Busby and Hirashima--STREAMFLOW RELATIONS, SAN BERNARDINO AND EASTERN SAN GABRIEL MTS., CALIF.

GENERALIZED STREAMFLOW RELATIONS OF THE SAN BERNARDINO AND EASTERN SAN GABRIEL MOUNTAINS CALIFORNIA

OPEN—FILE REPORT

U.S. DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
Water Resources Division
Menlo Park, California, 1972
PREPARED IN COOPERATION WITH THE
SAN BERNARDINO COUNTY FLOOD CONTROL DISTRICT

UNITED STATES
DEPARTMENT OF THE INTERIOR
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By

Mark W. Busby and George T. Hirashima

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GENERALIZED STREAMFLOW RELATIONS OF THE SAN BERNARDINO AND EASTERN SAN GABRIEL MOUNTAINS, CALIFORNIA

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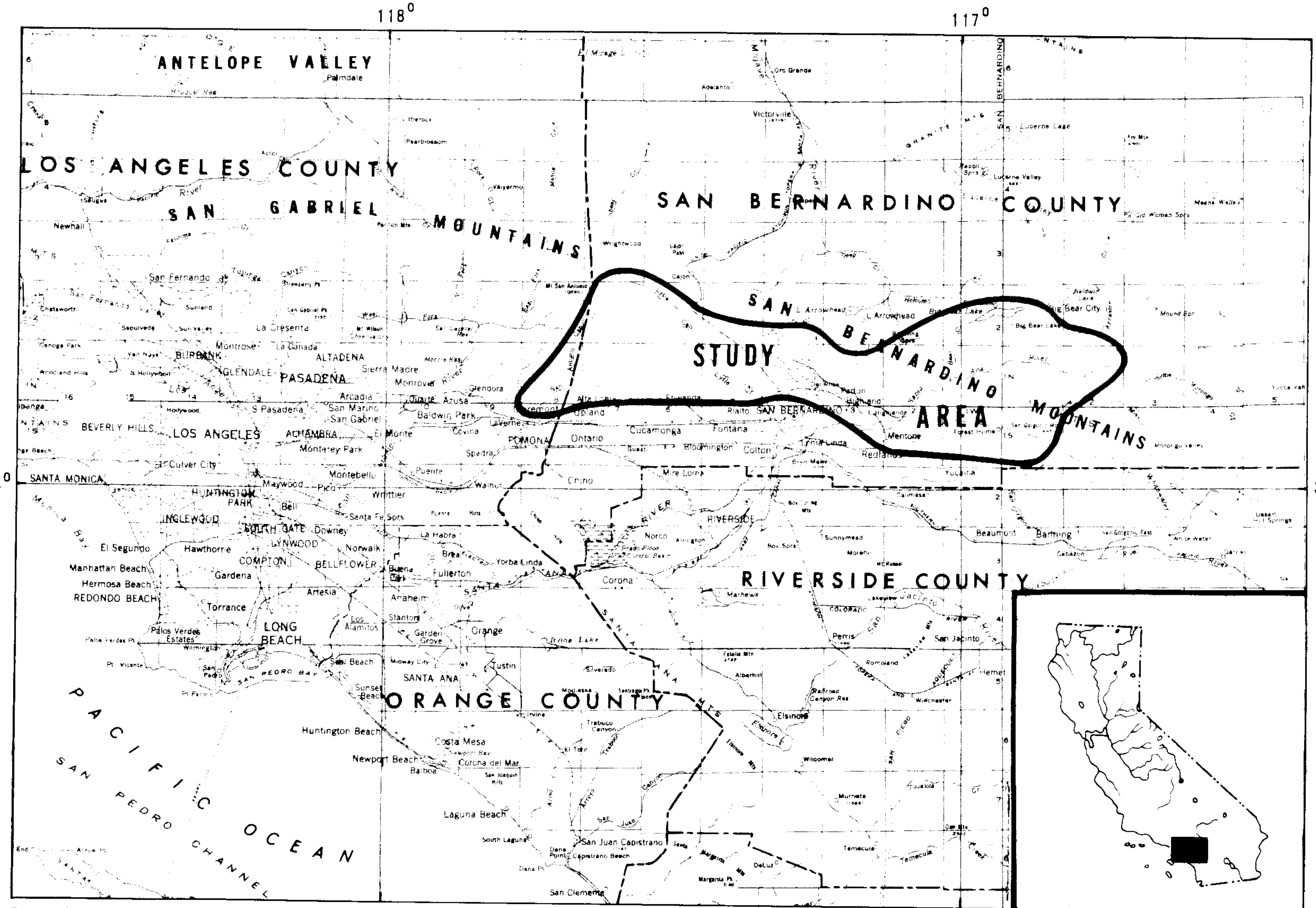
ABSTRACT

Generalized relations for surface-water flow characteristics have been developed for the San Bernardino and the eastern San Gabriel Mountains within the Santa Ana River drainage. Flow characteristics were related to various sets of eight basin characteristics by a statistical correlation method. The 26 streamflow characteristics represented high, low, and medium flows--the flows used in most design studies.

The developed relations allow estimation of any of the flow characteristics for any stream site whether gaged or ungaged within the study area. The statistical errors of estimation involved in using the relations are presented to allow evaluation of the estimated flow characteristics.

INTRODUCTION

This report is for that part of the San Bernardino and eastern San Gabriel Mountains drained by the Santa Ana River and its tributaries (fig. 1). It has been prepared to provide generalized relations for surface-water characteristics for use in project planning by the San Bernardino County Flood Control District and by other water agencies operating in the county. This project planning has as its broad objective the conservation, control, and utilization of the water resources of the county.



Base from U.S. Geological Survey
state base map 1:1,000,000, 1961

118°　0　6　12　18 MILES　117°

FIGURE 1.--Study area.

INTRODUCTION

This report is one of a planned series covering the water resources of the area. This report discusses the generalized flow characteristics of the mountain area to allow determination of the quantities of water available. The other reports will discuss the use of water-spreading facilities to conserve the water and the effects on the flow regimes of urbanization on the valley floor.

The study area is the wettest in San Bernardino County. The water originating in the area is relied upon to supply some of the needs of water users in the lower valleys, mainly through the use of water spreading to induce artificial recharge.

Because the county's water needs are large, and growing larger every year, full utilization must be made of the runoff from the study area. A prerequisite for the planning of the development of the water resources of the area is a detailed description of the supply, including both the spatial and the time distribution of runoff. This report attempts to fill that need for the most populated part of the county.

Various aspects of the hydrology of the area have been reported by several investigators. One of the principal studies was by Troxell and others (1954). The reports of other studies are listed in the selected references.

The mass of data collected by the U.S. Geological Survey (1960, 1963, 1970) in the study area has been analyzed to define the generalized streamflow in the area. There are several ways of generalizing streamflow occurrence; the method chosen for this study was that of statistical correlation of streamflow characteristics with topographic and climatic characteristics of the watershed.

In this study all records of streamflow in the area that represent natural flow conditions, or that could be adjusted to natural flow by adding the diversions, were used if they had at least 10 years of record. Only the observed streamflow record was used in computing the streamflow characteristics, such as mean monthly or mean annual discharge. No attempt was made to select records covering a common base period, to fill in missing records, or to adjust streamflow statistics to represent any selected time or base period. Generalization using records from whatever periods may be available is consistent with considering them as random data and will usually lead to the best description of long-term expectancy. The known disadvantages of not adjusting the records (including a wider variance of errors of prediction of streamflow characteristics) are considered less undesirable than the possible bias introduced by a base or common period, if the common period is one in which the flow is either higher or lower than the long-term mean.

This study by the U.S. Geological Survey was made in cooperation with the San Bernardino County Flood Control District. The report was prepared by the Geological Survey under the general direction of R. Stanley Lord, district chief in charge of water-resources investigations in California, and under the immediate direction of James L. Cook and R. E. Miller, successive chiefs of the Garden Grove subdistrict.

DESCRIPTION OF AREA

Geology and Physiography

The San Bernardino and San Gabriel Mountains are distinguished by their rugged terrain, steep-walled canyons, and sharp peaks, some of which reach elevations of more than 10,000 feet. The mountains are composed mostly of schist and gneiss, of Precambrian to Mesozoic age. This metamorphic complex was intruded by plutonic masses, generally of granitic composition but including a broad spectrum of lithologic types. Shale, sandstone, quartzite, and altered limestone are found in parts of the San Gabriel Mountains. Sandstone and conglomerate, of Tertiary age, are clearly evident in the San Bernardino Mountains to the north and east. Remnants of Pleistocene alluvial-fan deposits scattered throughout the mountain areas are evidence of still-active tectonism throughout the ranges.

The streams draining the San Bernardino and San Gabriel Mountains can be divided into two groups. In the first group are the streams that drain the steep mountain front. In the second group are the streams that drain the high and less-rugged interior of the mountains. The streams of this second group, and those of the first group that debouch into the upper Santa Ana River basin, create flood problems of economic importance.

Climate

The previously described mountains in the study area form a barrier to the prevailing winds that sweep moisture-laden air masses in from the ocean. As the air masses rise over the barrier, the moisture in them is precipitated on the windward side of the barrier.

The climate is temperate and humid at the higher elevations. This contrasts with the semiarid climate in the lowlands to the south and the arid climate north of the mountains. However, precipitation in the area is distinctly seasonal, little occurring during the period July through September. The seasonal distribution of precipitation is controlled mainly by the existence of an anticyclonic cell off the coast of California during the summer. This anticyclone becomes firmly established in mid-summer and, except for sporadic reappearances, disappears in October. The frequent winter precipitation occurs when the anticyclonic cell is not present or is far south of its usual position.

Temperatures are quite varied, as would be expected in an area containing both mountains and deserts. The summers are warm and dry, with only slightly cooler temperatures in the mountains. Temperatures of more than 100°F in the valleys and of near 90°F in the mountains are common. Winters are usually mild, although freezing temperatures occur almost every year and snow accumulates in the mountains in December, January, and February.

Precipitation and Runoff

About 81 percent of the annual precipitation occurs during the 5 months from November through March. Table 1 gives mean monthly precipitation in percentage of the mean annual for two stations in the mountains and two stations in the lowlands near the study area. Some snow falls in the area, but snow does not remain on the ground for any appreciable length of time except at elevations above 5,000 feet.

TABLE 1.--*Distribution of mean monthly precipitation at selected stations*

Station	Elevation of station (feet)	Mean annual Precipitation (inches)	Mean monthly precipitation in percentage of mean annual precipitation											
			Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
Squirrel Inn No. 2	5,680	40.99	4.71	8.00	17.59	18.44	21.80	15.98	8.78	2.02	0.34	0.22	0.51	1.61
Lake Arrowhead	5,205	39.90	4.11	10.60	16.42	20.80	18.87	15.01	9.40	2.41	.30	.25	.98	.85
Redlands	1,318	14.25	5.47	7.16	15.72	18.18	18.60	17.61	8.63	4.21	.63	.35	1.40	2.04
San Bernardino County Hospital (in city of San Bernardino)	1,125	16.57	4.53	7.85	16.60	19.91	19.37	16.66	8.69	3.50	.54	.18	.84	1.33

Mean annual precipitation in the area is influenced by elevation, shape, steepness, and direction of mountain slopes in relation to the moisture-bearing winds. Because the winds come from the Pacific Ocean, precipitation is heavier on the southern and western slopes of the mountains than on the northern and eastern slopes. Figure 2 is part of an unpublished isohyetal map compiled by S. E. Rantz of the U.S. Geological Survey in 1967 from several sources. The precipitation is highly variable, so that even in the more humid parts of the area annual precipitation in some years may be but a small fraction of the long-term mean.

Because runoff is the residual of precipitation after the extractions of evaporation, transpiration, and percolation have taken their share, runoff tends to be even more variable than the precipitation.

The mean annual precipitation on the drainage areas of the streams whose annual runoff was used in this study ranges from 10.00 inches to 35.00 inches and averages 25.18 inches. Runoff ranges from 0.54 inches to 17.2 inches, or 5.4 percent and 50.6 percent, respectively, of the precipitation. For the group of 29 stations studied for annual runoff, the runoff averages 6.34 inches, or 23.2 percent of the average precipitation.

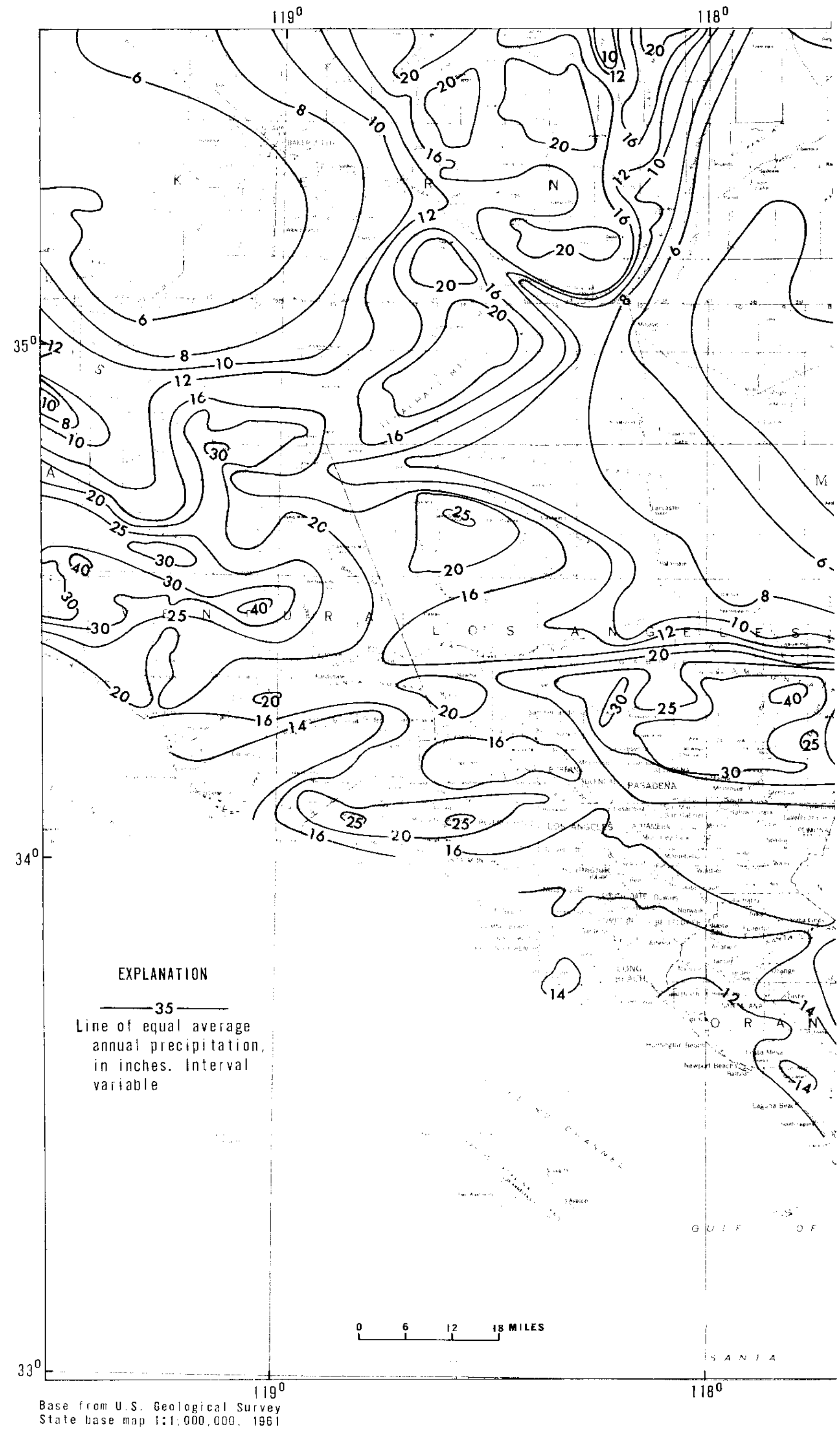


FIGURE 2.--Mean annual precipitation.

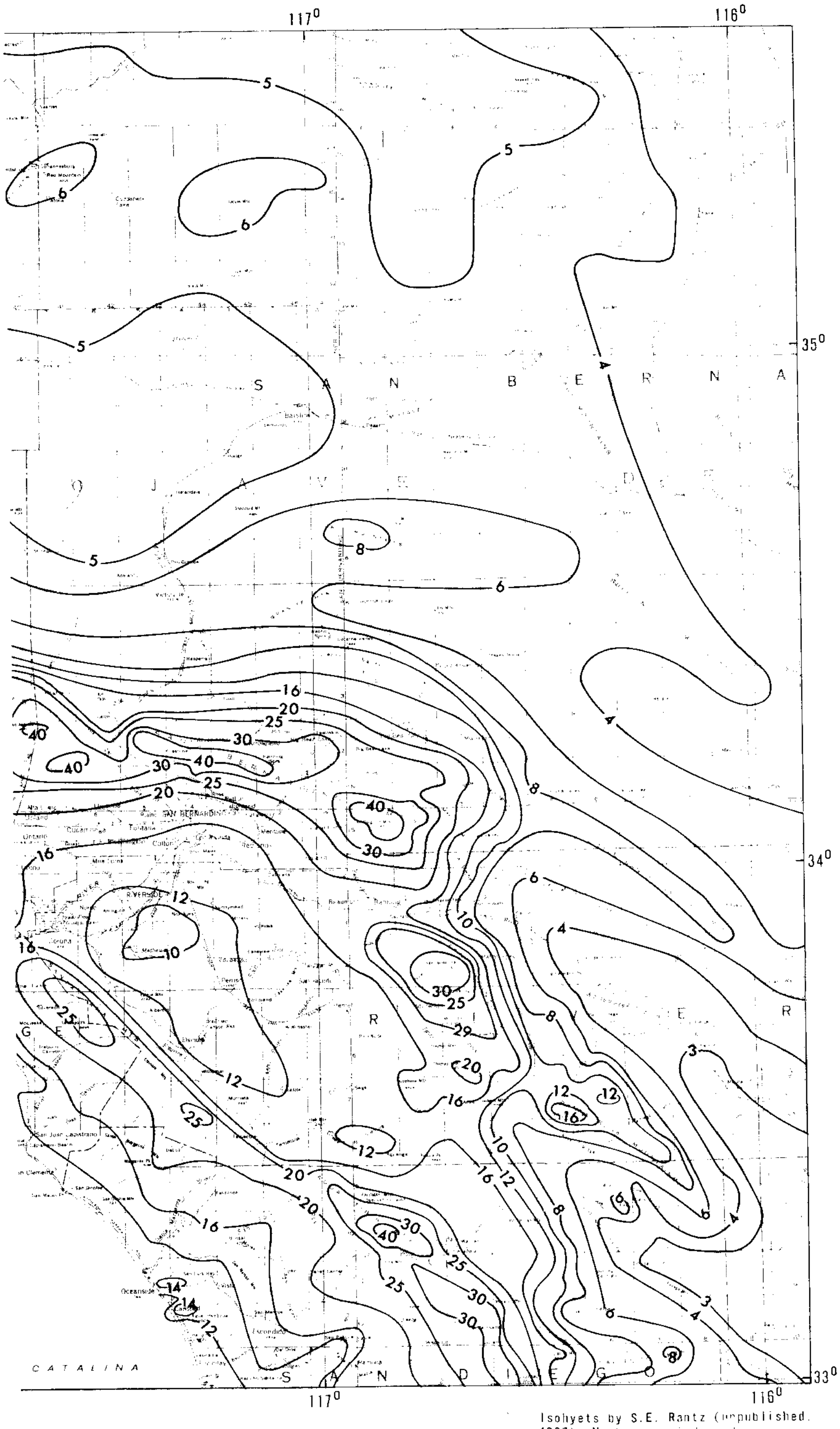


FIGURE 2.--Continued.

The San Bernardino and eastern San Gabriel Mountains receive most of their precipitation during the period November through March (table 1). During these 5 months almost 60 percent of the annual runoff occurs. During April, May, and June another 30 percent occurs, making a total of about 90 percent in 8 months. Thus, little runoff occurs in the 4 months from July through October.

