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CALIFORNIA'S 1974-1975 WATER YEAR . . .

. . . was a "good" water year – good from the standpoint that the State's surface water resources were replenished abundantly and over a sufficiently long period of time to achieve an excellent water "harvest" with generally little inconvenience or hardship. This favorable situation allowed the Department of Water Resources to move ahead in planning the most advantageous use and management of the State's water resources to keep pace with the changing times.

To match the new developments in water resources management, this publication is also changing. Following a practice begun with the 1973 Edition, *Summary of Water Conditions in California,* (Bulletin No. 120-73) the present edition is being expanded to encompass more fully the water situation in the State. Within the major categories of precipitation, surface water, ground water, and water quality, long-term trends are emphasized. Information about specific topics, such as evaporative demand, changes in ground water levels in the San Joaquin Valley, flood insurance, and the quality of Clear Lake, is presented for each category. A special related topic, "Urban Water Use", is also included.

Water Conditions in the 1974-1975 Water Year

While this was a good year, the events that made it so unfolded slowly. The rain and snow that refill the State's surface and ground water reservoirs every year were late in arriving. Only about one-half the precipitation normally expected from November through January fell in that period. The deficiency that resulted was overcome in February, March, and April, however. Much of what fell in the latter weeks of this period was snow, which was accompanied by cooler-than-normal temperatures that lasted through the spring months. While some warm periods did occur, there were no prolonged "hot spells", and as a result, no major floods. (Heavy rainfall in some areas brought local flooding to lowlands; thunderstorms over desert regions caused flash flooding; and some early snowmelt resulted in minor flooding.) The cool temperatures delayed the planting and, primarily, harvesting of crops. Reservoir storage was above normal during the year and remained so at its close.

Ground water conditions, which do not readily respond to climatological variations because they change too slowly, were not altered materially from the previous year. Water levels in wells in central and southern California continued to decline, except where surface water supplies are being imported and the ground and surface supplies being managed. Correspondingly, the quality of the State's surface water supplies remained as good as or better than in prior years, and the ground water supplies were unchanged.

Water Planning and Management in 1974-1975

The year was also a good one from the standpoint of advances in the technical, institutional, and legal aspects of planning and management of the State's water resources. In the spring of 1975, the Department began work on its Water Action Plan. Created as a revision of the water management element of the California Water Plan, the Action Plan will concentrate on developing courses of action to find solutions to water-related issues that must be resolved now or in the near future. Recognizing that there are no absolute technical answers to these problems, the Department is searching for politically and socially responsible solutions that are consistent with today's social and environmental goals. The Water Action Plan will involve a strong conservation program and maximum use of existing water supplies in a manner that is consistent with good water management practice. Persons wishing to become involved in the Water Action Plan or desiring further information should contact the Department.

In the field of ground water resources management, a number of significant developments took place. Foremost among these were court decisions on three major cases involving ground water law, of which the case, *City of Los Angeles* v. *City of San Fernando*, is especially significant. In acknowledging the importance of "public interest" in the use of ground water and underground storage space, the courts have lifted time-worn legal barriers to the establishment of more rational planning for the management of the State's ground water resources.

Such decisions will lead to meaningful conjunctive use of surface and ground water supplies through deliberate efforts to achieve maximum beneficial use and conservation of the State's water resources. These efforts will involve use of underground storage space, as well as above-ground storage and delivery, including, where appropriate, deliberate, temporary over-drafting of a basin as part of a coordinated plan. The Department intends to "practice what it preaches" by taking advantage of ground water resources management opportunities. The Department and an Ad Hoc Committee of the Southern California Water Conference have cooperated in an examination of the possibility of operating ground water basins conjunctively with the State Water Project. The period being studied is the approaching six to eight years before buildup of deliveries to full schedule and an expected increase in power costs take place. A prototype program under development is envisioned to proceed as long as technically feasible beyond the early years of delivery. A similar activity is under examination in southern Kern County.

Another important event in Kern County was the execution of an agreement between the U. S. Bureau of Reclamation and the Department to "wheel" (transport) federal water through the Cross Valley Canal. The canal will deliver water to both federal and state project service areas. When deliveries begin next year, these will be the first federal water supplies guaranteed to be delivered in accordance with both federal and state water quality standards.

The Department released several milestone publications dealing with a variety of subjects during the year.

These were:

Bulletin No.	
63-5	*Sea-Water Intrusion: Inventory of Coastal Ground Water Basins* . October 1975. (The first report on this subject for the entire coast since 1957.)
118	*California's Ground Water* . September 1975. (The first comprehensive publication dealing with ground water on a statewide basis.)
160-74	*The California Water Plan — Outlook in 1974* . November 1974. (The third update since the California Water Plan was issued in 1957. For the first time, key water issues are discussed and a range of predictions made for California.)
166-2	*Urban Water Use in California* . October 1975. (Statistics on water use for the decade 1960-1970.)
190	*Water and Power from Geothermal Resources in California* . December 1974. (First comprehensive report on geothermal development.)
192	*Plan for Improvement of the Delta Levees* . May 1975. (Proposals to benefit the entire Sacramento-San Joaquin Delta and reduce the expenditure of public funds for flood damage repair.)
193	*Desalting Alternatives in Ten California Communities* . December 1974. (An assessment of desalting techniques that might be used to provide good quality water for isolated communities.)
200	*California State Water Project* . November 1974. (In six volumes; four were issued in 1975. A history of the planning, financing, design, construction, and operation of the California State Water Project to the present.)

The term "water year", which appears throughout this publication, means a 12-month period that begins October 1 and ends September 30. It is used in California and other western states to describe water events within the natural calendar in which they occur. Normally, in California, October 1 marks the transition from typically dry to typically rainy conditions. At the same time, crops have been or are being harvested, and the agricultural use of water, estimated to be 85 percent of the total used in the State, has diminished. Reservoirs have also been drawn down to their lowest levels to meet all demands. Thus the October 1-September 30 period provides the soundest framework in which to account for the condition of water supplies.

Further information about data and related material presented in this report is available in the Department's Division of Planning and in the District Offices, whose locations are listed on the back cover.

The Department also issues reports on water conditions and water supply forecasts in February, March, April, and May each year as part of the Bulletin No. 120 series.

PRECIPITATION

PRECIPITATION CONDITIONS

EVAPORATIVE DEMAND

Precipitation is the deposit of rain, snow, hail, sleet, or mist on the earth. And, as is the case here, the term is used to refer to the quantity of water deposited, no matter in which of these forms it reaches the earth's surface. For example, to make use of information about snowfall, the quantity of snow must be converted into the volume of water that fell.

Precipitation falling on the Sierra Nevada

PRECIPITATION CONDITIONS

Considering the State as a whole, the amounts of rain and snow that fell on California from October 1974 through September 1975 were typical of most years. This precipitation was distributed in a characteristic pattern that varied from just below normal in southern California south of the Tehachapi Mountains to slightly above normal in the rest of the State. Figures 1 and 2 depict this distribution in percent of normal and in inches.

Persistent high barometric pressures throughout the State dominated the weather pattern through the customarily wet period, November through January, yielding only about half the precipitation usually expected. By the end of January, the seasonal accumulation was only 65 percent of normal. This drought was finally broken by vigorous cyclonic activity over the Pacific Ocean that brought heavy precipitation to the State during February and March, thus compensating for the deficiency of the previous months.

Storms diminished over most of the State in mid-spring. May was the driest month of the season, with precipitation measuring only 20 percent of normal.

A widespread two-day storm in August showered the Central Valley and drenched the Sierra Nevada. Blue Canyon precipitation station, situated in the Sierras in Placer County, received a record total of 3.1 inches (7.9 centimetres), more than 15 times the usual amount for that month.

September precipitation fell only in the southern portion of the Sierra Nevada and the Lahontan hydrologic area in eastern California. Bishop, lying in Owens Valley at the northern end of Inyo County, received 1.18 inches (3 cm), about 650 percent of normal. This was the greatest total amount ever to fall at that site in any September.

The wettest spot in the State was the Blue Creek Mountain precipitation station in the Klamath River drainage basin, which had a 12-month total of 121.97 inches (310 cm). Daggett, in the Mojave Desert, was the driest location. It received only 1.56 inches (4 cm) for the entire year.

Figure 3 compares the 1974-1975 precipitation at eight cities with that which fell there in previous years. This 55-year record also demonstrates the differences in precipitation from north to south and west to east.

The late-season storms in March and April delayed accumulation of the peak snowpack. Most mountain areas did not reach their maximum values until around May 1, about a month later than usual. Snow sampling surveys showed that snow-stored water was about 135 percent of normal for the State on April 1. By May 1, this value had increased to 145 percent.

The April 1 water content of snow in the Sierra Nevada watersheds that drain to the Central Valley ranged from about 90 percent of normal for the Kern River Basin to about 180 percent for the Feather River Basin. These values had risen about 10 to 15 percent by May 1. A similar increase occurred in the watersheds of the Lahontan area. Snowpack water content in the North Coastal area was 170 percent of normal on April 1 and remained unchanged on May 1.

The extent of the Sierra snowpack on April 1, 1975, appears in Figure 4, and the water content of accumulated snowpack, in Figure 5.

FIGURE 1. PRECIPITATION IN PERCENT OF NORMAL

1974-1975

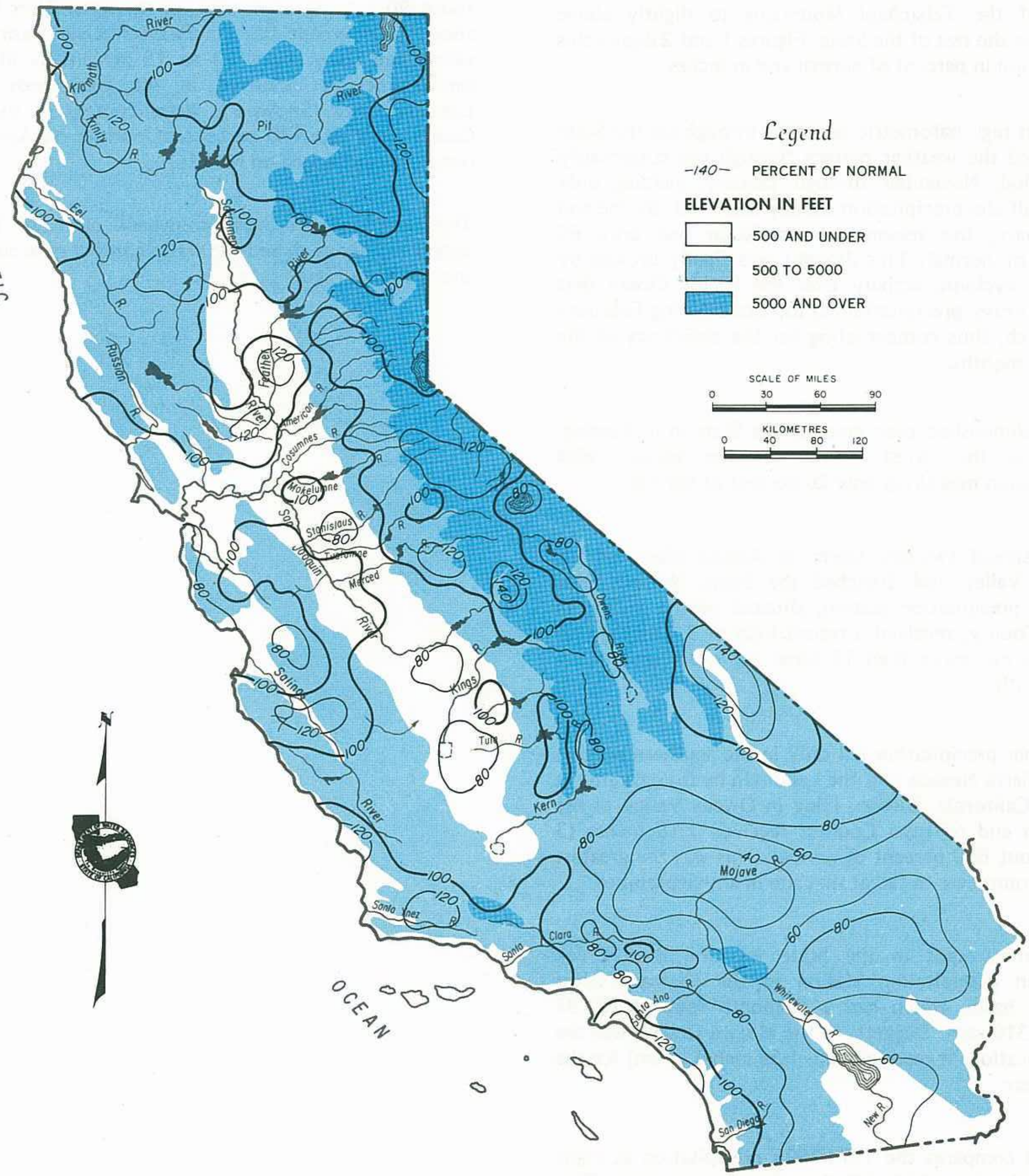


FIGURE 2. PRECIPITATION IN INCHES
1974 - 1975

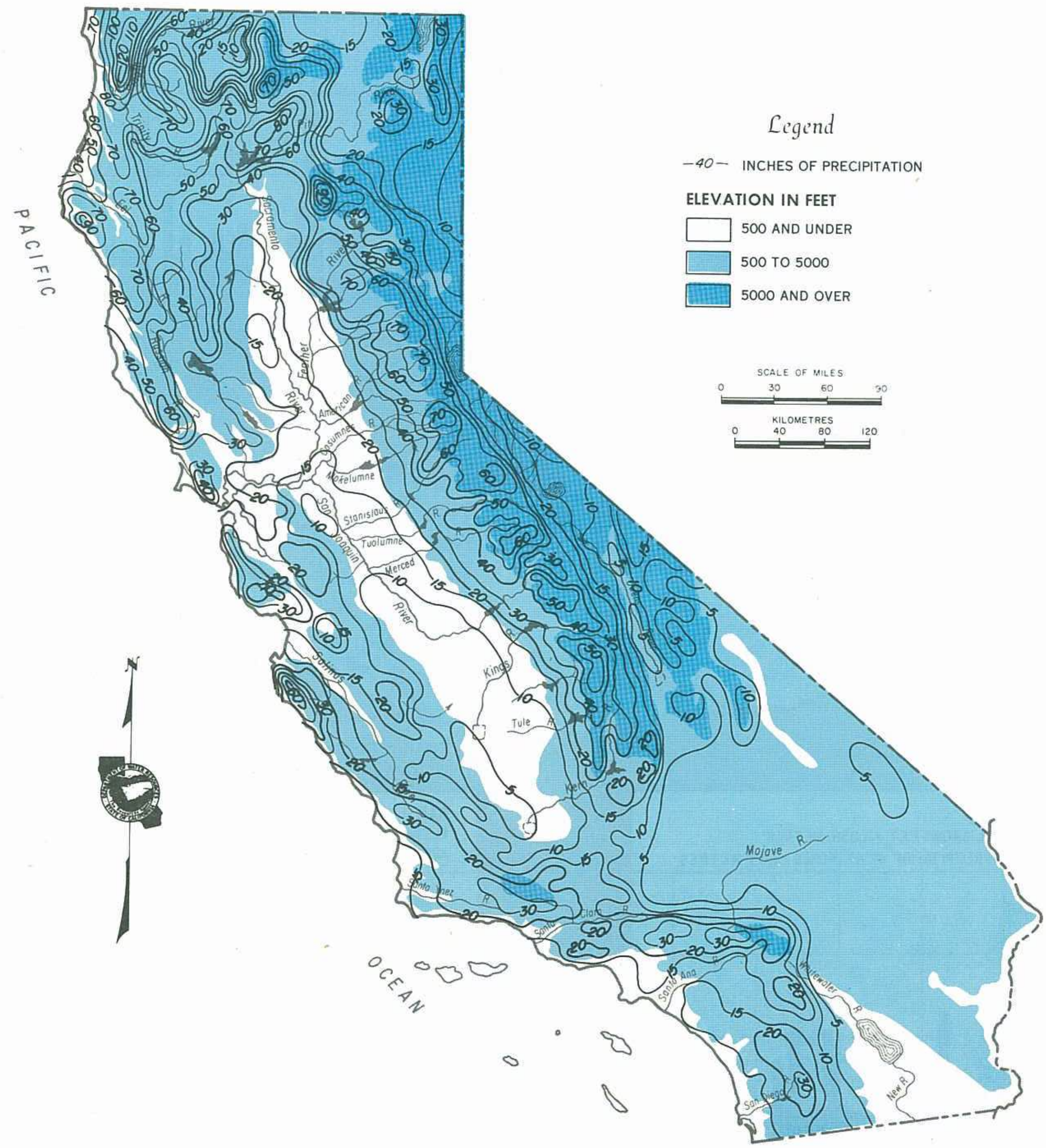
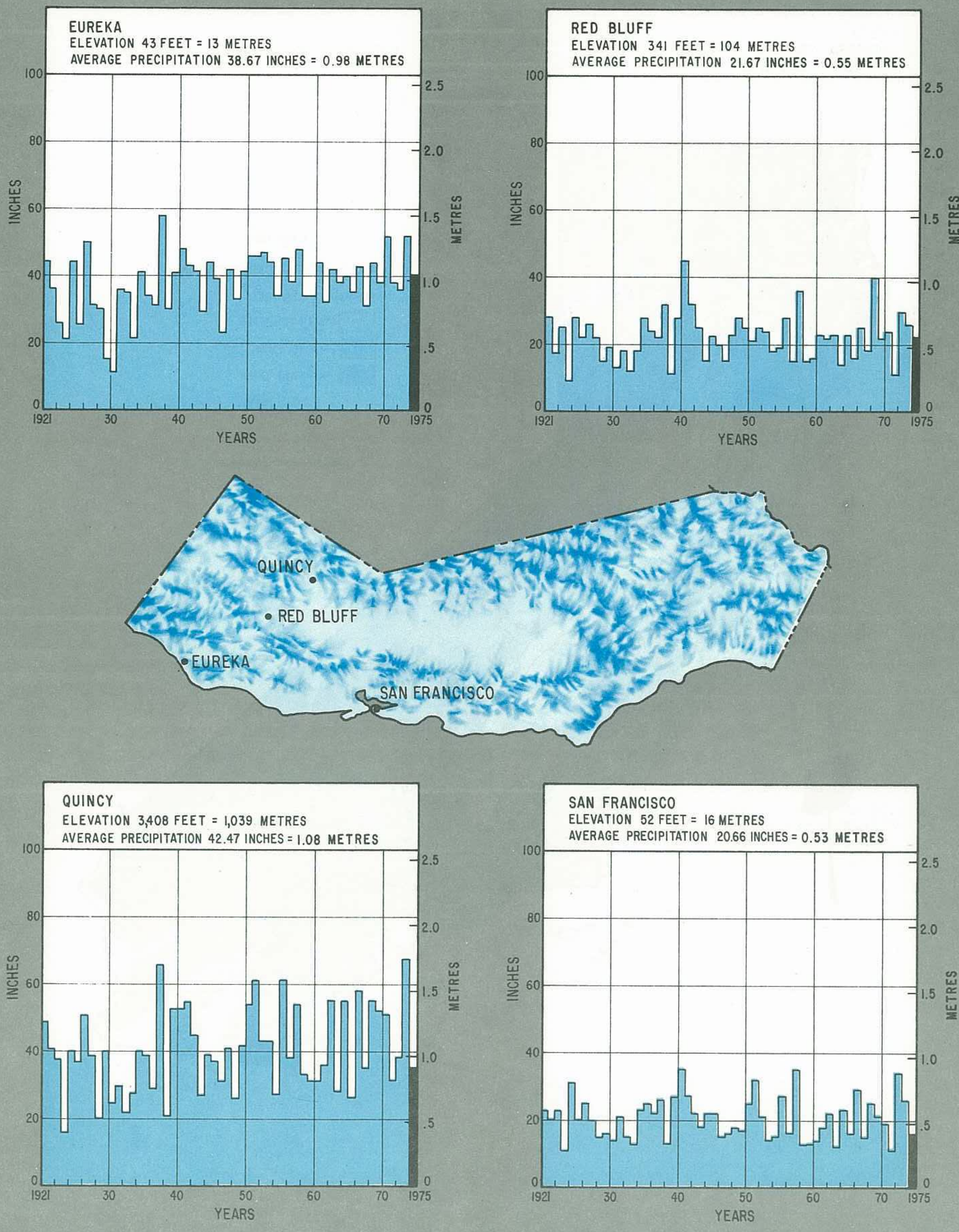
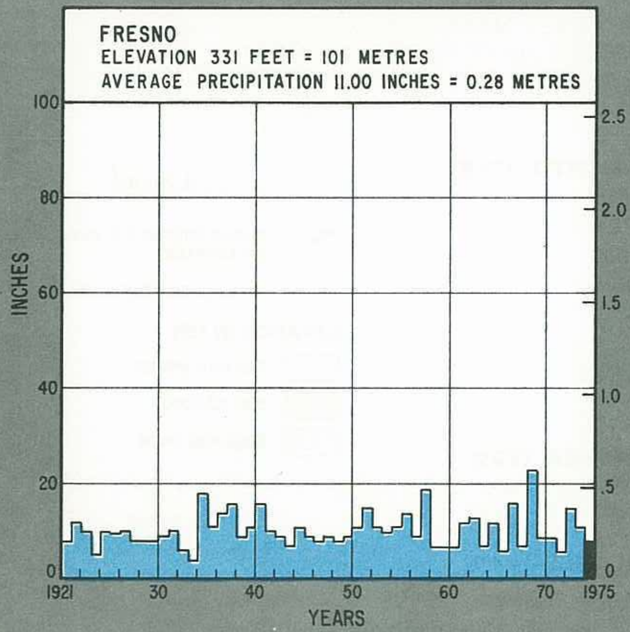
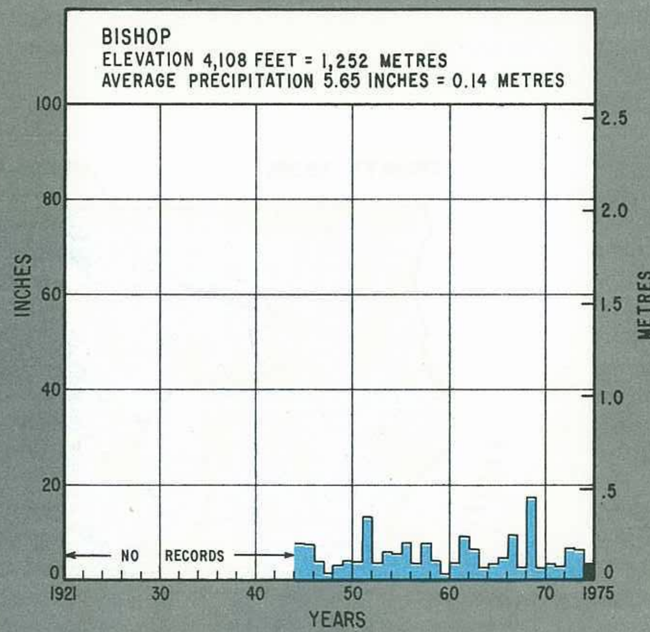


