	-11
Big Bear Lake Dam	75	37.88	57.88	+53	35.90	-5
Mount Wilson FC 338 B	54	33.10	45.42	+37	28.86	-13
Ozena	54	13.38	24.86	+86	10.76	-20
Desert:						
Indio U. S. Date Garden	80	3.18	4.53	+42	2.54	-20

During the year, 1957-58, the 14th year of a predominantly dry period that began in 1944, the annual precipitation at all 10 stations was above the average for the period of record. The average departure for this group of stations was plus 48 percent, only a few percent less than the average departure at the same group of stations for the wet year 1952.

RUNOFF

The precipitation, after first satisfying the soil-moisture deficiencies in the root zone of the native vegetation in mountain and foothill areas and of the agricultural crops in the valley-floor areas, recharges the ground-water reservoirs or drains into the stream channels as runoff. That part of the precipitation appearing as runoff follows the same cyclic pattern shown by the total precipitation as plotted in figure 3. However, the cyclic pattern defined by runoff is often more pronounced because the annual runoff may represent only a very small part of annual precipitation. For example, the annual runoff for San Gabriel River basin, as measured near Azusa, has ranged from as little as 0.86 inch for the water year ending September 30, 1899, to a maximum of 36.4 inches for the water year ending September 30, 1922, with an average of 9.9 inches for a 63-year period of record.

This range in annual runoff, together with its time sequence of wet and dry periods, is shown in figure 4 for the gaging station on San Gabriel River near Azusa and the gaging station on Santa Ana River near Mentone. Records for both stations reflect the runoff from rugged mountain basins within the San Bernardino and the Angeles National Forests, and the runoff at these two stations is assumed to be typical of the mountain runoff in those areas where the basinwide average annual precipitation ranges from 30 to 40 inches. Both records show the same cyclic patterns as those of the annual precipitation. To accentuate this distribution, the graphs have been separated into the generally accepted divisions for wet and dry periods of the region, with the average annual runoff for each of these periods shown by the crosshatched area.

It is evident from an inspection of figure 5 that both records contain 3 dry and 2 wet periods and consequently each mean for the period of record tends to be affected by the greater number of dry years. On the basis of the records for San Gabriel River near Azusa, the 49-year period of 1895-1944 and the 54-year period of 1904-58 represent the least affected records because each contains 2 wet and 2 dry periods. For Santa Ana River near Mentone, the least affected records are those for the 47-year period 1896-1943 and for the 53-year period 1905-58. As there are but a few gaging stations in southern California where records are of sufficient length to contain these [illegible]

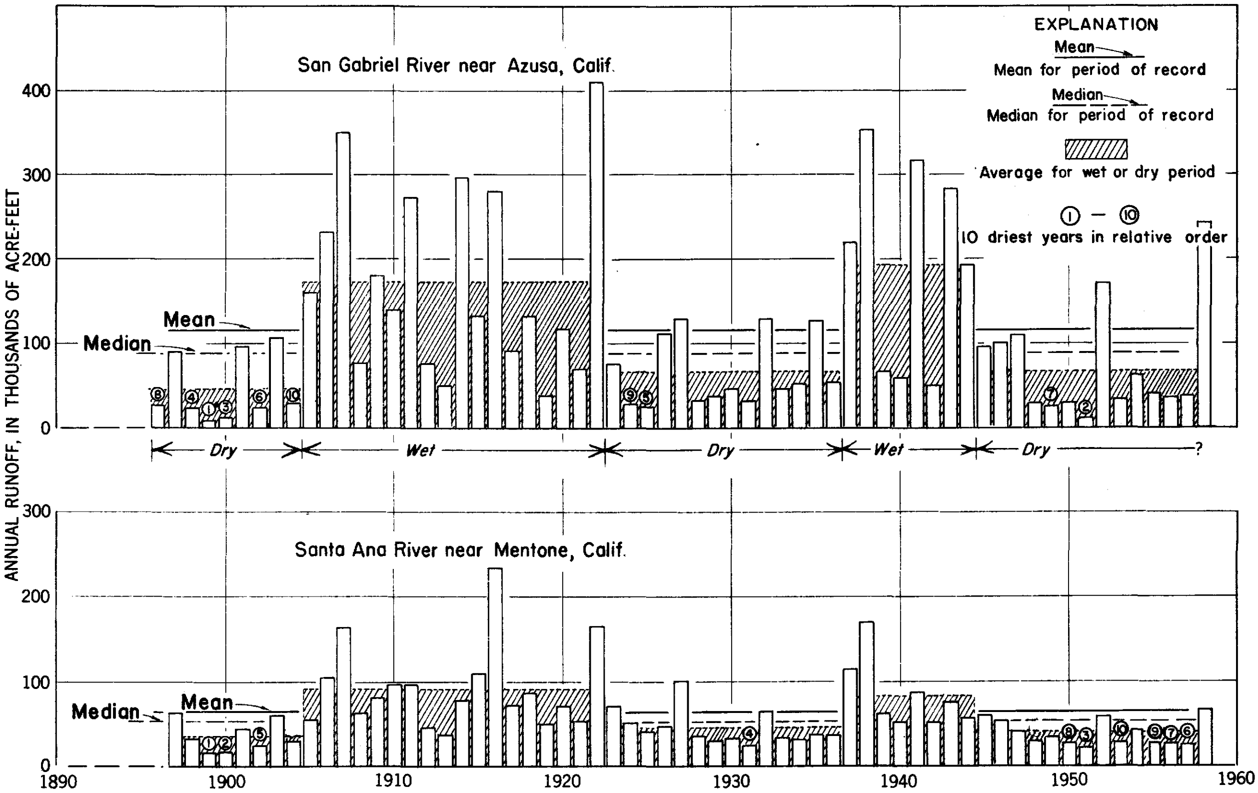

Figure 4.—Annual runoff distribution, 1895–1958.

necessary to consider the use of shorter periods, each containing a single wet and dry sequence. The beginning and the ending of each of these periods, together with the mean annual runoff for each period, are included in figure 5.

The obvious variability of the data for short periods suggests that it is doubtful that the longtime mean can be used as a direct measure of dependable runoff for any randomly selected period. Consequently the longtime mean annual runoff becomes merely an indirect measure of the relative runoff among basins rather than a measure of surface water that is usable or available during extended critical periods.

Despite the inadequacy of the longtime base mean for use in reference to most water problems in southern California, the use of mean values as a measure of central tendency is desirable for convenience. Furthermore, mean values based on a common time period (and designated base means) are of more use for direct comparisons between basins than are longtime means based on time periods of different length. Admittedly, selection of a common time period must be arbitrary because of differences from place to place in the beginning and end of wet and dry periods and lack of clear definition of the lengths of these periods. But, aside from this deficiency, base means, when properly interpreted, have considerable significance in many parts of southern California.

For the water-resources summary, the 30-year period beginning October 1920 and ending September 1950 was initially selected for a base period, and was used through the 1956 edition of the summary (Circular 399). October 1920 was chosen as the beginning date so that the base period would conform closely to that of the standard period October 1920 to September 1945 for which median monthly discharge is computed and used for national coverage in the Water Resources Review of the U. S. Geological Survey and the Canadian Water Resources Division. The choice of the beginning data also enable the inclusion, in data for the base period, of many records for shorter periods of runoff that could be extended back to October 1920 with a minimum loss of accuracy.

For this edition of the summary, as with the preceding edition (Circular 404), the 35-year period from October 1920 to September 1955 is used for computing base means. It is