Figure 3 shows the precipitation at Squirrel Inn No. 2 in the San Bernardino Mountains above San Bernardino and the runoff from Waterman Canyon Creek near Arrowhead Springs just north of San Bernardino. The precipitation bar graph shows the variability of Squirrel Inn No. 2. The precipitation averaged 40.99 inches, but ranged from 14.13 inches in 1947 (34.5 percent of mean) to 78.84 inches in 1969 (192 percent of mean), or a range of more than 5 times. The runoff bar graph shows that the variation of runoff is similar to that of precipitation. The runoff averaged 7.61 inches (1,840 acre-feet) and ranged from 0.86 inch in 1961 (212 acre-feet) or 11 percent of the mean to 37.3 inches in 1969 (9,020 acre-feet) or 490 percent of the mean, or a range of more than 43 times.

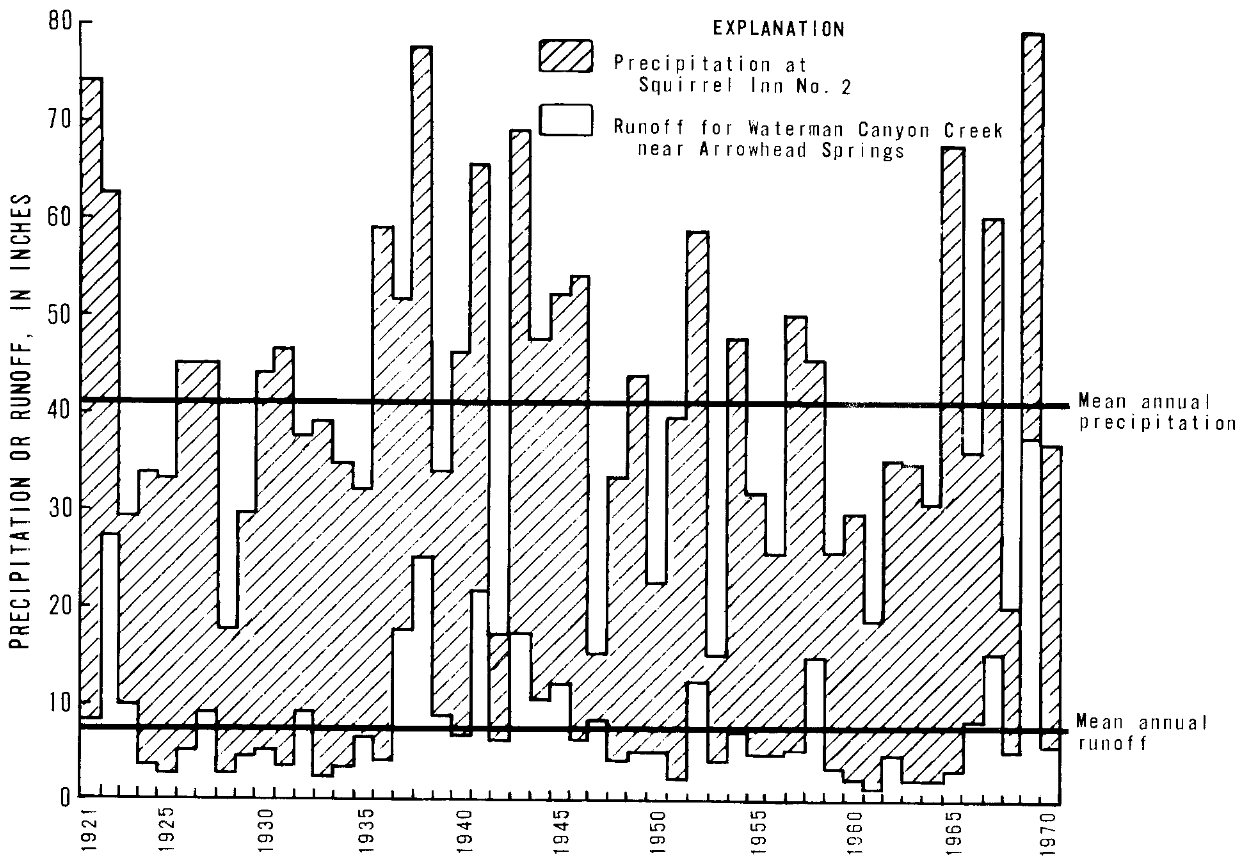


FIGURE 3.--Annual precipitation and runoff.

Santa Ana River Basin

The Santa Ana River has its source high in the eastern part of the San Bernardino Mountains. The river flows generally west from its source and then southwest into the San Bernardino Valley where it is joined by most of its principal tributaries. The river then continues its southwestward course toward a gap in the Santa Ana Mountains where it empties into the reservoir formed by Prado Dam. During floods, some water from the Santa Ana basin flows out of Prado reservoir and is wasted into the Pacific Ocean. Along its course, the Santa Ana River is the source of water supply for extensive agricultural lands.

METHOD OF ANALYSIS

Gaging of all sites on all streams in the basin is neither possible nor desirable. The available records, therefore, provide only a sample of the areal extent of the streamflow. In addition, because streamflow records have been collected for only a limited period, they provide only a sample of the streamflow variations in time.

Because of this sampling of streamflow, definition of the streamflow at any desired site requires a method of transferring available streamflow information. Many transfer methods have been proposed. They range from the simple extrapolation or interpolation of information gathered at two sites on the same stream, to rainfall-runoff techniques, to complex statistical and mathematical methods that simultaneously consider many streamflow records and the environmental characteristics of the contributing drainage basin above each gage.

After a survey of known transfer methods, the multiple-regression method showed the most promise and efficiency. This is a statistical method of handling sample data that can relate a streamflow characteristic to the topographic and climatic characteristics of the drainage basins that affect streamflow. Other studies have shown that multiple-regression methods have successfully related streamflow to topographic and climatic characteristics. Therefore, multiple-regression analysis was used to develop separately the relations between the streamflow characteristics (dependent variables) and the drainage-basin characteristics (independent variables).

Briefly, multiple regression provides a linear mathematical equation of the relation between a single dependent variable and the independent variables. It also provides a measure of the accuracy of the defined relation (the standard error of estimate) and of the usefulness of each independent variable in the relation.

The usefulness of each independent variable to any relation is judged both on the basis of its statistical significance and on the basis of the reduction in the standard error that is brought about by including the variable. Those independent variables that had a 90-percent or greater probability of effectiveness were classed as significant to that equation. In a few of the regressions some independent variables having less than a 90-percent probability of effectiveness were also used in the equation because their inclusion would decrease the standard error by at least 1 percent.

Past experience in many hydrologic studies has shown that flows are linearly related to most hydrologic characteristics if the logarithms of each are used. Therefore, logarithmic transformation of all streamflow and hydrologic characteristics was done before computations were performed.

A high-speed digital computer performed the voluminous computations required for regression analysis. The procedure involved entering a single streamflow variable along with the selected hydrologic variables into the computer for each of the gaging stations in the area. The technique first computes the regression equation, standard error of estimate, and effectiveness of the most significant independent variable. The system then automatically repeats the computations, adding the next most significant independent variable. This process of recomputation, adding the next most effective independent variable, was repeated until all variables were used in the regression. After all the independent variables for a given streamflow characteristic had been evaluated, the entire process was repeated using another streamflow characteristic as the dependent variable and the selected set of hydrologic characteristics as independent variables.

The equation with the greatest number of independent variables, all of which are significant, would ordinarily be used to make predictions unless other considerations modify the choice. If an independent variable is significant but has only a small effect on the standard error, it might be omitted.

One of the practical requisites in multiple-regression analysis is that the various independent variables not be highly correlated among themselves. Violation of this criterion can lead to unstable values for the regression coefficients and to difficulties in interpreting the effectiveness of the independent variables included in the equation. Although it is preferable to have a set of topographic and climatic variables that are entirely independent of each other, this is not possible because nearly all topographic and climatic variables exhibit some degree of interdependence. To investigate the amount of non-independence, a simple partial correlation coefficient matrix of the evaluated hydrologic characteristics was obtained for this study, and the results are shown in table 2. In table 2 a value of 1.00 means perfect correlation and a value of -1.00 means perfect inverse correlation.

TABLE 2.--*Simple correlation matrix of basin characteristics*

	Area	Precipitation	Length	Slope	Precipitation intensity	Forest	Elevation >5,000 feet	Evapotranspiration
Area	1.000	-0.511	0.942	0.634	-0.419	-0.492	0.469	0.614
Precipitation		1.000	-.502	.417	.622	.499	-.133	-.325
Length			1.000	-.603	-.395	-.477	.416	.548
Slope				1.000	.109	.283	.023	-.548
Precipitation intensity					1.000	.384	.383	-.112
Forest						1.000	-.172	-.232
Elevation >5,000 feet							1.000	.471
Evapotranspiration								1.000

STREAMFLOW CHARACTERISTICS

Streamflow records have been collected on many streams in or near the study area. Many of the records, however, do not represent the natural flow of the streams and could not be used in this study. The 35 gaging-station records that were used were chosen because they represent natural flow conditions, or could be adjusted to represent natural flow, and were at least 10 years in length. Of the 35 gaging stations, 14 are in the Santa Ana River basin, two in the Mojave River basin, four in the San Gabriel River basin, nine in the Los Angeles River basin, two in Antelope Valley, and four on desert streams near Palm Springs (fig. 4). The addition of the 21 stations to the 14 within the Santa Ana basin provides a good range in drainage-area size and precipitation, the two basin characteristics that were found to be most closely related to the streamflow characteristics used in the multiple-regression equations.

Although 35 gaging stations were selected for the regression analysis, some of the flow characteristics for some stations could not be used. For example, for Little San Gorgonio Creek near Beaumont, the low flows were not used because several small diversions that did not affect the high flows distorted the low-flow figures. The peak flow and the maximum average 1- to 15-day flow having a 50-year recurrent interval were not determined at any station with less than 25 years of record.

Mean flows.--The mean of the annual mean discharges and of each of the monthly mean discharges was computed for each gaging station to provide 13 indices of average streamflow. Additionally, 5-month (November through March) and 8-month (November through June) means were computed and used in the relations, but the results were not reported because the relations were less reliable, and less useful, than the relations for the annual mean.

In this report Q_a represents the mean of the annual discharges and q_n represents the mean of the monthly discharges, with n denoting the month, starting with January as 1.

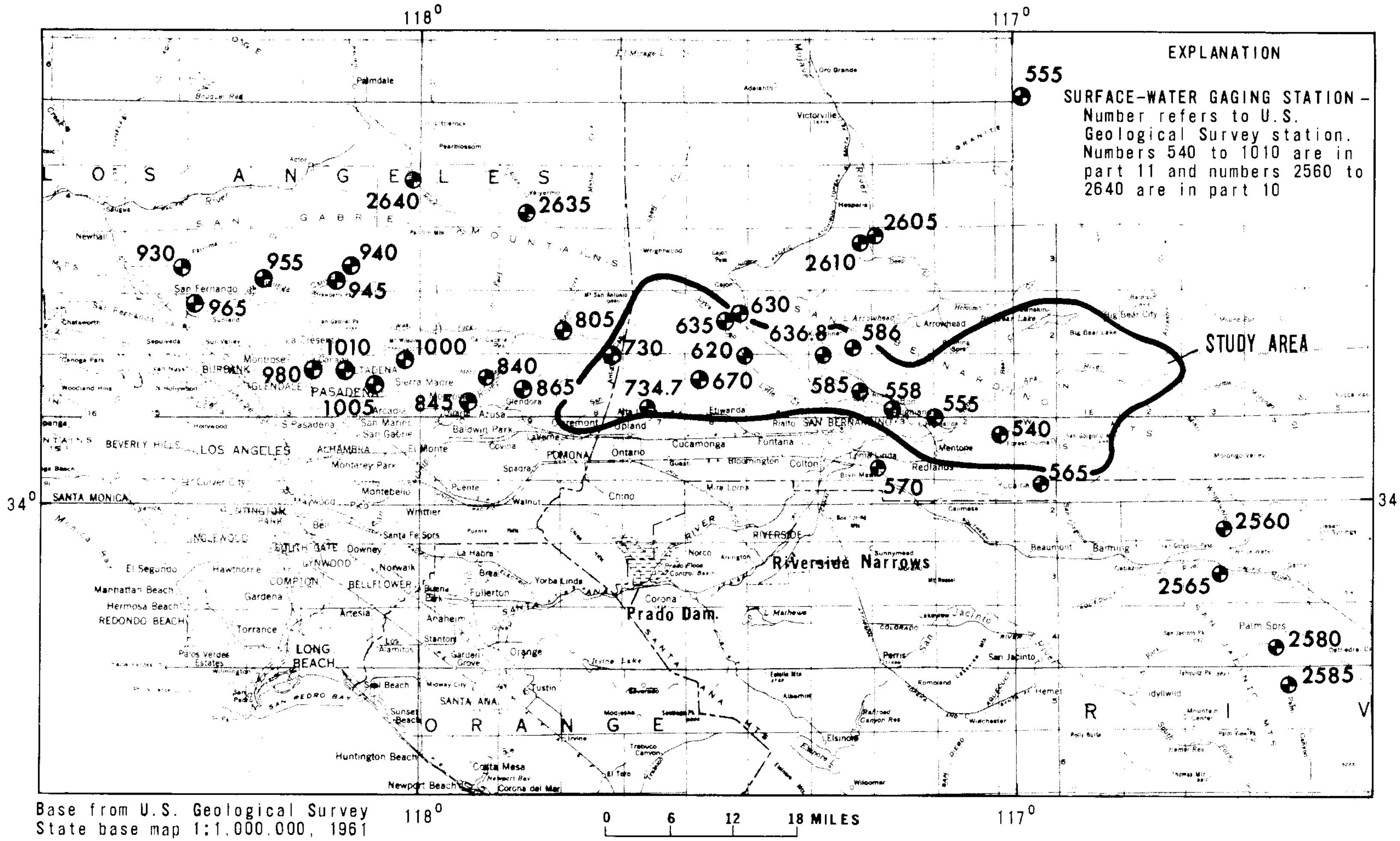


FIGURE 4.--Location of gaging stations.

Momentary flood peaks.--The annual maximum discharges expected to be exceeded at the gaging site on the average of once each 2, 5, 10, 25, and 50 years were determined from the records for each gaging station, except that the discharges for a recurrence interval of 50 years were not used if the record was less than 25 years in length. In this report the momentary flood peaks are represented by P_n, where the subscript represents the recurrence interval in years. The flood peaks were determined by methods outlined by the Water Resources Council (1967). No search for information on historic floods was made for this study.

Flood volumes.--The annual maximum flood-discharge volumes for four time intervals and two recurrence intervals were determined from each record. These discharges represent the highest average flow for a 1-day, 3-day, 7-day, and 15-day period that can be expected to be exceeded on the average of once each 2 and 50 years. The symbol $V_{n,m}$ represents the flood volumes in this report, where n represents 1, 3, 7, or 15 days, and m is the 2- or 50-year recurrence interval. The flood volumes were also determined by a method similar to that outlined by the Water Resources Council (1967).

DRAINAGE-BASIN CHARACTERISTICS

The meteorologic and topographic characteristics of a stream basin, herein called basin characteristics, affect the streamflow from that basin. Precipitation, the primary source of streamflow, varies from basin to basin in the report area. Streamflow reflects precipitation variations and is further varied by differences in surface characteristics, drainage patterns, storage of water in the soil mantle, water loss by evaporation and transpiration, and possibly subterranean flow into or out of the basins. Such physical characteristics of a basin that may influence streamflow commonly can be represented by simplified indices.

Some of the basin characteristics, such as geology, cannot yet be satisfactorily represented by easily determined numerical indices. Most characteristics can be evaluated from maps or tabular data. The practical limitations of time and of the statistical procedures used required the selection of a limited number of basin variables. Variables used in this study were selected on the basis of hydrologic, hydraulic, geologic, and meteorologic principles; upon the degree of success experienced in use of certain variables in previous studies; and on the ease of enumeration. The further criterion that regression analysis produces optimum results if the independent variables are not highly correlated among themselves was also considered in selecting the independent variables.

The basin characteristics selected for evaluation as independent variables in the regression and the method of evaluation are given below. The values of the characteristics for the 35 stations used in the analysis are given in appendix A.

Drainage area.--Drainage area (A) can intuitively be considered a logical cause of streamflow variation between sites. Drainage areas, in square miles, shown in the latest Geological Survey streamflow reports were used in this study.

Mean annual precipitation.--Mean annual precipitation (P) is a measure of the quantity of water supplied to a drainage basin and thus constitutes the potential runoff. For each drainage area, mean annual precipitation in inches was determined by planimetering the isohyetal map of figure 2. Most of the isohyets of figure 2 were compiled from isohyetal maps prepared by the U.S. Weather Bureau for 1931-60. Some additional detailing was from isohyetal maps compiled using data from the U.S. Corps of Engineers for 1907-56.

Main-channel length.--Main-channel length (L) was selected as an indication of basin shape in conjunction with drainage area. Values of main-channel length in miles, from the gaging station to the basin divide, were measured on topographic maps with a pair of dividers set to a scale length of 0.1 mile.

Main-channel slope.--Main-channel slope (S) is another factor that can intuitively be assumed to influence streamflow. For this study a simple index of slope developed and successfully used by Benson (1962, 1964) was selected. This index is the average slope in feet per mile of the main channel between points 10 percent and 85 percent of the distance upstream from the gaging station to the basin divide.

Precipitation intensity.--Many investigators (Benson, 1962; Chow, 1964; Linsley and others, 1949) have found precipitation intensity to be a useful variable in explaining the basin-to-basin variations in floodflows. For this study, the precipitation intensity selected was the maximum 24-hour precipitation expected to be exceeded on the average of once each 2 years. Values of this index (I), in inches, as shown in figure 5, were taken from figure 20 of Technical Paper 28 of the U.S. Weather Bureau (1956).

Forested area.--Forests may affect streamflow by transpiration, by causing direct evaporation losses as precipitation is intercepted, and by modifying the accumulation and melting of snow. The index of forest cover (F) used is the percentage of total drainage area shown as forested on the topographic maps, increased by the value of 1.0 to avoid difficulties associated with the use of zeros in the regression analysis.

Elevation.--Although elevation itself may not directly cause streamflow variation, it may serve as an index to other factors that cause basin-to-basin streamflow variation but are difficult to evaluate. Radiation, temperature, wind, vegetation, and basin ruggedness, for example, may vary with elevation. For this study the index of elevation (E) selected is the percentage, increased by the value of 1.0, of each drainage area that lies higher than 5,000 feet above mean sea level.

Potential evapotranspiration.--Because runoff is the residual of precipitation after all extractions have been met, one of the larger of the extractions, evapotranspiration, could be expected to be related to streamflow. As an index of this evapotranspiration, lake evaporation (*Ev*), in inches, was evaluated for all basins from figure 6. This figure is from a map showing average annual lake evaporation in Technical Paper 37 of the U.S. Weather Bureau (1959).