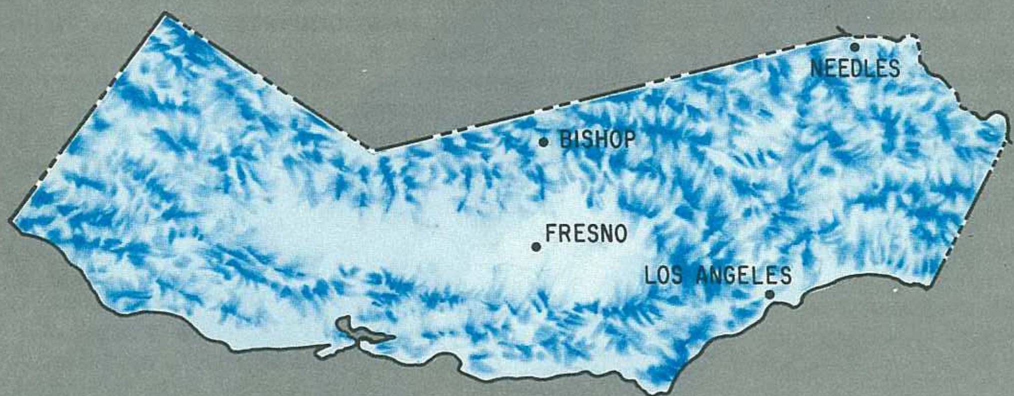
FIGURE 3. ANNUAL VARIATION IN

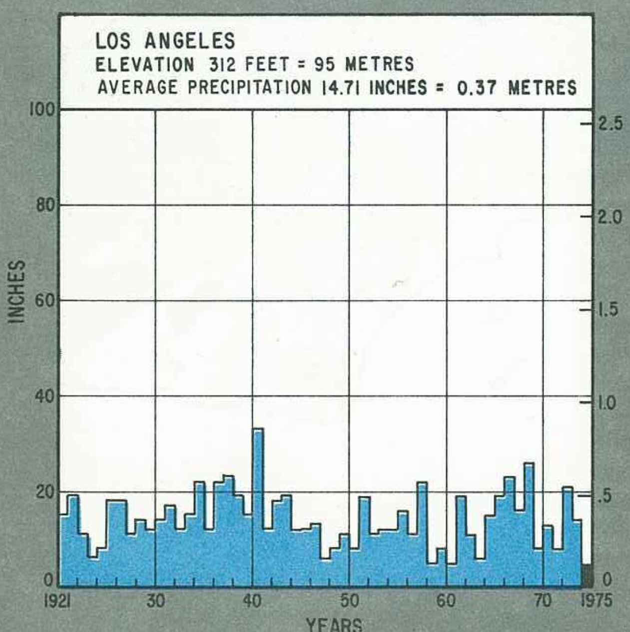


PRECIPITATION AT SELECTED CITIES









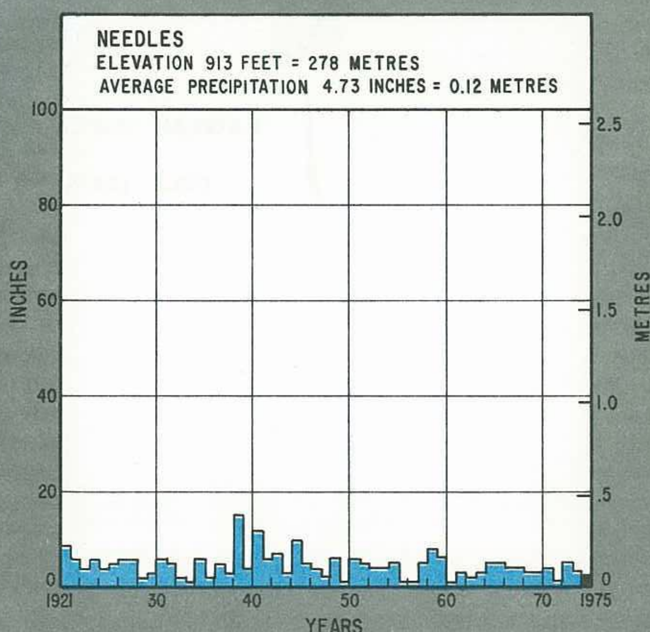


FIGURE 4. SNOWPACK ON APRIL 1, 1975, IN PERCENT OF AVERAGE

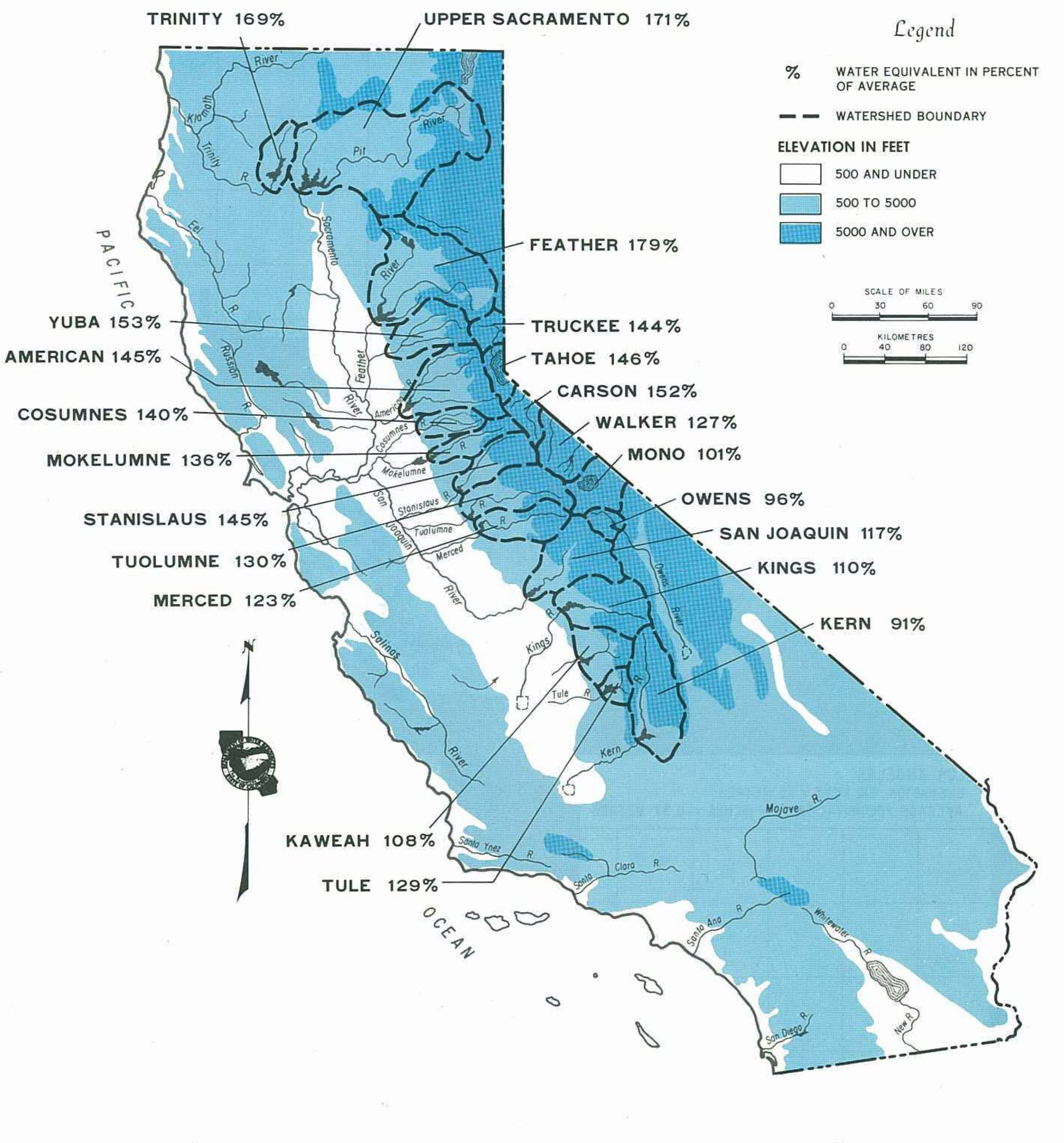
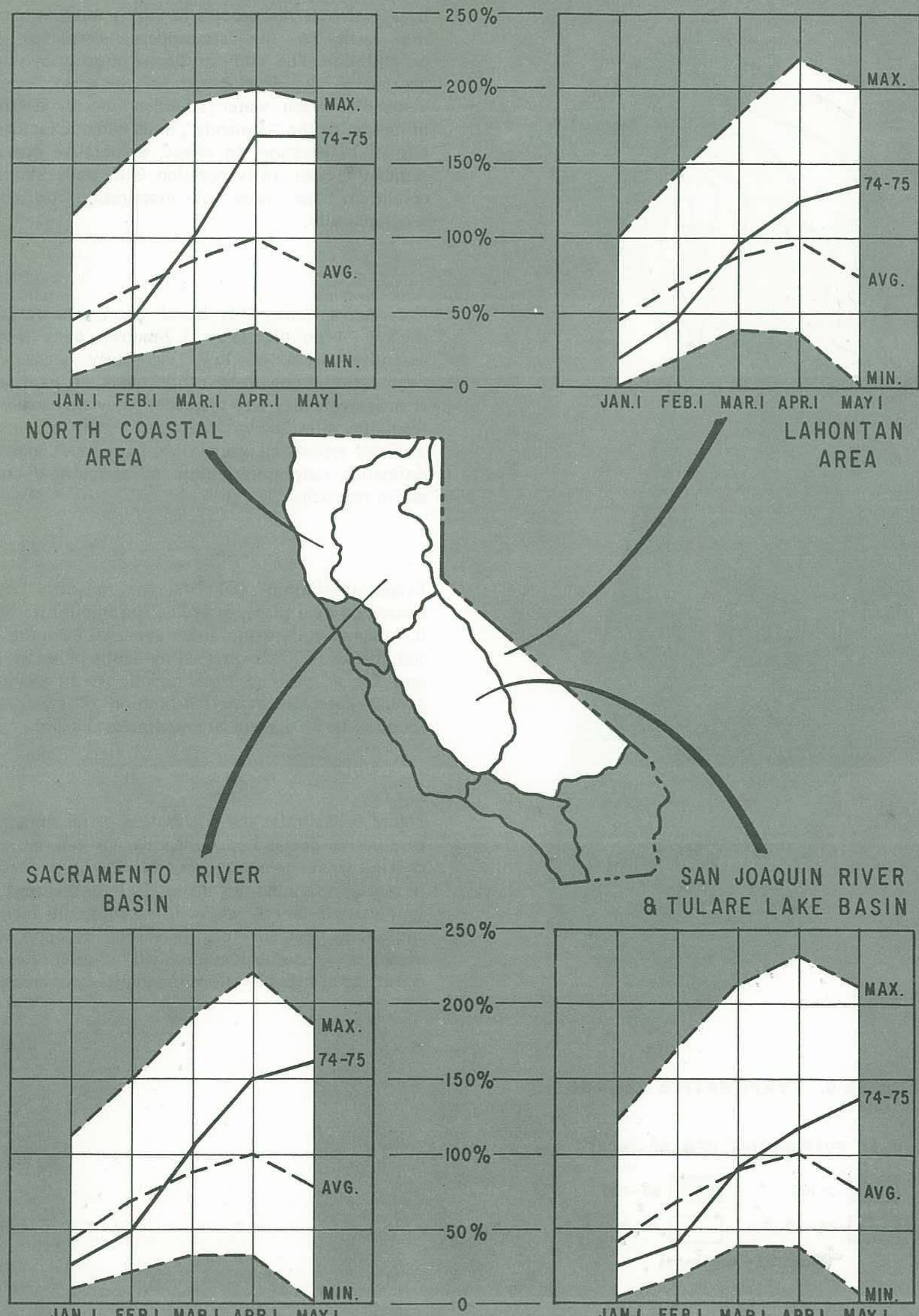


FIGURE 5. WATER CONTENT OF SNOWPACK ACCUMULATION IN PERCENT OF APRIL 1 AVERAGE



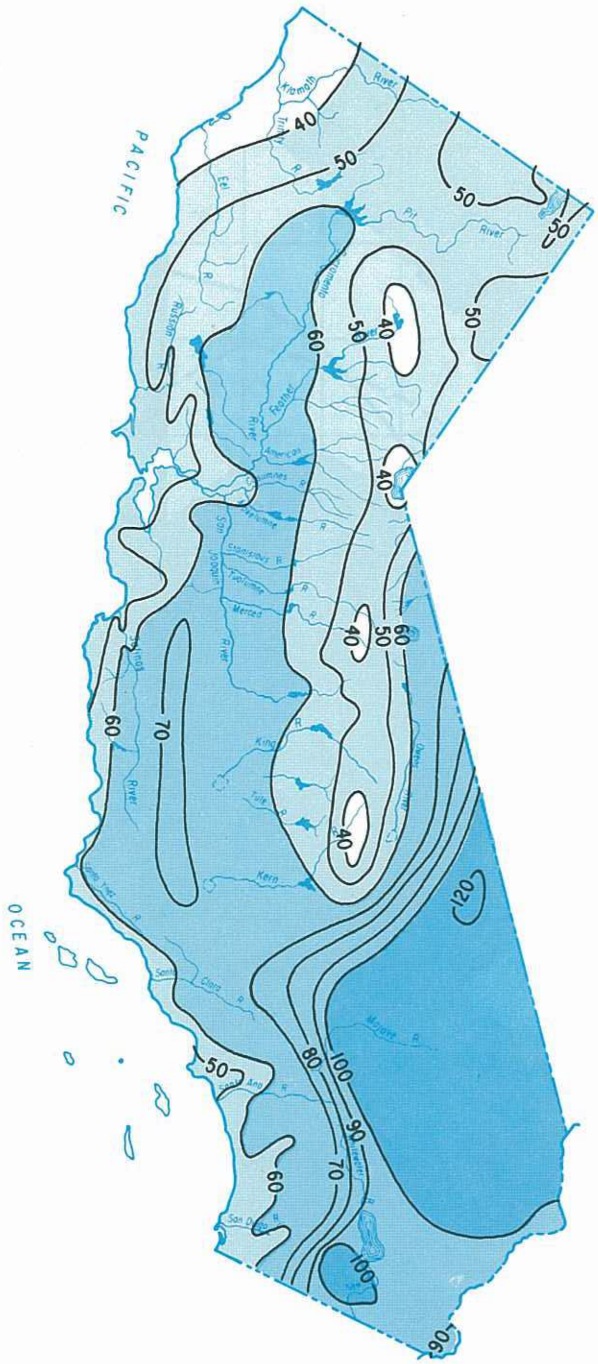


FIGURE 6. EVAPORATIVE DEMAND

ANNUAL EVAPORATIVE DEMAND-INCHES

- > 100
- 60 - 100
- 40 - 60
- < 40

I Inch = 2.54 Centimetres

EVAPORATIVE DEMAND

Evaporation is the process in which water returns from the earth to the atmosphere, there to become precipitation. The study of the use of water by vegetation has led to the development of the term "evaporative demand", which water scientists use to describe the influence, or the "demands", of all climatic factors on the rate of evaporation. In effect, evaporative demand is a standard measure of evaporation. Only under standardized conditions can rates of evaporation be compared geographically.

Evaporative demand is based upon evaporation from shallow 4-foot-diameter (1.2-metre) pans located in extensive areas of low, vigorously growing grass. Evaporation rates from other types of pans in other environments may vary markedly (they are usually higher) from the rates shown. Evaporative demand serves as a basis for estimating evaporation from small lakes and for estimating evapotranspiration of agricultural crops and native vegetation.

Evapotranspiration (ET) is the quantity of water consumed by a plant, including the amount transpired by it, retained in its tissue, and evaporated from the adjacent soil surface. ET is expressed as depth of water per unit area for a specified time period. As an example, the annual potential evapotranspiration of grass has been found to be 80 percent of evaporative demand.

Figure 6 illustrates the distribution of the annual rate of evaporative demand in California. As can be seen, the demand triples as one moves from the north coast, where it measures around 35 inches (90 centimetres), to the southeastern desert, where it exceeds 100 inches (250 cm). This pattern of increasing evaporation from northwest to southeast is modified by lower rates near the ocean and at high elevations in mountainous areas.

SURFACE WATER

SURFACE WATER CONDITIONS

WATER TRANSFERS AND OUTFLOW

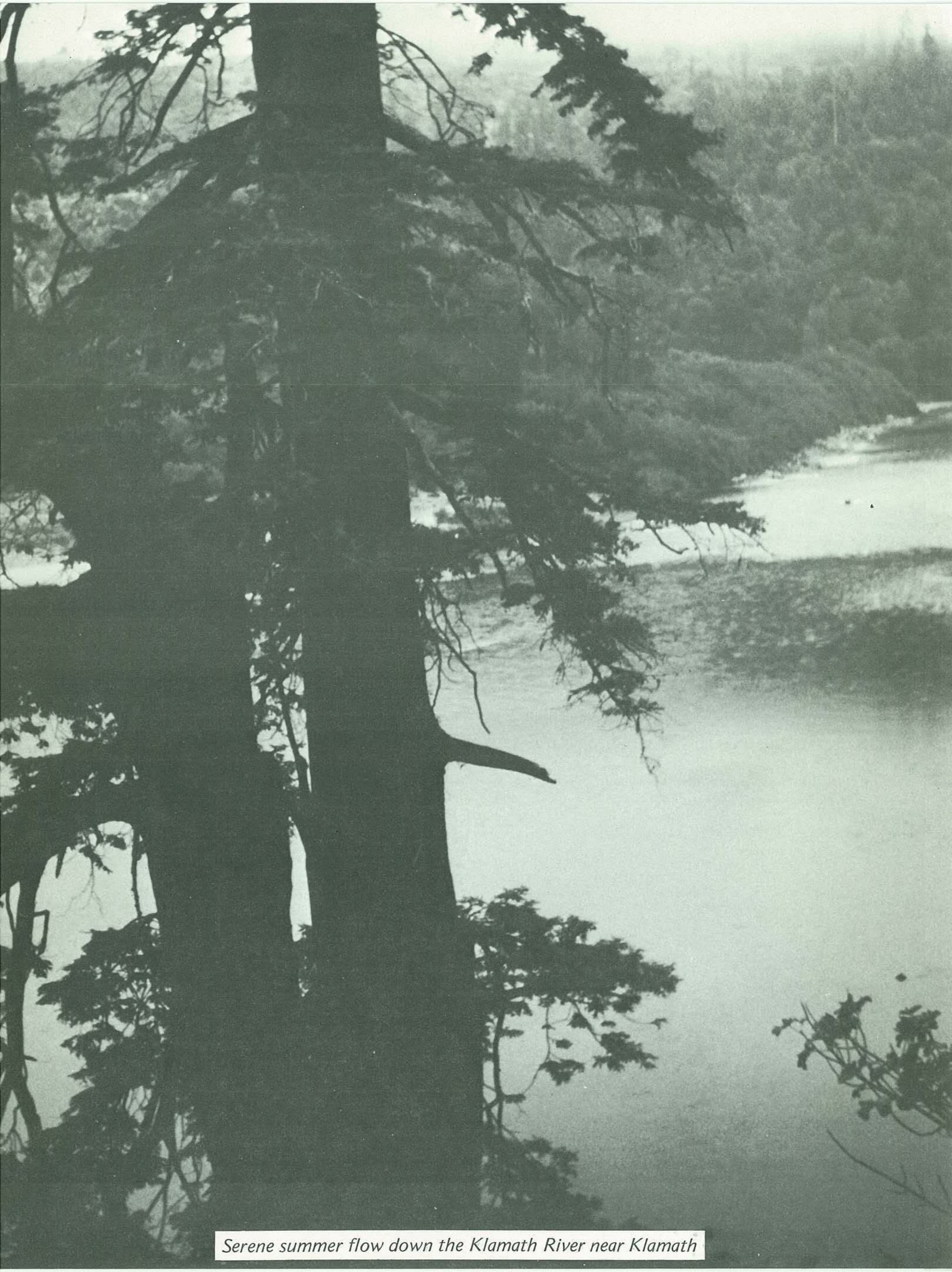
FLOOD FLOWS

FLOOD INSURANCE

RESERVOIR STORAGE

WASTE WATER

When precipitation in any form falls, some is taken up by vegetation and some enters the ground surface on its way underground, but the bulk of it runs off the surface to form streams or fill lakes. Such water is called surface water. Included in this section are discussions of various aspects of surface water movement and storage.



Serene summer flow down the Klamath River near Klamath

SURFACE WATER CONDITIONS

Runoff during the 1974-1975 water year was average or higher in most of the State, except for the coastal basins and desert areas of southern California where the values were lower than normal (Figure 7). North and Central Coastal hydrologic area streams had the highest values – 125 to 130 percent of normal, while those of the South Coastal area averaged only 80 percent of normal. Flows in the major streams of the Central Valley were generally above average, except for the Kaweah, Tule, and Kern Rivers in the southern San Joaquin Valley, where flows were in the 80 to 95 percent range.

Natural runoff is reported as streamflow and other drainage from a watershed in which there are no artificial obstructions such as dams to impede the flow. One example is the inflow to Lake Shasta on the upper Sacramento River, where runoff in that region is calculated as if there were no irrigation diversions and no water held in storage for the generation of hydroelectric power upstream from the lake. By omitting the effects of internal transfers of water, water development forecasters and planners are able to determine readily the water "crop" that is being produced in each drainage basin. Actual flows are recorded at many locations and the results used later to confirm forecasts and to study the internal workings of streams in the major hydrologic areas of the State. Natural runoff data for the 1974-1975 water year are listed to the right. More detailed data are presented in Table 1.

In terms of percent of normal, the runoff from melting snow from April to July for streams flowing into the Central Valley, North Coast, and Lahontan areas appears to have been somewhat higher than the total water year runoff. April-July snowmelt flows ranged from 120 percent of normal in the San Joaquin Valley to 145 percent in the North Coastal area. Sacramento Valley and Lahontan area streams were about 130 percent of normal. The start of snowmelt runoff was delayed about a month by late season storms and cool temperatures, but, by mid-June, flow rates had progressed into a normal pattern. Annual variation in runoff since 1921 for eight streams is shown in Figure 8.

Although down about 600,000 acre-feet (740.1 cubic hectometres) from last year, statewide reservoir storage at the close of the water year was still 110 percent of normal. This was more than 2 million ac-ft (2,467 hm^3) above the normal level for October 1. Interstate storage projects on the Colorado River were storing 140 percent of normal, 5 percent above the 1973-1974 water year, which was a gain of about 3 million ac-ft (3,700.5 hm^3). (Reservoir storage is discussed more fully on page 29.)