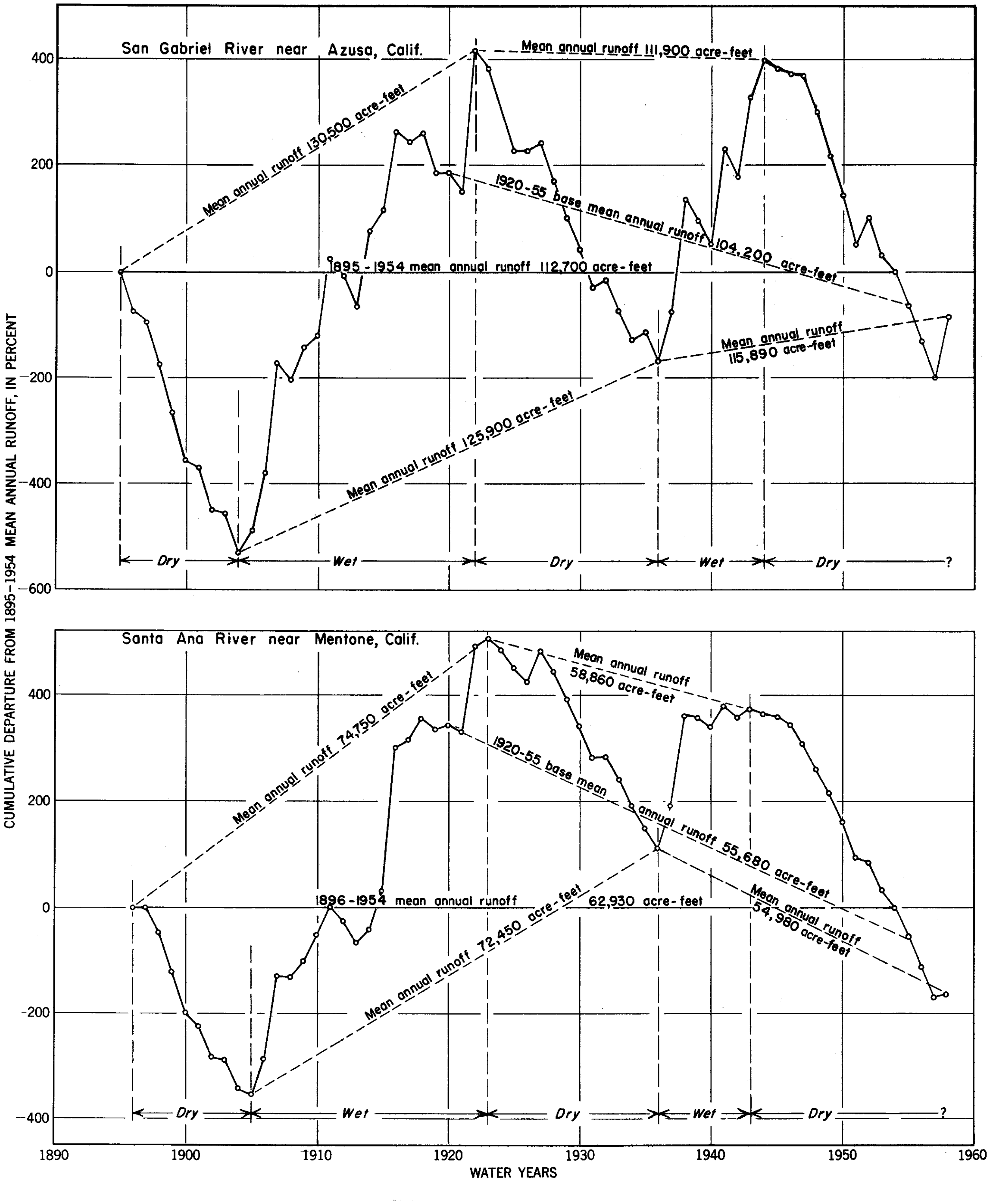

Figure 5.—Mean annual runoff for different periods, 1895-1958.

contemplated that the 35-year period will be used through the 1960 edition of the summary. The base mean for the 35-year period are a few percent lower than those for the 30-year period, which should be borne in mind when comparing percentage departures in this edition of the summary with those in Circular 399 and earlier editions.

RUNOFF FOR THE WATER YEAR 1957-58

Runoff for the water year 1957–58 at the 15 gaging stations shown on figure 2 is briefly summarized in table 2 and compared with the average annual runoff for the 35-year base period of 1920–55. The purpose of table 2 is to provide a general index of the surface runoff throughout southern California for the water year ending September 30, 1958. Typical of the region is the wide range of the 1957–58 runoff, 0.42 to 24.0 inches, which is due largely to the areal distribution of precipitation.

Departure of the 1957–58 runoff from the 35-year base mean at all but two stations reflect the relatively wet year prevalent in all except the southern-most parts of southern California. The average runoff for the 1957–58 water year was 9.12 inches over the 1,464 square miles of area drained by streams listed in table 2, or about 2.25 times the 35-year base mean annual runoff.

In contrast, the average annual runoff for this group of basins during the relatively wet year 1951–52 was 6.87 inches, or about 1.70 times the 35-year base runoff. During the 1956–57 water year the average annual runoff was 1.41 inches, or about one-sixth that of 1957–58.

CURRENT DRY PERIOD

The typical southern California runoff distribution shown in figure 4 indicates that the water year ending September 30, 1958, was

Table 2.—Runoff and peak discharge for the water year 1957-58, and average annual runoff for the dry period 1944-58 at selected gaging stations.

Station and reference number on figure 2.	Drainage area (square mile)	1920-55 base-mean annual runoff (acre-feet)	1957-58 runoff			Average annual runoff for 1944-58 dry period			Peak discharge (cubic feet per second)	
			Acre-feet	Inches	Departure from base-mean annual runoff (percent)	Acre-feet	Inches	Departure from base-mean annual runoff (percent)	Water-year 1957-58	Period of record
Pacific slope basins										
Cottonwood Creek at Morena Dam (799)	120	11,250	2,680	0.42	-76	2,950	0.46	-74	....	....
Santa Ysabel Creek at Sutherland Dam (304)	58	12,340	14,540	4.7	+18	5,130	1.7	-58	....	....
Murrieta Creek at Temecula (721)	220	9,380	14,220	1.2	+52	4,160	.35	-56	5,730	17,500
Santa Ana River near Mentone (102)	202	55,680	67,230	6.2	+21	39,030	3.6	-30	2,170	52,300
Cucamonga Creek near Upland (616)	10.1	5,710	12,370	23.0	+117	4,340	8.1	-24	410	10,300
East Fork San Gabriel River near Camp Bonita (765)	88.2	48,910	112,700	24.0	+130	37,200	7.9	-24	2,720	46,000
Arroyo Seco near Pasadena (4)	16.4	6,270	11,270	12.9	+80	3,710	4.2	-41	719	8,620
Santa Anita Creek near Sierra Madre (377)	10.5	4,360	11,480	20.5	+163	3,220	5.8	-26	867	5,200
Sespe Creek near Fillmore (182)	254	70,980	226,200	16.7	+219	50,240	3.7	-29	28,400	56,000
San Jose Creek near Goleta (845)	5.54	....	4,830	16.4	....	1,120	3.8	....	790	1,960
Huasna River near Santa Maria (638)	119	12,540	48,940	7.7	+290	9,190	1.4	-27	4,230	11,400
Arroyo Grande at Arroyo Grande (821)	106	14,940	46,750	8.3	+213	11,420	2.0	-24	4,030	5,370
The Great Basin										
Palm Canyon Creek near Palm Springs (647)	94.0	4,390	7,290	1.5	+66	1,690	0.34	-62	1,130	3,850
Deep Creek near Hesperia (666)	137	44,270	106,000	14.5	+139	31,710	4.3	-28	12,400	46,600
Big Rock Creek near Valyermo (499)	23.0	12,100	25,020	20.4	+107	8,870	7.2	-27	399	8,300

another relatively wet year in a predominantly dry period that has persisted since October 1944. Whether or not the above-average runoff during 1957–58 forecasts the abatement of this dry period is unknown. What is known, however, is that dry periods of more than 14 years have occurred in southern California. Tree-growth studies by Schulman suggest that southern California may have had dry periods of more than 40 years duration.

A measure of the relative dryness of the dry periods of record is afforded by numbering the 10 driest years, for each of the 2 stations shown in figure 4, in their order of dryness. Of these 20 years for both stations 9 occurred in the very dry 9-year period ending September 30, 1904. The current dry period is next in order with 8 dry years, and the 14-year period ending September 30, 1936, had the least number of dry years, containing only 3 of the 20 years.

The average annual runoff for the current dry period and its departure from the base mean is included in table 2. For most of the stations the influence of the 1957–58 runoff on the average annual runoff for the 1944–58 dry period has reduced the departure from the 35-year base mean. The average departure during the current 14-year dry period for the basins listed is minus 32 percent in contrast with a departure of minus 44 percent for the 13-year dry period 1944–57.

PEAK DISCHARGE

Of more than usual interest, in a year that has above-average precipitation and runoff, is the magnitude of the peak discharges. Table 2 shows the peak discharge at each of several index gaging stations during the water year 1957–58 and also the peak discharge for the period of record to facilitate a rough comparison of the relative intensities of the individual storm events. Except those for the gaging stations on Murrieta Creek, San Jose Creek, Arroyo Grande, and Palm Canyon Creek, all period-of-record peak discharges are those which occurred during the flood of March 1938.

Peak discharges in 1958 at all stations except Big Rock Creek near Valyermo occurred during the storms of April 1–3, a period in which the peak discharge of Sespe Creek near Fillmore reached a magnitude of 50 percent of the 1938 maximum. During 1952 water year, the only other relatively wet year in the current dry period, peak discharges at these same stations were generally less (except on Murrieta Creek and Palm Canyon Creek) than those of the 1958 water year; the 1952 peak discharge at Sespe Creek near Filmore was only 41 percent of 1938 maximum.