RESULTS

Table 3 summarizes the results of the multiple-regression analysis. These analyses defined mathematical equations of the form:

$$\log Y = \log a + b_1 \log X_1 + b_2 \log X_2 \ldots + b_n \log X_n$$

or its equivalent form:

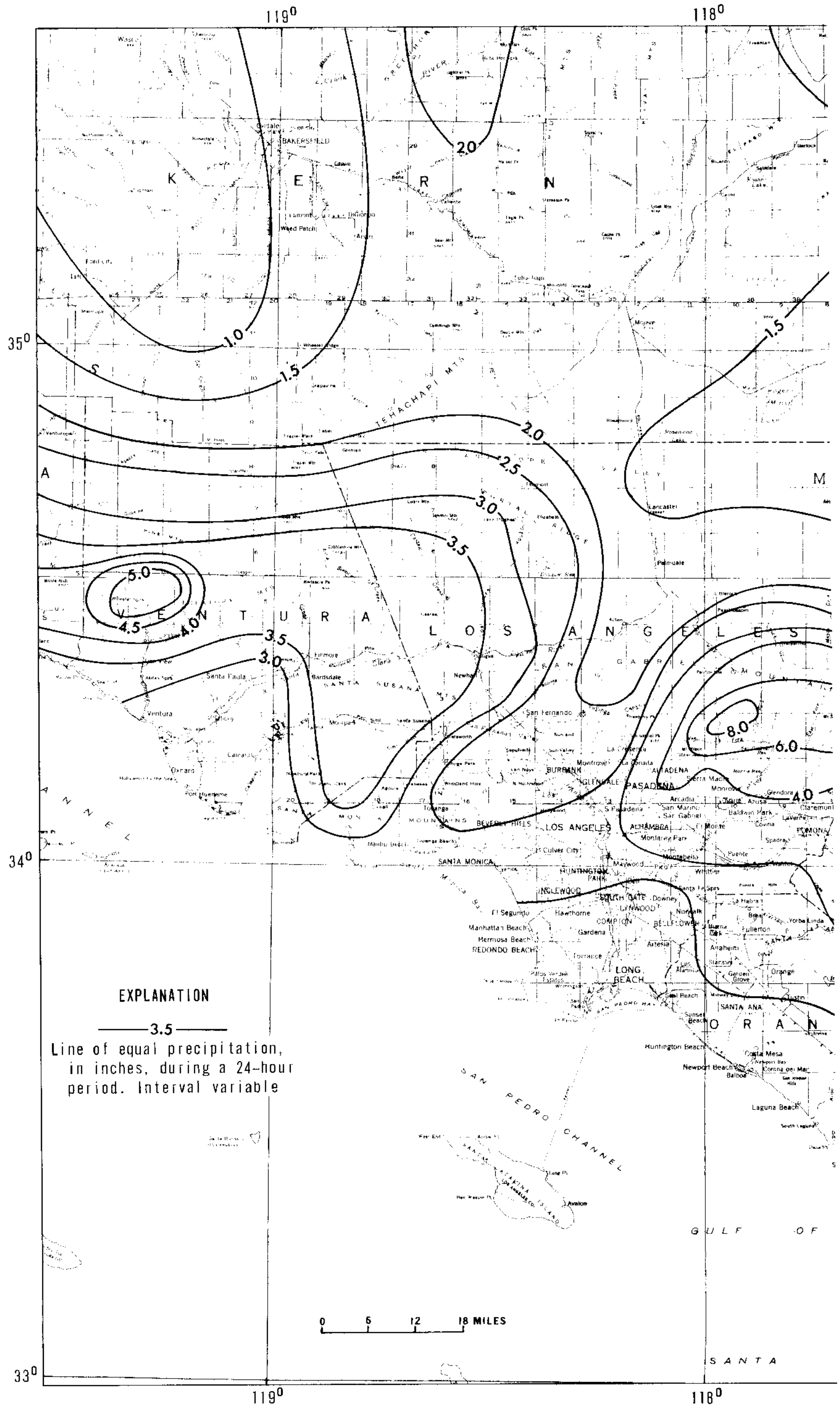
$$Y = a\, X_1^{b_1}\, X_2^{b_2} \ldots X_n^{b_n}$$

where Y represents a streamflow characteristic, X_1 to X_n represent basin characteristics, a represents the regression constant, and b_1 to b_n represent regression coefficients.

The first column of table 3 indicates the streamflow characteristic studied. The next set of columns shows the computed regression constant and regression coefficients for that streamflow characteristic. The last two columns show, respectively, the standard error of estimate both in logarithmic units and as an approximate equivalent percentage.

In general, the table shows several relations for each flow characteristic. The top line for each characteristic shows its standard deviation, a measure of the error in using the mean of the sample data as an estimate of that characteristic at any site. The second line indicates the most accurate relation when using one independent variable, and succeeding lines indicate more complex relations of increasingly superior accuracy. The last line for each streamflow characteristic shows the most accurate relation in which all basin characteristics are effective with at least 90-percent confidence. For the majority of relations in table 3 the regression coefficients are statistically significant at the 95-percent confidence level. A few relations are shown with regression coefficients that are significant at the 90-percent level, and in two cases with the regression coefficients not significant at the 90-percent level; in each instance inclusion of the coefficient reduced the standard error by at least one percent.

All the streamflow characteristics previously discussed are included in table 3 except the November through March 5-month mean flow and the November through June 8-month mean flow. These two were not included because the associated regression errors were larger than the regression error for the mean annual flow, and they therefore should not be used as annual-flow indicators.



Base from U.S. Geological Survey
State base map 1:1,000,000, 1961

FIGURE 5.--Two-year 24-hour precipitation.

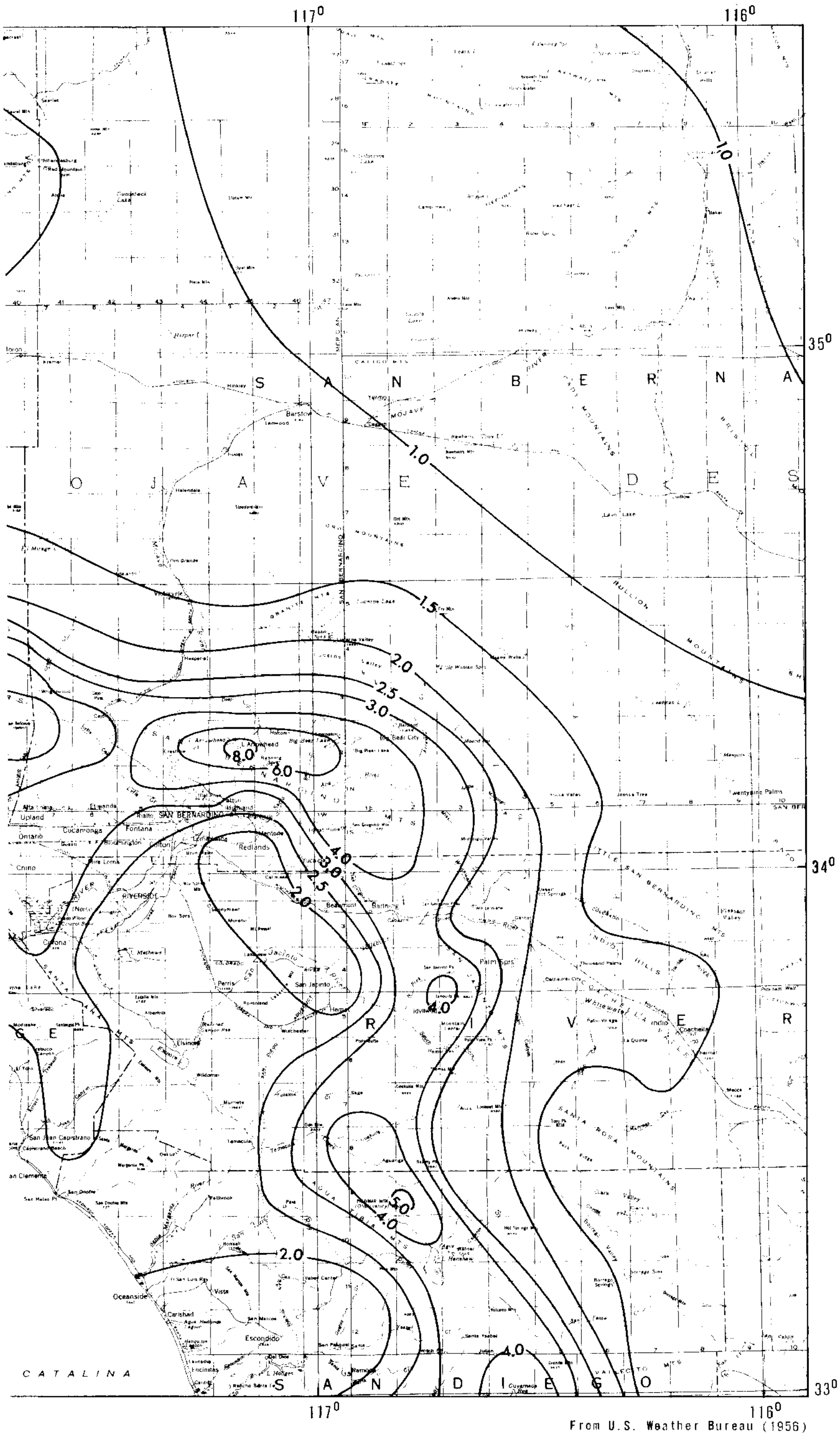


FIGURE 5.--Continued.

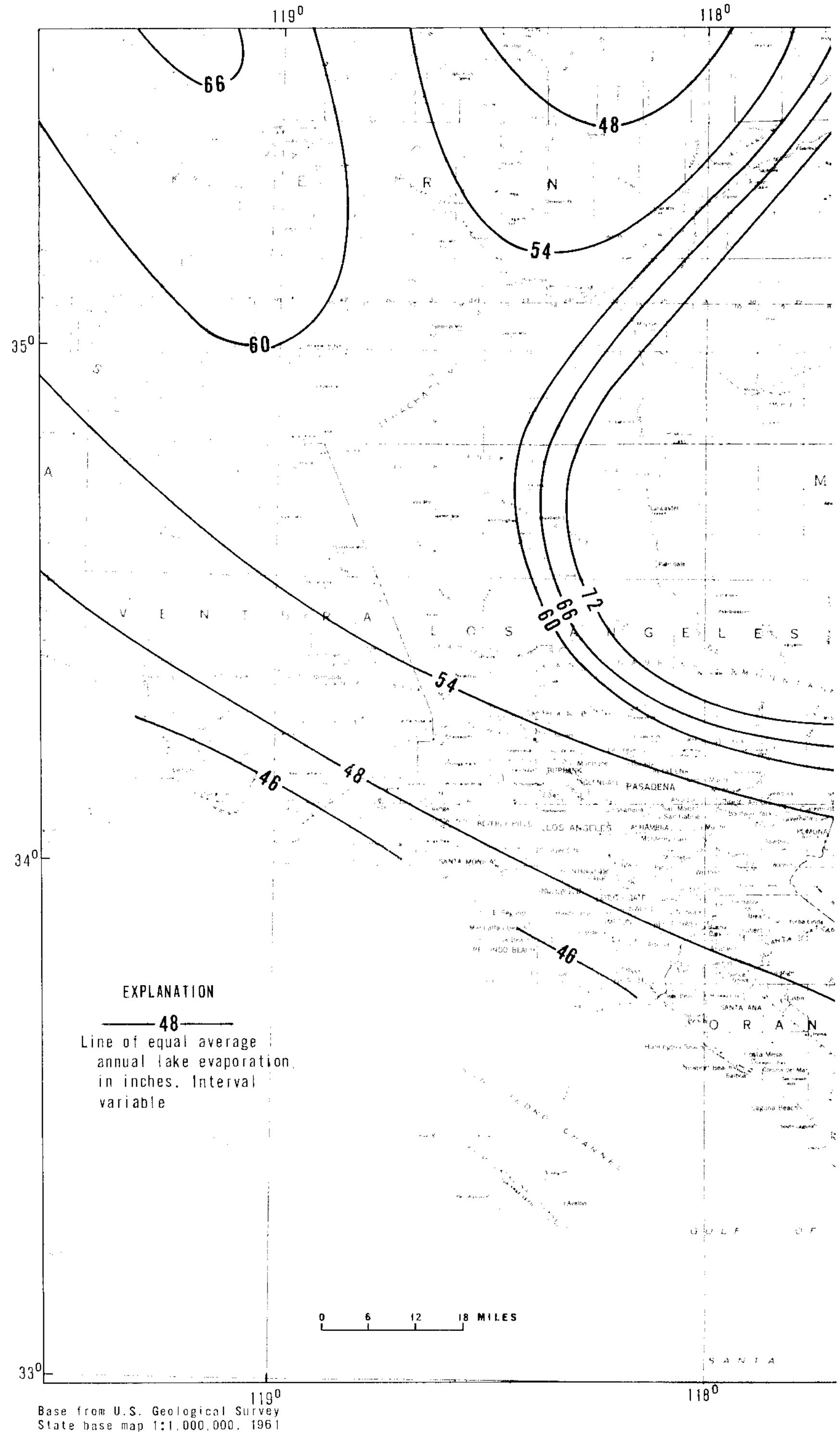


FIGURE 6.--Average annual lake evaporation.

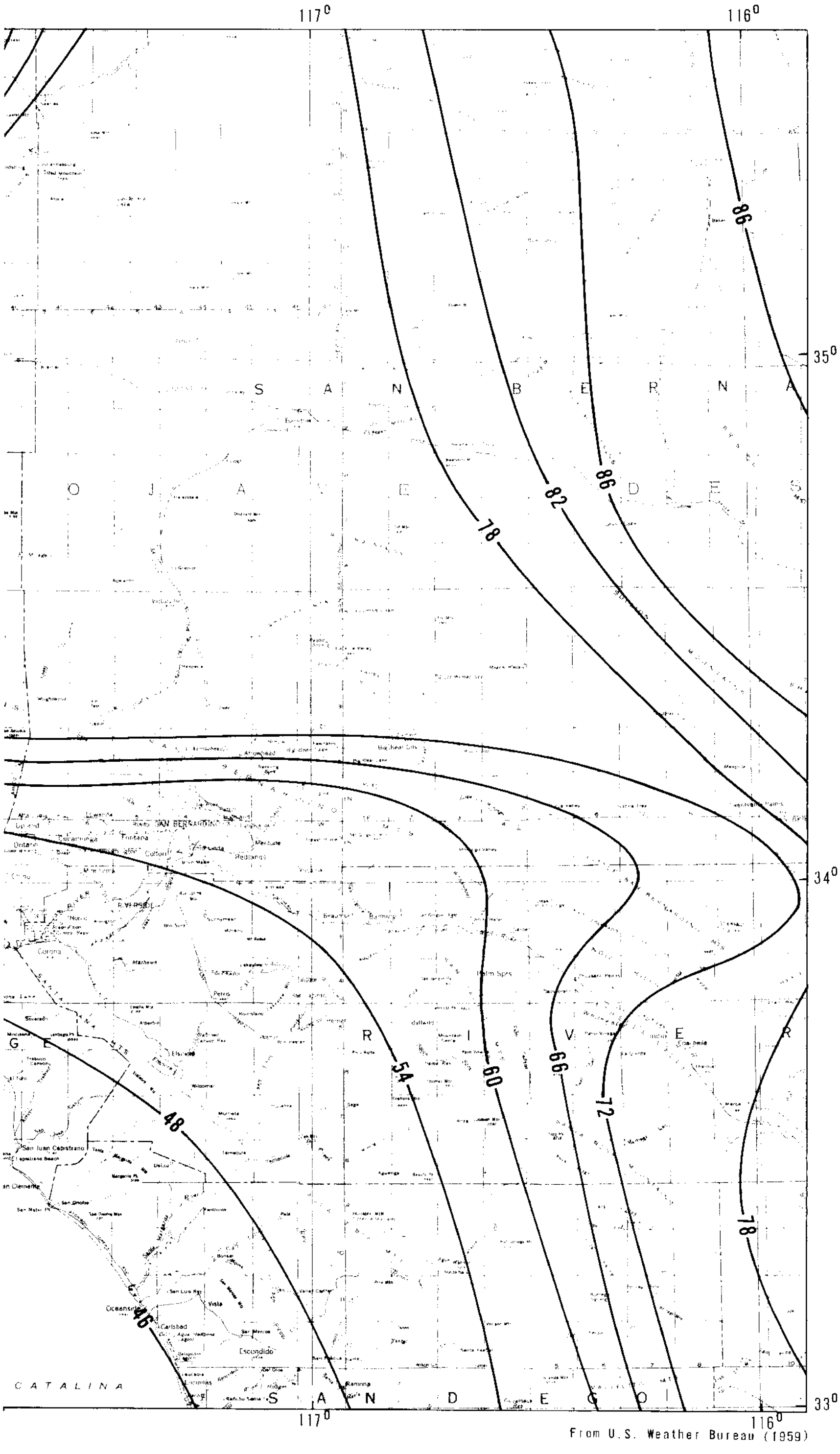


FIGURE 6.--Continued.

TABLE 3.--*Summary of constant and coefficients for regression equation*

$$Q = aA^{b_1}\ P^{b_2}\ L^{b_3}\ S^{b_4}\ I^{b_5}\ F^{b_6}\ E^{b_7}\ T^{b_8}$$

[All regression coefficients are statistically significant at the 5-percent level except those preceded by the letter a which are significant at the 10-percent level and those preceded by the letter b which are nonsignificant at the 10-percent level. Top line for each flow characteristic shows its standard deviation.]

Flow index	Regression constant	Regression coefficient: Drainage area	Mean annual precipitation	Main channel length	Main channel slope	Precipitation intensity	Forest	Elevation >5,000 feet	Potential evapotranspiration	Standard error: Log units	Percent
Q_a	--	--	--	--	--	--	--	--	--	0.477	133
	0.836	0.74	--	--	--	--	--	--	--	.382	90.7
	$.141 \times 10^{-3}$	1.00	2.40	--	--	--	--	--	--	.228	54.9
	$.312 \times 10^{-4}$	1.12	2.28	--	0.25	--	--	--	--	.217	52.1
	$.189 \times 10^{-8}$	1.02	2.34	--	.32	--	--	--	a2.27	.209	50.0
q_1	--	--	--	--	--	--	--	--	--	.489	138
	.952	.74	--	--	--	--	--	--	--	.327	82.6
	$.679 \times 10^{-4}$	1.02	2.64	--	--	--	--	--	--	.208	49.7
	$.286 \times 10^{-7}$	.91	2.71	--	--	--	--	--	a1.90	.203	48.5
q_2	--	--	--	--	--	--	--	--	--	.502	143
	1.321	.80	--	--	--	--	--	--	--	.315	79.1
	$.109 \times 10^{-2}$	1.01	1.97	--	--	--	--	--	--	.256	62.4
	$.160 \times 10^{-2}$	1.04	1.44	--	--	0.79	--	--	--	.247	60.0
q_3	--	--	--	--	--	--	--	--	--	.508	146
	1.512	.79	--	--	--	--	--	--	--	.326	82.3
	$.670 \times 10^{-3}$	1.02	2.13	--	--	--	--	--	--	.257	62.7
	$.103 \times 10^{-2}$	1.05	1.54	--	--	a.89	--	--	--	.245	59.5
q_4	--	--	--	--	--	--	--	--	--	.529	154
	1.101	.82	--	--	--	--	--	--	--	.344	87.8
	$.120 \times 10^{-3}$	1.09	2.52	--	--	--	--	--	--	.247	60.0
	$.972 \times 10^{-3}$	1.04	2.76	--	--	--	b-0.60	--	--	.241	58.4
q_5	--	--	--	--	--	--	--	--	--	.551	164
	.966	.67	--	--	--	--	--	--	--	.460	127
	$.125 \times 10^{-4}$	1.03	3.08	--	--	--	--	--	--	.346	88.4
	$.346 \times 10^{-6}$	1.32	2.81	--	.60	--	--	--	--	.291	72.1
	$.743 \times 10^{-13}$	1.16	2.89	--	.70	--	--	--	3.61	.271	66.5
q_6	--	--	--	--	--	--	--	--	--	.598	186
	.780	.51	--	--	--	--	--	--	--	.557	166
	$.167 \times 10^{-5}$	.94	3.57	--	--	--	--	--	--	.432	117
	$.121 \times 10^{-9}$	.80	3.65	--	--	--	--	--	b2.33	.434	117
	$.547 \times 10^{-17}$	1.11	3.32	--	.97	--	--	--	5.06	.310	77.6
	$.248 \times 10^{-18}$	a.68	3.42	a0.74	.99	--	--	--	5.61	.304	75.9
q_7	--	--	--	--	--	--	--	--	--	.782	294
	$.371 \times 10^{-1}$	--	--	--	a.35	--	--	--	--	.750	292
	$.790 \times 10^{-5}$	--	--	1.78	1.38	--	--	--	--	.635	204
	$.854 \times 10^{-9}$	--	2.73	2.20	1.26	--	--	--	--	.583	178
	$.790 \times 10^{-24}$	--	3.05	1.83	1.57	--	--	--	7.85	.525	153
q_8	--	--	--	--	--	--	--	--	--	.888	380
	.128	--	--	--	--	--	--	0.74	--	.745	269
	$.226 \times 10^{-2}$	--	--	--	--	2.31	--	.89	--	.702	242
	$.742 \times 10^{-4}$	--	--	--	a.61	2.24	--	.84	--	.667	222
	$.231 \times 10^{-7}$	--	--	1.60	1.31	2.86	--	.59	--	.598	186
q_9	--	--	--	--	--	--	--	--	--	.843	341
	$.972 \times 10^{-1}$	--	--	--	--	--	--	.78	--	.667	222
	$.169 \times 10^{-2}$	--	--	--	--	2.31	--	.92	--	.615	194
	$.894 \times 10^{-4}$	--	--	--	a.52	2.25	--	.89	--	.585	179
	$.162 \times 10^{-6}$	--	--	1.25	1.08	2.74	--	.69	--	.541	159
q_{10}	--	--	--	--	--	--	--	--	--	.909	399
	$.249 \times 10^{-1}$	--	--	--	.62	--	--	--	--	.890	382
	$.322 \times 10^{-5}$	--	--	1.88	1.40	--	--	--	--	.787	298
	$.702 \times 10^{-22}$	--	--	1.40	1.78	--	--	--	8.98	.737	264
	$.126 \times 10^{-28}$	--	3.20	1.84	1.68	--	--	--	10.10	.673	225
q_{11}	--	--	--	--	--	--	--	--	--	.556	166
	.530	.67	--	--	--	--	--	--	--	.465	129
	$.932 \times 10^{-5}$	1.03	2.99	--	--	--	--	--	--	.360	92.7
	$.234 \times 10^{-6}$	1.33	2.72	--	.61	--	--	--	--	.304	75.9
	$.193 \times 10^{-14}$	1.13	2.82	--	.74	--	--	--	4.37	.274	67.4
	$.105 \times 10^{-12}$	1.68	2.69	-.96	.71	--	--	--	3.67	.256	62.4