NATURAL RUNOFF BY AREA

HYDROLOGIC AREA	WATER YEAR NATURAL FLOW IN PERCENT OF NORMAL
North Coastal	125
San Francisco Bay	100
Central Coastal	130
South Coastal	80
Central Valley	
Sacramento Basin	110
San Joaquin and Tulare Lake Basins	105
Lahontan	110
ENTIRE STATE	115

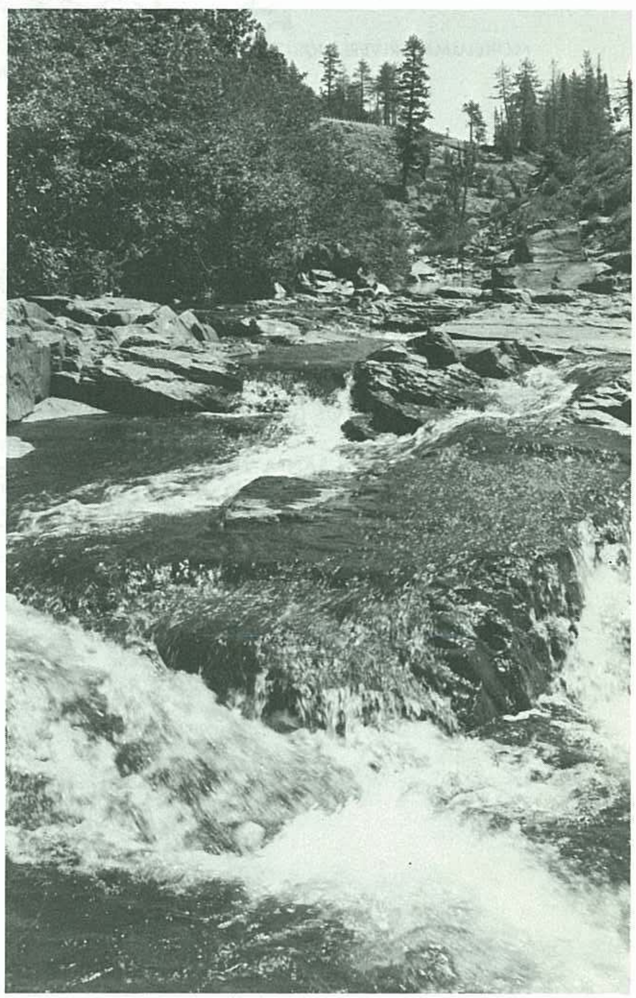


FIGURE 7. NATURAL RUNOFF, 1974-1975

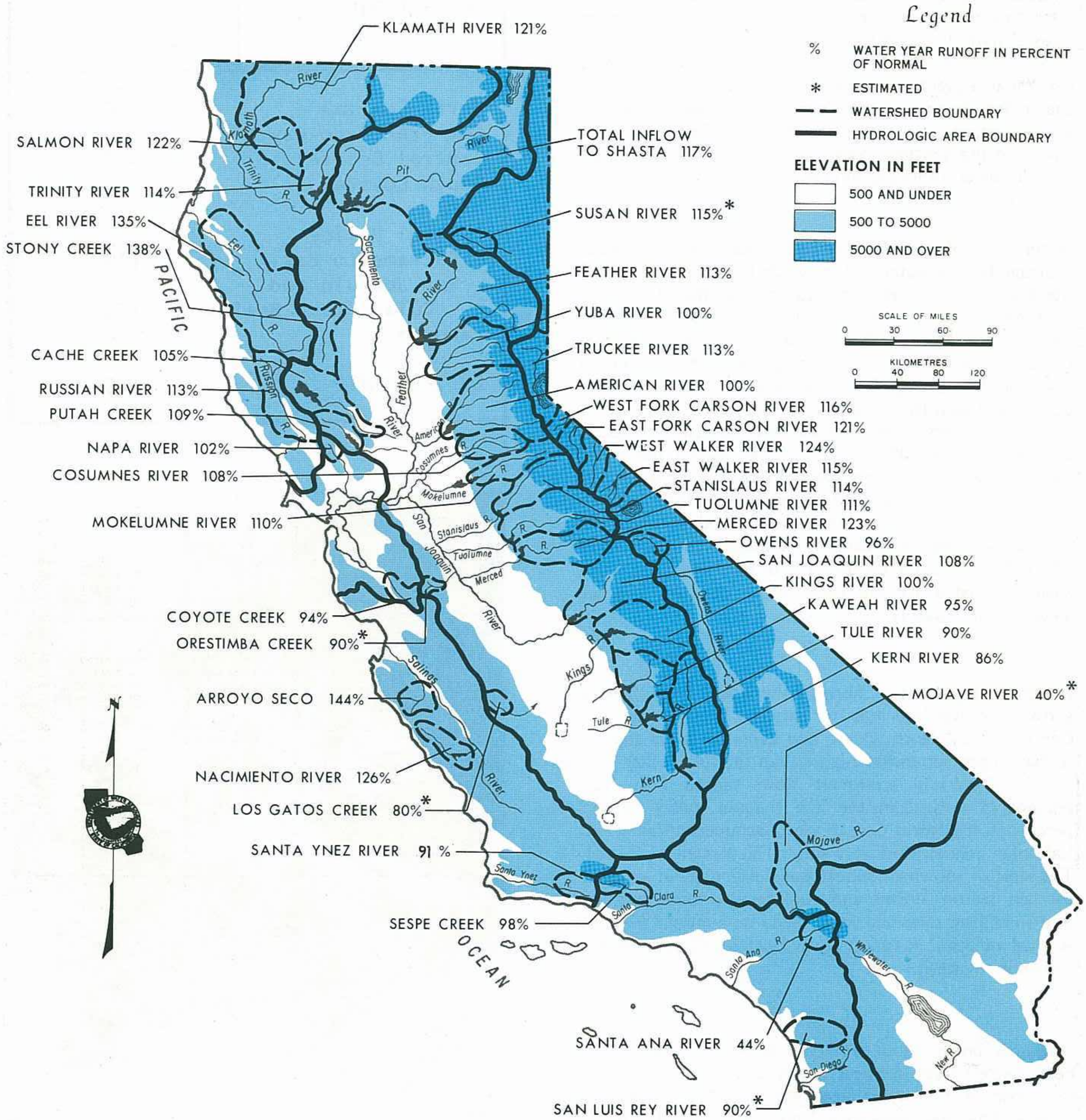
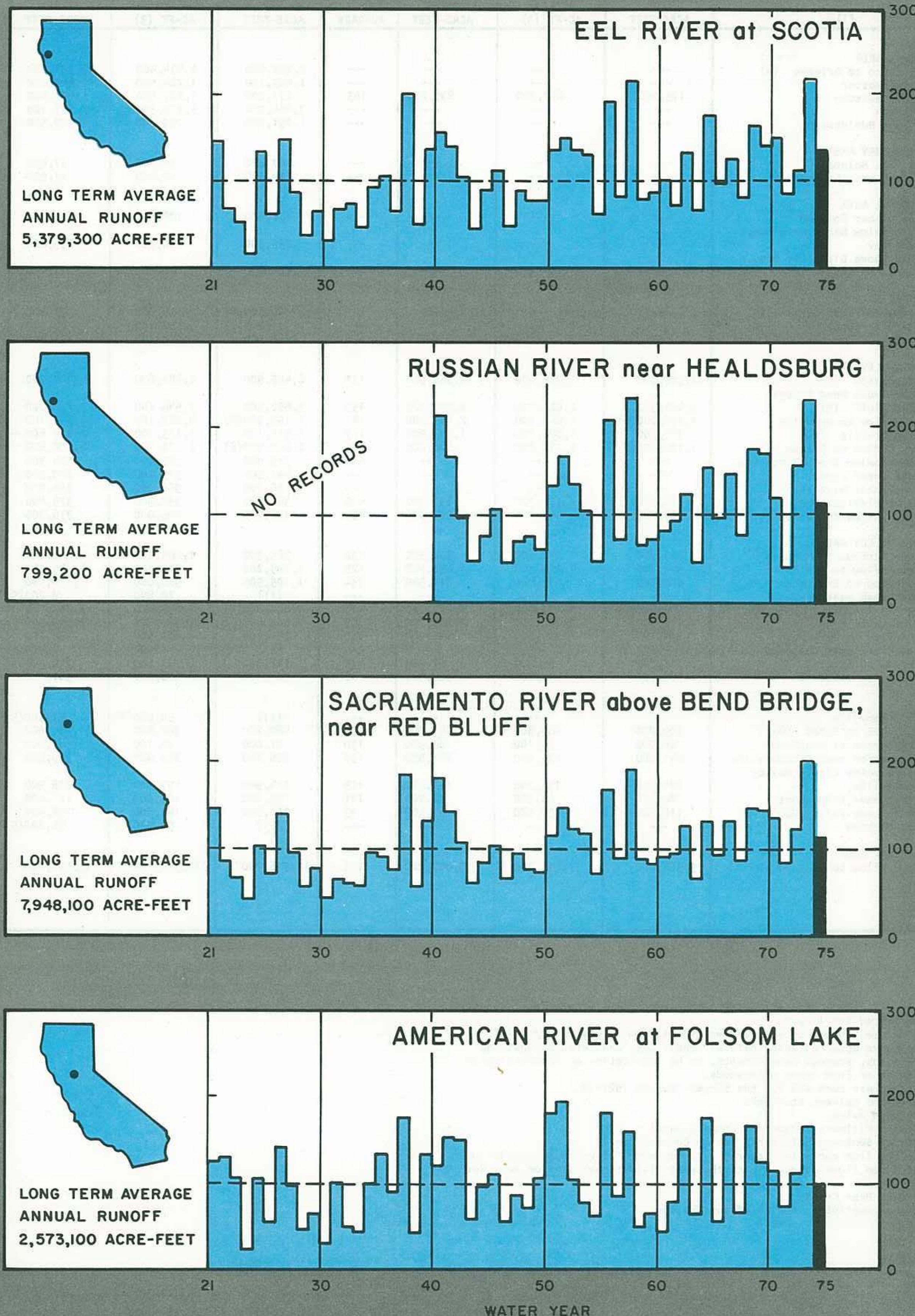


TABLE 1. STREAMFLOW DATA FOR SELECTED STREAMS

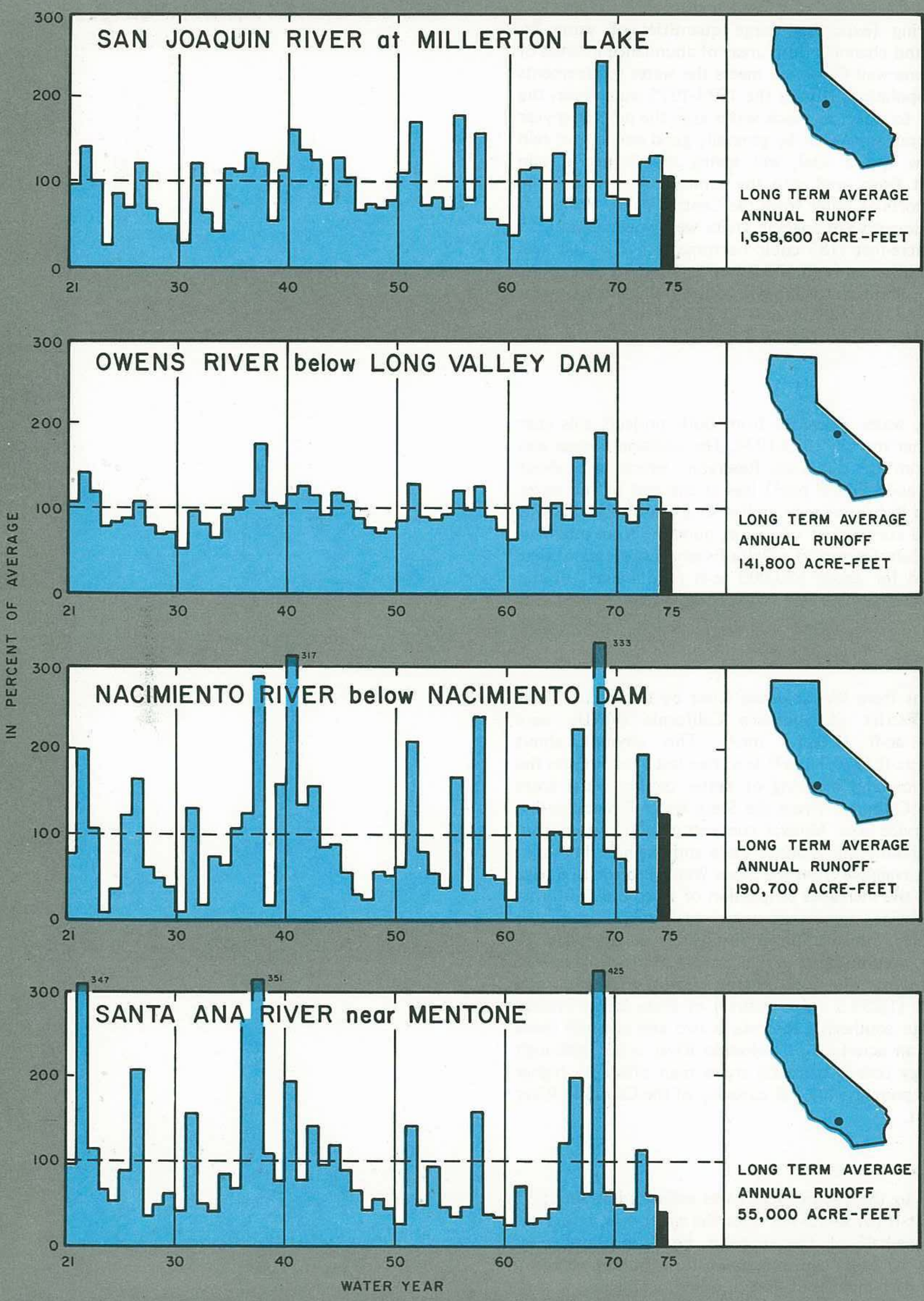
AREA, STREAM, AND STATION (1)	SNOWMELT PERIOD APRIL 1, 1975 - JULY 31, 1975 MEASURED FLOW ACRE-FEET	NATURAL RUNOFF (2) 50-YEAR AVERAGE AC-FT (3)	NATURAL RUNOFF (2) PERIOD TOTAL ACRE-FEET	NATURAL RUNOFF (2) PERCENT OF AVERAGE	WATER YEAR OCTOBER 1, 1974 - SEPTEMBER 30, 1975 MEASURED FLOW ACRE-FEET	NATURAL RUNOFF (2) 50-YEAR AVERAGE AC-FT (3)	NATURAL RUNOFF (2) ANNUAL TOTAL ACRE-FEET	NATURAL RUNOFF (2) PERCENT OF AVERAGE
NORTH COASTAL AREA								
Klamath, Copco to Orleans (4)	---	---	---	---	5,258,000	4,434,400	5,351,000	121
Salmon at Somesbar	---	---	---	---	1,495,100	1,224,500	1,495,100	122
Trinity at Lewiston	175,200	617,300	895,200	145	271,200	1,227,400	1,402,000	114
Eel at Scotia	---	---	---	---	7,064,300	5,379,300	7,237,100	135
Russian near Healdsburg	---	---	---	---	1,051,800	799,200	902,500	113
SAN FRANCISCO BAY AREA								
Napa near St. Helena	---	---	---	---	67,800	66,500	67,800	102
Coyote Creek near Madrone	---	---	---	---	34,300	45,400	42,900	94
CENTRAL COASTAL AREA								
Arroyo Seco near Soledad	---	---	---	---	156,600	108,500	156,600	144
Nacimiento below Nacimiento Dam, near Bradley	---	---	---	---	235,500	190,700	239,600	126
Santa Ynez above Gibraltar Dam, near Santa Barbara	---	---	---	---	33,600	40,800	37,100	91
SOUTH COASTAL AREA								
Sespe Creek near Fillmore	---	---	---	---	75,300(6)	76,900	75,300	98
Santa Ana near Mentone	---	---	---	---	31,900(7)	55,000	24,400	44
San Luis Rey at Oceanside	---	---	---	---	8,000	38,200	34,500(5)	90(5)
SACRAMENTO VALLEY AREA								
Inflow to Shasta (8)	2,368,900	1,776,600	2,368,900	133	6,405,900	5,481,600	6,405,900	117
Sacramento above Bend Bridge, near Red Bluff (9)	3,462,300	2,421,700	3,223,100	133	9,892,300	7,948,100	9,212,000	116
Feather, inflow to Oroville	1,136,000(8)	1,862,300	2,633,500	141	3,197,300(8)	4,287,100	4,854,100	113
Yuba at Smartville (10)	712,500	1,081,500	1,377,900	127	1,911,100	2,273,700	2,271,600	100
American, inflow to Folsom	1,126,100(8)	1,320,800	1,648,000	125	2,669,900(8)	2,573,100	2,570,800	100
Stony Creek below Black Butte Dam	---	---	---	---	519,900	387,000	534,300	138
Cache Creek near Capay	---	---	---	---	447,900	515,000	540,200	105
Putah Creek near Winters	---	---	---	---	336,700	360,000	394,000	109
Cosumnes at Michigan Bar	188,700	131,700	191,300	145	363,800	350,900	379,400	108
Mokelumne, inflow to Pardee	419,700	465,700	605,000	130	758,700	705,000	776,300	110
SAN JOAQUIN VALLEY AREA								
Stanislaus, inflow to Melones	343,900	717,400	932,300	130	585,100	1,085,300	1,240,400	114
Tuolumne, inflow to Don Pedro	941,800	1,194,500	1,490,500	125	1,795,200	1,791,300	1,993,100	111
Merced, inflow to Exchequer	600,500	607,800	816,900	134	1,105,500	920,000	1,134,500	123
Orestimba Creek near Newman	---	---	---	---	(11)	10,800	9,700(5)	90(5)
San Joaquin, inflow to Millerton	1,097,800(8)	1,192,700	1,413,000	118	1,824,800(8)	1,658,600	1,795,600	108
Kings, inflow to Pine Flat	1,117,400	1,162,100	1,265,700	109	1,552,400	1,567,600	1,559,900	100
Kaweah, inflow to Terminus	297,600	269,800	296,000	110	384,200	402,500	382,200	95
Los Gatos Creek near Coalinga	---	---	---	---	(11)	3,000	2,400(5)	80(5)
Tule, inflow to Success	68,800	59,200	67,400	114	122,300	133,300	120,500	90
Kern, inflow to Isabella	379,700	419,800	368,400	88	561,700	626,600	541,400	86
LAHONTAN AREA								
Susan at Susanville	---	---	---	---	(11)	50,000(5)	57,500(5)	115(5)
Truckee, Tahoe to Farad (4)	309,000	263,800	367,900	139	482,200	380,800	431,600	113
West Fork Carson at Woodfords	66,500	51,100	66,500	130	81,000	70,100	81,000	116
East Fork Carson near Gardnerville	241,800	181,500	241,800	133	300,800	247,900	300,800	121
West Walker below Little Walker near Coleville	184,100	142,700	184,100	129	218,900	177,100	218,900	124
East Walker near Bridgeport	80,200	60,300	72,700	121	123,000	105,600	121,600	115
Owens below Long Valley Dam	116,100	59,500	55,500	93	261,800	141,800	136,400	96
Mojave at Barstow	---	---	---	---	(11)	90,000(5)	36,000(5)	40(5)
COLORADO DESERT AREA								
Colorado, inflow to Lake Powell	9,368,000	7,636,800	10,407,000	136	13,916,000	11,314,200	13,577,000	120

(1) Reservoir inflow data are based on observed flows at stations downstream from listed facility.
(2) The natural runoff of a stream at any station is the runoff which would have occurred under natural conditions, unaltered by upstream diversions, storage developments, or by exportation or importation of water to or from other watersheds.
(3) Averages are computed for the 50-year period 1921-70.
(4) Accretions between stations.
(5) Estimated value.
(6) Includes Fillmore Irrigation Company canal.
(7) Includes Southern California Edison Company canal.
(8) Computed from operating records -- unadjusted for upstream regulation.
(9) Unimpaired flows compatible to those at discontinued station near Red Bluff.
(10) Includes Deer Creek.
(11) Data not available at time of publication.

FIGURE 8. ANNUAL NATURAL



RUNOFF AT SELECTED STATIONS



WATER TRANSFERS AND OUTFLOW

Transferring (exporting) large quantities of water by streams and channels from areas of abundance to areas of need is one way California meets the water requirements of its population. During the 1974-1975 water year, the necessity to divert as much water as in the preceding year was lowered somewhat by generally good amounts of rain and snow and a cool, wet spring that helped sustain snowmelt flows well into the summer. As a result, the total exports of water from the Central Valley Project at the Sacramento-San Joaquin Delta were down about 0.15 million acre-feet (185 cubic hectometres) from last year to 2.5 million ac-ft (3,083.8 hm^3). Total water exports from the State Water Project at the Delta this past year were about 1.4 million ac-ft (1,712.9 hm^3), which was about 500,000 ac-ft (616.8 hm^3) less than the year before.

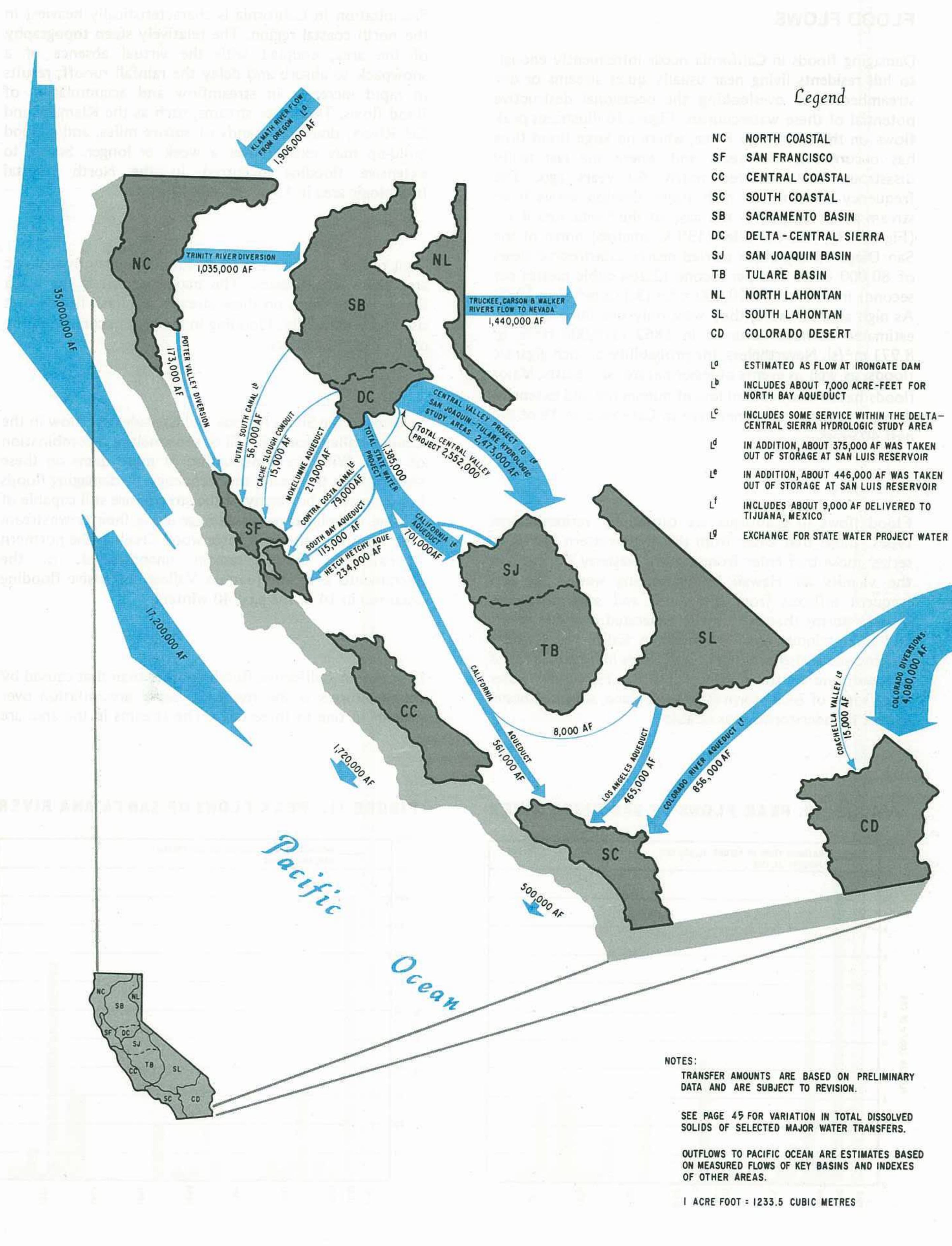
However, water deliveries from both projects this year were higher than in 1973-1974. The additional water was taken from the San Luis Reservoir, which held about 800,000 ac-ft (986.8 hm^3) less at the end of the water year than it did one year earlier. One reason for this was scheduled curtailment of export pumping from mid-May through July (as part of a Delta fishery test program) that accounted for about 580,000 ac-ft (715.4 hm^3) of the reduction. The reservoir is expected to be refilled this winter.

Diversions from the Colorado River by the Metropolitan Water District of Southern California (MWD) were 880,000 ac-ft (1,085.5 hm^3). This amount, about 300,000 ac-ft (370.1 hm^3) less than last year, reflects the substitution and blending of better quality water from northern California (from the State Water Project) in the MWD service area. Mineral concentration of water from the Colorado River is about three and one-half times that of water available from the State Water Project (see page 45), and the increased proportion of northern California water provides significant water quality benefits to the water users. Substitution of this better quality water is, however, accomplished at the expense of increased energy consumption. The net energy required to lift one acre-foot (1,233.5 cubic metres) of State Water Project water into southern California is two and one-half times that for an acre-foot of Colorado River water, although the energy cost is currently more than offset by higher rates for pumping the full capacity of the Colorado River Aqueduct.

Outflow to the Pacific Ocean was estimated at about 55 million ac-ft (67,842.5 hm^3) for the water year, which was about one-half of the previous year's outflow. This estimate is based on measured flow in key streams, together with indexes of flow at other locations.