SURFACE STORAGE

Currently there is about 1.5 million acre-feet of surface storage capacity in southern California for municipal, domestic, and irrigational uses. Most of this storage capacity has been obtained by building dams across mountain stream channels. However, because of the many adverse topographic features, such as steepness of the stream channels and narrowness of the canyons, construction costs are high and reservoir capacities small. Only 5 reservoirs of 115 built have a capacity in excess of 100,000 acre-feet. Because of the relatively small capacity, it is impossible for many reservoirs to store the excessive flood runoff occurring during wet periods for use in the following dry periods. Furthermore, some of these reservoirs were not built to store local flood runoff but to store and distribute imported waters from Owens Valley and the Colorado River.

Additional storage capacity of more than 400,000 acre-feet has been obtained through the utilization of reservoirs constructed to provide flood control in the valley-floor areas. Although these flood-control reservoirs are primarily for retarding the flood runoff, a certain amount of water is conserved because provision is made, when possible, to control release of flood water to recharge ground-water basins.

Data on the operation of 12 reservoirs during the current dry period are given in table 3. These reservoirs, built to store water for domestic, municipal, or irrigational uses, have a combined capacity of about 55 percent of the present total reservoir capacity in southern California. Except for a small amount of Colorado River water delivered to Lake Hodges, El Capitan, and Santiago reservoirs, the only source of inflow to each reservoir during 1958 was from local runoff.

The Morena and Barrett Reservoirs in the Tia Juana River basin are the most southerly

Table 3.—Storage in selected surface reservoirs.

Reservoir	Average annual inflow 1920–55 (acre-feet)	Present capacity at spill-way level (acre-feet)	Storage ratio (years)	Storage				Change in storage 1957–58 (acre-feet)	Storage on Sept. 30, 1944		Change in storage 1944–58 (acre-feet)
				Sept. 30, 1957		Sept. 30, 1958					
				Acre-feet	Percent of capacity	Acre-feet	Percent of capacity		Acre-feet	Percent of capacity	
Morena and Barrett	24,800	94,970	3.8	1,270	1.3	1,960	2.1	+690	89,900	86	-87,940
El Capitan	38,600	112,810	2.9	2,540	2.2	43,560	39	+41,020	79,700	68	-36,140
Lake Hodges	33,280	33,550	1.0	[a]3,460	10	7,000	21	+3,540	31,100	93	-24,100
Lake Henshaw	24,410	194,300	8.0	[b]1,080	.6	[b]20,400	10	+19,320	144,000	74	-123,600
Vail Lake	9,810	49,370	5.0	560	1.1	6,860	14	+6,300	...	...	...
Big Bear Lake	...	72,200	...	1,950	2.7	21,290	29	+19,340	47,600	66	-26,310
Santiago	11,220	25,000	2.2	3,700	15	19,900	80	+16,200	20,400	82	-500
Matilija	20,910	7,020	.34	5,250	75	7,000	100	+1,750	...	...	...
Jameson Lake	3,840	6,760	1.8	[b]1,260	19	6,160	91	+4,900	6,050	89	+110
Gibraltar	30,540	14,780	.48	10,340	70	13,220	89	+2,880	6,120	38	+7,100
Cachuma	60,700	204,900	3.4	30,150	14	196,890	96	+166,740	...	...	...
Total	[c]268,000	815,660	3.0	61,560	7.5	344,240	42	+282,680	424,870	78	-291,380

[a] Mostly Colorado River water.
[b] Approximately.
[c] Includes estimate for Big Bear Lake.

of these 12 reservoirs. At the end of the preceding dry year, September 30, 1957, both reservoirs were almost empty. At the end of the 1958 water year, which was relatively dry in that region, the reservoirs were still almost empty. Farther north, however, at Cachuma reservoir, the storage at the end of the 1957 water year amounted to 14 percent of capacity, and at the end of the 1958 water year was within a few percent of spillway capacity. This relatively large retention reflects the above-average precipitation occurring in this area during the very wet 1958 water year, a year that produced in the contributing area a volume of runoff equivalent to about 3.4 times the mean-annual inflow to the reservoir.

Column 4 of table 3 gives storage ratio, which is defined as the ratio of usable capacity to average annual inflow. It is expressed in years and is the time required, assuming average inflow, to impound a volume of water equal to the usable capacity of the reservoir.

GROUND WATER

Over a large part of southern California, the most readily available and best distributed water reserve is the water stored in the deep alluvial deposits of the valley-floor areas. A major part of the water requirements of the region has been and is being supplied by pumping from these sources. The magnitude of these water reserves is difficult to measure; however, they have been estimated by Eckis[2] to be about 7.5 million acre-feet in the alluvial deposits in the basins of the Los Angeles, San Gabriel, and Santa Ana Rivers in a zone 100 feet thick extending from 50 feet above to 50 feet below the water levels of January 1933.

The rapid industrial and urban growth has overtaxed these local ground water reserves. As a consequence the current rate of extraction often exceeds the average rate of recharge, creating an overdraft. Currently, many ground-water basins in southern California now have, or are threatened by, overdrafts.

The usefulness of a ground-water reservoir, like a surface-water reservoir, is dependent upon its size, the magnitude of the annual increments of recharge, and the annual rate of withdrawal. Also, like a surface reservoir, the ground-water reservoir must capture its water in the wet periods and retain it in storage to meet the needs of the following dry periods.

The valleys of southern California contain a large number of ground-water basins, many having complex geologic and hydrologic features. Changes in water levels differ considerably from basin to basin, depending upon

[2]Eckis, Rollin, 1934, Geology and ground-water storage capacity of valley fill (South Coastal Basin Investigation): California Dept. Public Works, Div. Water Resources, Bull. 45.

the relationship between natural recharge and pumping draft. Consequently it has been necessary to confine the detailed analysis of the changes in water levels to the few observation wells indicated on figure 2.

The records of change in water level in six selected observation wells for their period of record are shown on figure 6. The division into wet and dry periods is arbitrary and based on figure 5. A light dashed line indicates the rate of decline during each dry period and is based chiefly on the driest years during that period. Assuming that ground-water recharge during all dry periods is small and of about the same magnitude, an increase in the rate of decline becomes a measure of the increase in ground-water withdrawals.

At the end of the 1957 water year, almost all water levels were the lowest for the period of record—a reflection of the great increase in regional water requirements and the excess of withdrawals over the small increments of recharge during the preceding 13-year dry period. At the end of the 1958 water year, water levels generally reflected the above-average precipitation over much of the region and the continued use of either imported water or stored storm runoff for artificial recharge of the ground-water basins.

WESTERN SAN DIEGO COUNTY

Ground-water levels in most of the coastal alluvial valleys of western San Diego County rose slightly during the 1958 water year, reversing the downward trend which, since 1940 had brought many wells to the lowest levels of the entire period of record. However, in parts of the Tia Juana and San Dieguito basins the downward trend continued. At the present time, areas of known or threatened sea-water intrusion exist in the basins of the Tia Juana, Otay, San Diego, and San Luis Rey Rivers.

RIVERSIDE COUNTY

The ground-water levels in the arid and semiarid San Jacinto basin have declined steadily since the first observations of 1904. The Riverside County Flood Control and Water Conservation District reports that the water level in observation well 4S/1W-35R1 near the city of San Jacinto, was about 190 feet below land surface in September 1958; this well was flowing in 1917. Similarly the water level in a second well 4S/3W-33R1, near the city of Perris, was about 186 feet below the land surface during September 1958 in an area where the water level was about 20 feet below the land surface during March 1904. Both areas now are using a limited amount of Colorado River water—at double the cost of water pumped in the area in an effort to supplement the depleted water reserves.

At the end of the 1958 water year, ground-water levels in many areas of the county had risen an average of about 3 feet, a reflection of the decrease in pumping as a result of heavy rains of the 1958 season and the increased use of imported Colorado River water. Imported water now is equal to about one-third of the water obtained from local sources in western Riverside County.

SAN BERNARDINO VALLEY

The San Bernardino Valley is a relatively deep alluvial valley in the upper Santa Ana River basin, east of metropolitan Los Angeles. The water needs of the valley's agricultural and urban developments are supplied from local surface and ground-water sources.

The longest available record of changes in ground-water levels is that for the Williams well (1S/3W-17C1). This record (fig. 6) began in 1892 and indicates the response to seasonal changes caused by pumping and recharge and to the long-term changes associated with wet and dry periods. These changes tend to give the water-level fluctuation a general cyclic distribution in time that coincides closely with that of the wet and dry periods shown on figure 5.