TABLE 3.--*Summary of constant and coefficients for regression equation* $Q = aA^{b_1} P^{b_2} L^{b_3} S^{b_4} I^{b_5} F^{b_6} E^{b_7} T^{b_8}$--Continued

Flow index	Regression constant	Regression coefficient								Standard error	
		Drainage area	Mean annual precipitation	Main channel length	Main channel slope	Precipitation intensity	Forest	Elevation >5,000 feet	Potential evapotranspiration	Log units	Percent
q_{12}	--	--	--	--	--	--	--	--	--	0.511	147
	0.772	0.80	--	--	--	--	--	--	--	.329	83.2
	$.204 \times 10^{-3}$	1.04	2.28	--	--	--	--	--	--	.249	60.5
	$.428 \times 10^{-4}$	1.16	2.13	--	0.29	--	--	--	--	.235	56.8
	$.296 \times 10^{-3}$	1.10	2.34	--	.27	--	b-0.53	--	--	.231	55.7
P_2	--	--	--	--	--	--	--	--	--	.495	140
	$.132 \times 10^{2}$	--	--	1.33	--	--	--	--	--	.306	76.4
	1.096	--	--	1.54	--	1.26	--	--	--	.275	67.6
	1.190	.42	--	.85	--	1.36	--	--	--	.269	66.0
P_5	--	--	--	--	--	--	--	--	--	.495	140
	$.807 \times 10^{2}$	.81	--	--	--	--	--	--	--	.269	66.0
	9.353	.92	--	1.13	--	--	--	--	--	.241	58.4
	6.386	.58	--	.63	--	1.13	--	--	--	.236	57.1
P_{10}	--	--	--	--	--	--	--	--	--	.488	138
	$.148 \times 10^{3}$	.83	--	--	--	--	--	--	--	.235	56.8
	$.224 \times 10^{2}$	.93	--	--	--	.99	--	--	--	.210	50.3
	3.064	.97	a.72	--	--	a.66	--	--	--	.205	49.0
	1.872	.68	a.78	b.56	--	a.64	--	--	--	.200	47.7
P_{25}	--	--	--	--	--	--	--	--	--	.489	138
	$.660 \times 10^{3}$	.84	--	--	--	--	--	--	--	.210	50.3
	2.351	.99	1.33	--	--	--	--	--	--	.167	39.4
P_{50}	--	--	--	--	--	--	--	--	--	.486	137
	$.485 \times 10^{3}$	.81	--	--	--	--	--	--	--	.258	63.0
	9.886	.93	1.07	--	--	--	--	--	--	.238	57.6
$V_{1,2}$	--	--	--	--	--	--	--	--	--	.560	168
	6.862	.80	--	--	--	--	--	--	--	.379	98.8
	$.353 \times 10^{-2}$	1.03	2.10	--	--	--	--	--	--	.328	82.9
	$.230 \times 10^{-2}$	1.15	2.26	--	--	--	--	-0.17	--	.313	78.5
	$.502 \times 10^{-8}$	1.02	2.31	--	--	--	--	-.21	3.25	.296	73.6
$V_{3,2}$	--	--	--	--	--	--	--	--	--	.571	173
	4.453	.78	--	--	--	--	--	--	--	.409	109
	$.605 \times 10^{-3}$	1.05	2.47	--	--	--	--	--	--	.340	86.5
	$.406 \times 10^{-3}$	1.16	2.62	--	--	--	--	-.15	--	.329	83.2
	$.452 \times 10^{-9}$	1.02	2.67	--	--	--	--	-.19	3.42	.312	77.9
$V_{7,2}$	--	--	--	--	--	--	--	--	--	.579	177
	2.876	.77	--	--	--	--	--	--	--	.425	114
	$.168 \times 10^{-3}$	1.06	2.70	--	--	--	--	--	--	.343	87.4
	$.346 \times 10^{-8}$	.92	2.71	--	--	--	--	--	a2.71	.335	85.0
	$.940 \times 10^{-10}$	1.01	2.88	--	--	--	--	a-.17	3.51	.321	80.8
$V_{15,2}$	--	--	--	--	--	--	--	--	--	.590	182
	1.901	.77	--	--	--	--	--	--	--	.438	119
	$.479 \times 10^{-4}$	1.09	2.94	--	--	--	--	--	--	.343	87.4
	$.534 \times 10^{-9}$	.94	2.95	--	--	--	--	--	a2.86	.333	84.4
	$.306 \times 10^{-10}$	1.01	3.08	--	--	--	--	a-.14	3.49	.326	82.3
$V_{1,50}$	--	--	--	--	--	--	--	--	--	.500	142
	$.126 \times 10^{3}$	.86	--	--	--	--	--	--	--	.248	60.3
	$.344 \times 10^{-3}$	1.11	--	--	--	--	2.67	--	--	.175	41.4
	$.173 \times 10^{-2}$	1.14	a.78	--	--	--	1.74	--	--	.169	39.9
$V_{3,50}$	--	--	--	--	--	--	--	--	--	.484	136
	$.798 \times 10^{2}$	.83	--	--	--	--	--	--	--	.239	57.9
	.382	1.04	1.45	--	--	--	--	--	--	.185	43.9
	$.683 \times 10^{-2}$	1.08	a.85	--	--	--	a1.30	--	--	.180	42.6
$V_{7,50}$	--	--	--	--	--	--	--	--	--	.470	131
	$.509 \times 10^{2}$	.78	--	--	--	--	--	--	--	.256	62.4
	.129	1.02	1.63	--	--	--	--	--	--	.191	45.4
$V_{15,50}$	--	--	--	--	--	--	--	--	--	.462	128
	$.350 \times 10^{2}$	.74	--	--	--	--	--	--	--	.277	68.2
	$.442 \times 10^{-1}$	1.00	1.81	--	--	--	--	--	--	.200	47.7

ACCURACY OF RELATIONS

The standard error of estimate is a measure of the accuracy of a developed regression relation. It shows the variation in the streamflow characteristic that is unexplained by the basin characteristics used and, therefore, indicates the level of success of each relation. The standard error of estimate means that if estimates for a large number of sites are made using a given relation, about two-thirds of these estimates would be within the stated standard error of the true value and about 95 percent would be within twice the standard error.

Accuracy of the defined relations is shown in figure 7. This figure indicates that the defined relations are more accurate for the higher flows than for the lower flows. This is somewhat misleading, however, because the absolute values of the low flows are so small that a large percentage error is still a small flow difference. A surprising result was the relatively high error for the mean annual flow. In all similar studies made previously, the mean annual flow was the best defined of all the relations. Possibly, in the San Bernardino and San Gabriel Mountain area, the mean annual flow is more closely related to the low flows than to the high flows.

Because of this unexpected larger error for the mean annual flow, the means of two other flow periods were tried. The 5-month rainy season from November through March and the 8-month period from November through June were selected and the means were regressed against the basin characteristics. The error for these two periods proved to be even larger. Consequently, they were dropped from further consideration.

The errors for all the relations are quite large, a situation that may be typical of the diverse southern California watersheds. Crippen and Beall (1970) reported even larger errors for the south-coast region in a report covering the entire State of California.

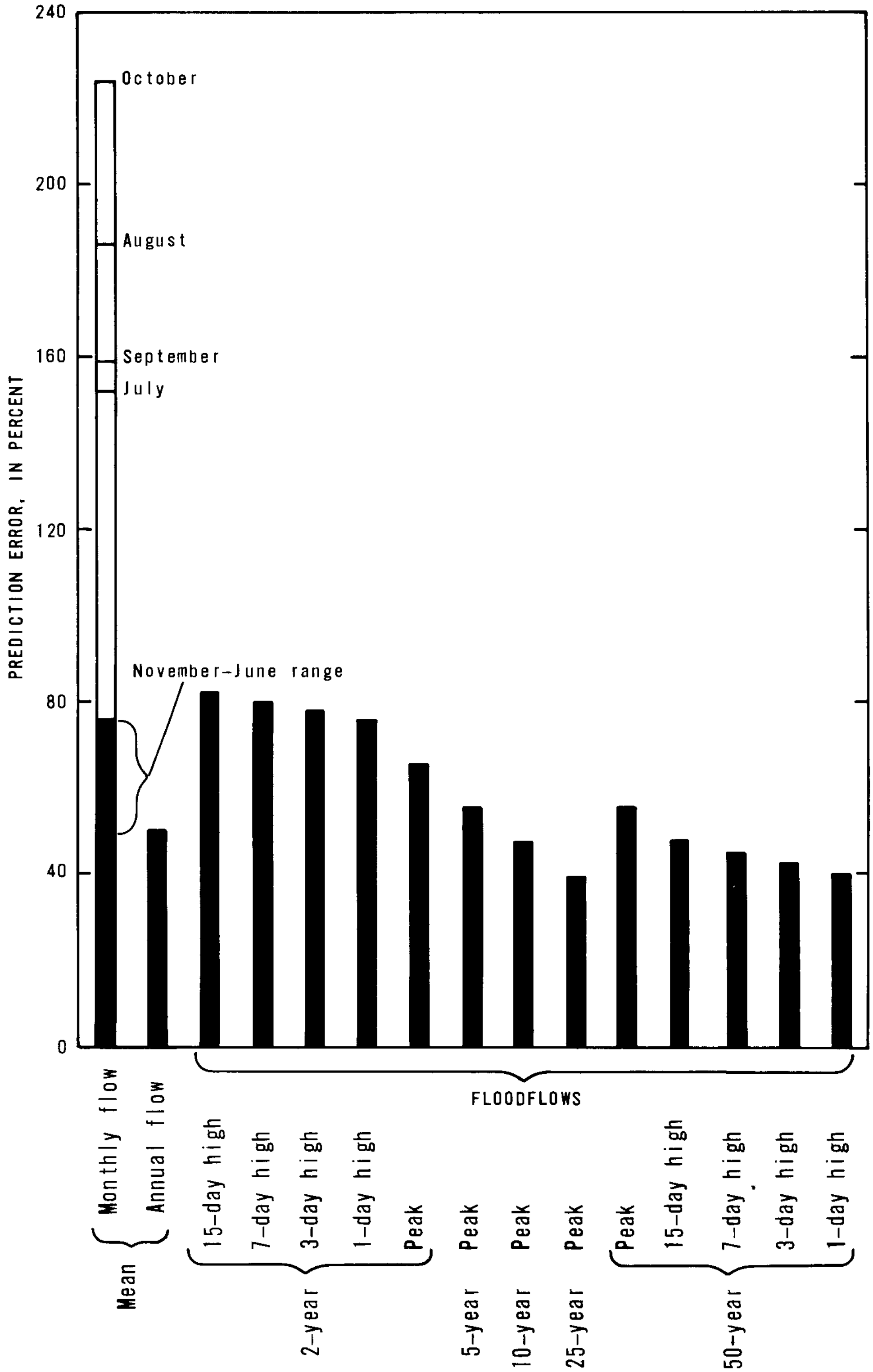


FIGURE 7.--Accuracy of defined relations.

APPLICATION OF EQUATIONS

Specific methods are presented in this section for computing any of the streamflow characteristics desired. Because the methods only use data readily available on maps, graphs, or tables, any desired streamflow characteristic for any stream channel site within the study area can be determined without field investigation. No previous streamflow records are required by the methods. The methods can also be used at sites where limited streamflow records are available or where regionally smoothed data are desired.

Several limitations in the application of the equations should be recognized. The relations were developed using only unregulated streamflow records, so that results will also represent unregulated flows. Any effects of man such as urbanization or flood control must be assessed separately and the computed streamflow characteristics adjusted accordingly. The relations should not be used for drainage areas greater than 140 square miles or less than 1.5 square miles. In addition, the relations are not applicable for stream sites on the valley floor. Only those sites where the total basin upstream is in the mountains or in the foothills are subject to determination of streamflow characteristics by the equations.

The first step in the application of the equations is to assemble the values of the significant basin characteristics. The step-by-step procedure for determining the eight characteristics follows:

(1) Drainage area.--The drainage area (A) is determined by locating the site on a Geological Survey topographic map, scale: 1:24,000 or 1:62,500, and outlining the drainage above the site. This area is then planimetered to give the drainage area in square miles.

(2) Annual precipitation.--The annual precipitation (P) is determined from figure 2 by locating the basin and reading the value of annual precipitation in inches at the centroid of the basin by interpolating between isohyets.

(3) Channel length.--The channel length (L) is determined from the same topographic map as used for determination of the drainage area. The river mile distance from the site to the basin divide, following the path of the main channel shown on that map is measured. The main channel is considered that channel which drains the largest basin. This distance is most easily measured by setting a pair of dividers to 0.1 mile and counting the steps up the main channel.

(4) Channel slope.--The channel slope (S) is determined from the same topographic map as used for determination of the drainage area. The values of 10 percent and 85 percent of the channel length computed in (3) above are determined. These points are located on the topographic map. This places one point 10 percent of the distance above the site, and the other point 15 percent of the distance below the headwaters. The elevation of the streambed is then determined at these two points by interpolating between contours. The channel slope is then computed between the 10- and 85-percent points and is expressed in feet per mile.

(5) Precipitation intensity.--The precipitation intensity (I) is determined from figure 5 by locating the basin and reading the value of the intensity in inches at the centroid of the basin by interpolating between isohyets.

(6) Forest cover.--The forest cover (F) is determined on the topographic map that shows forest cover as green shading. This should be the same map as used for determination of the drainage area. The area with green shading within the drainage outline is planimetered to give the area of forest cover in square miles. This figure is then divided by the drainage area to give a percentage, and finally 1 percent is added to eliminate any zeros from the computation.

(7) Elevation greater than 5,000 feet.--The elevation greater than 5,000 feet (E) is determined from the same topographic map as used for determination of drainage area. The 5,000-foot contour line is located, and the area above this contour within the basin is planimetered to give the area above 5,000 feet. This is then divided by the drainage area to give a percentage and then, as above, 1 percent is added.

(8) Evapotranspiration.--The evapotranspiration (T) is determined from figure 6 by locating the basin and reading the value of the evapotranspiration, in inches, at the centroid of the basin by interpolating between isopleths.

The values of these eight basin characteristics for the 35 stations used in the analysis are given in appendix A.

The various equations using the basin characteristics were discussed earlier. The general equation in its logarithmic transformation form is as follows:

$$\log Q = \log a + b_1 \log A + b_2 \log P + b_3 \log L + b_4 \log S + b_5$$

$$\log I + b_6 \log F + b_7 \log E + b_8 \log T$$

where Q equals flow characteristic, a and b are coefficients whose values are listed for each equation in table 4, and the eight basin characteristics are described earlier.

After completing the determination of the basin characteristics, a convenient method for solving any of the equations is to copy the logarithms of the values onto a strip of paper to match the appropriate columns of table 4. Then place the strip of paper below the coefficients of the line (equation) to be solved and multiply each coefficient by its respective value on the strip of paper and add the products. The antilog of the sum provides the answer for that particular flow characteristic.

Several examples of solutions for a number of flow characteristics are given in appendix A. The basin characteristics for each of the 35 stations used in the analysis are given in appendix B, with the solutions from the regression equations for the 26 flow characteristics given in appendix C.

Appendix D summarizes the results for all the flow characteristics for each station.

TABLE 4.--*Values of coefficients for logarithmic solutions of streamflow characteristics*

[In this table a and b coefficients are used for solving the general equation:
$\log Q = \log a + b_1 \log A + b_2 \log P + b_3 \log L + b_4 \log S + b_5 \log I + b_6 \log F + b_7 \log E + b_8 \log T$;
if no coefficient is shown, that term is omitted]

Streamflow characteristics	Coefficients								
		Area A	Precipitation P	Length L	Slope S	Intensity I	Forest F	Elevation E	Evapotranspiration T
	Log a	b_1	b_2	b_3	b_4	b_5	b_6	b_7	b_8
Mean annual	-8.724	1.024	2.349		0.317				2.271
Mean January	-7.544	.909	2.717						1.905
Mean February	-2.796	1.036	1.437			0.790			
Mean March	-2.987	1.055	1.542			.891			
Mean April	-3.012	1.039	2.760				-0.605		
Mean May	-13.129	1.162	2.893		.704				3.608
Mean June	-18.605	.680	3.422	0.744	.992				5.606
Mean July	-24.102		3.046	1.827	1.572				7.848
Mean August	-7.636			1.598	1.314	2.869		0.591	
Mean September	-6.790			1.249	1.078	2.741		.692	
Mean October	-28.898		3.203	1.836	1.677				10.099
Mean November	-12.980	1.683	2.690	-.962	.710				3.667
Mean December	-3.529	1.104	2.342		.267		-.528		
2-year flood	.076	.425		.850		1.363			
5-year flood	.805	.580		.634		1.134			
10-year flood	.272	.679	.780	.557		.643			
25-year flood	.371	.989	1.331						
50-year flood	.995	.935	1.071						
1-day, 2-year high	-8.299	1.016	2.309					-.209	3.246
3-day, 2-year high	-9.345	1.018	2.669					-.199	3.415
7-day, 2-year high	-10.027	1.008	2.876					-.170	3.506
15-day, 2-year high	-10.514	1.012	3.077					-.135	3.495
1-day, 50-year high	-2.763	1.141	.779				1.738		
3-day, 50-year high	-2.166	1.082	.848				1.303		
7-day, 50-year high	-.888	1.019	1.626						
15-day, 50-year high	-1.355	1.002	1.817						

RELATION TO RECHARGE BASINS

This study has developed relations to allow the estimation of many streamflow characteristics for any stream site within the Pacific drainage of the eastern San Gabriel Mountains or the San Bernardino Mountains of southern California. Even though the errors involved in some of these estimations are quite large, the relations are probably the best presently available. When more data are obtained or new techniques are evolved, better relations may be possible.

Many of these relations have a direct application to the study by Moreland (1972) on artificial recharge in the upper Santa Ana Valley. In the selection of possible alternative locations of recharge basins, the quantity of water available for recharge is a necessary factor. For locations where no streamflow data have been gathered, the streamflow characteristics, in particular the high-flow volumes, can be determined by the methods outlined in this report. These discharges can then be used in the design and selection of the recharge basins.

SELECTED REFERENCES

Benson, M. A., 1962, Factors influencing the occurrence of floods in a humid region of diverse terrain: U.S. Geol. Survey Water-Supply Paper 1580-B, 64 p.

_____1964, Factors affecting the occurrence of floods in the Southwest: U.S. Geol. Survey Water-Supply Paper 1580-D, 72 p.

Burnham, W. L., and Dutcher, L. C., 1960, Geology and ground-water hydrology of the Redlands-Beaumont area, California, with special reference to ground-water outflow: U.S. Geol. Survey open-file rept., 352 p.