Major water transfers between the various hydrologic areas, inflows to the State, and outflows to the Pacific Ocean and Nevada are depicted in Figure 9.

FIGURE 9. WATER TRANSFERS AND OUTFLOW, 1974-1975



FLOOD FLOWS

Damaging floods in California occur infrequently enough to lull residents living near usually quiet streams or dry streambeds into overlooking the occasional destructive potential of these watercourses. Figure 10 illustrates peak flows on the San Diego River, where no large flood flow has occurred in 35 years and where the last really disastrous flow occurred nearly 60 years ago. The frequency with which high flows develop varies from stream to stream, as in the case of the Santa Ana River (Figure 11), just 80 miles (130 kilometres) north of the San Diego River, which carried nearly catastrophic flows of 80,000 cubic feet per second (2,264 cubic metres per second) in 1969 and 110,000 ft^3/s (3,113 m^3/s) in 1939. As high as these were, they were only one-third the flow estimated to have occurred in 1862 (317,000 ft^3/s, or 8,971 m^3/s). Nevertheless, the probability of such gigantic floods, as well as events of lesser hazard, still exists. Major floods have in fact caused loss of human life and extensive damage to property somewhere in California in 18 of the past 40 years.

Flood flows in California are caused by various storm types: those that enter from the northwestern Pacific in series; those that enter from a more westerly direction in the vicinity of Hawaii in undulating waves; the less frequent influxes from the south and southeast; and thunderstorms that are usually generated over the desert and mountainous areas of southern California. Rapidly melting snow also produces flood flows in certain areas of northern and central California. In the 1974-1975 water year, some of each storm type took place, although none, except thunderstorms, was sizable.

Precipitation in California is characteristically heaviest in the north coastal region. The relatively steep topography of the area, coupled with the virtual absence of a snowpack to absorb and delay the rainfall runoff, results in rapid increases in streamflow and accumulation of flood flows. The larger streams, such as the Klamath and Eel Rivers, drain thousands of square miles, and a flood build-up may extend over a week or longer. Severe to extensive flooding occurred in the North Coastal hydrologic area in 15 of the last 40 winters.

Most of the streams in the San Francisco Bay hydrologic area drain small basins. The major stream is the Napa River. Flood flows on these streams are flash floods that rise and end rapidly. Flooding in the area occurred in nine of the past 40 winters.

Streams of the Sierra Nevada and Cascades overflow in the Central Valley from rainfall or snowmelt or a combination of these. With the construction of more dams on these streams over the years, the frequency of damaging floods has decreased, but many of the streams are still capable of causing occasional major damage along their downstream reaches. A few, such as Cottonwood Creek in the northern Sacramento Basin, remain uncontrolled. In the Sacramento and San Joaquin Valleys, extensive flooding occurred in 14 of the past 40 winters.

In southern California, flooding other than that caused by thunderstorms is the result of heavy precipitation over periods of one to three days. The streams in the area are

FIGURE 10. PEAK FLOWS OF SAN DIEGO RIVER

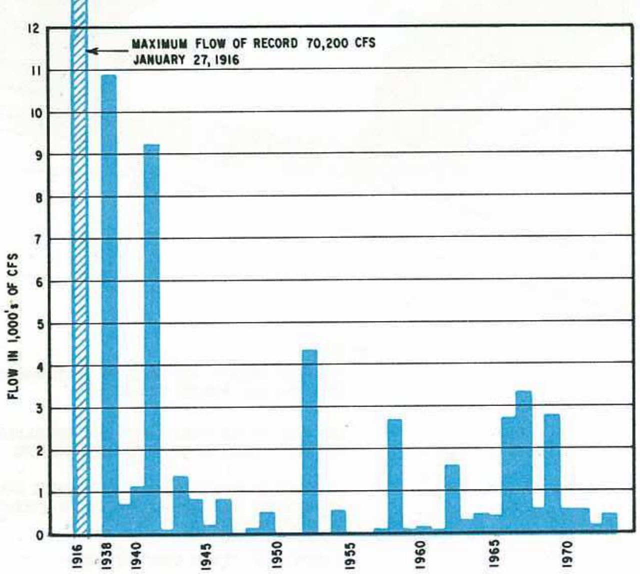
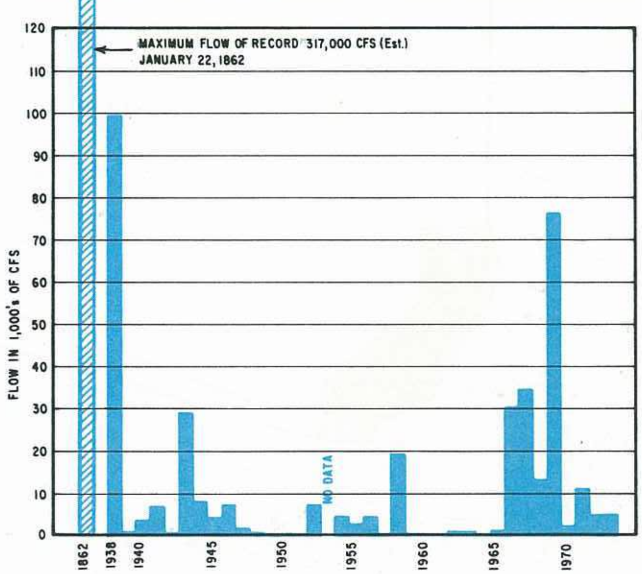


FIGURE 11. PEAK FLOWS OF SANTA ANA RIVER



small and intermittent, but the steep watersheds produce large volumes of runoff within a short period. Since 1938, extensive flood damage unrelated to thunderstorms has occurred during six years.

Total flood damage prevented to date throughout California by flood-control projects is estimated to be nearly two billion dollars. However, some streams still remain uncontrolled or are only partly controlled, and many areas are entirely unprotected. These facts, coupled with the fact that a truly devastating flood can occur in any year, is reason to remain concerned.

Flood Flows in 1974-1975

The first portion of the winter of 1974-1975, from October 1974 through January 1975, was relatively dry for California. The greatest storm of this period, which broke into the State in early December, caused earth slides and local flooding in Los Angeles County and some roofs collapsed there.

During mid-February, a series of seven weather fronts moved into northern and central California, bringing substantial precipitation. Runoff brought the Eel, Russian, and Sacramento Rivers to flood stage. No major damage was reported, but several farm families and a number of head of livestock were evacuated because of flooding in the Eel River delta. Early in March an intense storm was centered briefly on the South Coastal hydrologic area of the State, bringing local flooding and the usual mud and rock slides in Topanga Canyon and other locations in the Santa Monica Bay area.

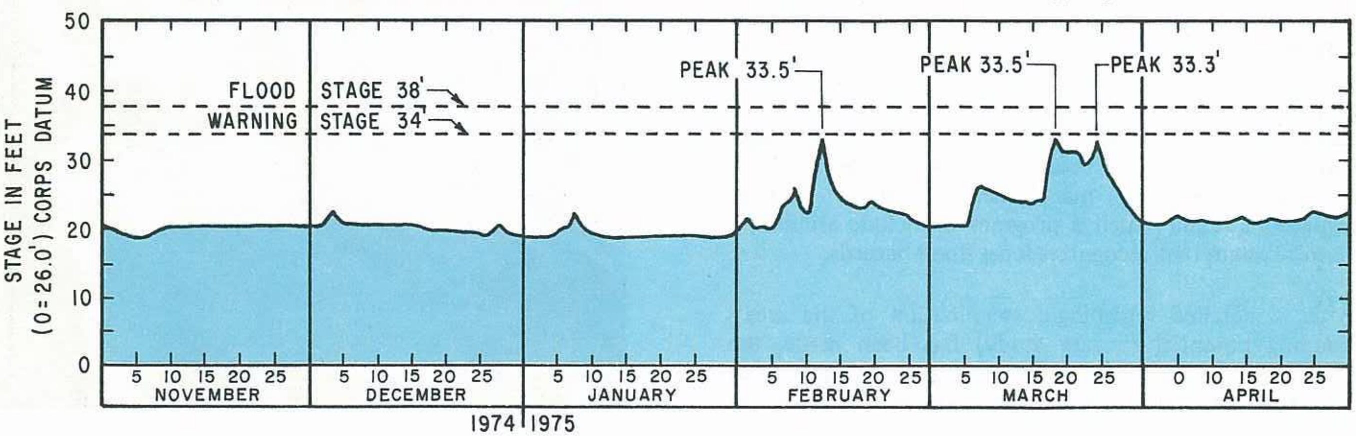
For northern California, the most significant storm event of the season occurred during mid-March when a semistationary weather system brought heavy precipitation in several waves over the North Coastal and Upper Sacramento Valley hydrologic areas. These rains produced flood stages on the Eel and Smith Rivers on the north coast, and at two stations (Tehama Bridge and Vina-Woodson Bridge) on the Sacramento River. Flooding in the Eel River delta again necessitated evacuation of many head of livestock and several families. Local flooding and mud slides caused more than $1 million damage to highways and county roads in Humboldt County, prompting the county to declare a local state of emergency; no state or federal aid, however, was requested.

Figure 12, a hydrograph, shows the height of water at Sacramento River at Bend Bridge. The pattern typifies the low to moderate stream stages experienced throughout most of the State during the first portion of the season, and the moderate to high stages that occurred in February and March 1975. Note that at this station, although the flow never rose to flood stage, the warning stage was reached twice. In the Sacramento-San Joaquin Valley drainage area, the major reservoirs and flood control project works prevented any major flood damage during this season. The Sacramento River bypass system again carried substantial flows through the Valley to San Francisco Bay. The first weir overflow occurred at Tisdale Weir on February 8; the last overflow ended there on April 2. No flood control project levees were damaged during the season.

A warm period in mid-June 1975 produced snowmelt runoff to the Stanislaus River (in central California) that resulted in flood warning stages at Orange Blossom Bridge, east of Oakdale, and prompted evacuation of livestock from low-lying lands.

In early September 1975, moist unstable air stemming from tropical disturbance Caroline in the Gulf of Mexico worked westward to southern California, and produced heavy rainstorms and flash floods in most of the mountains and desert areas from Bishop in Mono County on the north to San Diego. Large sections of highways were closed and one life was lost.

FIGURE 12. HYDROGRAPH OF SACRAMENTO RIVER AT BEND BRIDGE



FLOOD INSURANCE

The bill the federal government has had to meet for repairing the damage caused by floods throughout the United States for many years has been enormous. The average cost of flood disaster relief from 1955 to 1969 was about $363 million a year. The total for that period was $5.45 billion. From 1970 through 1975, $7.9 billion was spent to repair flood damage throughout the country. Current annual flood losses run as high as an average $1.3 billion nationwide.

Costs such as these impelled Congress to enact the National Flood Insurance Program in 1968, thereby making low-cost flood protection available for the first time. The program was set up to assist owners of property that was situated in communities whose governing bodies agreed to restrict development of their flood-prone lands. Because land use control was generally unpopular and because so few communities were willing to restrict development in order to make this insurance available to their residents, Congress enacted the Flood Disaster Protection Act of 1973. This bill significantly altered the flood insurance program by declaring that Congress would, in effect, no longer sanction the investment of federal funds in buildings situated on floodplains unless the owners obtained flood insurance. Flood insurance is not generally available from private insurers. Therefore, many communities that were subject to frequent flooding were forced to enter the federal program or face the loss of mortgage money from the Federal Housing Administration or the Veterans Administration, as well as from banks, savings and loan associations, and credit unions, most of which are either regulated or supervised by the federal government.

The impact of the 1973 legislation in California is demonstrated by the fact that 360 communities are today eligible for flood insurance; in 1973, the number was 120.

The purpose of the flood insurance program is to provide a financial umbrella for those who built without full knowledge of a flood threat and, at the same time, to make builders aware of the hazard of future flooding so that they will erect buildings in safe areas.

The flood insurance program has two phases. The first of these is called the emergency program, during which only half the ultimate amount of insurance coverage is available to property owners, and the land use restrictions are minimal. A home may be insured for up to $35,000 at the subsidized uniform rate of $0.25 per $100 of coverage. During this phase, the community must have only a minimum floodplain management program. Federal regulations require such a program to include a building permit system that recognizes local flood hazards.

After a detailed hydrologic examination of the area's flooding potential (a rate study) has been made, the community is converted into the regular program. The results of the study are displayed on maps that show the water surface elevations of the base (100-year) flood. With these elevations known, the community must require all new construction to be elevated or flood-proofed up to this level. Since this requires more expensive construction, developers are discouraged from locating in flood hazard areas. An additional deterrent is a rate structure for the mandatory insurance premium that puts a heavy penalty on low first-floor elevations (low in relationship to the 100-year flood).

Homes that were in existence at the time the rate study was published can continue to have $35,000 worth of coverage of the $0.25 rate. If desired or if required as a condition for federal financial assistance, a second $35,000 of coverage can be obtained at the actuarial rate. New construction can only be insured at the actuarial rate.

Since it is state policy to encourage local government to implement floodplain management at the earliest possible date, the Department of Water Resources has proposed that it make rate studies for the Federal Insurance Administration. A study of one of the southern California counties is expected to begin soon.

RESERVOIR STORAGE

Total amounts of water stored in every major hydrologic area were above normal at the close of the 1974-1975 water year, indicating to California water users that there are good prospects of meeting most statewide commitments for water during the present year. Statewide reservoir storage at the end of the water year was 110 percent of normal, an overall drop of about 600,000 acre-feet (740.1 cubic hectometres) from one year ago. Despite this decrease, however, the quantity of water stored in reservoirs was still more than 2 million ac-ft (2,467 hm^3) above normal.

Storage increased in the North Coastal, San Francisco Bay, South Coastal, and Sacramento Valley hydrologic areas and declined in the San Joaquin Valley and Lahontan areas.

Major reservoirs in the Sacramento Valley held amounts of water ranging from about 80 to 125 percent of normal, with an overall value of 107 percent. This represented a gain of about 170,000 ac-ft (209.7 hm^3) over last year and is about 860,000 ac-ft (1,060.8 hm^3) above the 10-year October 1 average.

San Joaquin Valley reservoirs, although registering a decrease of slightly more than one million ac-ft (1,233.5 hm^3) below last year, were still about 620,000 ac-ft (764.8 hm^3) above normal. The largest decreases in storage occurred at the San Luis and Pine Flat Reservoirs, which accounted for about 90 percent of the difference between this water year and last. Storage in other reservoirs generally ranged from about 50 to 130 percent of normal, with a total value of 113 percent.

Interstate reservoirs on the Colorado River serving California were storing 140 percent of the October 1 average, 5 percent higher than last year, which was an increase of about 3 million ac-ft (3,700.5 hm^3). Of this amount, about 2,200,000 ac-ft (2,713.7 hm^3) were stored at Lake Powell and about 800,000 ac-ft (986.8 hm^3) at Lake Mead.

Reservoir storage data is summarized in Table 2, and the storage in all reservoirs whose capacity exceeds 100,000 ac-ft (123 hm^3) is listed in Table 3.

TABLE 2. SUMMARY OF RESERVOIR STORAGE DATA, 1974-1975

THOUSANDS OF ACRE-FEET

AREA	NUMBER OF RESERVOIRS	TOTAL CAPACITY	10-YEAR AVERAGE 1965-74	STORAGE OCTOBER 1 1975	PERCENT OF AVERAGE	PERCENT OF CAPACITY
INTRASTATE:						
North Coastal	8	2,938	2,150	2,328	108	79
San Francisco Bay	18	696	397	448	113	64
Central Coastal	9	1,047	583	832	143	79
South Coastal	31	2,495	1,038	1,085	105	43
Sacramento Valley	47	16,866	11,685	12,546	107	74
San Joaquin Valley	31	9,815	4,872	5,495	113	56
Lahontan	8	426	307	313	102	73
Subtotal	152	34,283	21,032	23,047	110	67
INTERSTATE:						
North Coastal	3	1,205	560	738	132	61
Lahontan	5	1,085	746	795	107	73
Colorado Desert (1)	4	53,533	30,138	42,310	140	79
Subtotal (1)	12	55,823	31,444	43,843	139	79
TOTAL (1)	164	90,106	52,476	66,890	127	74

(1) Includes data for Lake Mead and Lake Powell which regulate flow of the Lower Colorado River, the major source of water for the Colorado Desert and South Coastal areas.

TABLE 3. STORAGE IN MAJOR RESERVOIRS

AREA AND DRAINAGE BASIN	RESERVOIR	OPERATOR	CAPACITY (1) ACRE-FEET	STORAGE AS OF OCTOBER 1 (ACRE-FEET) 10-YEAR AVERAGE 1965-1974	1974	1975	PERCENT OF AVERAGE
NORTH COASTAL AREA							
KLAMATH RIVER	UPPER KLAMATH(2)	US BUREAU RECLAMATION	584,000	279,800	370,100	384,400	137
KLAMATH RIVER	CLEAR LAKE(2)	US BUREAU RECLAMATION	526,800	239,800	294,500	302,700	126
TRINITY RIVER	CLAIR ENGLE	US BUREAU RECLAMATION	2,448,000	1,892,900	1,995,800	2,040,700	108
RUSSIAN RIVER	LAKE MENDOCINO	US CORPS OF ENGINEERS	122,500	60,500	51,300	62,500	103
SAN FRANCISCO BAY AREA							
CALAVERAS CREEK	CALAVERAS(3)	CITY-CO SAN FRANCISCO	100,000	57,100	18,500	72,600	127
CENTRAL COASTAL AREA							
SAN ANTONIO RIVER	SAN ANTONIO	MONTEREY CO FCWCD	350,000	206,600(6)	262,700	300,000	145
NACIMIENTO RIVER	NACIMIENTO	MONTEREY CO FCWCD	350,000	107,300	228,800	223,100	208
SANTA YNEZ RIVER	CACHUMA	US BUREAU RECLAMATION	204,900	166,100	182,000	184,500	111
SOUTH COASTAL AREA							
COYOTE CREEK	CASITAS	CASITAS MUNICIPAL WD	254,000	162,000	221,900	222,200	137
PIRU CREEK	LAKE PIRU	UNITED WATER CON DIST	101,200	23,400	12,200	17,200	74
PIRU CREEK	PYRAMID(3)	CALIF DEPT WATER RES	171,200	163,700(5)	166,300	163,700	100
CASTAIC CREEK	CASTAIC(3)	CALIF DEPT WATER RES	323,700	189,200(5)	145,200	189,200	100
---	PERRIS(3)	CALIF DEPT WATER RES	131,500	96,300(5)	102,200	96,300	100
TRIB CAJALCO CREEK	LAKE MATHEWS(4)	METROPOLITAN WATER DIST	182,000	109,400	97,500	121,500	111
SAN JACINTO RIVER	LAKE ELSINORE	CALIF DEPT PARKS AND REC	125,000	22,100	14,000	8,300	38
SAN LUIS REY RIVER	HENSHAW	VISTA IRRIGATION DIST	203,600	7,400	2,000	2,000	27
SAN DIEGO RIVER	EL CAPITAN(3)	CITY OF SAN DIEGO	116,500	22,600	15,000	16,300	72
CENTRAL VALLEY AREA							
SACRAMENTO RIVER	SHASTA	US BUREAU RECLAMATION	4,552,000	3,353,600	3,658,300	3,569,500	106
CLEAR CREEK	WHISKEYTOWN	US BUREAU RECLAMATION	241,100	222,500	217,700	235,600	106
N FK FEATHER RIVER	LAKE ALMANOR	PAC GAS AND ELEC CO	1,308,000	816,600	968,400	906,000	111
BUCKS CREEK	BUCKS LAKE	PAC GAS AND ELEC CO	103,000	60,800	70,200	70,200	115
FEATHER RIVER	OROVILLE	CALIF DEPT WATER RES	3,537,600	2,495,300(6)	2,397,000	2,857,500	115
NORTH YUBA RIVER	NEW BULLARDS BAR	YUBA CO WATER AGENCY	961,300	632,200(6)	736,500	617,100	98
SOUTH YUBA RIVER	SPAULDING SYSTEM	PAC GAS AND ELEC CO	137,400	75,000	67,300	73,200	98
BEAR RIVER	CAMP FAR WEST	SO SUTTER WATER DIST	103,000	48,000	81,100	58,700	122
M FK AMERICAN RIVER	FRENCH MEADOWS	PLACER CO WATER AGENCY	133,700	94,200	95,200	95,100	101
RUBICON RIVER	HELL HOLE	PLACER CO WATER AGENCY	208,400	132,600(6)	158,000	152,500	115
SILVER CREEK	UNION VALLEY	SACRAMENTO MUN UD	271,000	176,300	159,200	144,400	82
AMERICAN RIVER	FOLSOM	US BUREAU RECLAMATION	1,010,300	689,600	772,800	773,000	112
STONY CREEK	BLACK BUTTE	US CORPS OF ENGINEERS	160,000	31,300	34,800	39,300	126
CACHE CREEK	CLEAR LAKE	YOLO COUNTY FCWCD	420,000	81,300	84,900	77,200	95
PUTAH CREEK	LAKE BERRYESSA	US BUREAU RECLAMATION	1,600,000	1,380,100	1,404,900	1,381,400	100
N FK MOKELUMNE RIVER	SALT SPRINGS	PAC GAS AND ELEC CO	139,400	83,000	77,200	70,700	85
MOKELUMNE RIVER	PARDEE	EAST BAY MUN UD	210,000	191,500	194,200	201,200	104
MOKELUMNE RIVER	CAMANCHE	EAST BAY MUN UD	431,500	269,900	336,500	336,800	125
CALAVERAS RIVER	NEW HOGAN	US CORPS OF ENGINEERS	325,000	154,800	218,600	145,000	94
STANISLAUS RIVER	MELONES	PAC GAS AND ELEC CO	112,600	22,600	21,100	11,800	52
CHERRY CREEK	CHERRY LAKE	CITY-CO SAN FRANCISCO	268,800	144,300	197,900	179,800	125
TUOLUMNE RIVER	HETCH HETCHY	CITY-CO SAN FRANCISCO	360,400	252,500	272,800	263,100	104
TUOLUMNE RIVER	DON PEDRO	TURLOCK-MODESTO ID	2,030,000	775,300(6)	1,461,200	1,596,600	206
MERCED RIVER	LAKE MCCLURE	MERCED IRRIG DISTRICT	1,026,000	548,300(6)	724,600	706,500	129
SAN JOAQUIN RIVER	MAMMOTH POOL	SO CALIFORNIA EDISON CO	122,700	37,100	34,600	46,700	126
MONO CREEK	THOMAS A EDISON	SO CALIFORNIA EDISON CO	125,000	96,900	112,400	91,400	94
STEVENSON CREEK	SHAVER LAKE	SO CALIFORNIA EDISON CO	135,300	80,900	80,600	86,900	107
SAN JOAQUIN RIVER	MILLERTON LAKE	US BUREAU RECLAMATION	520,600	175,300	139,100	160,100	91
SAN LUIS CREEK	SAN LUIS(3)	US BUREAU REC-CALIF DWR	2,038,800	1,378,400(6)	1,852,400	1,031,600	75
HELMS CREEK	COURTRIGHT	PAC GAS AND ELEC CO	123,300	44,200	60,500	61,000	138
N FK KINGS RIVER	WISHON	PAC GAS AND ELEC CO	128,000	84,900	99,900	104,500	123
KINGS RIVER	PINE FLAT	US CORPS OF ENGINEERS	1,001,500	434,400	465,800	354,400	82
KAWEAH RIVER	TERMINUS	US CORPS OF ENGINEERS	150,000	17,300	8,000	9,600	55
KERN RIVER	ISABELLA	US CORPS OF ENGINEERS	570,000	189,800	279,600	175,900	63
LAHONTAN AREA							
LITTLE TRUCKEE RIVER	STAMPEDE(2)	US BUREAU RECLAMATION	226,500	147,000(6)	192,900	148,800	101
TRUCKEE RIVER	LAKE TAHOE(2,7)	US BUREAU RECLAMATION	744,600	545,800	580,000	579,600	106
OWENS RIVER	LAKE CROWLEY	LOS ANGELES DEPT WP	183,500	137,700	145,700	156,900	114
COLORADO DESERT AREA							
COLORADO RIVER	LAKE POWELL(2,7)	US BUREAU RECLAMATION	25,002,000	11,589,500	18,010,000	20,202,000	174
COLORADO RIVER	LAKE MEAD(2,7)	US BUREAU RECLAMATION	26,102,000	16,587,600	19,358,000	20,154,000	122
COLORADO RIVER	LAKE MOHAVE(2,7)	US BUREAU RECLAMATION	1,810,000	1,401,500	1,382,000	1,385,000	99
COLORADO RIVER	LAKE HAVASU(2,7)	US BUREAU RECLAMATION	619,000	559,300	559,400	569,000	102

(1) Total capacity to nearest hundred acre-feet.
(2) Interstate reservoir used jointly by California and adjacent states.
(3) Includes foreign water.
(4) Stores only imported Colorado River water.
(5) New reservoir -- average considered equal to current storage.
(6) Less than 10-year average.
(7) Data based on active or usable capacity tables.