The rate of decline during the first and second dry periods was about 4.2 feet per year. However, during the current dry period the rate of decline increased to about 10 feet per year. This increase in rate of decline reflects an increase in ground-water use that, when contrasted with the average rate and duration of recharge during wet periods of record, forecasts a condition of overdraft in the near future.

The San Bernardino Valley Water Conservation District reports that, owing to the above-average precipitation and duration of

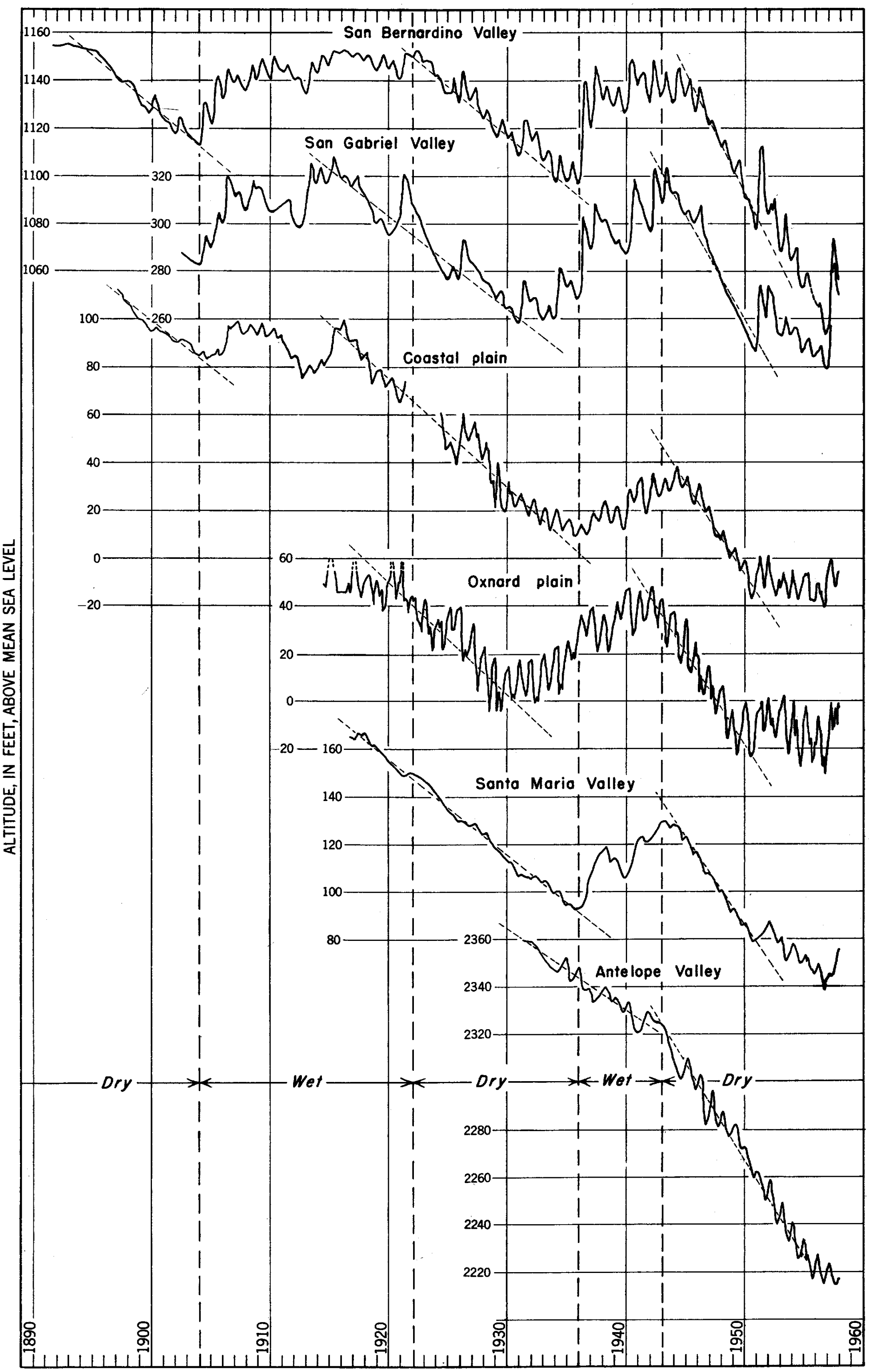

Figure 6.—Water-level fluctuations at selected observation wells.

runoff during the 1958 water year, a great number of irrigation wells in the valley were not used for several months. At the end of the water year ground-water levels had risen from 2 to 30 feet above the record-low levels established in 1957, and the water level in the vicinity of the Williams well, which went dry in July 1956, began to recover in April 1958, as shown by water-level records obtained since March 1957 from a companion well (1S/3W-17C3) drilled to replace the Williams well.

SAN GABRIEL VALLEY

The San Gabriel Valley is a deep alluvial valley in the San Gabriel River basin along the toe of the San Gabriel Mountains. The ground-water-storage capacity of these deposits is believed to be about 1.2 million acre-feet in a zone 100 feet thick, ranging from 50 feet above to 50 feet below the January 1933 water level.[3] The once extensive agricultural acreage in this valley is rapidly being converted into an urban area. Most of the water requirements of the valley are met by local ground-water reserves.

The record obtained at the Baldwin Park observation well 1S/10-18 (fig. 6) is assumed to represent ground-water conditions throughout the valley. The average rate of water-level decline, which was about 3.9 feet per year during the dry period 1922–36, increased to 8.8 feet per year during the current dry period. During the last few years, this rate of decline has moderate, owing partly to the wet year 1951–52 and partly to the increased use of imported Colorado River water in the area.

The Los Angeles County Flood Control District reports that ground-water levels over most of the San Gabriel main and tributary basins were higher in the fall of 1958 than in the fall of 1957. This is the first time since 1952 that an annual recovery in water levels occurred in the main basin. There were a few wells in the vicinity of Alhambra in which water levels were 3 or 4 feet lower at the end of the water year than levels recorded late in 1957, but in the main basin water levels rose 5 to 10 feet near Whittier Narrows, and toward the eastern extremity of the basin near Covina the level in one well rose 40 feet during 1958.

[3] See footnote page 10.

COASTAL PLAIN

The coastal plain is the broad, flat area extending southeastward along the coast from Santa Monica to Newport Beach and inland to the Santa Monica and Santa Ana Mountains, the Puente and San Jose Hills, and lesser foothills. Three major streams, the Santa Ana, San Gabriel, and Los Angeles Rivers, cross the plain to discharge into the ocean. The rich agricultural lands of the plain have been converted gradually into extensive urban and suburban areas. Currently, the coastal plain is the most densely populated and industrialized section of southern California.

The water-bearing deposits underlying the plain are composed of marine and alluvial material that locally are 2,500 feet or more thick. Less than 20 years ago the water stored in these deposits was still the principal source of water for the area. Because of the rapid increase in water needs during recent years, it has been necessary to import a substantial part of the water requirements from Owens Valley and the Colorado River. Even with these imported waters, the ground-water reserves have been so depleted that sea water has intruded these deposits along many sections of the coast.

Systematic observations of change in ground-water level in the coastal plain have been noted at the Neff well (4S/10-22L2) and its companion wells near Anaheim since 1898. These records (fig. 6) have been used as an index of changes in the water level of the coastal plain. During the 59-year period of record at this site, a net decline of 132 feet (from 112 feet above sea level to 20 feet below sea level) was observed. This decline, which has not been uniform, occurred largely during the three dry periods. An average rate of decline of 3.9 feet per year in the first dry period increased to 4.6 feet per year during the second dry period and to 7.6 feet per year in the current dry period. During the last few years, this rate of decline has decreased, owing partly to recharge during the wet year 1951–52 and partly to greater use of imported waters.

The Orange County Water District reports an average rise in ground-water levels of about 5 feet in wells throughout the eastern part of the coastal plain during 1958, and at the end of the 1958 water year the average elevation of these ground-water levels was 10.5 feet below sea level. About 83,000 acre-feet of Colorado River water was spread to replenish the underground basin, and an additional 36,000 acre-feet of Colorado River water was purchased by cities and other water users for direct use in areas previously supplied solely from local sources.

Near Montebello, in the northern forebay area of the plain, the Los Angeles County Flood Control District reports that water levels rose an average of about 40 feet during the 1958 water year in contrast to an average 5-foot decline during 1957. The rise was attributed to the recharge from local runoff and imported water totalling about 170,000 acre-feet to the forebay area during the year. Changes in water levels in the central part of the plain ranged from an average rise of 5 feet in the vicinity of Lakewood to a decline of 5 feet in the vicinity of Southgate during the year.