Chow, V. T., Ed., 1964, Handbook of applied hydrology: New York, McGraw-Hill Book Co., 1418 p.

Crippen, J. R., and Beall, R. M., 1970, A proposed streamflow data program for California: U.S. Geol. Survey open-file rept., 46 p.

Dutcher, L. C., and Garrett, A. A., 1963, Geologic and hydrologic features of San Bernardino area, California, with special reference to underflow across the San Jacinto fault: U.S. Geol. Survey Water-Supply Paper 1419, 114 p.

Lee, C. H., 1912, Subterranean storage of flood waters by artificial methods in San Bernardino Valley, California: Sacramento, Calif., Conserv. Comm. of Calif. rept. for 1912, p. 335-400.

Linsley, R. K., Kohler, M. A., and Paulhus, J. L. H., 1949, Applied hydrology: New York, McGraw-Hill Book Co., 689 p.

Lippincott, J. B., 1902a, Development and application of water near San Bernardino, Colton, and Riverside, California, Part 1: U.S. Geol. Survey Water-Supply Paper 59, p. 1-95.

_____1902b, Development and application of water near San Bernardino, Colton, and Riverside, California, Part 2: U.S. Geol. Survey Water-Supply Paper 60, p. 97-141.

Mendenhall, W. C., 1905, The hydrology of San Bernardino Valley, California: U.S. Geol. Survey Water-Supply Paper 142, 124 p.

Moreland, J. A., 1972, Artificial recharge in the upper Santa Ana Valley, southern California: U.S. Geol. Survey open-file rept., 51 p.

Thomas, D. M., and Benson, M. A., 1970, Generalization of streamflow characteristics from drainage-basin characteristics: U.S. Geol. Survey Water-Supply Paper 1975, 55 p.

Troxell, H. C., 1953, The influence of ground-water storage on the runoff in the San Bernardino and eastern San Gabriel Mountains of southern California: Am. Geophys. Union Trans. v. 34, no. 4, p. 552-562.

Troxell, H. C., and others, 1942, Floods of March 1938 in southern California: U.S. Geol. Survey Water-Supply Paper 844, 399 p.

______1954, Hydrology of the San Bernardino and eastern San Gabriel Mountains, California: U.S. Geol. Survey Hydrol. Inv. Atlas HA-1, 13 sheets.

U.S. Geological Survey, 1960, Compilation of records of surface waters of the United States through September 1950, parts 10 and 11-A: U.S. Geol. Survey Water-Supply Papers 1314, 1315-B.

______1963, Compilation of records of surface waters of the United States, October 1950 to September 1960, parts 10 and 11: U.S. Geol. Survey Water-Supply Papers 1734, 1735.

______1970, Surface-water supply of the United States, 1961-65, parts 10 and 11: U.S. Geol. Survey Water-Supply Papers 1927, 1928.

U.S.Weather Bureau, 1956, Rainfall intensities for local drainage design in western United States: U.S. Weather Bureau Tech. Paper 28, 48 p.

______1959, Evaporation maps for the United States: U.S. Weather Bureau Tech. Paper 37, 13 p.

Waananen, A. O., 1969, Floods of January and February 1969 in central and southern California: U.S. Geol. Survey open-file rept., 233 p.

Water Resources Council, 1967, A uniform technique for determining floodflow frequencies: Bull. 15, 15 p.

Water Resources Engineers, Inc., 1969, An investigation of salt balance in the upper Santa Ana River basin: Walnut Creek, Calif., 198 p.

APPENDIX A

SAMPLE SOLUTIONS OF EQUATIONS

Because of the complexity of the use of the equations, several sample solutions are presented. The first example is to determine the 3-day, high-flow, volume-frequency curve for East Twin Creek near Arrowhead Springs, Calif., at the Geological Survey gaging station.

The San Bernardino North, Calif., and Harrison Mountain, Calif., Geological Survey topographic maps, scale 1:24,000, were used to determine the basin characteristics for this site. The drainage area above this site was planimetered and determined to be 8.80 square miles. The annual precipitation was determined from figure 2 as 27 inches. The channel length as measured on the topographic maps was 5.3 miles. From the topographic maps the elevation at the 10-percent point (0.53 mile) was 1,800 feet and the elevation at the 85-percent point (4.51 miles) was 4,840 feet. This gave a fall of 3,040 feet in 3.98 miles or a slope of 764 feet per mile. The precipitation intensity was determined from figure 5 as 4.5 inches. In determining the forest cover, it was easier to measure the one small clear area on the San Bernardino North map and the several areas on the Harrison Mountain map and subtract from the total drainage area. This gave a forest cover area of 8.53 square miles or 97 percent. Adding the 1 percent gives a forest cover of 98 percent. The area at an elevation greater than 5,000 feet was planimetered to be 0.59 square mile or 6.7 percent. Adding the 1 percent gives a factor of 7.7 percent. The evapotranspiration was determined from figure 6 as 60 inches. Table A1 is a summary of these characteristics with the logarithmic values needed for the solution.

TABLE A1.--*Basin characteristics for East Twin Creek near Arrowhead Springs, Calif.*

Symbol	Characteristic	Value	Log value
A	Drainage area	8.80	0.944
P	Mean annual precipitation	27	1.431
L	Main-channel length	5.3	.725
S	Main-channel slope	764	2.883
I	2-year, 24-hour precipitation intensity	4.5	.653
F	Percentage of area forest covered + 1 percent	98	1.991
E	Percentage of area at elevation >5,000 feet + 1 percent	7.7	.886
T	Mean annual potential evapotranspiration	60	1.778

The equation for the maximum 3-day, 2-year high flow ($V_{3,2}$) with the coefficients from table 4 is

$$\log V_{3,2} = -9.345 + 1.018 \log A + 2.669 \log P - 0.199 \log E + 3.415 \log T.$$

Adding the logarithms of the basin characteristics gives

$$\log V_{3,2} = -9.345 + 1.018 \times 0.944 + 2.669 \times 1.431$$

$$- 0.199 \times 0.886 + 3.415 \times 1.778.$$

Solving this equation, $\log V_{3,2} = 1.332$ and its antilog $V_{3,2} = 21.5$ cfs (cubic feet per second). Similarly, calculation of the 3-day, 50-year high flow ($V_{3,50}$) would be as follows:

$$\log V_{3,50} = -2.166 + 1.082 \log A + 0.848 \log P + 1.303 \log F$$

and

$$\log V_{3,50} = -2.166 + 1.082 \times 0.944 + 0.848 \times 1.431 + 1.303 \times 1.991.$$

As above, $\log V_{3,50} = 2.665$ and its antilog $V_{3,50} = 462$ cfs. If either the total frequency curve or any other frequencies are desired, the above 2-year and 50-year results should be plotted on logarithmic probability paper and the desired results determined by linear interpolation. Figure A1 is such a plot for East Twin Creek near Arrowhead Springs, Calif.

The second example is to determine the January and February monthly and the annual mean flow for Deer Canyon Creek near Etiwanda, Calif. The site is at the frontline fire road crossing found on the Cucamonga Peak, Calif., topographic map. The drainage area above this site was 3.72 square miles. The annual precipitation from figure 2 was 35 inches. The channel length was found to be 4.1 miles. The elevation at the 10-percent point (0.41 mile) was 2,895 feet, and the 85-percent point (3.52 miles) was 6,820 feet. This gave a fall of 3,925 feet in 3.11 miles or a slope of 1,262 feet per mile. The precipitation intensity from figure 5 was 6.0 inches. The forest area was determined as 3.49 square miles or 94 percent. Adding the 1 percent gave a forest cover of 95 percent. The area above the 5,000-foot elevation was 2.49 square miles or 67 percent. The percentage at an elevation greater than 5,000 feet was thus 68 percent. The evapotranspiration from figure 6 was 63 inches. Table A2 summarizes these data.

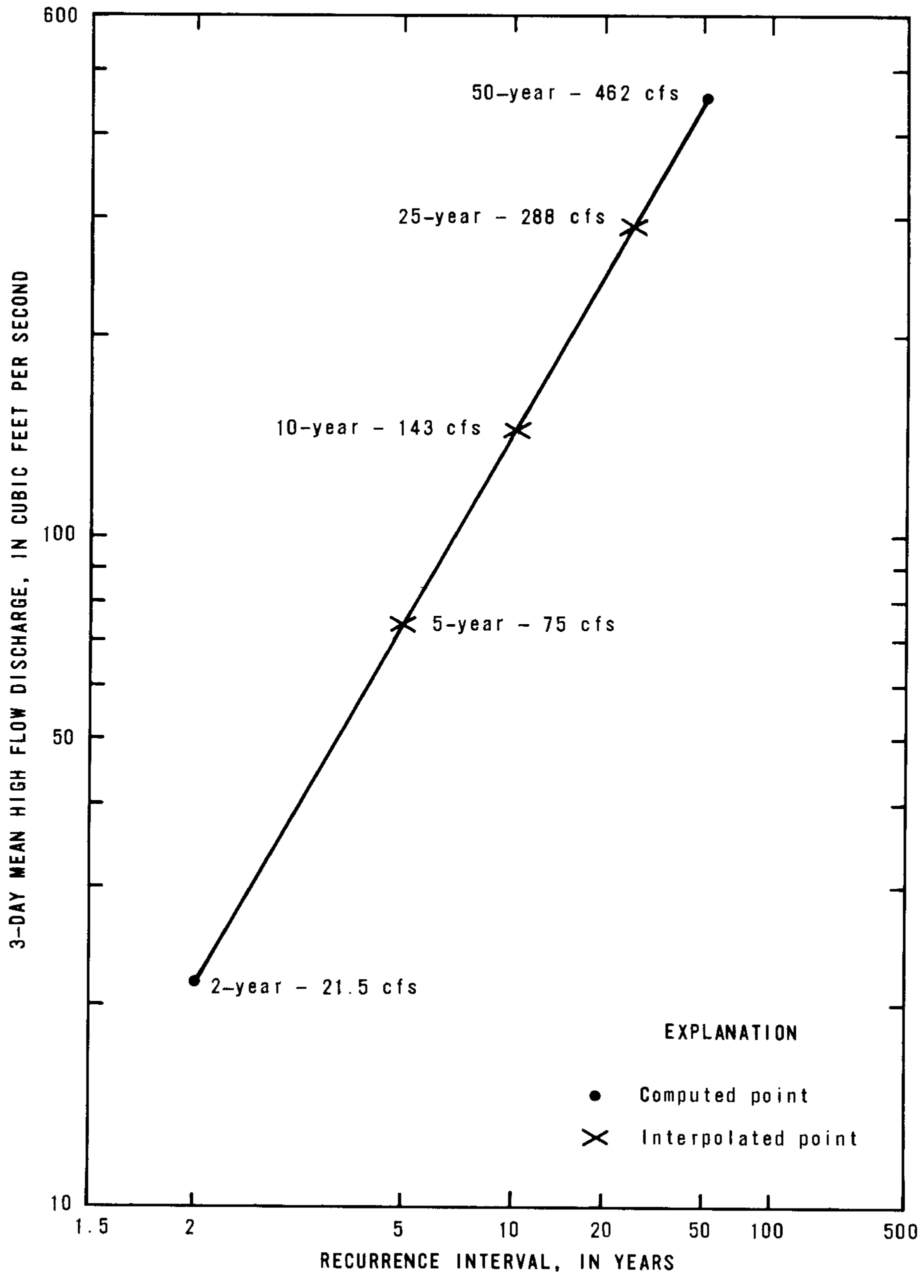


FIGURE A1.--Three-day mean high flow frequency curve for East Twin Creek near Arrowhead Springs, California.

TABLE A2.--*Basin characteristics for Deer Canyon Creek near Etiwanda, Calif.*

Symbol	Characteristic	Value	Log value
A	Drainage area	3.72	0.571
P	Mean annual precipitation	35	1.544
L	Main-channel length	4.1	.617
S	Main-channel slope	1,262	3.101
I	2-year, 24-hour precipitation intensity	6.0	.778
F	Percentage of area forest covered + 1 percent	95	1.978
E	Percentage of area at elevation >5,000 feet + 1 percent	68	1.833
T	Mean annual potential evapotranspiration	63	1.799

The equation for the mean annual flow Q_a with the coefficients from table 4 is

$$\log Q_a = -8.724 + 1.024 \log A + 2.349 \log P + 0.317 \log S + 2.271 \log T.$$

Adding the logarithms of the basin characteristics gives

$$\log Q_a = -8.724 + 1.024 \times 0.571 + 2.349 \times 1.544 + 0.317 \times 3.101 + 2.271 \times 1.799.$$

Solving this equation gives $\log Q_a = 0.556$ and its antilog $Q_a = 3.60$ cfs. The equations for the January and February mean monthly flows q_n with their coefficients from table 4 are

$$\log q_1 = -7.544 + 0.909 \log A + 2.717 \log P + 1.905 \log T$$

$$\log q_2 = -2.796 + 1.036 \log A + 1.437 \log P + 0.790 \log I.$$

Adding the logarithms of the basin characteristics gives

$$\log q_1 = -7.544 + 0.909 \times 0.571 + 2.717 \times 1.544 + 1.905 \times 1.799$$

$$\log q_2 = -2.796 + 1.036 \times 0.571 + 1.437 \times 1.544 + 0.790 \times 0.778.$$

Solving these equations gives

$\log q_1 = 0.597$ and $q_1 = 4.0$ cfs

$\log q_2 = 0.629$ and $q_2 = 4.3$ cfs.

Whenever a group of values are computed together, answers should be examined for consistency. In this example, if all 12 months had been solved for, and if several values appeared to be a little high when compared with the remainder of the months and the normal expected annual cycle, these could be adjusted. These adjustments normally, however, would be well within the accuracy limits of the equations.

The next example will be to solve for the flood-frequency curve for Deer Canyon Creek near Etiwanda, Calif. The basic characteristics were determined in the previous example (table A2).

The equations for the five flood-frequency characteristics from table 4 are

$$\log P_2 = 0.076 + 0.425 \log A + 0.850 \log L + 1.363 \log I$$

$$\log P_5 = 0.805 + 0.580 \log A + 0.634 \log L + 1.134 \log I$$

$$\log P_{10} = 0.272 + 0.679 \log A + 0.780 \log P + 0.557 \log L + 0.643 \log I$$

$$\log P_{25} = 0.371 + 0.989 \log A + 1.331 \log P$$

$$\log P_{50} = 0.995 + 0.935 \log A + 1.071 \log P.$$

Adding the logarithms of the basin characteristics gives

$$\log P_2 = 0.076 + 0.425 \times 0.571 + 0.850 \times 0.617 + 1.363 \times 0.778$$

$$\log P_5 = 0.805 + 0.580 \times 0.571 + 0.634 \times 0.617 + 1.134 \times 0.778$$

$$\log P_{10} = 0.272 + 0.679 \times 0.571 + 0.780 \times 1.544 + 0.557 \times 0.617 + 0.643 \times 0.778$$

$$\log P_{25} = 0.371 + 0.989 \times 0.571 + 1.331 \times 1.544$$

$$\log P_{50} = 0.995 + 0.935 \times 0.571 + 1.071 \times 1.544.$$

Solving these gives

$\log P_2 = 1.904$ and $P_2 = 80$ cfs

$\log P_5 = 2.410$ and $P_5 = 257$ cfs

$\log P_{10} = 2.708$ and $P_{10} = 510$ cfs

$\log P_{25} = 2.991$ and $P_{25} = 979$ cfs

$\log P_{50} = 3.183$ and $P_{50} = 1,520$ cfs.

The last example will be to determine the 100-year flood for Deer Canyon Creek. To determine the 100-year flood requires computation of the five flood-frequency points and an extrapolation to the 100-year value. From the previous example, these values are

$$P_2 = 80 \text{ cfs}$$

$$P_5 = 257 \text{ cfs}$$

$$P_{10} = 510 \text{ cfs}$$

$$P_{25} = 979 \text{ cfs}$$

$$P_{50} = 1{,}520 \text{ cfs}$$

These values are plotted on logarithmic probability paper as shown in figure A2. From this curve, the 100-year flood is determined as 2,250 cfs.

Similarly, any of the other flow characteristics can be computed. By using the relations expressed by the equations, or the coefficients in table 4, estimates of virtually any needed streamflow characteristic can be computed for any site or streams tributary to the Pacific Ocean within the eastern San Gabriel Mountains or San Bernardino Mountains.

Appendix B is a tabulation of the eight basin characteristics for the 35 stations used to develop the set of basic equations.

Appendix C is a tabulation of the 26 flow characteristics computed from the regression equations for the 35 stations used in the analysis.

Appendix D is a summary by station of the 26 flow characteristics computed from the regression equations and the basin characteristics.

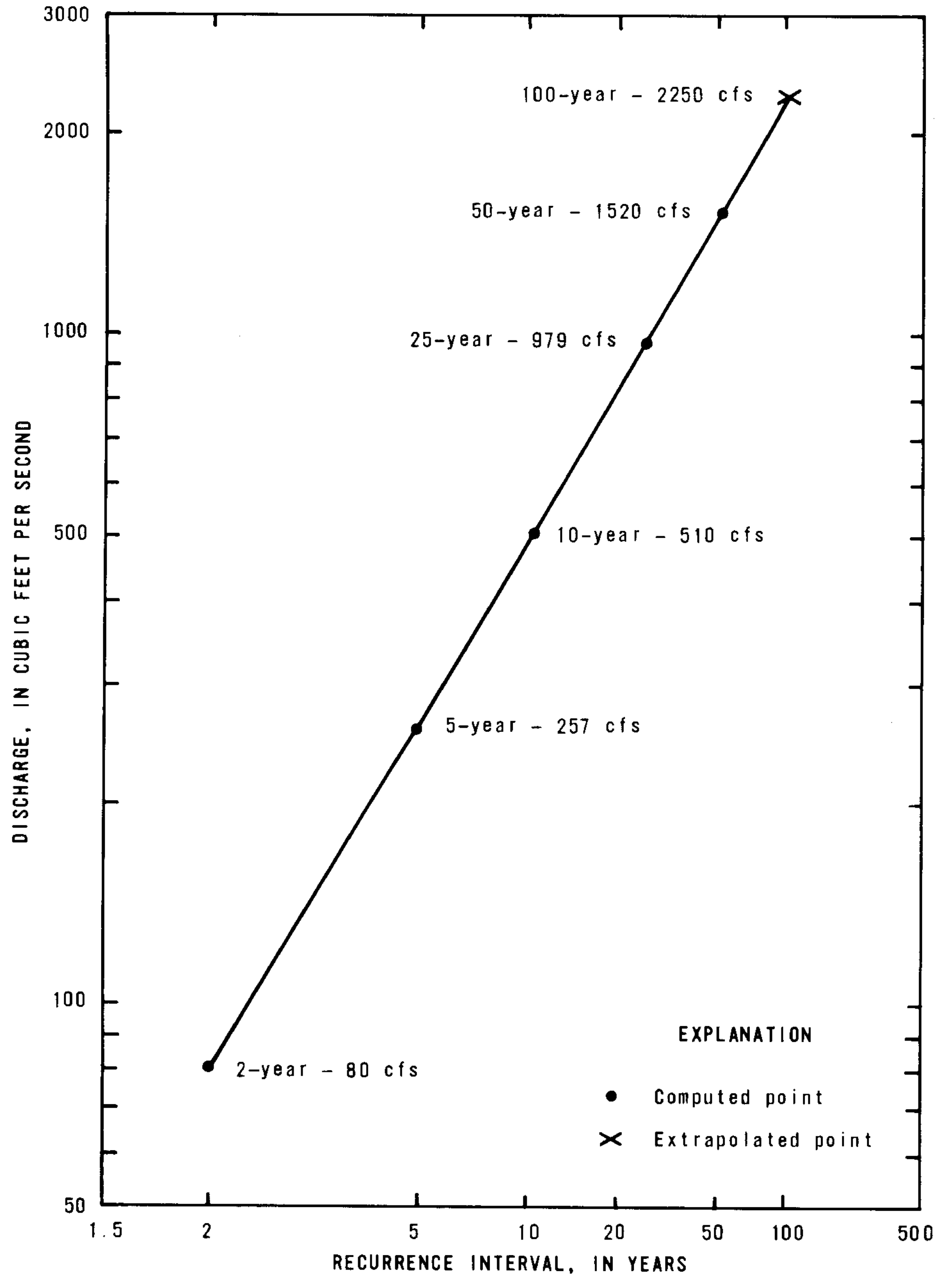


FIGURE A2.--Flood-frequency curve for Deer Canyon Creek near Etiwanda, California.