WASTE WATER

In the field of waste water and, particularly, waste water reclamation, two major undertakings were started in 1975. The first was the initiation of a concentrated effort to deal with public health concerns regarding the use of waste water to recharge ground water basins from which domestic water supplies are obtained. The second was adoption, in concept, of a plan to incorporate reclaimed waste water with a federal water development project just getting under way.

Health Aspects of Waste Water Reclamation

The State Water Code directs that efforts be made to encourage the development of waste water reclamation projects to help meet the growing water requirements of the State. To this end, the Department of Health, the Department of Water Resources, and the State Water Resources Control Board met in 1974 to explore ways of resolving health considerations surrounding the use of reclaimed waste water to recharge ground water basins from which domestic water supplies are extracted. The three agencies agreed to form the Consulting Panel on Health Aspects of Waste Water Reclamation for Ground Water Recharge. Its purposes were: (1) to define health problems and potential hazards related to using reclaimed waste water to recharge ground water basins which are a source of domestic water supplies; (2) to identify what information was needed about conditions under which reclaimed waste water could be so used; (3) to plan the approach state agencies should take to develop this information; and (4) to recommend an investigatory program to provide this information, including specific research and demonstration projects.

The panel has 11 members eminent in the fields of toxicology, sanitary engineering, water supply service and research, ground water hydrology, risk analysis, public health and epidemiology, and genetics, and also includes one person from the public at large.

The panel met in April, June, and October, 1975, and is expected to report its findings in spring 1976. This report should materially aid the State in developing a program to assess potential health hazards and to provide research needed to ensure that waste water reclamation projects for recharging ground water basins can be planned to protect the public health.

Prior to the meetings of the panel, a series of five task reports was prepared to present an information package on the state of the art of waste water reclamation for ground water recharge. After reviewing the five reports, the panel requested a single-volume report.* This was prepared by the staffs of the three agencies.

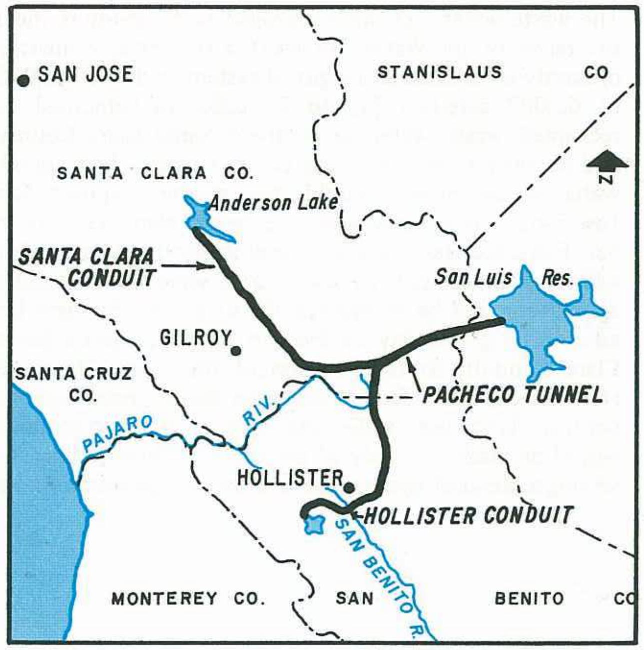


FIGURE 13. SAN FELIPE PROJECT

Waste Water Reclamation in Relation to the San Felipe Project

The San Felipe Project (Figure 13), to be constructed by the U. S. Bureau of Reclamation, will take water from San Luis Reservoir (a joint facility of the State Water Project and the Central Valley Project) and transport it through a tunnel near Pacheco Pass to Santa Clara and San Benito Counties.

Early in September 1975, the Department of Water Resources and the Santa Clara Valley Water District (the major contractor for San Felipe Project water) resolved several issues which enabled the Department to recommend support for construction of the project. One of the issues was settled when the water district modified its proposed contract with the Bureau of Reclamation to accommodate reclaimed waste water as a provisional limitation of its maximum entitlement to water service from the project. At the same time, the district agreed to cooperate with the Department in securing a major waste water reclamation project for unrestricted agricultural use in the project service area, based upon a finding of feasibility by 1990.

**The "State-of-the-Art" Review of Health Aspects of Wastewater Reclamation for Groundwater Recharge,* November 1975.

The waste water reclamation project under study to meet the terms of the Water District-Department agreement is presently envisioned as a regional system to deliver 40,000 to 60,000 acre-feet (49 to 74 cubic hectometres) of reclaimed waste water to southern Santa Clara County and possibly to northern San Benito County. As planned, water in the project would start at the proposed San Jose-Santa Clara waste water treatment plant near South San Francisco Bay; possibly travel to another location for additional treatment; be diverted to serve local irrigated agriculture; and be routed parallel to and in the same (or adjacent) right-of-way as the San Felipe Project's Santa Clara Conduit, to the junction of the Santa Clara and Hollister conduits. Studies on water quality needs, source control, land use, water use, and ownership patterns would be made. A study of use of the Hollister Canal for serving a blend of waste water and San Felipe water would be made on the basis that all urban uses will be met with ground water. A distribution system would be included as part of the delivery system. This project could also include integration of waste water from Gilroy and Morgan Hill for reclamation.

In addition to this concept of a long-range regional waste water reclamation project, the Department will be working closely with the Santa Clara Valley Water District on its proposed pilot studies at Milpitas and Gilroy of crop response to use of reclaimed waste water for irrigation. These studies will not only serve as valuable prototypes for planning the regional waste water reclamation project but, in the case of Gilroy, will assist materially in solving the city's existing waste disposal problem.

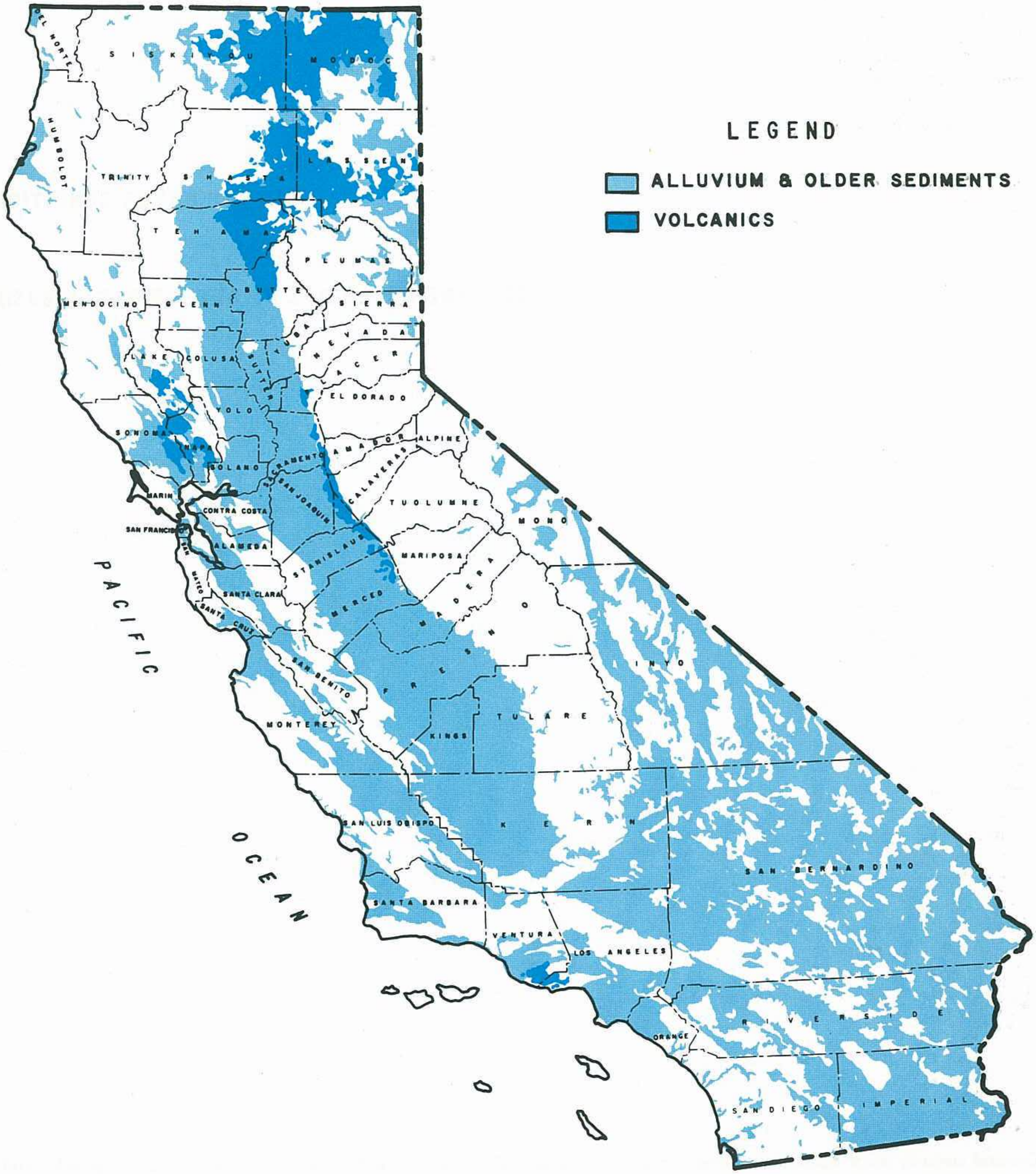
GROUND WATER

GROUND WATER CONDITIONS

STORAGE POTENTIAL OF GROUND WATER BASINS

Ground water is water naturally trapped beneath the surface of the earth. It is the water that fills the pores in gravels, sands, and clays, and cracks in rocks, even hairline fractures. Ground water is removed from the earth by water wells, hydraulic structures that contain lifting mechanisms, or pumps. The ground water resource is vast – 90 percent of the world's fresh water (excluding icebergs) lies underground – but, unfortunately, very little of it occurs in the underground lakes and streams described in some fiction.

FIGURE 14. AREAS OF GROUNDWATER OCCURRENCE



GROUND WATER CONDITIONS

Ground water makes up about 40 percent of the water used annually in California. In some localities, it is the only source of water. At left (Figure 14) is a map showing the areas in which the principal ground water deposits are located. However, the uncolored portions, which represent the hilly and mountainous areas of the State, are not devoid of ground water. Shallow soil mantles or fractures in the rocks often supply small quantities of ground water that are sufficient for household needs.

Also included in this issue is a discussion of the storage potential of the ground water basins in California (page 40).

Ground Water Levels

Ground water levels in most areas of California, as measured in the spring of 1975, did not change materially from the 1974 measurement, except in areas which are feeling the effect of a number of years of importation of surface water and where management of the ground water supply, in conjunction with imported supply, is a growing reality, or in areas where extraction is overtaking replenishment. The average depth to ground water in 24 ground water areas of the State is shown in Figure 15.

Northern California. In the Sacramento Valley, average ground water levels rose slightly in Tehama and Shasta Counties, fell slightly in Butte and Glenn Counties, and remained stable in Colusa County. Water levels in the northern part of the Valley generally remained higher than they have been since the early and mid-1960s. Levels in other areas of northern California, including the northeast and north coastal counties, were slightly lower than in the previous spring, except for Scott Valley, where average water levels rose more than three feet (0.9 metre). The greatest drop in all northern California was a decrease of more than three feet in Surprise Valley in the North Lahontan region.

Central California. Water levels have continued to fall gradually in Sacramento and San Joaquin Counties in the area designated as the Folsom South Service Area. A drop of one foot (0.3-metre) occurred during the past year. A 10-foot (3.0 metre) rise in levels was recorded in northern Santa Clara County, an area that has experienced a continuous rise in levels (a total exceeding 60 feet, or 18 metres) since 1967, reflecting the delivery of State Water Project water since 1962 and the corresponding reduction in pumping from wells. In other parts of the south Sacramento Valley and the San Francisco Bay hydrologic area, levels did not vary much.

In the San Joaquin Valley, ground water levels remained stable, with changes varying from a drop of two feet (0.6 metre) to a rise of two feet (0.6 metre). Exceptions were in the South San Joaquin Municipal Utility District, where levels dropped 11 feet (3.4 metres), and in the Arvin-Edison Water Storage District located just southeast of Bakersfield, which experienced a rise of more than 10 feet (3.0 metres).

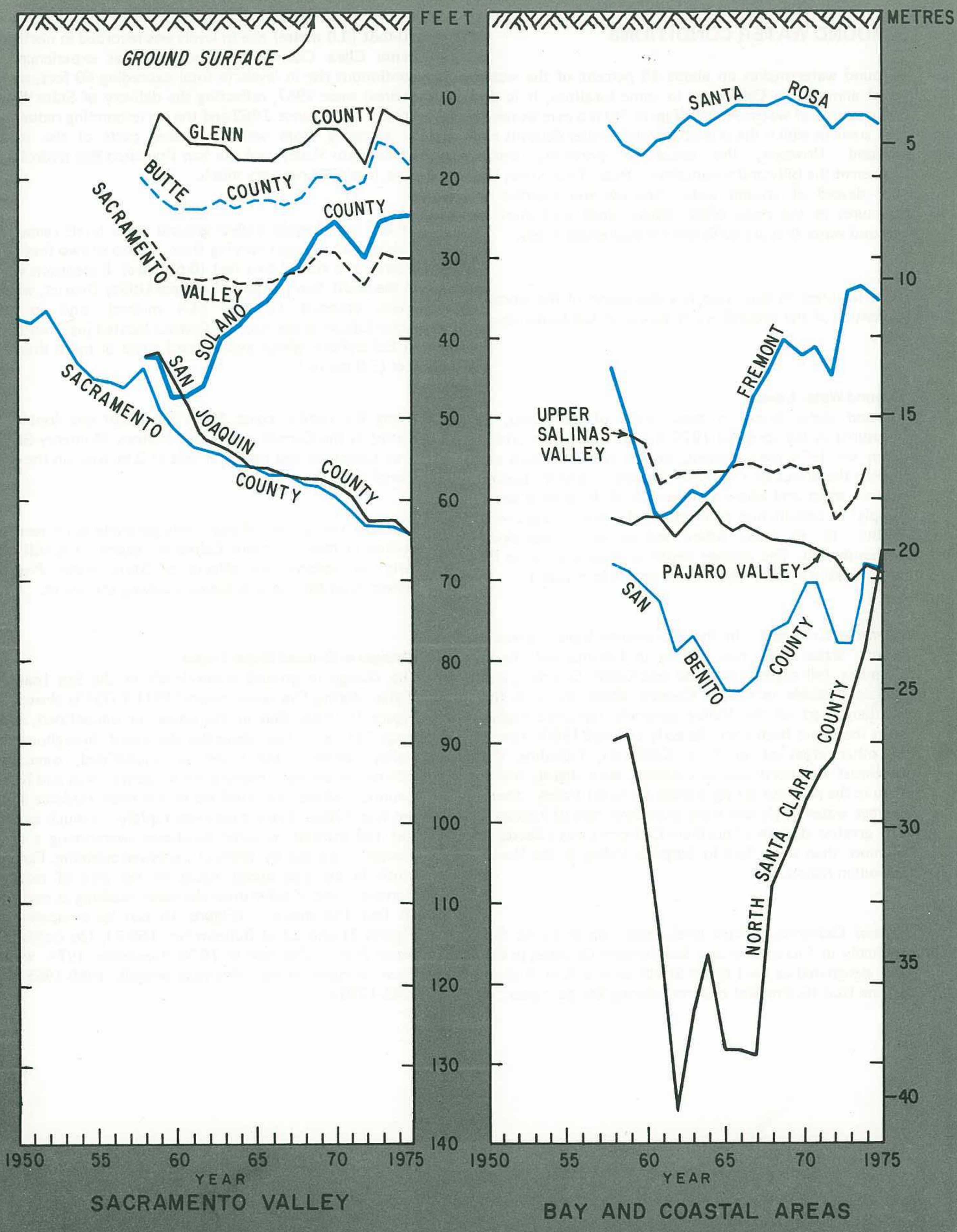
Along the central coast, levels fell about one foot (0.3 metre) in the Carmel and Pajaro Valleys (Monterey-Santa Cruz Counties) and rose four feet (1.2 metres) on the east side of the Salinas Valley.

Southern California. Water levels generally continued to decline in most southern California basins. It is still too early to observe the effects of State Water Project deliveries on the levels in basins receiving this water.

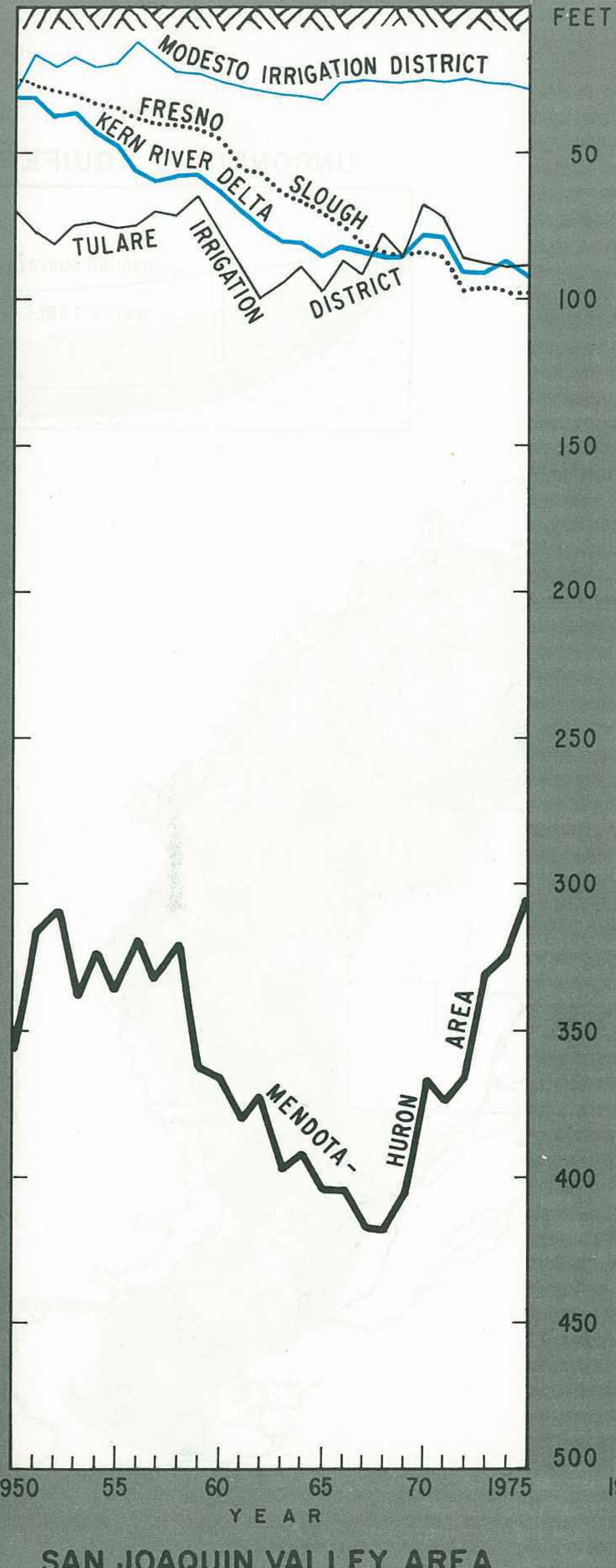
Changes in Ground Water Levels

The change in ground water levels in the San Joaquin Valley during five water years (1971-1975) is shown in Figure 16. Note that in the upper, or unconfined, zone (page 38), levels have generally decreased throughout the Valley, while in the lower, or unconfined, zone, the differences are very marked. In western Fresno and Kings Counties, where imported water has been available since the late 1960s, levels have risen rapidly, as much as 200 feet (60 metres) in some locations, overcoming a deep depression caused by years of excessive pumping. Farther south in an area about equal to the area of marked increase is one of substantial decrease, reaching as much as 60 feet (18 metres). (Figure 16 can be compared to Figures 21 and 22 of Bulletin No. 160-74, *The California Water Plan — Outlook in 1974*, November 1974, which show changes for two five-year periods, 1960-1965 and 1965-1970.)