OXNARD PLAIN

The Oxnard plain is a broad coastal plain that is one of the most important agricultural and urban areas in Ventura County. Water-level observations made by the Ventura County Water Resources Division at well 9-U-9 in the city of Oxnard (fig. 6) are assumed to represent changes in the ground-water reserves of the plain. Since 1943 the water level at this site has declined almost continuously. Between 1943 and 1951 the average rate of decline was about 7.4 feet per year. This trend was reversed temporarily by recharge during the wet year 1952. However, since 1953 the decline in water level has continued at a rate somewhat less than that before 1952.

The Ventura County Water Resources Division reports that water levels of the Oxnard plain rose about 19 feet during the year to an elevation of 6 feet below sea level in the fall of 1958. At the same time water levels in Pleasant Valley, an eastward extension of the Oxnard plain, were about 60 feet below sea level.

There is evidence of sea-water intrusion in wells near the ocean, and, according to the United Water Conservation District, the present area of salt-water contamination extends as much as 1 mile inland.

SANTA MARIA VALLEY

Changes in water level in well 10/34-14E2 (fig. 6) near the center of the Santa Maria Valley, in the northern part of Santa Barbara County, generally reflect the amount of ground water in storage for a large part of the valley. The records from this well show a continuous and almost uniform decline in water level at a rate of 4.0 feet per year during the dry years 1917–36. As a result of the large ground-water recharge during the wet period extending through 1944, the water level in this well rose about 35 feet. During the current dry period, the water level declined at an average rate of 7.4 feet per year to the lowest level on record, indicating a substantial increased draft on the ground-water reserves.

Ground-water levels in the Santa Maria, Cuyama, San Antonio, Carpinteria, and Goleta basins have risen significantly during the 1958 water year, owing to above-average precipitation. Also, water levels in the Santa Ynez River basin proper have risen slightly, but water levels in the upland areas of this basin have continued to decline.

ANTELOPE VALLEY

Antelope Valley, in Los Angeles and Kern Counties, is in the extreme west end of the Mojave Desert. Parts of this arid valley have been farmed successfully for more than 60 years. However, the steadily increasing water needs for agricultural and other uses have created a critical overdraft in the valley.

The bottom graph of figure 6 shows the changes in water level in a well near Lancaster; they are assumed to be an index of changes (water levels) in the large, heavily pumped part of the valley. During the last 27-year period the water level in this and nearby wells has declined about 146 feet. This decline, which persisted even during the wet years, clearly indicates that withdrawals exceeded the recharge. The rate of decline, which was about 3.4 feet per year during the 1922–36 dry period, has increased to 8.1 feet per year during the current dry period.

The Los Angeles County Flood Control District reports that ground-water levels in the Lancaster basin of this valley have declined only about 2 or 3 feet during the 1958 water year as contrasted with a decline of about 5 feet during 1957.

ARTIFICAL RECHARGE OF GROUND WATER

The Metropolitan Water District of Southern California reported that it sold about 188,000 acre-feet of Colorado River water at a cost of more than $2.2 million to the people of Los Angeles and Orange Counties during the 1958 water year chiefly to retard the rapid rate of decline in ground-water levels. This water was permitted either to infiltrate into the stream-channel deposits or to spread into highly permeable, specially prepared basins overlying the main ground-water bodies.

An additional 91,160 acre-feet of local storm runoff from the mountain and foothill areas during the 1958 water year was diverted from natural stream channels into the specially prepared basins for the purpose of recharging the ground-water reservoirs in Los Angeles County.

About 4,300 acre-feet of Colorado River water was put into injection wells along the coast in the vicinity of Manhattan Beach to maintain a fresh-water barrier against sea-water intrusion. Farther north, in the Santa Clara Valley, about 60,000 acre-feet of local storm runoff was released from Piru Lake to the Saticoy and El Rio spreading grounds in an effort to provide a barrier against sea-water intrusion in the Oxnard plain.

IMPORTED WATER

Southern California is a predominantly arid region which has less than 2 percent of the State's natural water supplies. Consequently,

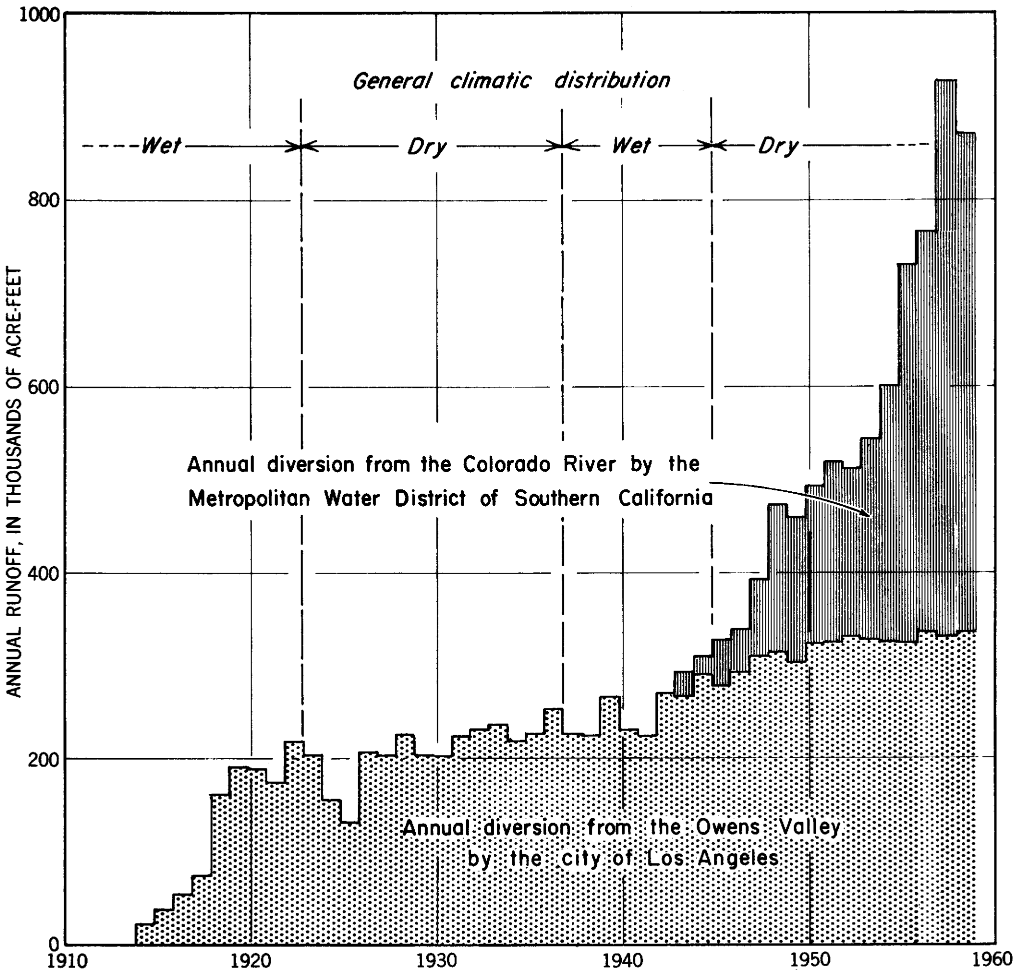

Figure 7.—Water imported into southern California.

to satisfy the ever-increasing water requirements of the area, water must be imported from distant sources.

Since 1913 the city of Los Angeles has used water imported from the Owens Valley, east of the Sierra Nevada and some 250 miles to the north. During the 1958 water year the Los Angeles aqueduct, operating at full capacity as in previous years, delivered 335,000 acre-feet from Owens Valley to the Los Angeles area.

By means of a 1,617-foot pumping lift and a 242-mile aqueduct the Metropolitan Water District of Southern California delivered 535,000 acre-feet from the Colorado River, to the greater Los Angeles and San Diego areas during the 1958 water year.

As indicated on figure 7 these annual imports have increased from 329,000 acre-feet in 1945 to 928,000 acre-feet in 1957—a net increase of 182 percent. About 45 percent of the annual water requirements in the coastal areas are now met by imported water.

RUNOFF FOR THE WATER YEAR 1956–57

Runoff data for the water year ending September 30, 1957, for all southern California gaging-station records currently published by the Geological Survey, are presented in table 4. The mean and median values of the annual runoff for the period of record and the relation of the annual runoff to the base mean are included for the stations with a record of sufficient length.

AREAL DISTRIBUTION

The normal tracks of storms moving over southern California are such that the precipitation along the coast generally decreases from north to south. The eastward movement of the storms is blocked by the high mountains whose barrier effect causes the greatest precipitation in the region to occur on their windward sides. Across the mountains the precipitation decreases rapidly to near zero in the desert areas.