APPENDIX B

BASIN CHARACTERISTICS FOR STATIONS USED IN ANALYSIS

Station number	Name	Area (sq mi) *A*	Annual precipitation (inches) *P*	Channel length (miles) *L*	Channel slope (ft/mi) *S*	Precipitation intensity (in/hr) *I*	Forest cover (percent) *F*	Elevation >5,000 ft. (percent) *E*	Evapotranspiration (inches) *T*
10256000	Whitewater River at White Water	57.4	26	17.4	418	3.3	84	67	58.5
10256500	Snow Creek near White Water	10.8	29	4.3	1,672	3.1	89	71	58
10258000	Tahquitz Creek near Palm Springs	16.8	24	9.3	878	3.0	90	75	59
10258500	Palm Canyon Creek near Palm Springs	93.3	10	20.8	231	1.9	44	38	63
10260500	Deep Creek near Hesperia	136	24	24.8	183	5.1	80	77	72
10261000	West Fork Mojave River near Hesperia	74.6	24	12.9	81.4	4.8	89	28	72
10263500	Big Rock Creek near Valyermo	22.9	23	7.1	409	5.0	96	87	72
10264000	Little Rock Creek near Little Rock	49.0	21	14.7	224	2.9	81	61	72
11054000	Mill Creek near Yucaipa	38.1	30	16.6	420	4.5	98	81	58.5
11055500	Plunge Creek near East Highlands	16.9	30	8.5	478	4.5	99	24	59
11055800	City Creek near Highland	19.6	32	8.8	359	4.5	100	23	60
11056500	Little San Gorgonio Creek near Beaumont	3.23	30	3.0	1,036	4.0	99	73	57
11057000	San Timoteo Creek near Redlands	119	17	19.0	210	4.5	66	4.3	55
11058500	East Twin Creek near Arrowhead Springs	8.80	27	5.3	764	4.5	98	7.7	60
11058600	Waterman Canyon Creek near Arrowhead Springs	4.65	35	3.6	622	5.0	101	1.0	60
11062000	Lytle Creek near Fontana	46.3	33	15.1	335	6.0	94	69	72
11063000	Cajon Creek near Keenbrook	40.6	19	13.6	174	6.0	99	13	72
11063500	Lone Pine Creek near Keenbrook	15.1	19	11.0	366	6.0	99	45	72
11063680	Devil Canyon Creek near San Bernardino	5.61	26	3.9	801	6.0	99	3.9	60
11067000	Day Creek near Etiwanda	4.59	35	4.2	1,466	6.0	97	63	57
11073000	San Antonio Creek near Claremont	16.6	34	6.1	722	5.8	99	87	58.5
11073470	Cucamonga Creek near Upland	10.1	35	5.6	810	5.5	100	51	57.5
11080500	East Fork San Gabriel River near Camp Bonita	84.6	31	16.6	330	6.0	95	31	72
11084000	Rogers Creek near Azusa	6.64	30	5.8	375	7.0	101	1.0	57
11084500	Fish Creek near Duarte	6.36	30	6.0	511	6.0	101	1.0	56
11086500	Little Dalton Creek near Glendora	2.72	29	3.6	524	6.0	101	1.0	57
11093000	Pacoima Creek near San Fernando	28.5	25	21.4	157	5.0	69	11	59
11094000	Tujunga Creek below Mill Creek, near Colby Ranch	64.9	24	13.8	100	5.0	101	38	70
11094500	Tujunga Creek near Colby Ranch	67.5	28	21.8	101	5.0	99	38	69
11095500	Tujunga Creek near Sunland	106	29	25.4	109	5.0	99	30	66
11096500	Little Tujunga Creek near San Fernando	21.1	27	6.5	212	5.0	92	1.0	57
11098000	Arroyo Seco near Pasadena	16.6	28	11.5	235	6.0	100	12	57
11100000	Santa Anita Creek near Sierra Madre	9.7	33	4.6	671	7.0	101	5.4	58.5
11100500	Little Santa Anita Creek near Sierra Madre	1.84	35	2.2	892	7.0	101	1.5	55
11101000	Eaton Creek near Pasadena	6.47	29	5.8	609	7.0	101	11	55.5

APPENDIX C

FLOW CHARACTERISTICS COMPUTED FROM REGRESSION EQUATIONS FOR STATIONS USED IN ANALYSIS

[Discharges in cubic feet per second]

Station number	Mean annual	Mean Jan.	Mean Feb.	Mean Mar.	Mean Apr.	Mean May	Mean June	Mean July	Mean Aug.	Mean Sept.	Mean Oct.	Mean Nov.	Mean Dec.
10256000	17.6	18.4	29.5	32.5	36.0	17.0	7.3	2.9	2.3	1.9	1.4	8.6	25.7
10256500	6.3	5.3	5.8	6.3	8.3	8.6	4.5	2.6	1.3	1.3	1.5	6.9	7.4
10258000	5.3	4.9	6.8	7.2	7.7	5.6	3.3	2.5	1.8	1.6	1.3	2.8	6.5
10258500	3.0	2.5	8.0	7.6	6.3	1.6	.4	.2	.2	.2	.1	1.1	5.6
10260500	43.5	48.3	90.5	105	72.9	43.4	18.3	6.1	5.1	4.3	4.3	25.1	45.5
10261000	18.2	28.0	46.3	53.0	36.6	12.2	3.4	.5	.3	.3	.3	9.6	17.9
10263500	8.2	8.5	13.2	14.8	9.1	8.5	4.1	1.9	2.0	2.2	1.5	6.6	6.5
10264000	11.9	13.3	16.6	17.7	17.3	10.4	4.8	2.1	.5	.5	1.5	6.0	11.3
11054000	16.2	18.7	30.2	34.7	31.8	16.0	8.7	4.2	5.8	4.7	2.1	6.7	21.1
11055500	7.5	9.1	13.0	14.7	13.6	7.0	3.6	1.6	1.1	1.0	.8	3.6	8.9
11055800	9.6	12.8	16.7	19.0	18.8	8.7	4.3	1.5	.8	.8	.8	4.7	11.2
11056500	1.6	1.9	2.1	2.3	2.4	1.6	1.0	.6	.8	1.0	.3	.9	1.8
11057000	9.6	10.0	43.5	48.1	27.5	5.7	1.1	.2	.5	.3	.1	4.2	20.1
11058500	2.2	3.9	5.7	6.3	5.2	1.2	.4	.1	.1	.1	.0	.7	2.5
11058600	3.2	4.4	4.6	5.3	5.4	3.1	1.9	.9	.1	.1	.5	1.8	3.2
11062000	36.9	43.1	53.3	63.8	52.0	47.7	33.0	16.7	7.7	6.5	13.2	23.8	31.5
11063000	7.2	8.5	21.0	23.7	9.6	5.2	2.2	.9	1.0	.9	.6	3.0	6.1
11063500	3.3	3.5	7.5	8.4	3.4	2.8	2.0	2.0	4.0	3.6	1.5	1.2	2.5
11063680	2.1	2.3	4.2	4.8	2.9	2.0	1.1	.6	.5	.4	.4	1.3	2.2
11067000	3.7	4.0	5.3	6.1	5.4	4.7	3.8	3.1	6.5	6.0	1.7	2.4	4.1
11073000	11.0	12.4	18.7	22.0	18.8	12.8	6.2	2.3	5.1	5.1	1.2	8.9	13.0
11073470	7.1	8.2	11.2	13.0	12.1	8.0	4.7	2.2	3.3	3.1	1.2	4.6	8.3
11080500	58.8	62.8	90.9	109	81.3	79.3	42.4	16.0	5.5	4.1	12.6	50.2	52.5
11084000	2.5	3.6	7.0	8.1	5.1	1.8	.9	.4	.2	.2	.2	.8	2.9
11084500	2.5	3.4	5.9	6.8	4.9	2.0	1.2	.6	.3	.2	.3	.9	3.0
11086500	1.0	1.5	2.3	2.6	1.8	.7	.4	.3	.1	.1	.1	.3	1.1
11093000	5.9	8.9	18.7	21.2	17.6	3.5	1.8	.9	1.0	.8	.4	1.0	9.3
11094000	15.8	23.3	41.4	47.4	29.4	10.8	3.4	.6	.6	.6	.4	7.5	15.1
11094500	22.9	35.8	53.8	62.7	47.4	16.9	7.7	2.2	1.2	1.1	1.3	7.4	23.0
11095500	36.6	54.5	90.3	106	83.4	28.5	11.0	2.5	1.5	1.3	1.4	13.5	41.9
11096500	5.2	7.8	15.3	17.4	13.4	3.3	.9	.2	.1	.0	.1	2.6	7.4
11098000	4.6	6.9	14.5	16.8	11.0	3.0	1.5	.6	1.1	.9	.2	1.2	6.1
11100000	5.8	7.0	11.9	14.1	9.8	6.0	2.9	1.1	1.0	.8	.6	4.1	6.5
11100500	1.2	1.6	2.3	2.7	2.1	1.0	.6	.3	.2	.2	.2	.6	1.3
11101000	2.4	3.1	6.5	7.5	4.5	2.0	1.1	.7	1.9	1.6	.3	.9	3.0

[Discharges in cubic feet per second]

Station number	2-yr. flood	5-yr. flood	10-yr. flood	25-yr. flood	50-yr. flood	1-day 2-yr. high	3-day 2-yr. high	7-day 2-yr. high	15-day 2-yr. high	1-day 50-yr. high	3-day 50-yr. high	7-day 50-yr. high	15-day 50-yr. high
10256000	384	1580	3930	9860	14300	129	78.3	50.2	35.4	4900	2780	1600	952
10256500	52.9	231	607	2180	3370	29.2	18.4	12.3	8.8	878	540	349	218
10258000	118	468	1060	2630	4160	30.8	18.2	11.7	8.1	1280	753	402	240
10258500	259	1260	2010	4470	8090	33.3	14.4	7.5	4.3	1320	901	556	273
10260500	1360	5360	10700	20800	29400	490	301	192	134	11300	6020	3390	1950
10261000	555	2330	4750	11500	16800	330	200	125	84.0	6870	3720	1840	1070
10263500	214	843	1520	3380	5310	70.9	42.7	27.7	19.1	1970	1100	515	303
10264000	261	1120	2500	6350	9800	134	78.0	48.7	32.8	3250	1870	964	551
11054000	473	1720	3960	7950	11400	114	72.8	48.5	35.4	4490	2460	1330	818
11055500	190	703	1570	3560	5310	65.9	41.7	27.1	18.9	1810	1040	582	362
11055800	208	784	1860	4490	6540	94.8	61.5	40.5	28.6	2290	1300	752	473
11056500	33.0	122	265	693	1130	8.7	5.5	3.7	2.7	274	173	108	69.0
11057000	862	3630	5930	11500	17900	147	74.0	39.6	23.4	5320	3120	1690	913
11058500	96.2	357	713	1620	2580	35.7	21.5	13.3	8.7	777	462	252	156
11058600	61.0	217	488	1220	1870	52.0	33.7	20.9	13.4	484	300	201	132
11062000	702	2520	5550	10900	15100	350	240	165	122	5620	3120	1900	1180
11063000	608	2180	3110	4610	7390	121	67.1	39.3	24.5	3440	1820	677	380
11063500	333	1080	1410	1730	2930	34.3	19.1	11.7	7.6	1110	623	247	141
11063680	90.6	314	517	989	1620	23.8	14.1	8.5	5.4	459	278	150	92.6
11067000	88.6	293	593	1200	1850	18.3	12.2	8.5	6.3	445	281	198	130
11073000	201	752	1670	4130	5970	64.2	43.0	29.7	22.3	1950	1130	701	447
11073470	141	503	1120	2630	3870	43.8	29.4	20.2	14.9	1150	686	443	286
11080500	984	3790	8390	18300	24800	661	440	290	207	10800	5770	3170	1930
11084000	168	530	893	1410	2220	44.3	27.0	16.1	10.0	645	387	224	142
11084500	138	443	801	1350	2130	40.0	24.3	14.5	9.0	614	369	215	136
11086500	62.3	196	330	559	928	16.5	9.9	5.9	3.7	227	143	85.6	54.7
11093000	600	1930	3470	4680	7120	86.6	51.0	31.0	20.3	1520	976	737	439
11094000	586	2350	4610	10000	14700	244	148	93.2	63.4	7300	3770	1600	930
11094500	879	3220	6880	12800	18000	347	221	144	101	8320	4370	2130	1280
11095500	1210	4600	10500	20900	28500	541	346	223	157	14300	7340	3580	2150
11096500	192	761	1550	3850	5840	112	66.0	38.1	23.3	1890	1100	615	374
11098000	360	1170	2090	3190	4850	57.0	34.8	21.8	14.6	1710	971	511	314
11100000	162	570	1090	2340	3500	62.1	40.0	25.5	17.2	1070	633	386	247
11100500	42.8	136	246	488	788	14.1	9.0	5.7	3.7	168	110	78.1	52.0
11101000	166	522	855	1320	2090	22.2	13.6	8.6	5.8	610	366	207	130

APPENDIX D

SUMMARY OF CHARACTERISTICS BY STATION

10256000 WHITEWATER RIVER AT WHITE WATER, CALIF.

Location.--Lat 33°56'48", long 116°38'24", in NW¼NW¼NE¼ sec. 2, T. 3 S., R. 3 E., Riverside County, on right bank 1.5 miles north of White Water and 3.5 miles upstream from San Gorgonio River. Prior to Oct. 1, 1969, at site 1.5 miles downstream.

Basin characteristics

Area (*A*), square miles	57.4
Annual precipitation (*P*), in inches	26
Channel length (*L*), in miles	17.4
Channel slope (*S*), in feet per mile	418
Precipitation intensity (*I*), in inches per hour	3.3
Forest cover (*F*), in percent	84
Elevation greater than 5,000 feet (*E*), in percent	67
Evapotranspiration (*T*), in inches	58.5

Mean flow (cubic feet per second)

Annual	17.6
January	18.4
February	29.5
March	32.5
April	36.0
May	17.0
June	7.3
July	2.9
August	2.3
September	1.9
October	1.4
November	8.6
December	25.7

Flood frequency (cubic feet per second)

2-year	384
5-year	1,580
10-year	3,930
25-year	9,860
50-year	14,300
[1]100-year	25,000

Flood-volume frequency (average cubic feet per second for period)

	2-year	50-year
1-day	129	4,900
3-day	78.3	2,780
7-day	50.2	1,600
15-day	35.4	952

[1]From curve drawn from other frequency points.

10256500 SNOW CREEK NEAR WHITE WATER, CALIF.

Location.--Lat 33°52'12", long 116°40'49", in SE¼NW¼NW¼ sec. 33, T. 3 S., R. 3 E., Riverside County, on left bank 50 feet upstream from Southern Pacific Railroad diversion dam, 500 feet downstream from unnamed tributary, 2.8 miles upstream from mouth, and 4.5 miles southwest of White Water.

Basin characteristics

Area (*A*), square miles	10.8
Annual precipitation (*P*), in inches	29
Channel length (*L*), in miles	4.3
Channel slope (*S*), in feet per mile	1,672
Precipitation intensity (*I*), in inches per hour	3.1
Forest cover (*F*), in percent	89
Elevation greater than 5,000 feet (*E*), in percent	71
Evapotranspiration (*T*), in inches	58

Mean flow (cubic feet per second)

Annual	6.3
January	5.3
February	5.8
March	6.3
April	8.3
May	8.6
June	4.5
July	2.6
August	1.3
September	1.3
October	1.5
November	6.9
December	7.4

Flood frequency (cubic feet per second)

2-year	52.9
5-year	231
10-year	607
25-year	2,180
50-year	3,370
[1]100-year	7,800

Flood-volume frequency (average cubic feet per second for period)

	2-year	50-year
1-day	29.2	878
3-day	18.4	540
7-day	12.3	349
15-day	8.8	218

[1]From curve drawn from other frequency points.

10258000 TAHQUITZ CREEK NEAR PALM SPRINGS, CALIF.

Location.--Lat 33°48'18", long 116°33'30", in NE¼SW¼SW¼ sec. 22, T. 4 S., R. 4 E., Riverside County, on left bank 2.2 miles southwest of Palm Springs and 7 miles upstream from mouth.

Basin characteristics

Area (*A*), square miles	16.8
Annual precipitation (*P*), in inches	24
Channel length (*L*), in miles	9.3
Channel slope (*S*), in feet per mile	878
Precipitation intensity (*I*), in inches per hour	3.0
Forest cover (*F*), in percent	90
Elevation greater than 5,000 feet (*E*), in percent	75
Evapotranspiration (*T*), in inches	59

Mean flow (cubic feet per second)

Annual	5.3
January	4.9
February	6.8
March	7.2
April	7.7
May	5.6
June	3.3
July	2.5
August	1.8
September	1.6
October	1.3
November	2.8
December	6.5

Flood frequency (cubic feet per second)

2-year	118
5-year	468
10-year	1,060
25-year	2,630
50-year	4,160
[1]100-year	7,000

Flood-volume frequency (average cubic feet per second for period)

	2-year	50-year
1-day	30.8	1,280
3-day	18.2	753
7-day	11.7	402
15-day	8.1	240

[1]From curve drawn from other frequency points.

10258500 PALM CANYON CREEK NEAR PALM SPRINGS, CALIF.

Location.--Lat 33°44'42", long 116°32'05", in NE¼SW¼SE¼ sec. 11, T. 5 S., R. 4 E., Riverside County, on right bank 0.8 mile upstream from Murray Canyon Creek and 6 miles south of Palm Springs.

Basin characteristics

Area (*A*), square miles	93.3
Annual precipitation (*P*), in inches	10
Channel length (*L*), in miles	20.8
Channel slope (*S*), in feet per mile	231
Precipitation intensity (*I*), in inches per hour	1.9
Forest cover (*F*), in percent	44
Elevation greater than 5,000 feet (*E*), in percent	38
Evapotranspiration (*T*), in inches	63

Mean flow (cubic feet per second)

Annual	3.0
January	2.5
February	8.0
March	7.6
April	6.3
May	1.6
June	.4
July	.2
August	.2
September	.2
October	.1
November	1.1
December	5.6

Flood frequency (cubic feet per second)

2-year	259
5-year	1,260
10-year	2,010
25-year	4,470
50-year	8,090
[1]100-year	9,500

Flood-volume frequency (average cubic feet per second for period)

	2-year	50-year
1-day	33.3	1,320
3-day	14.4	901
7-day	7.5	556
15-day	4.3	273

[1]From curve drawn from other frequency points.

10260500 DEEP CREEK NEAR HESPERIA, CALIF.

Location.--Lat 34°20'28", long 117°13'39", in NW¼NE¼SE¼ sec. 18, T. 3 N., R. 3 W., San Bernardino County, on right bank 0.5 mile upstream from confluence with West Fork Mojave River and 7 miles southeast of Hesperia.

Basin characteristics

Area (*A*), square miles	136
Annual precipitation (*P*), in inches	24
Channel length (*L*), in miles	24.8
Channel slope (*S*), in feet per mile	183
Precipitation intensity (*I*), in inches per hour	5.1
Forest cover (*F*), in percent	80
Elevation greater than 5,000 feet (*E*), in percent	77
Evapotranspiration (*T*), in inches	72

Mean flow (cubic feet per second)

Annual	43.5
January	48.3
February	90.5
March	105
April	72.9
May	43.4
June	18.3
July	6.1
August	5.1
September	4.3
October	4.3
November	25.1
December	45.5

Flood frequency (cubic feet per second)

2-year	1,360
5-year	5,360
10-year	10,700
25-year	20,800
50-year	29,400
[1]100-year	44,500

Flood-volume frequency (average cubic feet per second for period)

	2-year	50-year
1-day	490	11,300
3-day	301	6,020
7-day	192	3,390
15-day	134	1,950

[1]From curve drawn from other frequency points.