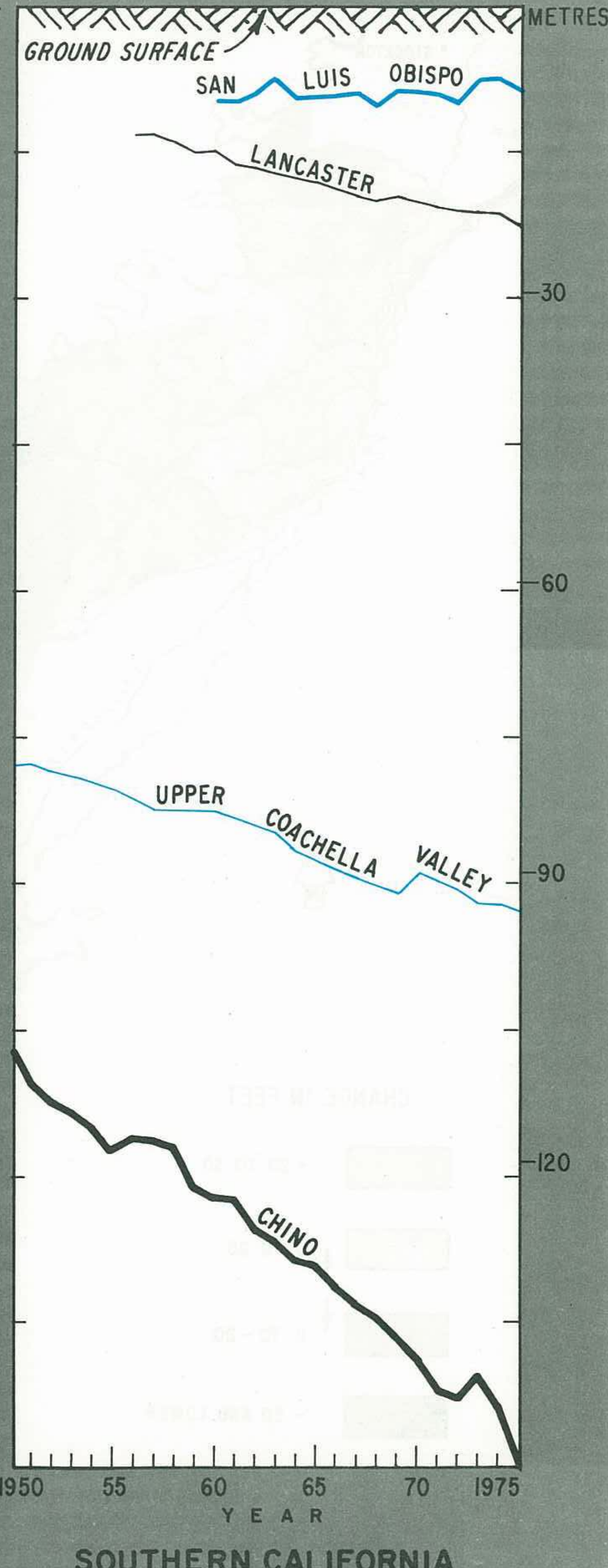
FIGURE 15. AVERAGE DEPTH



TO GROUND WATER

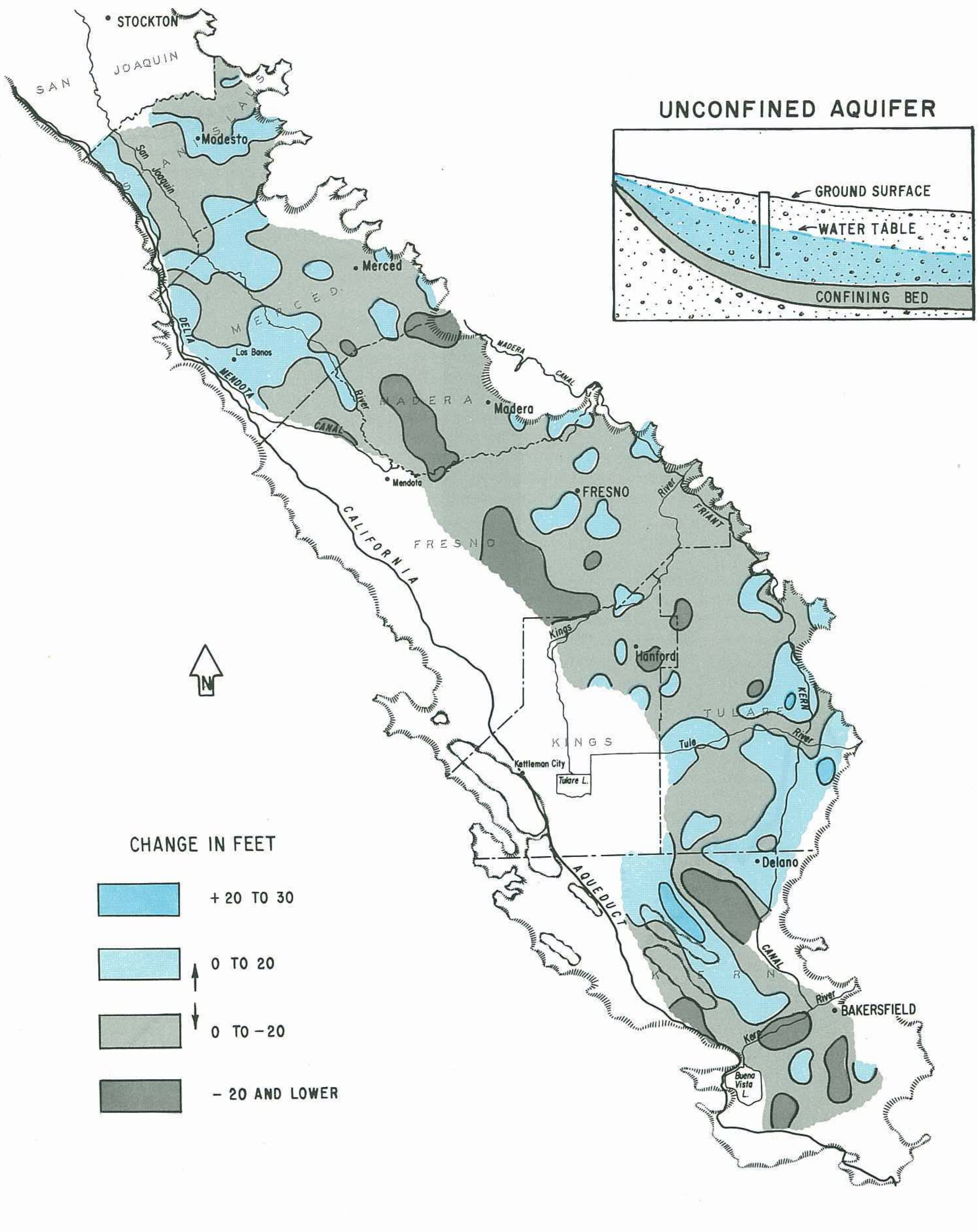


SAN JOAQUIN VALLEY AREA



SOUTHERN CALIFORNIA

FIGURE 16. CHANGE IN GROUND WATER LEVELS



IN SAN JOAQUIN VALLEY, 1971 - 1975

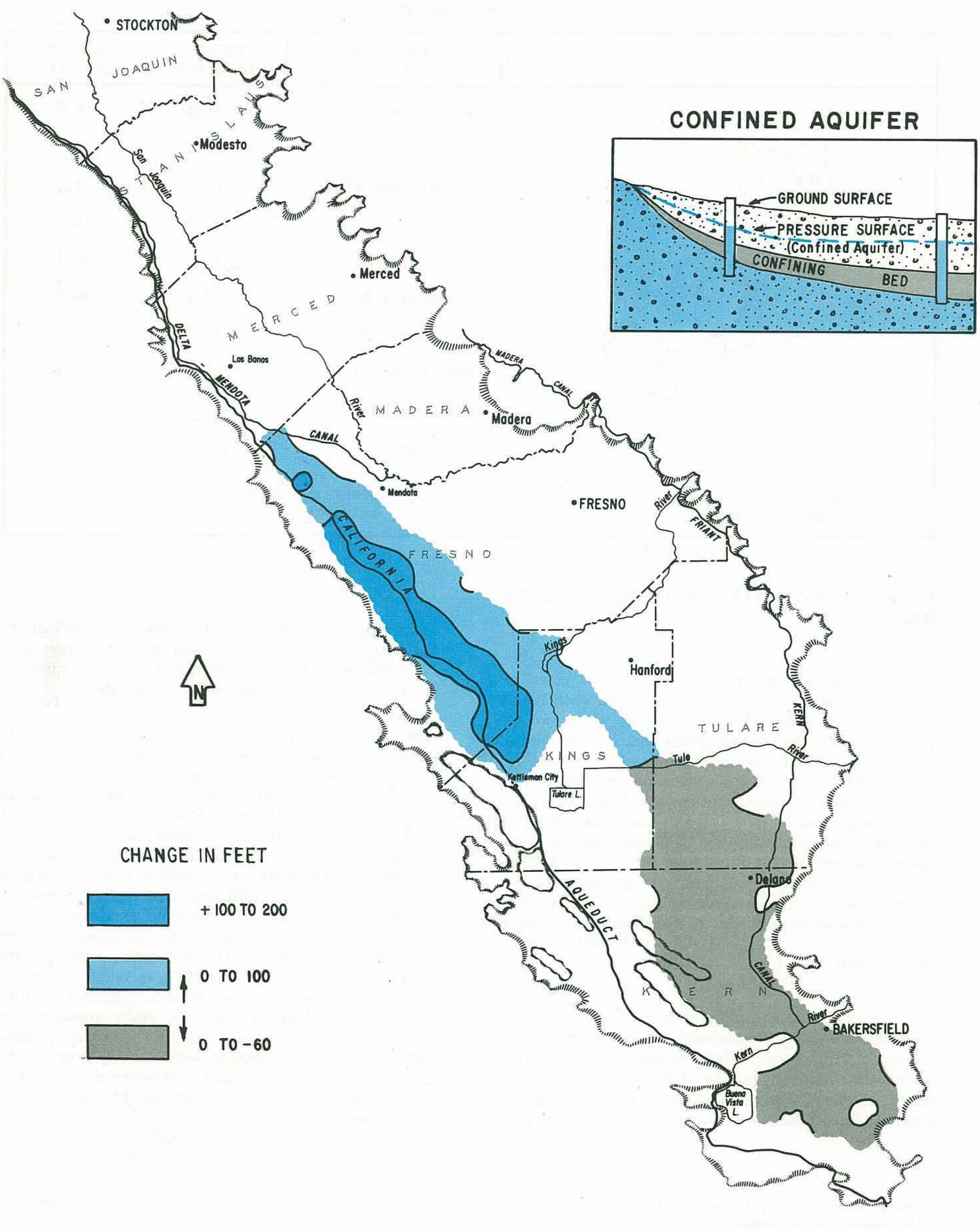
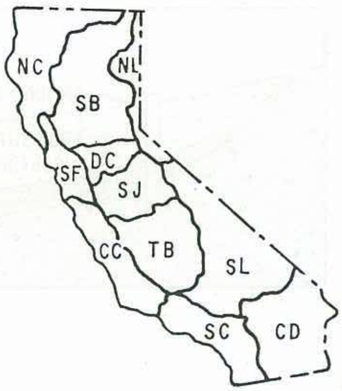


TABLE 4. ESTIMATED GROUND WATER STORAGE CAPACITY

MILLION ACRE-FEET1/



HYDROLOGIC AREA	TOTAL CAPACITY	USABLE CAPACITY
North Coastal	1.3	0.8
San Francisco Bay	28.4	1.6
Central Coastal	25.2	6.9
South Coastal	146.8	10.4
Sacramento Basin	139.3	22.1
San Joaquin Basin	570.5	80.0
North Lahontan	23.8	2/
South Lahontan	246.8	11.2
Colorado Desert	162.9	10.3
TOTALS	1,345.0	143.3

1/ One million acre-feet = 1,233.5 cubic hectometres (hm^3).

2/ Usable capacity has been determined for only one basin in this area.

STORAGE POTENTIAL OF GROUND WATER BASINS

Not all the space between grains of sand, bits of gravel, or fractures in rocks in California's vast ground water basins is filled with water. As the water is withdrawn by pumping, the unfilled space grows and, in some basins, more is taken out than is replenished by natural or artificial means (in such cases, "mining" of ground water is taking place). The sum of the pores and other interstices of a ground water basin is called its storage capacity. The estimated storage capacity of California's ground water basins is summarized in Table 4 for the major hydrologic areas of the State.* Engineers and geologists of the Department of Water Resources and the U. S. Geological Survey have so far been able to determine that the total capacity is 1.3 billion acre-feet (1.6 million cubic hectometres).

Nor can all the water contained in a basin be removed, either economically or technically. Thus, some portion of the capacity will be unavailable. In some basins, a portion of the water may not, because of its quality, be usable, at least until practical and feasible means of modifying that quality are found, such as desalting processes. Accordingly, it is important to know how much of the total capacity is usable. A total of 143 million ac-ft (176,000 hm^3) has been identified as usable capacity. Values for usable capacity also appear in Table 4.

The storage capacity of California's ground water basins could be used to increase the dependability of the State's water supplies by storing in ground water basins with available storage capability the surface water that is not needed or that will be wasted, and then, at a later date, extracting it. Thus, through planned management of both surface and ground water supplies, maximum benefits can be achieved. There are several areas in which recharge of ground water basins with imported surface water and planned conjunctive use of both surface and ground water are now being practiced or actively considered. Notable examples are in the Santa Clara Valley area near the southern end of San Francisco Bay, as well as in southern California, where a prototype project, to be located in the San Fernando Valley, is actively under consideration. Water delivered to the Valley from the State Water Project will be added to the ground water already stored in the San Fernando basin and later withdrawn through wells, thus making the most efficient use of ground water storage capacity.

*Detailed information on storage capacity of individual basins will be found in Bulletin No. 118, *California's Ground Water,* September 1975. However, determinations have not been made for all basins.

WATER QUALITY

WATER QUALITY CONDITIONS

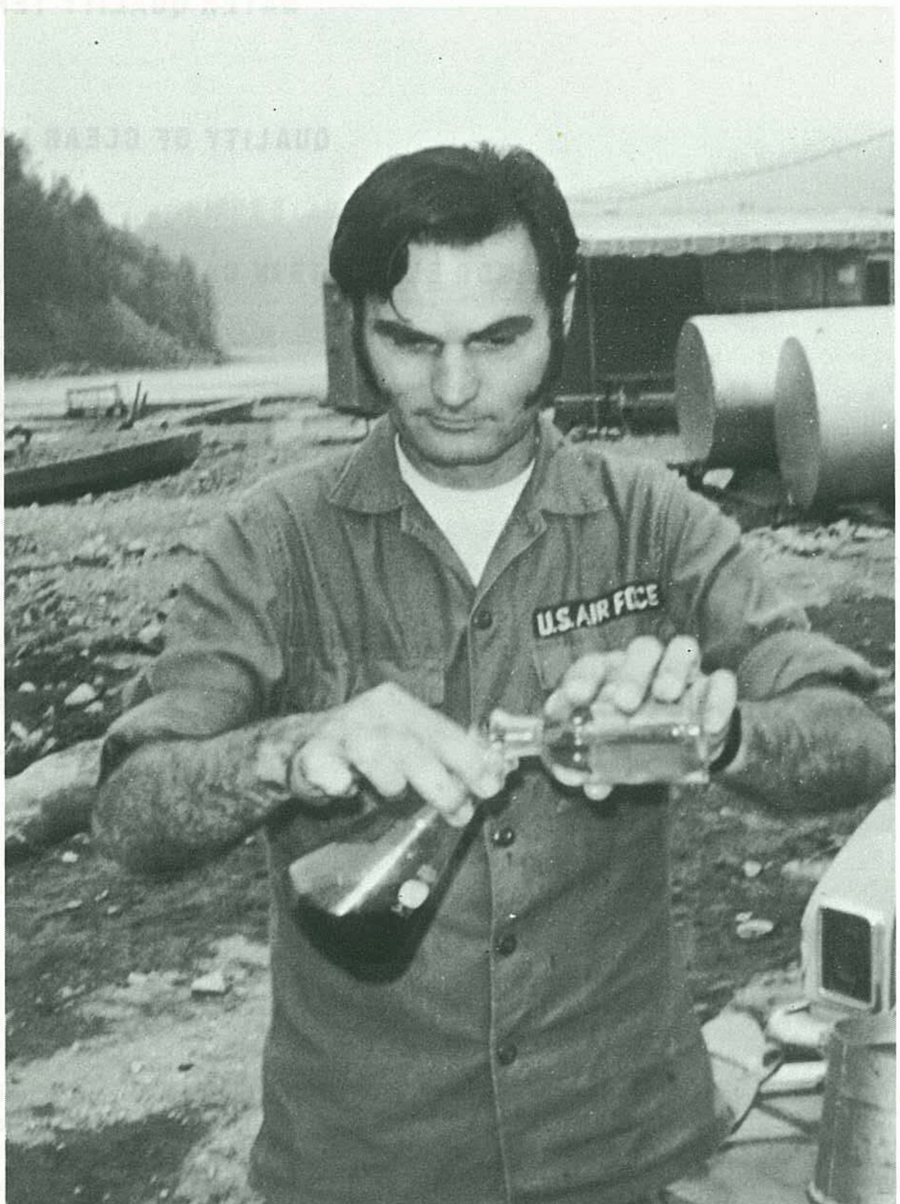
WATER QUALITY TERMS

QUALITY OF CLEAR LAKE

MINOR ELEMENTS IN CALIFORNIA WATER

SEDIMENT LOADS

The quality of water is described as those characteristics or properties which affect its suitability for use. These characteristics are categorized as physical, chemical, or biological. The quality of water deteriorates when any factor or number of factors within any of these categories changes unfavorably. Conversely, it improves when these detriments are overcome or modified. "Pollution" is a degree of deterioration which unreasonably affects the suitability of water for beneficial use. Surface water quality frequently deteriorates rapidly and dramatically. Changes in ground water quality, on the other hand, are slow and subtle, and, unlike surface water, difficult to reverse.



Department of Water Resources technician making a field determination of dissolved oxygen in a sample of water taken from the Klamath River

WATER QUALITY CONDITIONS

The 1974-1975 Water Year

The quality of California streams during the 1974-1975 water year varied only slightly from the normal seasonal fluctuations of poorer quality water at low flow and better quality at high flow. Mineral concentrations in North Coastal area streams decreased in response to the above-normal rainfall. In the Sacramento Valley, increases were slight, compared to the previous year. For streams in the rest of the State, concentrations remained unchanged or increased slightly. Variation in total dissolved solids* from season to season at 16 key locations in the State are listed in Table 5.

The overall good supply of water during the water year was reflected in the better quality of the major water transfers. In all cases, mineral content was lower or unchanged from the previous year. Seasonal variations in total dissolved solids of selected major water transfers are shown in Table 6.

The quality of the State's ground water resources did not change appreciably, compared to the 1973-1974 water year. One exception existed in parts of the San Gabriel Valley in northeastern Los Angeles County. An increase in nitrate concentrations here was reported, and pumping from a number of wells was therefore discontinued.

Long-Term Trends in Streams

Variations in the concentration of total dissolved solids (TDS) over the past 24 years are shown in Figure 17 for sampling stations situated on four significant California streams. Both the Klamath and Sacramento Rivers carry large volumes of water because both are fed by great quantities of precipitation and sustained by abundant runoff throughout the year. The Santa Clara River does not have these benefits. The contrast is dramatically demonstrated by their comparative mineral qualities. TDS concentrations in the Klamath and Sacramento Rivers seldom exceed 200 milligrams per litre (parts per million), while the concentrations in the Santa Clara River are often ten times as great.

Over this 24-year period, concentrations in the Klamath and Sacramento Rivers have varied little. Close examination shows a slight downward trend in TDS on both streams. This has occurred since 1965 in the Klamath and 1964 in the Sacramento. Variations in the San Joaquin River, which is a heavily regulated stream, reflect the marked changes in availability of water supplies. The extreme dry period, 1959-1961, is evidenced by the high concentrations of TDS. The Santa Clara River drains an area that is undergoing widespread development. As such, its quality at this measurement point is a composite of natural flow, domestic and industrial waste, agricultural return flow, and recently-imported water.

Salt-Water Intrusion in the Delta

The movement of salt water into the Sacramento-San Joaquin Delta has always been of concern to water users there and, with the advent of massive transfers of water from northern to central and southern California, is a much-discussed subject. Figure 18 depicts the recorded maximum intrusion of salt water into the Delta for various years, including 1975, measured by the concentration of chloride (the principal constituent of ocean water). The unit of 1,000 milligrams per litre is used to define the limit of intrusion. By way of comparison, the ocean contains about 18,000 mg/l of chloride and the Sacramento River, 7 mg/l. The value, 1,000 mg/l, is chosen as a concentration which, with sustained use of the water over a substantial period of time, will severely restrict the production of most crops.

The years 1931 and 1939 are years of record low flow and consequent encroachment of sea water far into the Delta. The year 1944 typifies those just preceding completion of Shasta Reservoir; 1952 and 1958, when runoff was far above normal (too large to be contained by the Central Valley Project); 1966, a "dry" year preceding completion of Oroville Dam; and 1970, a recent "average" year. The 1974-75 year was such a "good" year that a strong outflow sustained throughout the summer of 1975 kept salt water from penetrating much beyond the entrance to the Delta.

This section also includes discussions of the quality of Clear Lake (page 49), variation in ground water quality (page 51), minor elements in California water (page 52), and sediment loads (page 54).

*This and other terms used in discussing water quality are listed on page *44*.

TABLE 5. SEASONAL VARIATION IN TOTAL DISSOLVED SOLIDS AT SELECTED STREAM LOCATIONS, 1974-1975

STATION		FALL	WINTER	SPRING	SUMMER
River	At or Near	In Milligrams per Litre (equivalent to parts per million - ppm)			
Colorado	Imperial Dam	870	910	870	800
Eel	Scotia	220	70	100	160
Feather	Nicolaus	60	60	60	50
Klamath	Klamath	150	80	100	100
Mojave	Victorville	330	370	350	370
Russian	Guernveville	140	190	80	160
Sacramento	Keswick	60	80	70	70
Sacramento	Sacramento	70	100	70	100
Salinas	Gonzales	190	230	460	--
San Joaquin	Fresno	20	40	40	--
San Joaquin	Vernalis	270	380	240	400
Santa Ana	Mentone	140	150	110	140
Santa Ana	Prado Dam	380	670	740	410
Santa Clara	Santa Paula	1,350	1,370	900	1,300
Susan	Litchfield	260	250	150	300
Truckee	Farad	60	--	70	--

WATER QUALITY TERMS

These definitions are provided to assist the reader who is unacquainted with technical terminology used in the water quality portion of this report.

TOTAL DISSOLVED SOLIDS (TDS). Water is called the universal solvent because it readily dissolves most inorganic chemicals and, unless it has been carefully distilled in the laboratory, will contain various chemicals in solution. Even rain water, often called "pure", contains "dissolved solids". Thus, the term "total dissolved solids" means the amount of material in solution in a given volume of water. In the laboratory, TDS is determined by filtering out the "suspended solids" (those particles of undissolved matter that are held in suspension) from a measured sample of water, slowly evaporating the water, and measuring the amount of residue.

MILLIGRAMS PER LITRE (mg/l). The scientific units used in reporting the amount of material present in water (either dissolved or suspended) are milligrams per litre; that is, the amount of material, by weight, in a given volume of water. The term is essentially (but not technically) equivalent to the once-popular unit, "parts per million" (parts of material per one million parts of water).

ELECTRICAL CONDUCTANCE (EC). The ability of a substance to conduct a current of electricity is its electrical conductance. Pure liquid water has very low conductivity. The presence of chemicals in water make the solution more conductive. As the concentration of dissolved material increases, conductance increases. Consequently, measurement of conductance indicates the concentration of material in solution. Because conductance is the reciprocal of the resistance to the flow of an electric current and because resistance is relatively

TABLE 6. SEASONAL VARIATION IN TOTAL DISSOLVED SOLIDS OF SELECTED MAJOR WATER TRANSFERS, 1974 - 1975

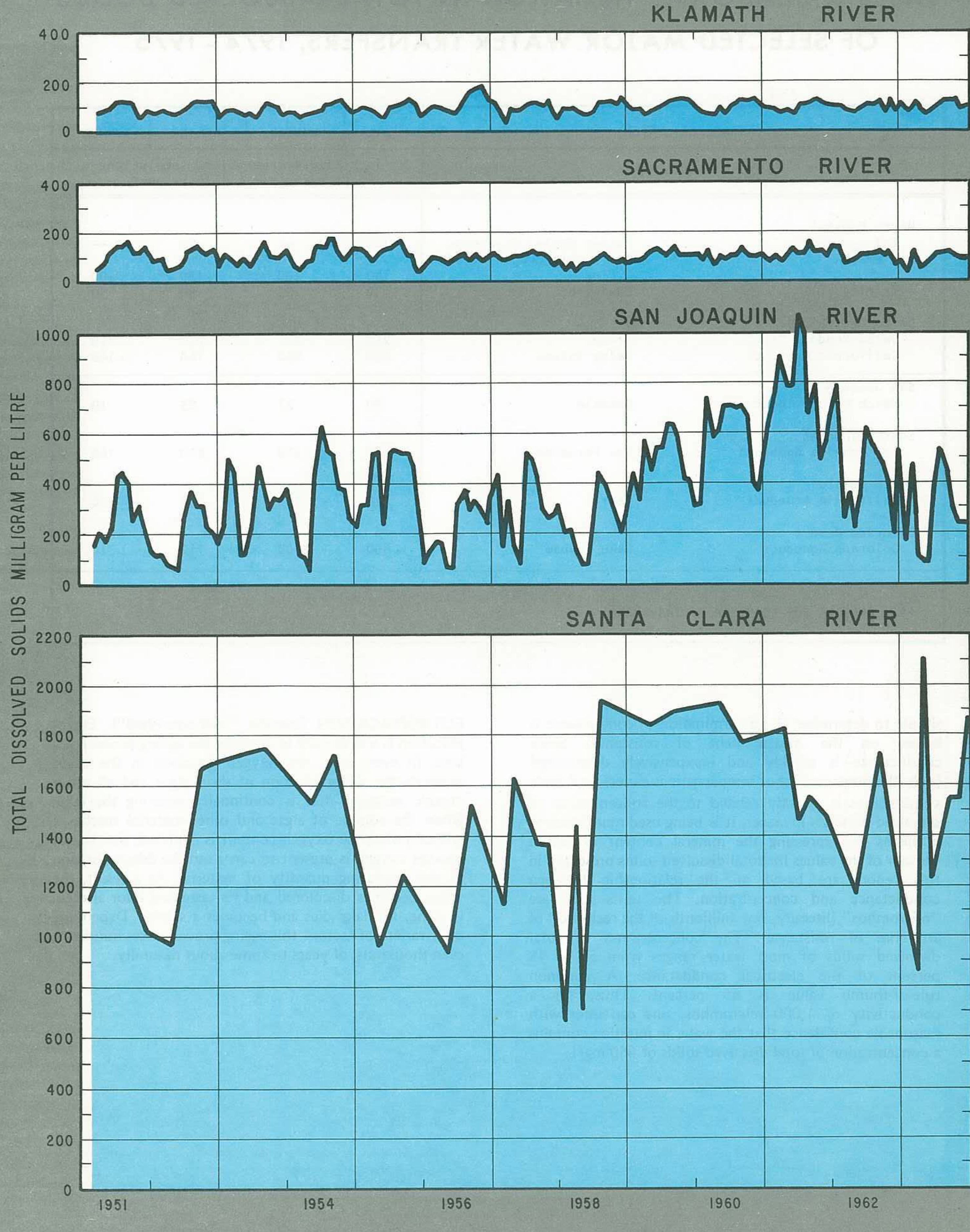
TRANSFER SYSTEM		FALL	WINTER	SPRING	SUMMER
Stream or System	At or Near	In Milligrams per Litre (equivalent to parts per million - ppm)			
North Coastal					
Eel	Potter Valley Diversion	100	--	70	--
Klamath	California-Oregon State Line	140	100	120	100
Trinity	Lewiston	50	55	50	50
Delta-Central Sierra					
Delta-Mendota Canal	Tracy	250	270	230	220
California Aqueduct	Delta Intake	220	260	160	140
San Joaquin					
Hetch Hetchy Aqueduct	Oakdale	20	23	25	19
South Lahontan					
Los Angeles Aqueduct	San Fernando	180	210	210	160
South Coastal					
California Aqueduct	Perris	220	210	230	270
Colorado Desert					
Colorado Aqueduct	Lake Havasu	690	700	710	710

*SEE PAGE 25 FOR LOCATION OF TRANSFERS

simple to determine, the determination of conductance is based on the measurement of resistance. Since conductance is quickly and inexpensively determined (only the measurement of temperature is easier), and since conductance is directly related to the concentration of dissolved minerals in water, it is being used more often as a means of expressing the mineral content of water. Certain of the values for total dissolved solids presented in this report are based on the relationship between conductance and concentration. The units used are "micromhos" (literally, one millionth of the reciprocal of an ohm of resistance). The concentration of total dissolved solids of most water ranges from 55 to 75 percent of the electrical conductance. A common rule-of-thumb value is 65 percent. Thus, for a conductivity of 1,000 micromhos, one can infer with reasonable confidence that the water in question contains a concentration of total dissolved solids of 650 mg/l.