A generalized areal distribution of the annual runoff for the water year ending on September 30, 1957, is shown on figure 8. The runoff quantities used to define this distribution were obtained from table 4; the quantities are relative as they express the departure, in percent, of the runoff for the 1957 water year from the mean of the 35-year period 1921–55.

The 1957 water year was very dry—the 13th year in a series of dry years—and the runoff from many valley streams in the agricultural areas was zero or nearly zero, representing departures as much as 100 percent below the 35-year base mean.

In sharp contrast, and reflecting precipitation on roofs of buildings and paved streets, runoff in the many highly urbanized valley-floor areas in or near Los Angeles was only 39 percent below the base mean. Departures of this magnitude are quite comparable to the departures experienced in the higher mountain areas fronting on the valley floors.

UNIT RUNOFF

Unit rates of runoff generally decrease rapidly as the streams cross the valley-floor areas and discharge into the ocean. In the predominantly agricultural areas, the 1957 runoff into the ocean was almost zero from the basins of the Tia Juana, San Luis Rey, and Santa Margarita Rivers. In contrast, the highly urbanized areas tributary to the Los Angeles River discharged into the ocean the equivalent of 59 acre-feet per square mile, or 1.1 inches of water over the basin. The street drainage in the Beverly Hills and Hollywood areas produced a 1957 runoff of 251 acre-feet per square mile, or 4.7 inches over the Ballona Creek basin.

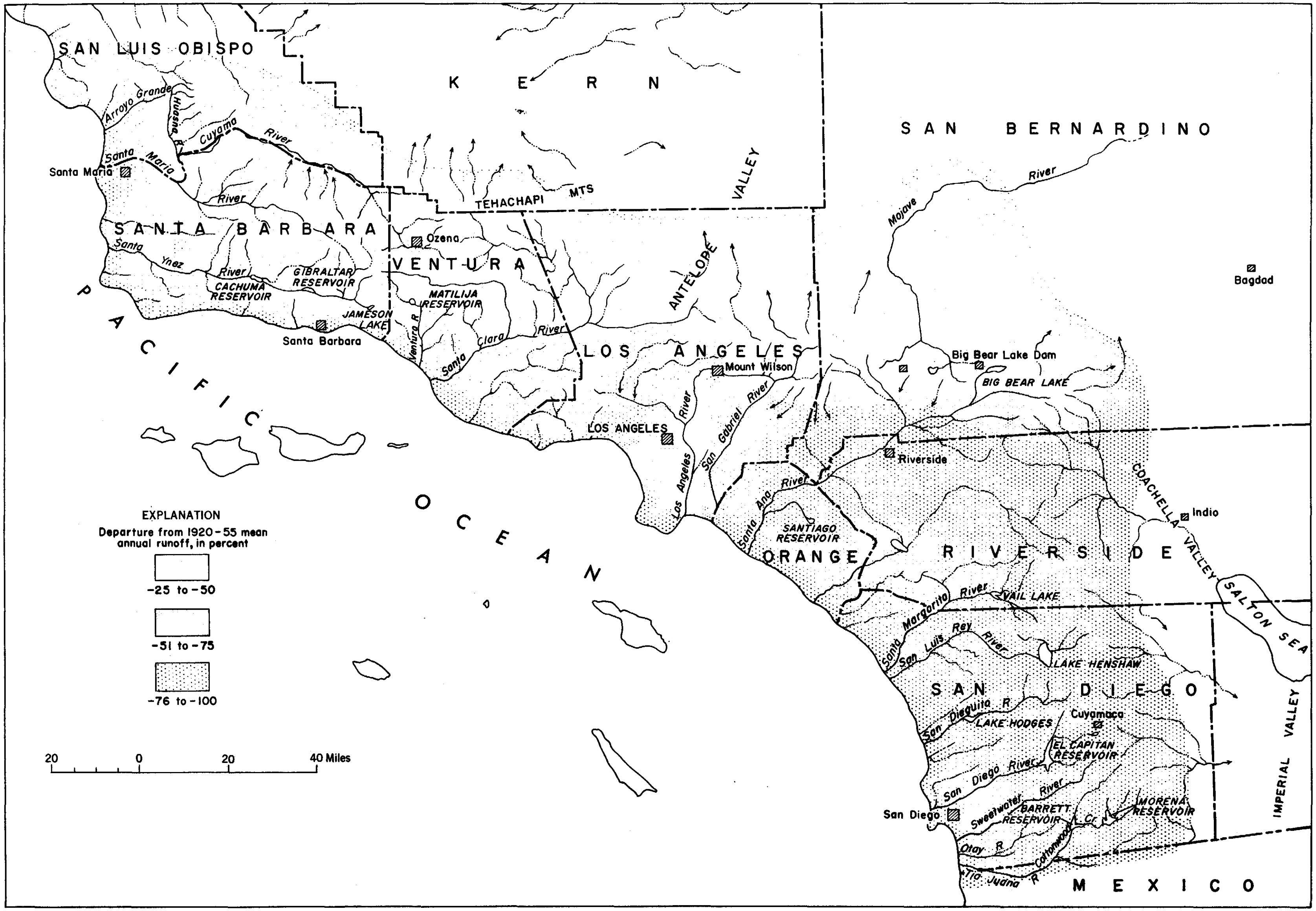

Figure 8.—Areal distribution of runoff for the water year 1956–57.

Table 4. --Runoff for the water year 1956-57.

Basin and stream	Drainage area (square miles)	1956-57 runoff: Acre-feet	1956-57 runoff: Acre-feet per square mile	1956-57 runoff: Departure from base mean (percent)	Period of record: Length (years)	Period of record: Mean annual runoff (acre-feet)	Period of record: Median annual runoff (acre-feet)	Base period: Mean annual runoff 1920-55 (acre-feet)
PACIFIC SLOPE BASINS								
Tia Juana River basin:								
Cottonwood Creek at Morena Dam[a]........	120	265	2.21	-98	21	10,400	5,800	11,250
Cottonwood Creek at Barrett Dam, near Dulzura	250	543	2.17	....	12	8,520	3,000	......
Cottonwood Creek above Tecate Creek near Dulzura.........................	316	100	.32	....	21	7,380	1,380	......
Campo Creek near Campo................	84.0	0	0	....	21	2,190	1,160	......
Tia Juana River near Dulzura	478	115	.24	....	21	11,950	3,910	......
Tia Juana River near Nestor	1,668	36	.02	....	22	36,560	8,690	......
Otay River basin:								
Jamul Creek near Jamul.................	72	160	2.22	....	17	......	......	......
Otay River at Savage Dam...............	98	636	6.49	....	21	......	......	......
Sweetwater River basin:								
Sweetwater River near Descanso..........	43.7	276	6.32	....	23	10,780	5,760	......
Sweetwater River at Loveland Dam, near Alpine[b]	100	448	4.48	....	13	4,020	1,650	......
Sweetwater River at Sweetwater Dam[b].....	181	959	5.30	....	70	......	......	......
San Diego River basin:								
Boulder Creek at Cuyamaca Reservoir, near Julian[c].........................	12.0	526	43.8	-88	13	1,970	870	4,360
San Diego River at El Capitan Dam[a].......	190	2,930	15.4	....	12	10,300	4,000	......
San Diego River near Santee.............	380	653	1.72	-97	42	20,420	3,330	20,410
San Dieguito River basin:								
Santa Ysabel Creek at Sutherland Dam.....	57	938	16.5	-92	36	15,170	8,400	12,340
Santa Ysabel Creek near Ramona	110	300	2.73	....	24	......	......	......
Santa Ysabel Creek near San Pasqual......	128	255	1.99	....	7	......	......	......
Guejito Creek near San Pasquel...........	24	120	5.00	....	10	676	360	......
Santa Maria Creek near Ramona..........	58	1.2	.02	....	18	3,840	510	......
San Dieguito River near San Pasqual	250	0	0	....	1	......	......	......
San Dieguito River at Lake Hodges[a].......	303	-389	-1.28	....	41	......	......	......
San Luis Rey River basin:								
West Fork San Luis Rey River near Warner Springs	25.6	....	.....	....	3	......	......	......
San Luis Rey River at Lake Henshaw, near Mesa Grande[d]...................	209	1,660	7.94	-93	35	21,430	12,100	24,410
San Luis Rey River at Monserate Narrows, near Pala..........................	383	0	0	....	14	7,820	2,320	......
San Luis Rey River near Bonsall..........	514	0	0	-100	28	17,880	6,590	21,970
San Luis Rey River at Oceanside..........	557	0	0	....	25	15,350	1,010	......
Santa Margarita River basin:								
Temecula Creek at Vail Dam, near Temecula..........................	319	925	2.90	-90	34	8,670	4,780	9,810
Murrieta Creek at Temecula	220	997	4.53	-89	27	7,460	1,950	9,380
Santa Margarita River near Temecula.....	592	3,470	5.86	-82	34	17,080	7,050	19,030
Santa Margarita River near Fallbrook.....	....	1,880	.....	-92	32	21,520	8,190	23,090
De Luz Creek near Fallbrook.............	47.9	65	1.36	....	6	5,760	......	......
Santa Margarita River at Ysidora.........	740	0	0	-100	33	24,620	8,400	27,450

Table 4. --Runoff for the water year 1956-57--Continued.