10261000 WEST FORK MOJAVE RIVER NEAR HESPERIA, CALIF.

Location.--Lat 34°20'27", long 117°14'24", in SW¼SW¼ sec. 18, T. 3 N., R. 3 W., San Bernardino County, San Bernardino National Forest, on left bank at highway bridge, 0.5 mile upstream from confluence with Deep Creek, and 6.5 miles southeast of Hesperia.

Basin characteristics

Area (*A*), square miles	74.6
Annual precipitation (*P*), in inches	24
Channel length (*L*), in miles	12.9
Channel slope (*S*), in feet per mile	81.4
Precipitation intensity (*I*), in inches per hour	4.8
Forest cover (*F*), in percent	89
Elevation greater than 5,000 feet (*E*), in percent	28
Evapotranspiration (*T*), in inches	72

Mean flow (cubic feet per second)

Annual	18.2
January	28.0
February	46.3
March	53.0
April	36.6
May	12.2
June	3.4
July	.5
August	.3
September	.3
October	.3
November	9.6
December	17.9

Flood frequency (cubic feet per second)

2-year	555
5-year	2,330
10-year	4,750
25-year	11,500
50-year	16,800
[1]100-year	24,500

Flood-volume frequency (average cubic feet per second for period)

	2-year	50-year
1-day	330	6,870
3-day	200	3,720
7-day	125	1,840
15-day	84.0	1,070

[1]From curve drawn from other frequency points.

10263500 BIG ROCK CREEK NEAR VALYERMO, CALIF.

Location.--Lat 34°25'15", long 117°50'19", in NW¼SE¼NE¼ sec. 20, T. 4 N., R. 9 W., Los Angeles County, on left bank 0.1 mile upstream from Punchbowl Canyon and 1.9 miles southwest of Valyermo.

Basin characteristics

Area (*A*), square miles	22.9
Annual precipitation (*P*), in inches	23
Channel length (*L*), in miles	7.1
Channel slope (*S*), in feet per mile	409
Precipitation intensity (*I*), in inches per hour	5.0
Forest cover (*F*), in percent	96
Elevation greater than 5,000 feet (*E*), in percent	87
Evapotranspiration (*T*), in inches	72

Mean flow (cubic feet per second)

Annual	8.2
January	8.5
February	13.2
March	14.8
April	9.1
May	8.5
June	4.1
July	1.9
August	2.0
September	2.2
October	1.5
November	6.6
December	6.5

Flood frequency (cubic feet per second)

2-year	214
5-year	843
10-year	1,520
25-year	3,380
50-year	5,310
[1]100-year	7,900

Flood-volume frequency (average cubic feet per second for period)

	2-year	50-year
1-day	70.9	1,970
3-day	42.7	1,100
7-day	27.7	515
15-day	19.1	303

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[1]From curve drawn from other frequency points.

10264000 LITTLE ROCK CREEK NEAR LITTLE ROCK, CALIF.

Location.--Lat 34°27'47", long 118°01'04", in SW¼SW¼NE¼ sec. 3, T. 4 N., R. 11 W., Los Angeles County, on right bank 0.3 mile upstream from Santiago Creek, 1.6 miles upstream from Little Rock Palmdale Irrigation District's dam, and 5 miles south of Little Rock.

Basin characteristics

Area (*A*), square miles	49.0
Annual precipitation (*P*), in inches	21
Channel length (*L*), in miles	14.7
Channel slope (*S*), in feet per mile	224
Precipitation intensity (*I*), in inches per hour	2.9
Forest cover (*F*), in percent	81
Elevation greater than 5,000 feet (*E*), in percent	61
Evapotranspiration (*T*), in inches	72

Mean flow (cubic feet per second)

Annual	11.9
January	13.3
February	16.6
March	17.7
April	17.3
May	10.4
June	4.8
July	2.1
August	.5
September	.5
October	1.5
November	6.0
December	11.3

Flood frequency (cubic feet per second)

2-year	261
5-year	1,120
10-year	2,500
25-year	6,350
50-year	9,800
[1]100-year	17,000

Flood-volume frequency (average cubic feet per second for period)

	2-year	50-year
1-day	134	3,250
3-day	78.0	1,870
7-day	48.7	964
15-day	32.8	551

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[1]From curve drawn from other frequency points.

11054000 MILL CREEK NEAR YUCAIPA, CALIF.

Location.--Lat 34°05'27", long 117°02'12", in NW¼NE¼NE¼ sec. 13, T. 1 S., R. 2 W., San Bernardino County, on left bank 50 feet downstream from bridge on State Highway 190-D, 3.9 miles north of Yucaipa, and 5.3 miles upstream from mouth.

Basin characteristics

Area (*A*), square miles	38.1
Annual precipitation (*P*), in inches	30
Channel length (*L*), in miles	16.6
Channel slope (*S*), in feet per mile	420
Precipitation intensity (*I*), in inches per hour	4.5
Forest cover (*F*), in percent	98
Elevation greater than 5,000 feet (*E*), in percent	81
Evapotranspiration (*T*), in inches	58.5

Mean flow (cubic feet per second)

Annual	16.2
January	18.7
February	30.2
March	34.7
April	31.8
May	16.0
June	8.7
July	4.2
August	5.8
September	4.7
October	2.1
November	6.7
December	21.1

Flood frequency (cubic feet per second)

2-year	473
5-year	1,720
10-year	3,960
25-year	7,950
50-year	11,400
[1]100-year	17,000

Flood-volume frequency (average cubic feet per second for period)

	2-year	50-year
1-day	114	4,490
3-day	72.8	2,460
7-day	48.5	1,330
15-day	35.4	818

[1]From curve drawn from other frequency points.

11055500 PLUNGE CREEK NEAR EAST HIGHLANDS, CALIF.

Location.--Lat 34°07'06", long 117°08'27", in SW¼NE¼NE¼ sec. 1, T. 1 S., R. 3 W., San Bernardino County, on left bank at mouth of canyon at crossing of North Fork ditch siphon, 1.8 miles northeast of East Highlands.

Basin characteristics

Area (*A*), square miles	16.9
Annual precipitation (*P*), in inches	30
Channel length (*L*), in miles	8.5
Channel slope (*S*), in feet per mile	478
Precipitation intensity (*I*), in inches per hour	4.5
Forest cover (*F*), in percent	99
Elevation greater than 5,000 feet (*E*), in percent	24
Evapotranspiration (*T*), in inches	59

Mean flow (cubic feet per second)

Annual	7.5
January	9.1
February	13.0
March	14.7
April	13.6
May	7.0
June	3.6
July	1.6
August	1.1
September	1.0
October	.8
November	3.6
December	8.9

Flood frequency (cubic feet per second)

2-year	190
5-year	703
10-year	1,570
25-year	3,560
50-year	5,310
[1]100-year	8,800

Flood-volume frequency (average cubic feet per second for period)

	2-year	50-year
1-day	65.9	1,810
3-day	41.7	1,040
7-day	27.1	582
15-day	18.9	362

[1]From curve drawn from other frequency points.

11055800 CITY CREEK NEAR HIGHLAND, CALIF.

Location.--Lat 34°08'38", long 117°11'16", in SE¼SW¼NW¼ sec. 27, T. 1 N., R. 3 W., San Bernardino County, on right bank 0.6 mile upstream from Highland Avenue and 1.5 miles northeast of Highland.

Basin characteristics

Area (*A*), square miles	19.6
Annual precipitation (*P*), in inches	32
Channel length (*L*), in miles	8.8
Channel slope (*S*), in feet per mile	359
Precipitation intensity (*I*), in inches per hour	4.5
Forest cover (*F*), in percent	100
Elevation greater than 5,000 feet (*E*), in percent	23
Evapotranspiration (*T*), in inches	60

Mean flow (cubic feet per second)

Annual	9.6
January	12.8
February	16.7
March	19.0
April	18.8
May	8.7
June	4.3
July	1.5
August	.8
September	.8
October	.8
November	4.7
December	11.2

Flood frequency (cubic feet per second)

2-year	208
5-year	784
10-year	1,860
25-year	4,490
50-year	6,540
[1]100-year	9,900

Flood-volume frequency (average cubic feet per second for period)

	2-year	50-year
1-day	94.8	2,290
3-day	61.5	1,300
7-day	40.5	752
15-day	28.6	473

[1]From curve drawn from other frequency points.

11056500 LITTLE SAN GORGONIO CREEK NEAR BEAUMONT, CALIF.

Location.--Lat 34°01'45", long 116°56'43", in NW¼SW¼NW¼ sec. 1, T. 2 S., R. 1 W., San Bernardino County, on downstream side of left abutment of bridge on Oak Glen Road, 3.0 miles upstream from Wallace Creek, and 7 miles north of Beaumont.

Basin characteristics

Area (*A*), square miles	3.23
Annual precipitation (*P*), in inches	30
Channel length (*L*), in miles	3.0
Channel slope (*S*), in feet per mile	1,036
Precipitation intensity (*I*), in inches per hour	4.0
Forest cover (*F*), in percent	99
Elevation greater than 5,000 feet (*E*), in percent	73
Evapotranspiration (*T*), in inches	57

Mean flow (cubic feet per second)

Annual	1.6
January	1.9
February	2.1
March	2.3
April	2.4
May	1.6
June	1.0
July	.6
August	.8
September	1.0
October	.3
November	.9
December	1.8

Flood frequency (cubic feet per second)

2-year	33.0
5-year	122
10-year	265
25-year	693
50-year	1,130
[1]100-year	1,890

Flood-volume frequency (average cubic feet per second for period)

	2-year	50-year
1-day	8.7	274
3-day	5.5	173
7-day	3.7	108
15-day	2.7	69.0

[1]From curve drawn from other frequency points.

11057000 SAN TIMOTEO CREEK NEAR REDLANDS, CALIF.

Location.--Lat 34°01'59", long 117°12'29", in NE¼NE¼NE¼ sec. 5, T. 2 S., R. 3 W., on downstream side of right abutment of county highway bridge, 2.0 miles southwest of Redlands and 3.4 miles downstream from Yucaipa Creek.

Basin characteristics

Area (*A*), square miles	119
Annual precipitation (*P*), in inches	17
Channel length (*L*), in miles	19.0
Channel slope (*S*), in feet per mile	210
Precipitation intensity (*I*), in inches per hour	4.5
Forest cover (*F*), in percent	66
Elevation greater than 5,000 feet (*E*), in percent	4.3
Evapotranspiration (*T*), in inches	55

Mean flow (cubic feet per second)

Annual	9.6
January	10.0
February	43.5
March	48.1
April	27.5
May	5.7
June	1.1
July	.2
August	.5
September	.3
October	.1
November	4.2
December	20.1

Flood frequency (cubic feet per second)

2-year	862
5-year	3,630
10-year	5,930
25-year	11,500
50-year	17,900
[1]100-year	24,900

Flood-volume frequency (average cubic feet per second for period)

	2-year	50-year
1-day	147	5,320
3-day	74.0	3,120
7-day	39.6	1,690
15-day	23.4	913

[1]From curve drawn from other frequency points.

11058500 EAST TWIN CREEK NEAR ARROWHEAD SPRINGS, CALIF.

Location.--Lat 34°10'45", long 117°15'53", in NW¼NE¼NE¼ sec. 14, T. 1 N., R. 4 W., San Bernardino County, on right bank 100 feet upstream from Del Rosa Water Co.'s diversion dam, 0.5 mile south of Arrowhead Springs, and 1.0 mile downstream from Strawberry Creek.

Basin characteristics

Area (*A*), square miles	8.80
Annual precipitation (*P*), in inches	27
Channel length (*L*), in miles	5.3
Channel slope (*S*), in feet per mile	764
Precipitation intensity (*I*), in inches per hour	4.5
Forest cover (*F*), in percent	98
Elevation greater than 5,000 feet (*E*), in percent	7.7
Evapotranspiration (*T*), in inches	60

Mean flow (cubic feet per second)

Annual	2.2
January	3.9
February	5.7
March	6.3
April	5.2
May	1.2
June	.4
July	.1
August	.1
September	.1
October	.0
November	.7
December	2.5

Flood frequency (cubic feet per second)

2-year	96.2
5-year	357
10-year	713
25-year	1,620
50-year	2,580
[1]100-year	3,800

Flood-volume frequency (average cubic feet per second for period)

	2-year	50-year
1-day	35.7	777
3-day	21.5	462
7-day	13.3	252
15-day	8.7	156

[1]From curve drawn from other frequency points.

11058600 WATERMAN CANYON CREEK NEAR ARROWHEAD SPRINGS, CALIF.

Location.--Lat 34°11'36", long 117°16'25", in NE¼NW¼NW¼ sec. 11, T. 1 N., R. 4 W., San Bernardino County, on left bank 0.8 mile northwest of Arrowhead Springs and 1.3 miles north of San Bernardino National Forest boundary.

Basin characteristics

Area (*A*), square miles	4.65
Annual precipitation (*P*), in inches	35
Channel length (*L*), in miles	3.6
Channel slope (*S*), in feet per mile	622
Precipitation intensity (*I*), in inches per hour	5.0
Forest cover (*F*), in percent	101
Elevation greater than 5,000 feet (*E*), in percent	1.0
Evapotranspiration (*T*), in inches	60

Mean flow (cubic feet per second)

Annual	3.2
January	4.4
February	4.6
March	5.3
April	5.4
May	3.1
June	1.9
July	.9
August	.1
September	.1
October	.5
November	1.8
December	3.2

Flood frequency (cubic feet per second)

2-year	61.0
5-year	217
10-year	488
25-year	1,220
50-year	1,870
[1]100-year	2,700

Flood-volume frequency (average cubic feet per second for period)

	2-year	50-year
1-day	52.0	484
3-day	33.7	300
7-day	20.9	201
15-day	13.4	132

[1]From curve drawn from other frequency points.

11062000 LYTLE CREEK NEAR FONTANA, CALIF.

Location.--Lat 34°12'44", long 117°27'25", in SE¼NW¼SE¼ sec. 36, T. 2 N., R. 6. W., San Bernardino County, on right bank 75 feet upstream from highway bridge, 0.7 mile upstream from right tributary, and 8 miles north of Fontana.

Basin characteristics

Area (*A*), square miles	46.3
Annual precipitation (*P*), in inches	33
Channel length (*L*), in miles	15.1
Channel slope (*S*), in feet per mile	335
Precipitation intensity (*I*), in inches per hour	6.0
Forest cover (*F*), in percent	94
Elevation greater than 5,000 feet (*E*), in percent	69
Evapotranspiration (*T*), in inches	72

Mean flow (cubic feet per second)

Annual	36.9
January	43.1
February	53.3
March	63.8
April	52.0
May	47.7
June	33.0
July	16.7
August	7.7
September	6.5
October	13.2
November	23.8
December	31.5

Flood frequency (cubic feet per second)

2-year	702
5-year	2,520
10-year	5,550
25-year	10,900
50-year	15,100
[1]100-year	19,500

Flood-volume frequency (average cubic feet per second for period)

	2-year	50-year
1-day	350	5,620
3-day	240	3,120
7-day	165	1,900
15-day	122	1,180

[1]From curve drawn from other frequency points.

11063000 CAJON CREEK NEAR KEENBROOK, CALIF.

Location.--Lat 34°16'01", long 117°27'33", in SE¼SW¼SE¼ sec. 12, T. 2 N., R. 6 W., San Bernardino County, on left bank 1,300 feet upstream from Lone Pine Creek and 1.2 miles north of Keenbrook.

Basin characteristics	
Area (*A*), square miles	40.6
Annual precipitation (*P*), in inches	19
Channel length (*L*), in miles	13.6
Channel slope (*S*), in feet per mile	174
Precipitation intensity (*I*), in inches per hour	6.0
Forest cover (*F*), in percent	99
Elevation greater than 5,000 feet (*E*), in percent	13
Evapotranspiration (*T*), in inches	72

Mean flow (cubic feet per second)	
Annual	7.2
January	8.5
February	21.0
March	23.7
April	9.6
May	5.2
June	2.2
July	.9
August	1.0
September	.9
October	.6
November	3.0
December	6.1

Flood frequency (cubic feet per second)	
2-year	608
5-year	2,180
10-year	3,110
25-year	4,610
50-year	7,390
[1]100-year	12,000

Flood-volume frequency (average cubic feet per second for period)

	2-year	50-year
1-day	121	3,440
3-day	67.1	1,820
7-day	39.3	677
15-day	24.5	380

[1]From curve drawn from other frequency points.

11063500 LONE PINE CREEK NEAR KEENBROOK, CALIF.

Location.--Lat 34°15'59", long 117°27'47", in SE¼SE¼SW¼ sec. 12, T. 2 N., R. 6 W., San Bernardino County, on right bank 50 feet upstream from The Atchison, Topeka and Santa Fe Railway Co. bridge, 150 feet upstream from mouth, and 1.1 miles north of Keenbrook.

Basin characteristics

Area (*A*), square miles	15.1
Annual precipitation (*P*), in inches	19
Channel length (*L*), in miles	11.0
Channel slope (*S*), in feet per mile	366
Precipitation intensity (*I*), in inches per hour	6.0
Forest cover (*F*), in percent	99
Elevation greater than 5,000 feet (*E*), in percent	45
Evapotranspiration (*T*), in inches	72

Mean flow (cubic feet per second)

Annual	3.3
January	3.5
February	7.5
March	8.4
April	3.4
May	2.8
June	2.0
July	2.0
August	4.0
September	3.6
October	1.5
November	1.2
December	2.5

Flood frequency (cubic feet per second)

2-year	333
5-year	1,080
10-year	1,410
25-year	1,730
50-year	2,930
[1]100-year	4,100

Flood-volume frequency (average cubic feet per second for period)

	2-year	50-year
1-day	34.3	1,110
3-day	19.1	623
7-day	11.7	247
15-day	7.6	141

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[1]From curve drawn from other frequency points.

11063680 DEVIL CANYON CREEK NEAR SAN BERNARDINO, CALIF.

Location.--Lat 34°12'12", long 117°20'02", in Muscupiabe Grant, San Bernardino County, on right bank 1.0 mile downstream from confluence of East Fork and West Fork and 7.0 miles northwest of San Bernardino.

Basin characteristics

Area (*A*), square miles	5.61
Annual precipitation (*P*), in inches	26
Channel length (*L*), in miles	3.9
Channel slope (*S*), in feet per mile	801
Precipitation intensity (*I*), in inches per hour	6.0
Forest cover (*F*), in percent	99
Elevation greater than 5,000 feet (*E*), in percent	3.9
Evapotranspiration (*T*), in inches	60

Mean flow (cubic feet per second)

Annual	2.1
January	2.3
February	4.2
March	4.8
April	2.9
May	2.0
June	1.1
July	.6
August	.5
September	.4
October	.4
November	1.3
December	2.2

Flood frequency (cubic feet per second)

2-year	90.6
5-year	314
10-year	517
25-year	989
50-year	1,620
[1]100-year	2,390

Flood-volume frequency (average cubic feet per second for period)

	2-year	50-year
1-day	23.8	459
3-day	14.1	278
7-day	8.5	150
15-day	5.4	92.6

[1]From curve drawn from other frequency points.

11067000 DAY CREEK NEAR ETIWANDA, CALIF.

Location.--Lat 34°11'06", long 117°32'20", in NW¼NW¼SW¼ sec. 8, T. 1 N., R. 6 W., San Bernardino County, on left bank 0.5 mile downstream from confluence of two main forks and 4 miles north of Etiwanda.

Basin characteristics

Area (*A*), square miles	4.59
Annual precipitation (*P*), in inches	35
Channel length (*L*), in miles	4.2
Channel slope (*S*), in feet per mile	1,466
Precipitation intensity (*I*), in inches per hour	6.0
Forest cover (*F*), in percent	97
Elevation greater than 5,000 feet (*E*), in percent	63
Evapotranspiration (*T*), in inches	57

Mean flow (cubic feet per second)

Annual	3.7
January	4.0
February	5.3
March	6.1
April	5.4
May	4.7
June	3.8
July	3.1
August	6.5
September	6.0
October	1.7
November	2.4
December	4.1

Flood frequency (cubic feet per second)

2-year	88.6
5-year	293
10-year	593
25-year	1,200
50-year	1,850
[1]100-year	2,700

Flood-volume frequency (average cubic feet per second for period)

	2-year	50-year
1-day	18.3	445
3-day	12.2	281
7-day	8.5	198
15-day	6.3	130

[1]From curve drawn from other frequency points.