EUTROPHICATION (literally "well-nourished"). Eutrophication is a term used to describe the ageing process of a lake. In every lake, the oxygen dissolved in the water supports the decomposition of dead algae and all other organic material that is continually entering the lake. When the volume of algae and other material reaches a critical point, the oxygen content is depleted; that is, not enough oxygen is present to carry out the decomposition of the increasing quantity of material. As a result, the water becomes discolored and its taste and odor altered. In time, the lake dies and becomes a swamp. Depending on a variety of factors, this ageing process takes hundreds, even thousands, of years to come about naturally.

FIGURE 17. VARIATION IN WATER QUALITY



IN SELECTED STREAMS, 1951 - 1975

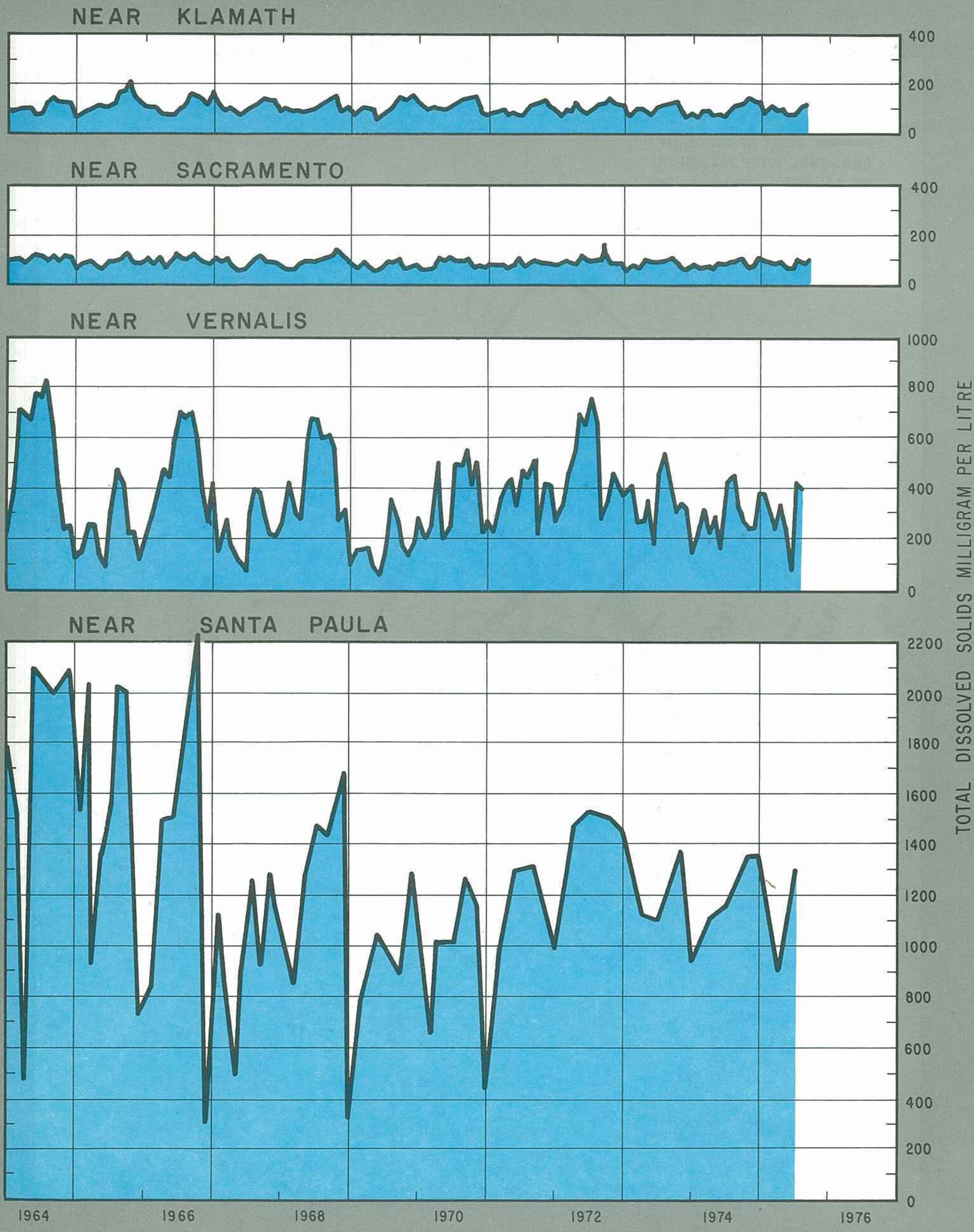
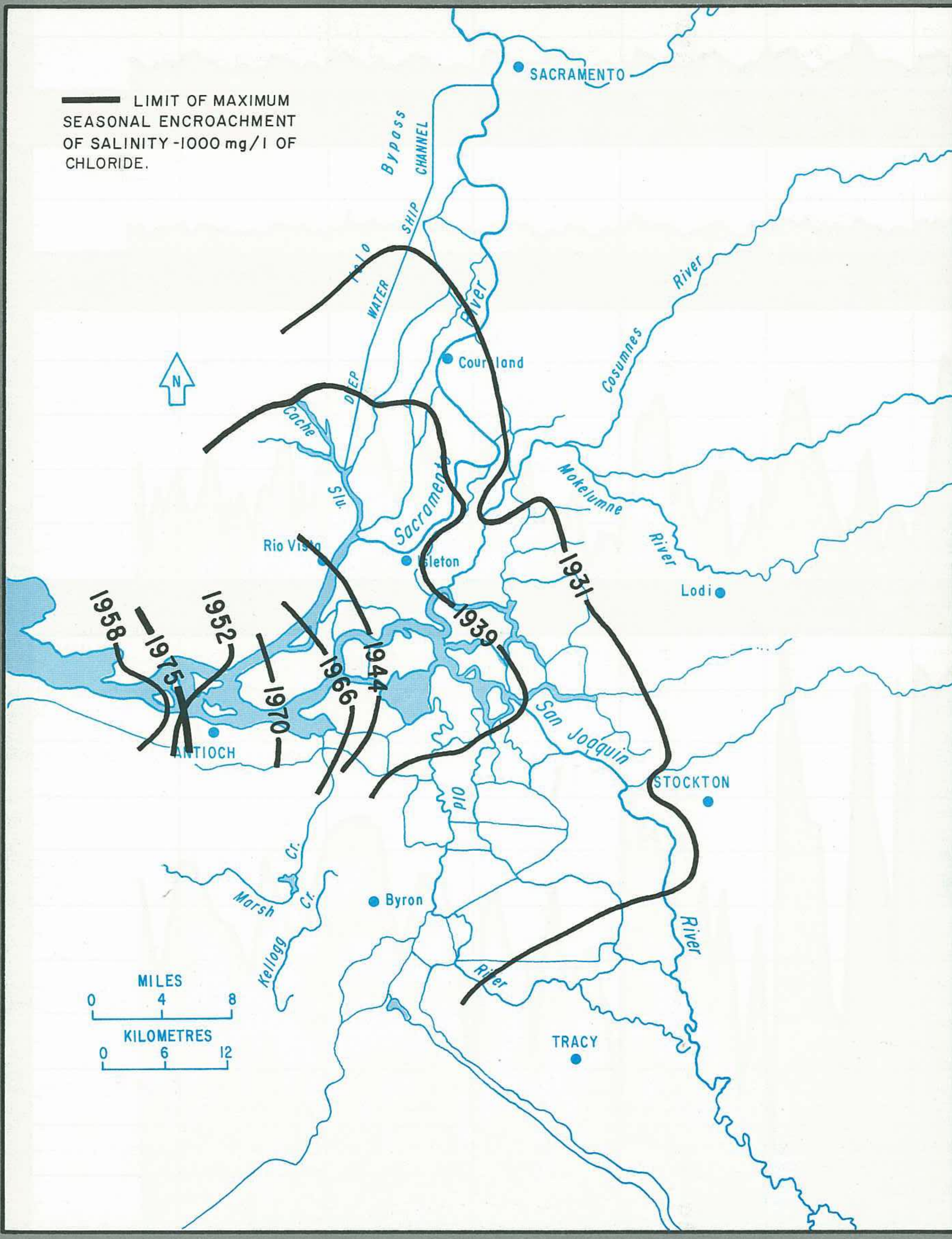


FIGURE 18. SALT-WATER INTRUSION IN THE SACRAMENTO-SAN JOAQUIN DELTA



QUALITY OF CLEAR LAKE

Clear Lake, situated at an elevation of 1,320 feet (402 metres) in Lake County, is the largest natural fresh body of water lying entirely within California. Located less than a three-hour drive from San Francisco or Sacramento, this warm-water lake's 68.5 square miles (177.4 square kilometres) provide recreation for more than 1¼ million people every year.

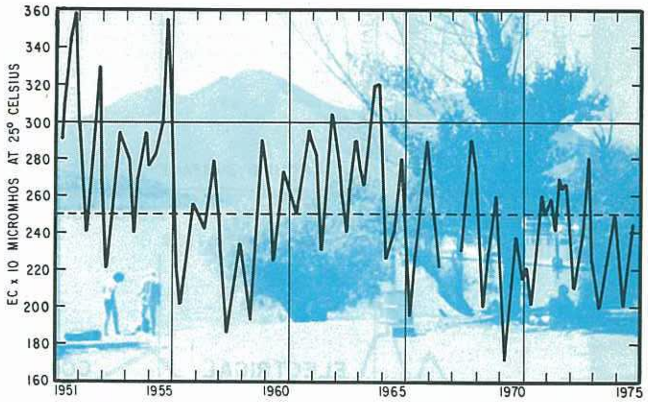
Although swimming and boating draw many visitors, the lake's chief attraction is its abundant population of bass, white catfish, white crappie, black crappie, bluegill, and brown bullheads. With an average of at least one fish caught for every hour of fishing, the annual angler harvest is about 20 pounds per acre (22 kilograms per square hectometre). This adds up to about 650 tons (590 tonnes) of fish. The lake also supports the only natural freshwater commercial fishery in California. The venture harvests more than 500,000 pounds (227,000 kilograms) of carp and blackfish.

Clear Lake can support this tremendous rate of productivity because of its large surface area, its relatively shallow depth of about 25 feet (7.6 metres), the large supply of nutrients in its inflow and sediments, and the numerous cloudfree days typical of the region. These conditions in combination create a situation that is almost ideal for biologic activity, and the lake has accordingly become eutrophic.* Not only does it contain enormous numbers of fish but it also supports other forms of aquatic life, such as blue-green algae. These tiny, one-celled plants have found the conditions in the lake so favorable that, at times, they multiply widely and become a considerable nuisance to swimmers, boaters, fishermen, and others at the lake.

The so-called Clear Lake gnat, which is actually a midge, is another drawback to residents and visitors. Although the adult gnat does not compete with people for food or fiber products, does not bite, and does not seriously affect public health, it is a major annoyance during the summer because it is a night-flying insect with a strong affinity for light. The illumination needed for outdoor lakeside activities attracts swarms of these creatures.

Attempts to control the gnat were first made in 1949, when DDT, a chlorinated hydrocarbon insecticide, was applied to the lake. This effort was successful at first, but the insect soon developed an immunity to the chemical. Moreover, the substance was proving detrimental to humans and animals. The use of DDT was discontinued, and another insecticide, methyl parathion, has taken its place. This chemical has several useful characteristics: it is effective in low concentrations, it deteriorates rapidly following application, and it seems to act only on the target organism, the gnats. Unfortunately, evidence is appearing that these insects are becoming immune to the methyl parathion as well.

VARIATION IN ELECTRICAL CONDUCTANCE IN CLEAR LAKE



Most of the constituents in water are minerals. Analyses of water samples collected by the Department of Water Resources for more than 20 years show the water in Clear Lake to be of good mineral quality, with values of electrical conductance that range from about 180 to 360 micromhos.

In July 1963, the Department of Water Resources began the first detailed investigation of the chemical quality of Clear Lake. Subsequent studies by the Department have shown that, during the summer, algal productivity reaches high levels and declines only when concentrations of nitrogen or phosphorus in the lake become depleted or when photosynthetic activity is reduced by turbidity.

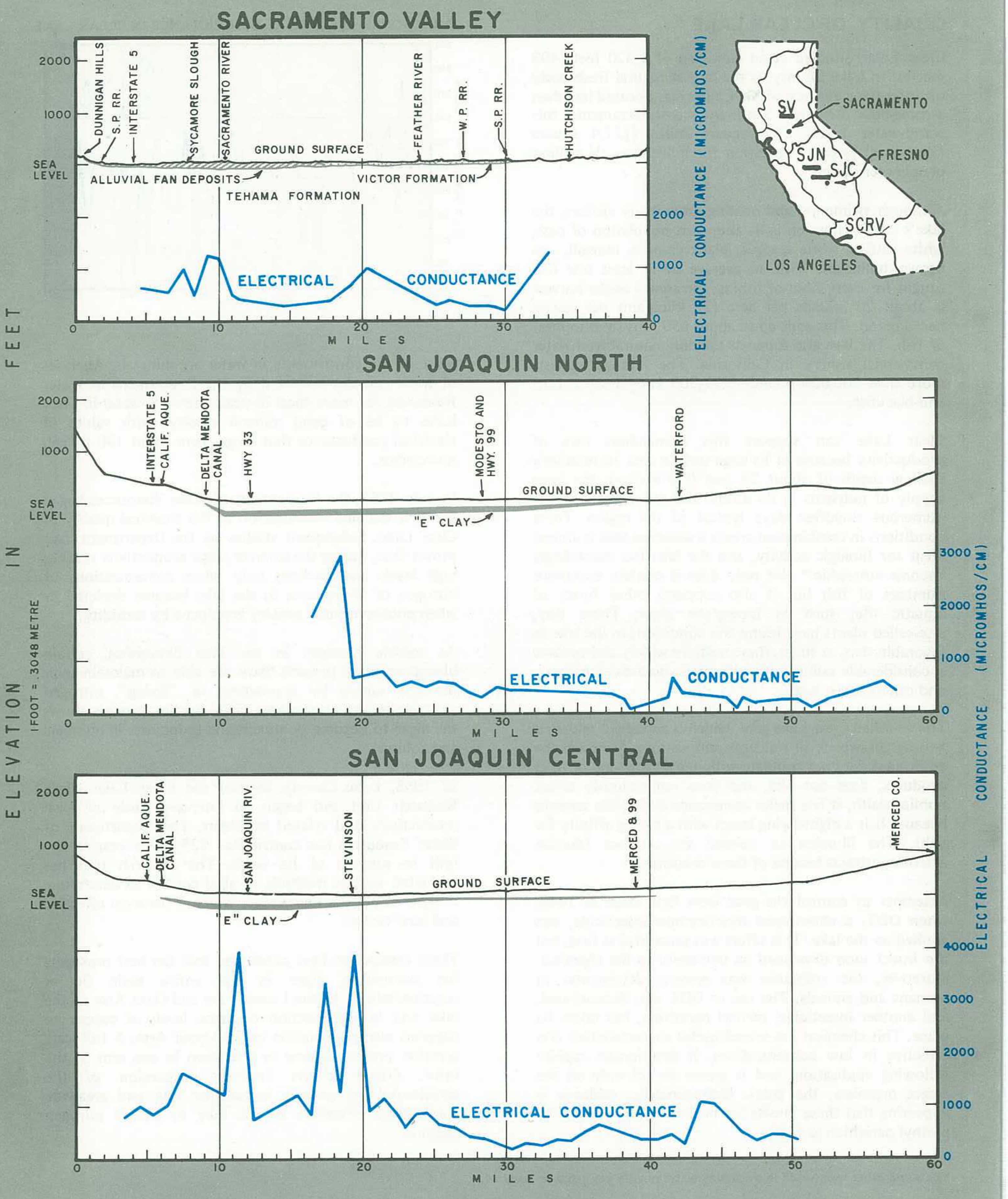
As soluble nitrogen in the lake diminishes, certain blue-green algae present there are able to maintain their nitrogen supply by converting, or "fixing", nitrogen available in the atmosphere. This fixation process allows the algae to become dominant and to increase in numbers and volume.

In 1968, Lake County formed the Clear Lake Algae Research Unit and began an intensive study of algal productivity and related problems. The Department of Water Resources has contributed $25,000 a year to the unit in support of its work. The research unit has evaluated various methods of algal control to determine, in light of present knowledge, which is the most effective and least costly.

These researchers have concluded that the best prospects for controlling algae in the entire basin lie in aeration/mixing in the Lower Arm and Oaks Arm of the lake and in introduction of trace levels of copper to suppress nitrogen fixation in the Upper Arm. A full-scale aeration project is now in operation in one arm of the lake. Other plans include expansion of the aeration/mixing process in another arm and areawide applications elsewhere in the lake to inhibit nitrogen fixation.

*This and other terms used in discussing water quality are listed on page 44.

FIGURE 19. VARIATION IN



GROUND WATER QUALITY

SANTA CLARA RIVER VALLEY

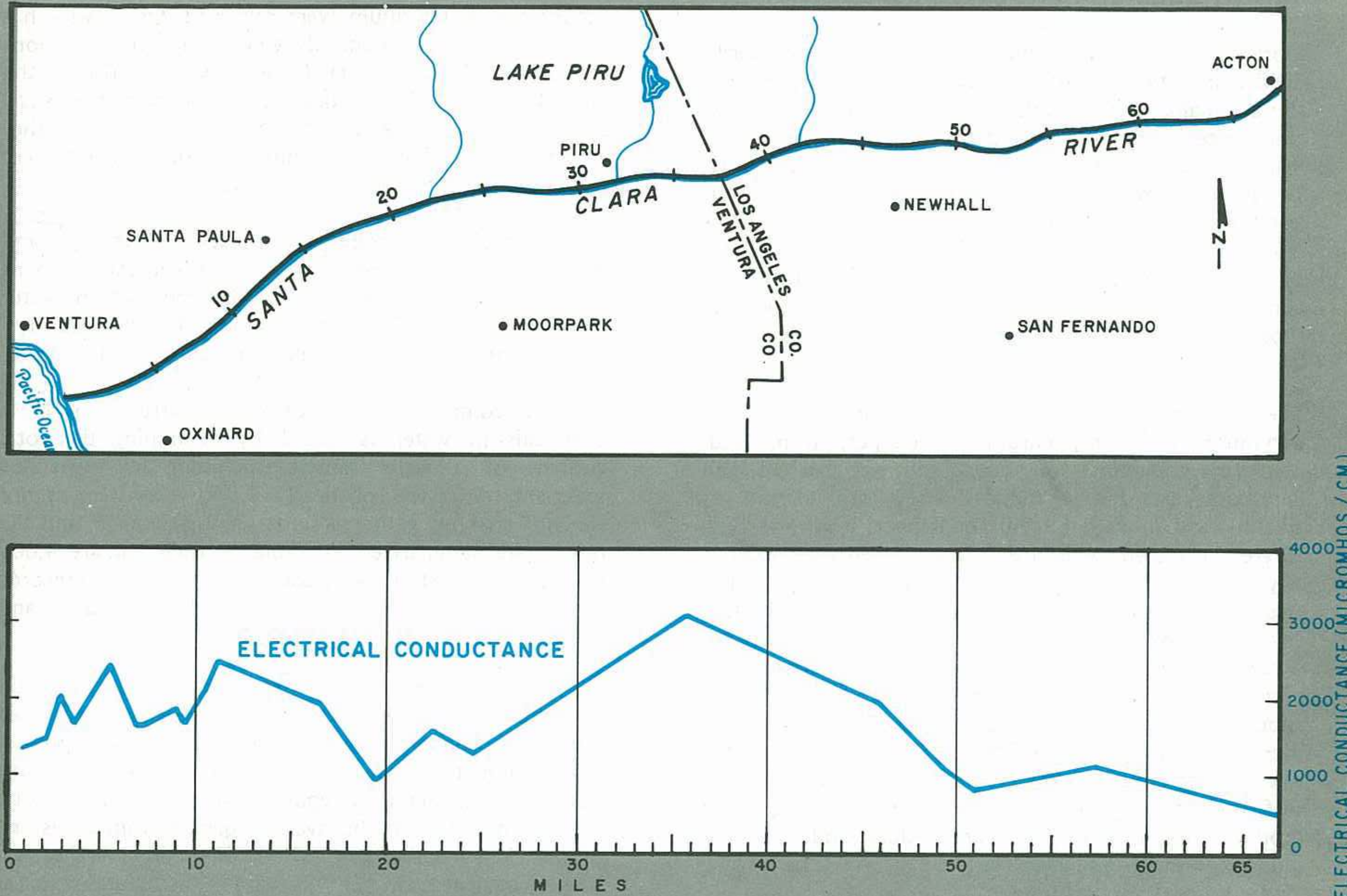


Figure 19 depicts the variation in the quality of water pumped from wells situated in four ground water areas in California in 1975. Electrical conductance (explained on page 44), a measurement of dissolved minerals in water, is used, rather than total dissolved solids. (TDS is normally about 65 percent of EC.)

On the page opposite, values found along three cross sections in the Central Valley are shown, together with principal geologic features. In each, the higher values generally appear in the western (left) portions of the cross section, reflecting the major differences in the quality of natural replenishment water and in geologic structure between the two sides of the Valley.