Basin and stream	Drainage area (square miles)	1956-57 runoff: Acre-feet	1956-57 runoff: Acre-feet per square mile	1956-57 runoff: Departure from base mean (percent)	Period of record: Length (years)	Period of record: Mean annual runoff (acre-feet)	Period of record: Median annual runoff (acre-feet)	Base period: Mean annual runoff 1920-55) (acre-feet)
San Juan Creek basin:								
San Juan Creek near San Juan Capistrano	110	1,750	15.9	....	29	......	......	....
Arroyo Trabuco near San Juan Capistrano[e]	36.5	117	3.21	-97	27	3,610	510	3,530
Aliso Creek basin:								
Aliso Creek at El Toro[e]	8.5	0.4	.05	-100	27	528	220	514
Peters Canyon Wash basin:								
San Diego Creek near Irvine	....	321	......	....	8	1,110	......	....
Santa Ana River basin:								
Santa Ana River near Mentone	202	25,760	128	-54	61	61,170	51,100	55,680
Mill Creek near Yucaipa	42.9	10,550	246	-57	29	23,460	16,700	24,500
Mill Creek near Mentone	51.7	365	7.06	....	18	1,890	510	....
Plunge Creek near East Highlands	16.6	3,240	195	....	38	......	......	....
Santa Ana River near San Bernardino	302	1,580	5.23	....	12	6,020	1,090	....
Little San Gorgonio Creek near Beaumont	2.61	3.6	1.38	....	9	58	......	....
San Timoteo Creek near Redlands	123	66	.54	-95	31	1,060	360	1,300
San Timoteo Creek near Loma Linda	....	698	......	....	3	......	......	....
East Twin Creek near Arrowhead Springs	8.6	1,680	195	-51	37	3,340	2,460	3,420
Waterman Canyon Creek near Arrowhead Springs	4.55	1,010	222	-47	39	1,950	1,380	1,900
City Creek near Highland	19.8	4,870	246	-35	38	7,380	5,430	7,530
Devil Canyon Creek near San Bernardino	6.16	1,600	260	-32	38	2,310	1,660	2,340
Lytle Creek near Fontana	46.9	12,060	257	-59	53	31,200	25,700	29,730
Cajon Creek near Keenbrook	40.9	3,450	84.4	-49	37	6,440	4,200	6,720
Lone Pine Creek near Keenbrook	15.0	267	17.8	-77	26	934	360	1,160
Warm Creek near Colton	259	8,960	34.6	....	37	......	......	....
Santa Ana River at Riverside Narrows, near Arlington	858	24,800	28.9	-54	27	40,070	29,300	53,860
Day Creek near Etiwanda	4.58	1,270	277	-68	28	3,830	2,720	3,950
Cucamonga Creek near Upland	10.1	1,840	182	-68	28	5,410	3,910	5,710
San Jacinto River near San Jacinto	140	5,260	37.6	-79	37	23,500	13,200	24,550
Bautista Creek near Hemet	39.4	3.4	.86	....	10	362	7	....
San Jacinto River near Elsinore	717	706	.98	....	41	......	......	....
Temescal Creek near Corona	....	5.8	......	....	28	2,710	29	....
San Antonio Creek near Claremont	16.9	7,610	450	-53	40	15,570	10,900	16,120
Santa Ana River below Prado Dam	1,462	46,950	32.1	....	17	......	......	....
Santa Ana River at county line, below Prado Dam	....	45,390	......	....	38	......	......	....
Santiago Creek at Santiago Dam, near Villa Park	63.2	2,510	39.7	-78	26	12,570	7,500	11,220
Santiago Creek near Villa Park	83.8	61	.73	....	37	......	......	....
Santiago Creek at Santa Ana	96.6	157	1.63	-67	28	3,830	580	4,750
Santa Ana River at Santa Ana	1,625	137	.08	-99	34	14,330	1,990	19,300
San Gabriel River basin:								
East Fork San Gabriel River near Camp Bonita[f]	88.2	23,630	268	-52	24	50,320	33,300	48,910
West Fork San Gabriel River at Camp Rincon[f]	102	13,350	131	-73	30	45,750	23,900	49,640
San Gabriel River near Azusa	211	37,140	176	-64	62	109,300	76,700	104,200
Rogers Creek near Azusa	6.4	440	68.8	-80	40	2,090	1,100	2,240
Fish Creek near Duarte	6.5	674	104	-78	40	2,810	1,700	3,010
San Gabriel River below Santa Fe Dam, near Baldwin Park	231	0	0	....	15	......	......	....
San Dimas Creek below San Dimas Dam[f]	16.2	436	26.9	....	1	......	......	....
Dalton Creek near Glendora	7.5	16	2.13	....	37	......	......	....
Little Dalton Creek near Glendora[f]	2.7	67	24.8	....	19	471	220	....

Table 4. --Runoff for the water year 1956-57--Continued.

Basin and stream	Drainage area (square miles)	1956-57 runoff: Acre-feet	1956-57 runoff: Acre-feet per square mile	1956-57 runoff: Departure from base mean (percent)	Period of record: Length (years)	Period of record: Mean annual runoff (acre-feet)	Period of record: Median annual runoff (acre-feet)	Base period: Mean annual runoff 1920-55 (acre-feet)
San Gabriel River basin--Continued								
San Gabriel River above Whittier Narrows Dam	....	[g]2,090	......	....	2	....	......	....
San Jose Creek near Whittier[f]	85.2	1,740	20.4	-70	28	5,890	3,620	5,860
San Gabriel River at Pico[f]	206	[h]3,480	16.9	-90	29	31,130	13,400	34,270
San Gabriel River at Spring Street, near Los Alamitos	216	896	4.15	....	30	18,410	1,770	....
Brea Creek below Brea Dam, near Fullerton	23.4	2.6	.11	....	15	463	140	....
Brea Creek at Fullerton[e]	26.2	44	1.68	....	27	819	330	....
Fullerton Creek below Fullerton Dam, near Brea	3.05	266	87.2	....	16	....	......	....
Fullerton Creek at Fullerton[e]	6.2	1,100	177	....	22	521	220	....
Coyote Creek near Artesia[f]	110	1,200	10.9	-79	28	5,680	2,960	5,620
Carbon Creek near Yorba Linda	20.4	6.2	.30	....	8	167	......	....
Los Angeles River basin:								
Los Angeles River at Sepulveda Dam	155	[i]9,900	63.9	....	14	12,570	9,480	....
Pacoima Creek near San Fernando[f]	28.2	774	27.4	-89	40	6,500	3,040	6,920
Tujunga Creek below Mill Creek, near Colby Ranch[f]	64.9	1,470	22.7	....	9	3,720	......	....
Tujunga Creek near Sunland[f]	106	2,290	21.6	-89	40	19,840	10,900	21,190
Haines Creek near Tujunga	1.2	24	20.0	....	25	280	140	....
Little Tujunga Creek near San Fernando[f]	21.0	35	1.67	-98	29	1,800	510	2,020
Tujunga Creek below Hansen Dam	148	22	.15	....	17	14,140	2,070	....
Los Angeles River at Los Angeles[f]	510	24,890	48.8	-39	28	41,190	24,600	40,790
Arroyo Seco near Pasadena	16.4	1,170	71.3	-81	43	6,530	3,500	6,270
Los Angeles River near Downey[f]	614	38,460	62.6	....	29	68,780	44,200	....
Sawpit Creek near Monrovia	5.3	723	136	-62	40	1,790	1,300	1,880
Santa Anita Creek near Sierra Madre	10.5	1,570	150	-67	41	4,080	2,600	4,360
Little Santa Anita Creek near Sierra Madre	1.9	249	131	-63	40	623	360	665
Eaton Creek near Pasadena	6.5	624	96.0	-78	39	2,640	1,650	2,820
Rio Hondo above Whittier Narrows Dam	....	9,890	.....	....	1	....	......	....
Rio Hondo near Montebello[f]	115	16,840	146	-57	29	37,280	26,100	39,240
Mission Creek near Montebello[f]	6	1,840	307	....	27	11,220	11,600	....
Mission Creek below Whittier Narrows Dam	....	1,240	......	....	1	....	......	....
Rio Hondo near Downey[f]	140	4,640	33	....	29	19,040	7,960	....
Los Angeles River at Long Beach[f]	....	48,750	......	-45	28	100,600	66,600	88,040
Ballona Creek basin:								
Ballona Creek near Culver City[f]	88.6	22,240	251	....	29	....	......	....
Topanga Creek basin:								
Topanga Creek near Topanga Beach[f]	17.9	374	209	-90	26	3,790	1,300	3,690
Malibu Creek basin:								
Malibu Creek at Crater Camp, near Calabasas[f]	103	444	4.31	-97	26	13,460	4,560	12,760
Santa Clara River basin:								
Santa Clara River at Los Angeles - Ventura county line[j]	651	3,280	5.04	....	5	5,720	......	....
Piru Creek above Lake Piru	371	9,610	25.9	....	2	....	......	....
Piru Creek below Santa Felicia Dam	420	11,590	27.6	....	2	....	......	....
Hopper Creek near Piru[j]	23.0	1,230	53.5	....	25	3,380	1,600	....
Sespe Creek near Wheeler Springs	50	2,200	44.0	....	9	3,320	......	....
Sespe Creek near Fillmore	254	23,780	93.6	-66	30	69,070	39,100	70,980
Santa Paula Creek near Santa Paula	40.0	3,530	88.2	-74	30	12,960	6,810	13,330