11-073000 SAN ANTONIO CREEK NEAR CLAREMONT, CALIF.

Location.--Lat 34°12'58", long 117°40'04", in SE¼SW¼NE¼ sec. 36, T. 2 N., R. 8 W., Los Angeles County, on right bank 0.5 mile upstream from Southern California Edison Co.'s Sierra powerplant, and 8.8 miles northeast of Claremont.

Basin characteristics

Area (*A*), square miles	16.6
Annual precipitation (*P*), in inches	34
Channel length (*L*), in miles	6.1
Channel slope (*S*), in feet per mile	722
Precipitation intensity (*I*), in inches per hour	5.8
Forest cover (*F*), in percent	99
Elevation greater than 5,000 feet (*E*), in percent	87
Evapotranspiration (*T*), in inches	58.5

Mean flow (cubic feet per second)

Annual	11.0
January	12.4
February	18.7
March	22.0
April	18.8
May	12.8
June	6.2
July	2.3
August	5.1
September	5.1
October	1.2
November	8.9
December	13.0

Flood frequency (cubic feet per second)

2-year	201
5-year	752
10-year	1,670
25-year	4,130
50-year	5,970
[1]100-year	8,400

Flood-volume frequency (average cubic feet per second for period)

	2-year	50-year
1-day	64.2	1,950
3-day	43.0	1,130
7-day	29.7	701
15-day	22.3	447

[1]From curve drawn from other frequency points.

11073470 CUCAMONGA CREEK NEAR UPLAND, CALIF.

Location.--Lat 34°10'26", long 117°37'51", in SW¼SE¼NE¼ sec. 17, T. 1 N., R. 7 W., San Bernardino County, on right bank 0.5 mile downstream from unnamed tributary, and 5.3 miles north of Upland.

Basin characteristics

Area (*A*), square miles	10.1
Annual precipitation (*P*), in inches	35
Channel length (*L*), in miles	5.6
Channel slope (*S*), in feet per mile	810
Precipitation intensity (*I*), in inches per hour	5.5
Forest cover (*F*), in percent	100
Elevation greater than 5,000 feet (*E*), in percent	51
Evapotranspiration (*T*), in inches	57.5

Mean flow (cubic feet per second)

Annual	7.1
January	8.2
February	11.2
March	13.0
April	12.1
May	8.0
June	4.7
July	2.2
August	3.3
September	3.1
October	1.2
November	4.6
December	8.3

Flood frequency (cubic feet per second)

2-year	141
5-year	503
10-year	1,120
25-year	2,630
50-year	3,870
[1]100-year	5,400

Flood-volume frequency (average cubic feet per second for period)

	2-year	50-year
1-day	43.8	1,150
3-day	29.4	686
7-day	20.2	443
15-day	14.9	286

[1]From curve drawn from other frequency points.

11080500 EAST FORK SAN GABRIEL RIVER NEAR CAMP BONITA, CALIF.

Location.--Lat 34°14'09", long 117°48'18", in NE¼NE¼ sec. 27, T. 2 N., R. 9 W., Los Angeles County, on right bank 1,600 feet upstream from mouth of Graveyard Canyon, 2.5 miles upstream from confluence with West Fork, and 2.5 miles west of Camp Bonita.

Basin characteristics

Area (*A*), square miles	84.6
Annual precipitation (*P*), in inches	31
Channel length (*L*), in miles	16.6
Channel slope (*S*), in feet per mile	330
Precipitation intensity (*I*), in inches per hour	6.0
Forest cover (*F*), in percent	95
Elevation greater than 5,000 feet (*E*), in percent	31
Evapotranspiration (*T*), in inches	72

Mean flow (cubic feet per second)

Annual	58.8
January	62.8
February	90.9
March	109
April	81.3
May	79.3
June	42.4
July	16.0
August	5.5
September	4.1
October	12.6
November	50.2
December	52.5

Flood frequency (cubic feet per second)

2-year	984
5-year	3,790
10-year	8,390
25-year	18,300
50-year	24,800
[1]100-year	35,000

Flood-volume frequency (average cubic feet per second for period)

	2-year	50-year
1-day	661	10,800
3-day	440	5,770
7-day	290	3,170
15-day	207	1,930

[1]From curve drawn from other frequency points.

11084000 ROGERS CREEK NEAR AZUSA, CALIF.

Location.--Lat 34°09'55", long 117°54'20", in NW¼NW¼ sec. 23, T. 1 N., R. 10 W., on left bank 0.5 mile upstream from mouth and 2.2 miles north of Azusa.

Basin characteristics	
Area (*A*), square mile	6.64
Annual precipitation (*P*), in inches	30
Channel length (*L*), in miles	5.8
Channel slope (*S*), in feet per mile	375
Precipitation intensity (*I*), in inches per hour	7.0
Forest cover (*F*), in percent	101
Elevation greater than 5,000 feet (*E*), in percent	1.0
Evapotranspiration (*T*), in inches	57

Mean flow (cubic feet per second)	
Annual	2.5
January	3.6
February	7.0
March	8.1
April	5.1
May	1.8
June	.9
July	.4
August	.2
September	.2
October	.2
November	.8
December	2.9

Flood frequency (cubic feet per second)	
2-year	168
5-year	530
10-year	893
25-year	1,410
50-year	2,220
[1]100-year	3,150

Flood-volume frequency (average cubic feet per second for period)

	2-year	50-year
1-day	44.3	645
3-day	27.0	387
7-day	16.1	224
15-day	10.0	142

[1]From curve drawn from other frequency points.

11084500 FISH CREEK NEAR DUARTE, CALIF.

Location.--Lat 34°09'57", long 117°55'24", in SW¼SW¼SW¼ sec. 15, T. 1 N., R. 10 W., Los Angeles County, on left bank 0.8 mile upstream from mouth of canyon and 3.2 miles northeast of Duarte.

Basin characteristics

Area (*A*), square miles	6.36
Annual precipitation (*P*), in inches	30
Channel length (*L*), in miles	6.0
Channel slope (*S*), in feet per mile	511
Precipitation intensity (*I*), in inches per hour	6.0
Forest cover (*F*), in percent	101
Elevation greater than 5,000 feet (*E*), in percent	1.0
Evapotranspiration (*T*), in inches	56

Mean flow (cubic feet per second)

Annual	2.5
January	3.4
February	5.9
March	6.8
April	4.9
May	2.0
June	1.2
July	.6
August	.3
September	.2
October	.3
November	.9
December	3.0

Flood frequency (cubic feet per second)

2-year	138
5-year	443
10-year	801
25-year	1,350
50-year	2,130
[1]100-year	2,850

Flood-volume frequency (average cubic feet per second for period)

	2-year	50-year
1-day	40.0	614
3-day	24.3	369
7-day	14.5	215
15-day	9.0	136

[1]From curve drawn from other frequency points.

11086500 LITTLE DALTON CREEK NEAR GLENDORA, CALIF.

Location.--Lat 34°10'03", long 117°50'15", in NE¼SE¼SE¼ sec. 17, T. 1 N., R. 9 W., Los Angeles County, on left bank 0.2 mile upstream from Angeles National Forest boundary and 2.6 miles northeast of Glendora.

Basin characteristics

Area (*A*), square miles	2.72
Annual precipitation (*P*), in inches	29
Channel length (*L*), in miles	3.6
Channel slope (*S*), in feet per mile	524
Precipitation intensity (*I*), in inches per hour	6.0
Forest cover (*F*), in percent	101
Elevation greater than 5,000 feet (*E*), in percent	1.0
Evapotranspiration (*T*), in inches	57

Mean flow (cubic feet per second)

Annual	1.0
January	1.5
February	2.3
March	2.6
April	1.8
May	.7
June	.4
July	.3
August	.1
September	.1
October	.1
November	.3
December	1.1

Flood frequency (cubic feet per second)

2-year	62.3
5-year	196
10-year	330
25-year	559
50-year	928
[1]100-year	1,350

Flood-volume frequency (average cubic feet per second for period)

	2-year	50-year
1-day	16.5	227
3-day	9.9	143
7-day	5.9	85.6
15-day	3.7	54.7

[1]From curve drawn from other frequency points.

11093000 PACOIMA CREEK NEAR SAN FERNANDO, CALIF.

Location.--Lat 34°20'07", long 118°23'50", in SE¼NE¼ sec. 24, T. 3 N., R. 15 W., Los Angeles County, on right bank 500 feet downstream from Pacoima Dam, 0.3 mile upstream from mouth of canyon, and 4 miles northeast of San Fernando.

Basin characteristics

Area (*A*), square miles	28.5
Annual precipitation (*P*), in inches	25
Channel length (*L*), in miles	21.4
Channel slope (*S*), in feet per mile	157
Precipitation intensity (*I*), in inches per hour	5.0
Forest cover (*F*), in percent	69
Elevation greater than 5,000 feet (*E*), in percent	11
Evapotranspiration (*T*), in inches	59

Flood frequency (cubic feet per second)

2-year	600
5-year	1,930
10-year	3,470
25-year	4,680
50-year	7,120
[1]100-year	8,000

[1]From curve drawn from other frequency points.

Mean flow (cubic feet per second)

Annual	5.9
January	8.9
February	18.7
March	21.2
April	17.6
May	3.5
June	1.8
July	.9
August	1.0
September	.8
October	.4
November	1.0
December	9.3

Flood-volume frequency (average cubic feet per second for period)

	2-year	50-year
1-day	86.6	1,520
3-day	51.0	976
7-day	31.0	737
15-day	20.3	439

11094000 TUJUNGA CREEK BELOW MILL CREEK, NEAR COLBY RANCH, CALIF.

Location.--Lat 34°18'33", long 118°08'40" (unsurveyed), Los Angeles County, Angeles National Forest, on left bank 500 feet downstream from Mill Creek and 2 miles west of Colby Ranch.

Basin characteristics

Area (A), square miles	64.9
Annual precipitation (P), in inches	24
Channel length (L), in miles	13.8
Channel slope (S), in feet per mile	100
Precipitation intensity (I), in inches per hour	5.0
Forest cover (F), in percent	101
Elevation greater than 5,000 feet (E), in percent	38
Evapotranspiration (T), in inches	70

Mean flow (cubic feet per second)

Annual	15.8
January	23.3
February	41.4
March	47.4
April	29.4
May	10.8
June	3.4
July	.6
August	.6
September	.6
October	.4
November	7.5
December	15.1

Flood frequency (cubic feet per second)

2-year	586
5-year	2,350
10-year	4,610
25-year	10,000
50-year	14,700
[1]100-year	24,500

Flood-volume frequency (average cubic feet per second for period)

	2-year	50-year
1-day	244	7,300
3-day	148	3,770
7-day	93.2	1,600
15-day	63.4	930

[1]From curve drawn from other frequency points.

11094500 TUJUNGA CREEK NEAR COLBY RANCH, CALIF.

Location.--Lat 34°18'22", long 118°09'24", just downstream from Lucas Creek, 400 feet upstream from crossing of Edison Road, 3.5 miles west of Colby Ranch, Los Angeles County, and 4 miles upstream from Big Tujunga Dam.

Basin characteristics

Area (*A*), square miles	67.5
Annual precipitation (*P*), in inches	28
Channel length (*L*), in miles	21.8
Channel slope (*S*), in feet per mile	101
Precipitation intensity (*I*), in inches per hour	5.0
Forest cover (*F*), in percent	99
Elevation greater than 5,000 feet (*E*), in percent	38
Evapotranspiration (*T*), in inches	69

Mean flow (cubic feet per second)

Annual	22.9
January	35.8
February	53.8
March	62.7
April	47.4
May	16.9
June	7.7
July	2.2
August	1.2
September	1.1
October	1.3
November	7.4
December	23.0

Flood frequency (cubic feet per second)

2-year	879
5-year	3,220
10-year	6,880
25-year	12,800
50-year	18,000
[1]100-year	29,000

Flood-volume frequency (average cubic feet per second for period)

	2-year	50-year
1-day	347	8,320
3-day	221	4,370
7-day	144	2,130
15-day	101	1,280

[1]From curve drawn from other frequency points.

11095500 TUJUNGA CREEK NEAR SUNLAND, CALIF.

Location.--Lat 34°18'02", long 118°16'04", in SW¼NW¼SW¼ sec. 32, T. 3 N., R. 13 W., Los Angeles County, on left bank 1,000 feet upstream from Gold Canyon, 2 miles upstream from mouth of canyon, and 4 miles northeast of Sunland.

Basin characteristics

Area (*A*), square miles	106
Annual precipitation (*P*), in inches	29
Channel length (*L*), in miles	25.4
Channel slope (*S*), in feet per mile	109
Precipitation intensity (*I*), in inches per hour	5.0
Forest cover (*F*), in percent	99
Elevation greater than 5,000 feet (*E*), in percent	30
Evapotranspiration (*T*), in inches	66

Mean flow (cubic feet per second)

Annual	36.6
January	54.5
February	90.3
March	106
April	83.4
May	28.5
June	11.0
July	2.5
August	1.5
September	1.3
October	1.4
November	13.5
December	41.9

Flood frequency (cubic feet per second)

2-year	1,210
5-year	4,600
10-year	10,500
25-year	20,900
50-year	28,500
[1]100-year	46,500

Flood-volume frequency (average cubic feet per second for period)

	2-year	50-year
1-day	541	14,300
3-day	346	7,340
7-day	223	3,580
15-day	157	2,150

[1]From curve drawn from other frequency points.

11096500 LITTLE TUJUNGA CREEK NEAR SAN FERNANDO, CALIF.

Location.--Lat 34°16'28", long 118°22'18", in Tujunga Grant, Los Angeles County, on downstream side of Foothill Boulevard bridge, 4 miles east of San Fernando.

Basin characteristics

Area (A), square miles	21.1
Annual precipitation (P), in inches	27
Channel length (L), in miles	6.5
Channel slope (S), in feet per mile	212
Precipitation intensity (I), in inches per hour	5.0
Forest cover (F), in percent	92
Elevation greater than 5,000 feet (E), in percent	1.0
Evapotranspiration (T), in inches	57

Flood frequency (cubic feet per second)

2-year	192
5-year	761
10-year	1,550
25-year	3,850
50-year	5,840
[1]100-year	9,600

[1]From curve drawn from other frequency points.

Mean flow (cubic feet per second)

Annual	5.2
January	7.8
February	15.3
March	17.4
April	13.4
May	3.3
June	.9
July	.2
August	.1
September	.0
October	.1
November	2.6
December	7.4

Flood-volume frequency (average cubic feet per second for period)

	2-year	50-year
1-day	112	1,890
3-day	66.0	1,100
7-day	38.1	615
15-day	23.3	374

11098000 ARROYO SECO NEAR PASADENA, CALIF.

Location.--Lat 34°13'20", long 118°10'36", in NW¼NW¼NE¼ sec. 31, T. 2 N., R. 12 W., Los Angeles County, on right bank 1.5 miles upstream from Millard Canyon and 5.5 miles northwest of Pasadena.

Basin characteristics

Area (*A*), square miles	16.6
Annual precipitation (*P*), in inches	28
Channel length (*L*), in miles	11.5
Channel slope (*S*), in feet per mile	235
Precipitation intensity (*I*), in inches per hour	6.0
Forest cover (*F*), in percent	100
Elevation greater than 5,000 feet (*E*), in percent	12
Evapotranspiration (*T*), in inches	57

Mean flow (cubic feet per second)

Annual	4.6
January	6.9
February	14.5
March	16.8
April	11.0
May	3.0
June	1.5
July	.6
August	1.1
September	.9
October	.2
November	1.2
December	6.1

Flood frequency (cubic feet per second)

2-year	360
5-year	1,170
10-year	2,090
25-year	3,190
50-year	4,850
[1]100-year	7,600

Flood-volume frequency (average cubic feet per second for period)

	2-year	50-year
1-day	57.0	1,710
3-day	34.8	971
7-day	21.8	511
15-day	14.6	314

[1]From curve drawn from other frequency points.

11100000 SANTA ANITA CREEK NEAR SIERRA MADRE, CALIF.

Location.--Lat 34°11'30", long 118°00'59", in SW¼NE¼NE¼ sec. 10, T. 1 N., R. 11 W., Los Angeles County, on right bank at head of Hermits Falls, 0.9 mile upstream from Big Santa Anita Dam, and 3 miles northeast of Sierra Madre.

Basin characteristics

Area (A), square miles	9.7
Annual precipitation (P), in inches	33
Channel length (L), in miles	4.6
Channel slope (S), in feet per mile	671
Precipitation intensity (I), in inches per hour	7.0
Forest cover (F), in percent	101
Elevation greater than 5,000 feet (E), in percent	5.4
Evapotranspiration (T), in inches	58.5

Mean flow (cubic feet per second)

Annual	5.8
January	7.0
February	11.9
March	14.1
April	9.8
May	6.0
June	2.9
July	1.1
August	1.0
September	.8
October	.6
November	4.1
December	6.5

Flood frequency (cubic feet per second)

2-year	162
5-year	570
10-year	1,090
25-year	2,340
50-year	3,500
[1]100-year	5,100

Flood-volume frequency (average cubic feet per second for period)

	2-year	50-year
1-day	62.1	1,070
3-day	40.0	633
7-day	25.5	386
15-day	17.2	247

[1]From curve drawn from other frequency points.

11100500 LITTLE SANTA ANITA CREEK NEAR SIERRA MADRE, CALIF.

Location.--Lat 34°11'13", long 118°02'35", in SE¼SW¼NW¼ sec. 9, T. 1 N., R. 11 W., on right bank 1.3 miles upstream from Sierra Madre Dam and 2 miles north of Sierra Madre.

Basin characteristics

Area (*A*), square miles	1.84
Annual precipitation (*P*), in inches	35
Channel length (*L*), in miles	2.2
Channel slope (*S*), in feet per mile	892
Precipitation intensity (*I*), in inches per hour	7.0
Forest cover (*F*), in percent	101
Elevation greater than 5,000 feet (*E*), in percent	1.5
Evapotranspiration (*T*), in inches	55

Mean flow (cubic feet per second)

Annual	1.2
January	1.6
February	2.3
March	2.7
April	2.1
May	1.0
June	.6
July	.3
August	.2
September	.2
October	.2
November	.6
December	1.3

Flood frequency (cubic feet per second)

2-year	42.8
5-year	136
10-year	246
25-year	488
50-year	788
[1]100-year	1,150

Flood-volume frequency (average cubic feet per second for period)

	2-year	50-year
1-day	14.1	168
3-day	9.0	110
7-day	5.7	78.1
15-day	3.7	52.0

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[1]From curve drawn from other frequency points.

11101000 EATON CREEK NEAR PASADENA, CALIF.

Location.--Lat 34°11'37", long 118°06'13", in SW¼SE¼SE¼ sec. 2, T. 1 N., R. 12 W., on right bank at mouth of canyon just upstream from bridge on old Mount Wilson toll road, and 4.5 miles northeast of Pasadena.

Basin characteristics

Area (*A*), square miles	6.47
Annual precipitation (*P*), in inches	29
Channel length (*L*), in miles	5.8
Channel slope (*S*), in feet per mile	609
Precipitation intensity (*I*), in inches per hour	7.0
Forest cover (*F*), in percent	101
Elevation greater than 5,000 feet (*E*), in percent	11
Evapotranspiration (*T*), in inches	55.5

Mean flow (cubic feet per second)

Annual	2.4
January	3.1
February	6.5
March	7.5
April	4.5
May	2.0
June	1.1
July	.7
August	1.9
September	1.6
October	.3
November	.9
December	3.0

Flood frequency (cubic feet per second)

2-year	166
5-year	522
10-year	855
25-year	1,320
50-year	2,090
[1]100-year	2,500

Flood-volume frequency (average cubic feet per second for period)

	2-year	50-year
1-day	22.2	610
3-day	13.6	366
7-day	8.6	207
15-day	5.8	130

[1]From curve drawn from other frequency points.