Table 4.--Runoff for the water year 1956-57--Continued.

Basin and stream	Drainage area (square miles)	1956-57 runoff: Acre-feet	1956-57 runoff: Acre-feet per square mile	1956-57 runoff: Departure from base mean (percent)	Period of record: Length (years)	Period of record: Mean annual runoff (acre-feet)	Period of record: Median annual runoff (acre-feet)	Base period: Mean annual runoff 1920-55 (acre-feet)
Ventura River basin:								
Matilija Creek above reservoir, near Matilija Hot Springs	51	4,900	96.1	....	9	9,050	......	......
Matilija Creek at Matilija Hot Springs	55	4,570	83.1	-78	30	20,360	9,630	20,910
North Fork Matilija Creek at Matilija Hot Springs	15.5	1,840	119	-69	28	5,990	2,900	5,860
San Antonio Creek at Casitas Springs [j]	....	217	......	....	8	2,160	......	......
Coyote Creek near Ventura	41.1	1,080	26.3	-87	29	8,690	3,400	8,620
Ventura River near Ventura	187	6,100	32.6	-87	30	51,470	23,900	46,590
Carpinteria Creek basin:								
Carpinteria Creek near Carpinteria	13.8	90	6.52	....	16	1,010	290	......
Atascadero Creek basin:								
Atascadero Creek near Goleta	18.3	567	31.0	....	16	1,460	652	......
San Jose Creek basin:								
San Jose Creek near Goleta	5.54	784	142	....	16	977	650	......
Santa Ynez River basin:								
Santa Ynez River at Jameson Lake, near Montecito [k]	13.8	533	38.6	-86	26	4,180	1,860	3,840
Santa Ynez River above Gibralter Dam, near Santa Barbara [m]	216	3,890	18.0	-87	37	29,330	9,660	30,540
Santa Ynez River below Gibralter Dam, near Santa Barbara [m]	216	71	......	....	37	25,120	7,240	......
Santa Ynez River below Los Laureles Canyon, near Santa Ynez	277	1,890	6.82	....	10	15,850	1,300	......
Santa Cruz Creek near Santa Ynez	73.8	2,100	28.5	....	15	7,020	4,340	......
Cachuma Creek near Santa Ynez	20.5	357	17.4	....	7	1,950		......
Santa Ynez River near Santa Ynez	422	2,890	6.85	....	27	61,160	12,760	......
Santa Agueda Creek near Santa Ynez	55.9	172	3.08	....	16	1,590	650	......
Zanja Cota near Santa Ynez	13.4	965	72.0	....	3	......	......	......
Santa Ynez River at Grand Avenue, near Santa Ynez	513	2,780	5.42	....	3	......	......	......
Santa Ynez River at Solvang	579	3,350	5.79	....	19	29,750	8,550	......
Santa Ynez River at Buellton	594	1,590	2.68	....	3	......	......	......
La Zaca Creek at Buellton	39.5	3.0	.08	....	16	174	22	......
Santa Ynez River near Beullton	668	1,730	2.59	....	5	8,390	......	......
Santa Ynez River at Santa Rosa Damsite, near Buellton	748	1,280	1.71	....	3	......	......	......
Santa Ynez River at Cooper's Reef, near Lompoc	755	1,130	1.50	....	3	......	......	......
Santa Ynez River below Santa Rita Creek, near Lompoc	781	920	1.18	....	3	......	......	......
Salsipuedes Creek near Lompoc	47.0	1,250	26.6	....	16	5,050	2,030	......
Santa Ynez River at narrows, near Lompoc	790	1,460	1.85	....	5	11,720	......	......
Santa Ynez River near Lompoc	790	1,110	1.41	....	32	83,330	29,410	......
Santa Ynez River at H Street, near Lompoc	816	37	.05	....	10	30,590	1,200	......
Santa Ynez River at 13th Street, near Lompoc	820	3.6	0	....	3	......	......	......
Santa Ynez River at barrier, near Surf	895	118	.13	....	10	34,550	1,320	......
San Antonio Creek basin:								
San Antonio Creek near Casmalia	....	1,690	.....	....	2	......	......	......

Table 4.--Runoff for the water year 1956-57--Continued.

Basin and stream	Drainage area (square miles)	1956-57 runoff			Period of record			Base period
		Acre-feet	Acre-feet per square mile	Departure from base mean (percent)	Length (years)	Mean annual runoff (acre-feet)	Median annual runoff (acre-feet)	Mean annual runoff 1920-55 (acre-feet)
Santa Maria River basin:								
Cuyama River near Ventucopa	90.0	2,500	27.8	....	12	3,740	2,320	......
Cuyama River near Santa Maria	912	701	.77	-95	27	14,260	7,020	13,970
Alamo Creek near Santa Maria	87.7	923	10.5	....	14	3,050	1,450	......
Huasna River near Santa Maria	119	689	5.79	-95	27	13,390	5,210	12,540
Sisquoc River near Sisquoc	290	3,420	11.8	....	14	16,220	9,410	......
La Brea Creek near Sisquoc	86.7	0	0	....	14	2,610	430	......
Tepusquet Creek near Sisquoc	28.9	197	6.82	....	14	724	430	......
Sisquoc River near Garey	....	95	......	....	16	15,420	5,360	......
Santa Maria River at Guadalupe	1,763	0	0	....	16	13,250	1,880	......
Arroyo Grande basin:								
Arroyo Grande at Arroyo Grande	106	3,320	31.3	-78	17	15,350	7,240	14,940
THE GREAT BASIN								
Salton Sea basin:								
Coyote Creek near Borrego Springs	144	1,440	10	....	7	1,860	......	......
Palm Canyon Creek near Borrego Springs	21.7	155	7.14	....	7	362	......	......
Whitewater River at White Water	57.4	5,030	87.6	....	8	7,530	......	......
Tahquitz Creek near Palm Springs	16.7	1,120	67.1	....	10	1,710	1,160	......
Palm Canyon Creek near Palm Springs	94.0	9.2	.98	-100	22	3,330	860	4,390
Andreas Creek near Palm Springs	8.78	997	114	....	9	1,400	......	......
Mojave River basin:								
Deep Creek near Hesperia	137	20,430	149	-54	44	54,330	40,710	44,270
West Fork Mojave River near Hesperia	74.8	3,120	41.7	-87	45	31,010	19,640	24,510
Mojave River at lower narrows, near Victorville	530	20,560	38.8	-65	32	55,450	32,390	58,270
Mojave River at Barstow	....	0	0	-100	27	20,630	72	25,690
Mojave River at Afton	....	753	......	....	7	1,920	......	......
Antelope Valley:								
Big Rock Creek near Valyermo	23.0	4,420	192	-63	34	10,890	6,540	12,100
Little Rock Creek near Little Rock[f]	49.0	4,560	93.1	-66	25	12,380	6,590	13,500

Basic data furnished by: (a) city of San Diego; (b) California Water and Telephone Co.; (c) Helix Irrigation District; (d) Vista Irrigation District; (k) Montecito County Water District; (m) city of Santa Barbara.

Records furnished by: (e) Orange County Flood Control District; (f) Los Angeles County Flood Control District; (j) Ventura County Water Resources Division.

Imported water: (g) adjusted for 39,350 acre-ft of Colorado River water; (h) adjusted for 14,540 acre-ft of Colorado River water; (i) adjusted for 1,600 acre ft of Owens River water.

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