On this page are shown EC values for wells adjacent to the Santa Clara River in southern California. Here, ground water generally moves from east to west (right to left) or downstream. Note that although the EC values vary, the trend in concentration is upward in the westward direction. The highest values, near the Los Angeles-Ventura County line, are similar to those of the Santa Clara River at this site, reflecting the minimal dilution available in this arid stretch of the Valley.

MINOR ELEMENTS IN CALIFORNIA WATER

Inorganic chemicals found in water are customarily divided into two groups. The common minerals, referred to as major constituents, are those that occur in abundance in solution, usually in concentrations ranging from one to several hundred milligrams per litre (mg/l). The minor elements, or constituents, are those that occur less frequently and in low concentrations, normally less than one milligram per litre. Minor elements are also called "trace elements" because they occur in such small concentrations, or "heavy metals" because the majority of those commonly analyzed are metals.

The elements discussed here will be arsenic, barium, beryllium, cadmium, chromium, copper, iron, lead, mercury, selenium, and zinc. All but barium and beryllium are heavy metals. They are classed as alkaline-earth metals. Except for copper, iron, and zinc, all are considered harmful to humans when they occur in any appreciable concentration in drinking water. Accordingly, health authorities have placed limiting concentrations on the amounts that may occur in drinking water supplies. Copper and zinc are also dangerous to humans, but the concentrations at which they are high enough to be harmful are so disagreeable to the taste that they are not normally considered to be hazardous. Iron is not harmful but it is considered a "nuisance" chemical. In sufficient concentration (above about 0.3 mg/l), it produces unpleasant tastes and odors and it stains plumbing fixtures and laundry.

In early summer, 1971, the Department of Water Resources undertook a sampling program to determine the concentration of six minor elements in representative waters in California. Samples were taken from 371 sources, including surface water at 256 sites on 123 streams, 16 canals, 29 lakes and reservoirs, and 12 bays and estuaries; and ground water from 115 wells. The six constituents were arsenic, barium, cadmium, lead, mercury, and selenium, all of which are considered toxic.

The most striking conclusion to be drawn from this overview was that, while these elements were present in the water examined, few were present in sufficient concentration to be of concern. *Of the 2,220 laboratory determinations made, only 11 (½ of one percent) produced values in excess of the concentrations considered harmful.* Excessive values were found in two cases for arsenic, in one for cadmium and lead, and in nine for selenium (five stream sites and four wells). The arsenic values were found in Mono Lake. Water in this saline lake is not used for a drinking water supply; therefore its content is of slight consequence. When the stream where cadmium was found was resampled in midsummer, no sign of the element was present. (This was the only incidence of cadmium.) Where selenium was discovered, the values exceeded the recognized limit (0.01 mg/l by 0.01 mg/l, except for one well.

In early 1975, all data gathered since 1961 on the occurrence of beryllium were reviewed. Only twice has this so-called toxic chemical been found (concentrations of 0.001 and 0.0013 mg/l). These were at a station on the Pit River near Canby, Modoc County in the northeastern corner of the State. Of the hundreds of other examinations, values of beryllium, if they existed, were below the minimum detectable limit.

The results above describe materials dissolved in water and do not include the proportion contained in the sediment that is carried in streams and filtered out in water treatment systems. Thus, in discussing the "drinkability" of water, only dissolved chemicals are considered.

A more complete picture of the occurrence of these chemicals in water is found by examining the total content of a water sample, including its suspended sediment. A review of nearly 7,800 records of minor element analyses gathered since 1950 was made, and the results are summarized in Table 7. Included are 4,000 records for 649 stations on 280 streams and 3,700 records for 2,600 wells located in 63 ground water basins and areas.

As might be expected, iron was more frequently determined because this is the chemical of most immediate concern. Some 1,700 values were reported, nearly four times as many as any of the other nine elements. Chromium is reported in two forms, as total chromium and in the hexavalent form. Chromium is one of the elements that can exist in water in several states. The hexavalent form (Cr^{+6}) is rare in the natural state (as chromate, $Cr0^{4}$), and when it is present in water, it is usually the result of the inflow of industrial waste. Only 67 values for hexavalent chromium were reported.

Most of the maximum values for streams in Table 7 are attributed to two sources. One of these sources is waste water in the stream, as, for example, the maximum for barium obtained in a sample from Ballona Creek, a concrete-lined channel in Los Angeles County carrying waste in the dry months. Another source is a considerable amount of sediment in the sample, as, for example, the maximum value for iron from a sample collected from Redwood Creek, a North Coastal area stream, at a time when it was in flood.

With ground water, the maximum values are more likely to be dissolved values, since ground water flows carry almost no sediment. The maximum for hexavalent chromium which, as has been stated, rarely exists in the natural form, is a single value from a southern California well located near a source of waste water. Again, iron is the most frequently reported constituent. Iron is the bane of many well owners, for in addition to the disagreeable taste and odor it imparts to water and the staining it causes, iron fosters the growth of iron bacteria.

Only occasionally and in scattered locations has the occurrence of minor elements presented serious problems.

TABLE 7. CONCENTRATIONS OF MINOR ELEMENTS 1/

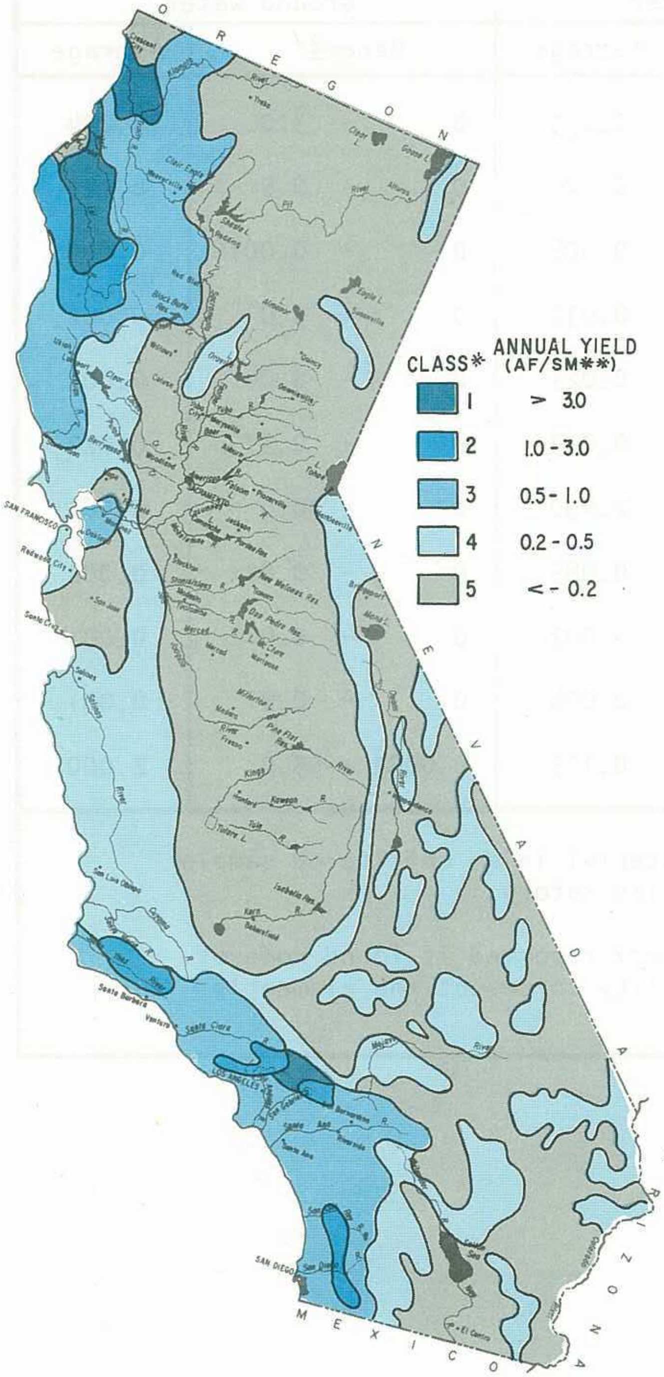
In Milligrams per Litre

Element	Surface Water		Ground Water	
	Range 2/	Average	Range 2/	Average
Arsenic	0 - 0.08	0.013	0 - 3.0	0.094
Barium	0.02 - 0.88	0.104	0 - 0.5	0.127
Cadmium	0.0007 - 0.11	0.008	0 - 0.0016	0.0003
Chromium (Hex)	0.01 - 0.15	0.037	0 - 5.0	0.002
Chromium (Total)	0 - 0.70	0.023	0 - 0.04	0.003
Copper	0.0007 - 0.75	0.033	0 - 0.37	0.022
Iron	0.008 - 228.0	2.490	0 - 70.6	0.563
Lead	0 - 2.4	0.085	0 - 0.02	0.002
Mercury	0 - 0.30	0.002	0 - 0.012	0.001
Selenium	0 - 0.015	0.004	0 - 0.01	0.001
Zinc	0.002 - 28.0	0.123	0.0003 - 95.0	2.000

1/ Determined as the total amount of material in an unfiltered sample following vigorous digestion in the laboratory.

2/ The zero value indicates the laboratory reported it found none of the element (to the limit of its ability to detect the element's presence).

FIGURE 20. ANNUAL SEDIMENT YIELD



* SEDIMENT YIELD CLASSES BASED ON 70 SUSPENDED SEDIMENT GAGING STATIONS & 100 RESERVOIR SEDIMENT SURVEYS

"FACTORS AFFECTING SEDIMENT YIELD" BY PACIFIC SOUTHWEST INTERAGENCY COMMITTEE (PSIAC)

** AF/SM - ACRE FEET PER SQUARE MILE

1 AF = 1233.5 CUBIC METRES (m^3)

1 mi^2 = 2.590 SQUARE KILOMETRES (km^3)

SEDIMENT LOADS

From the standpoint of water quality, sediment is the most common pollutant in streams and the major polluting material in volume in the world. From a geologic viewpoint, sediment is the natural result of the weathering and erosion of the continent, an integral part of a complex cycle of crustal change. Man's activity in a watershed, such as urban development, road building, farming or logging, can greatly increase the rate of erosion and resultant sediment production.

In California, the total sediment load of all streams is estimated to average 120 million tons annually (109 million tonnes), or about 61,000 acre-feet (75.24 cubic hectometres). Sediment yield is not uniform throughout the State (Figure 20). It varies from an annual average of about 0.1 acre-foot per square mile (47.6 cubic metres per square kilometre) to over 3.0 ac-ft/sq mi (1,429 m^3/km^2). The highest rates occur in the lower reaches of the Eel and Klamath Rivers and along the San Gabriel Front in southern California. The lowest rates occur in the Sierra Nevada, the Cascade Range, and the Central Valley.

Sediment deposition is both beneficial and detrimental. The detriments include increased flood damage, destruction of fish spawning beds, loss of reservoir storage capacity, and reduced fertility of soils. Some benefits are beach sand replenishment, formation of industrial sand and gravel deposits, and, occasionally, increased soil fertility.

The Department of Water Resources currently supports the operation of 20 suspended sediment stations over the State by the U. S. Geological Survey. These are largely concentrated in the North Coastal hydrologic area where the sediment loads are the greatest. Six are situated in the Eel River Basin where special measurements of bed load (coarse material moving on or near the streambed) are made.

The accompanying graphs for the Eel River at Scotia (Figure 21) and the Sacramento River at Sacramento (Figure 22) illustrate the large annual variation of sediment loads. The Eel River is an extreme case; its load has varied from 4.8 million tons (4.35 million tonnes) in the 1961-1962 water year to 168 million tons (152.4 million tonnes) in the 1964-1965 water year. The Eel River carried over 100 million tons (90.7 million tonnes) of sediments during the two-week flood of December 1964. The variation in the Sacramento River is much less, from 0.8 million tons (0.7 million tonnes) in 1972 to 5.6 million tons (5.1 million tonnes) in 1965. In terms of concentration, the difference between the streams is even more dramatic. For the Eel River, the overall average concentration is about 3,800 milligrams per litre; for the Sacramento River, it is about 110 mg/l.

The tremendous volume of sediment in motion at the time of the December 1964 flood on the Eel River was an extraordinary case, for it does not follow that above-average runoff will always produce above-average sediment discharge. This is illustrated in Figure 21, where the total runoff for each water year is plotted with the sediment discharge. In 1968, another "wet" year when there was much flooding, the volume of sediment produced was only one-sixth of that in 1965 and less than in 1970, when the runoff was just 60 percent of the 1958 value. In contrast, on the Sacramento River (Figure 22), a reasonable correlation apparently exists between runoff and sediment discharge, although, as with the Eel River, runoff in 1958 produced less sediment than in 1965 when the runoff was lower.

The collection of data on sediment discharge is also vital to the design of stream channel reservoirs used to store water for substantial periods of time. Inevitably, a certain amount of this storage is lost because of the deposition of sediment. Accordingly, reservoirs on watercourses are designed to accommodate the influx of sediment. This volume is referred to as "dead storage". Most of the storage reservoirs in California are located in basins which do not produce much sediment. Dead storage has been provided in these reservoirs so that there will be adequate storage capacity for the life of each feature.

FIGURE 21. SUSPENDED SEDIMENT, EEL RIVER AT SCOTIA

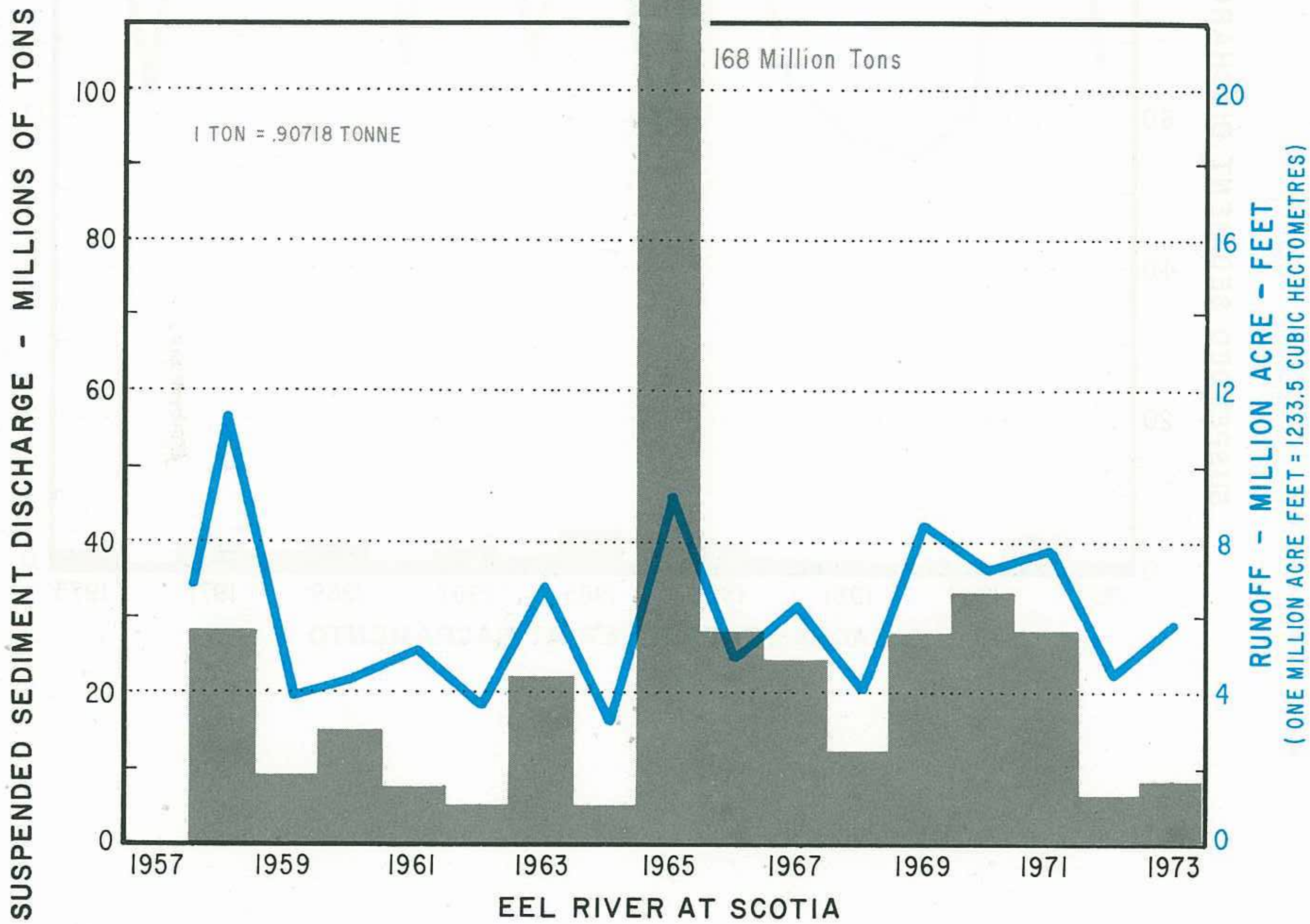
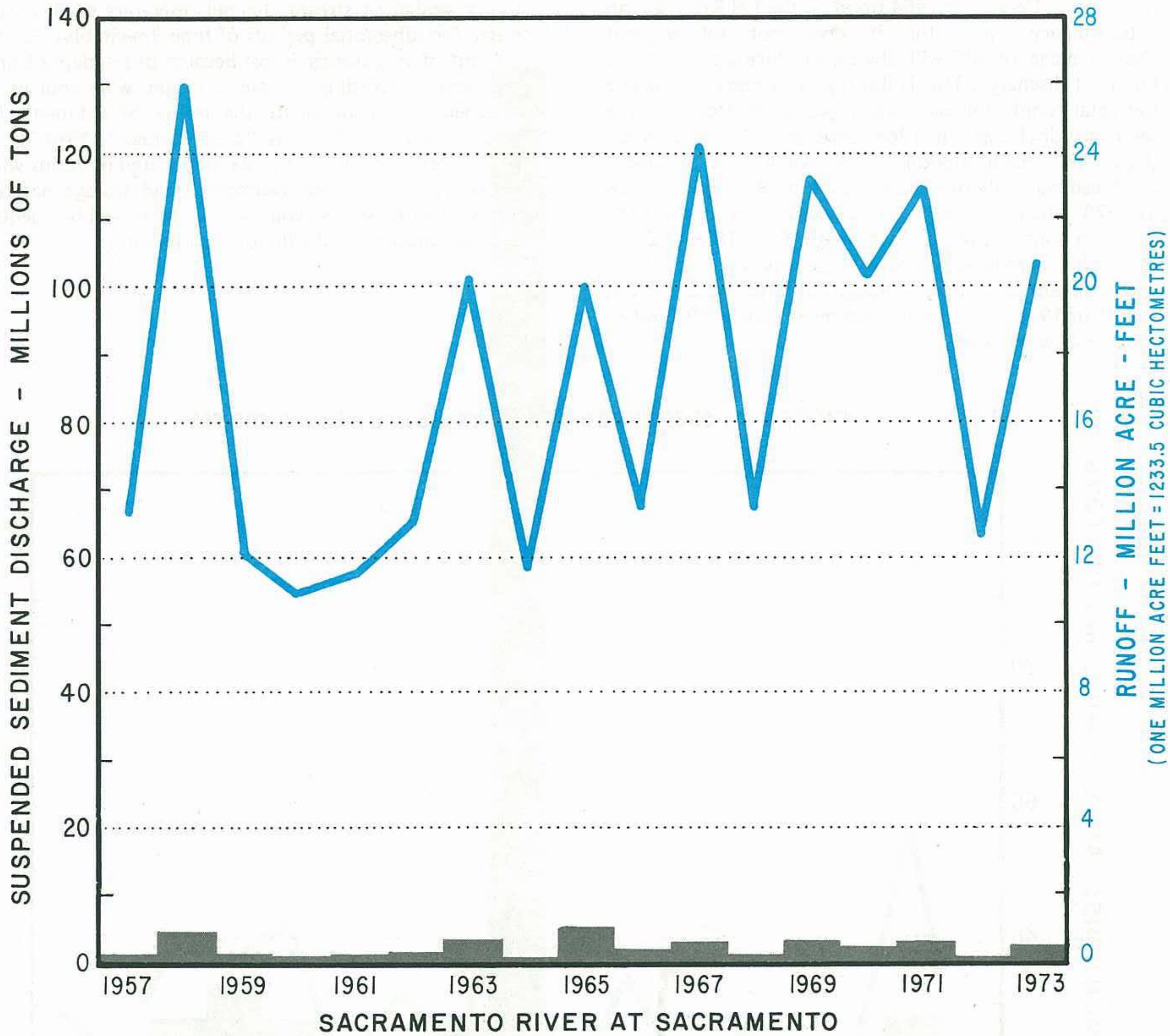
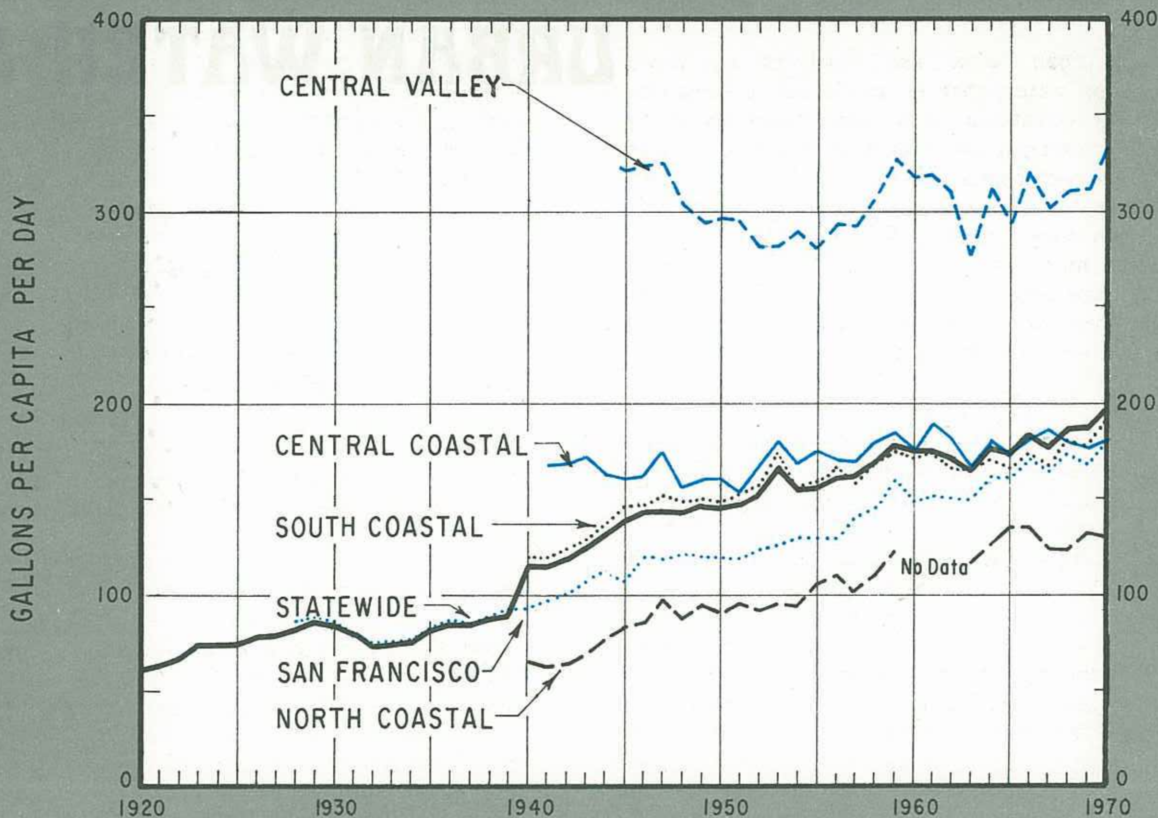


FIGURE 22. SUSPENDED SEDIMENT, SACRAMENTO RIVER AT SACRAMENTO

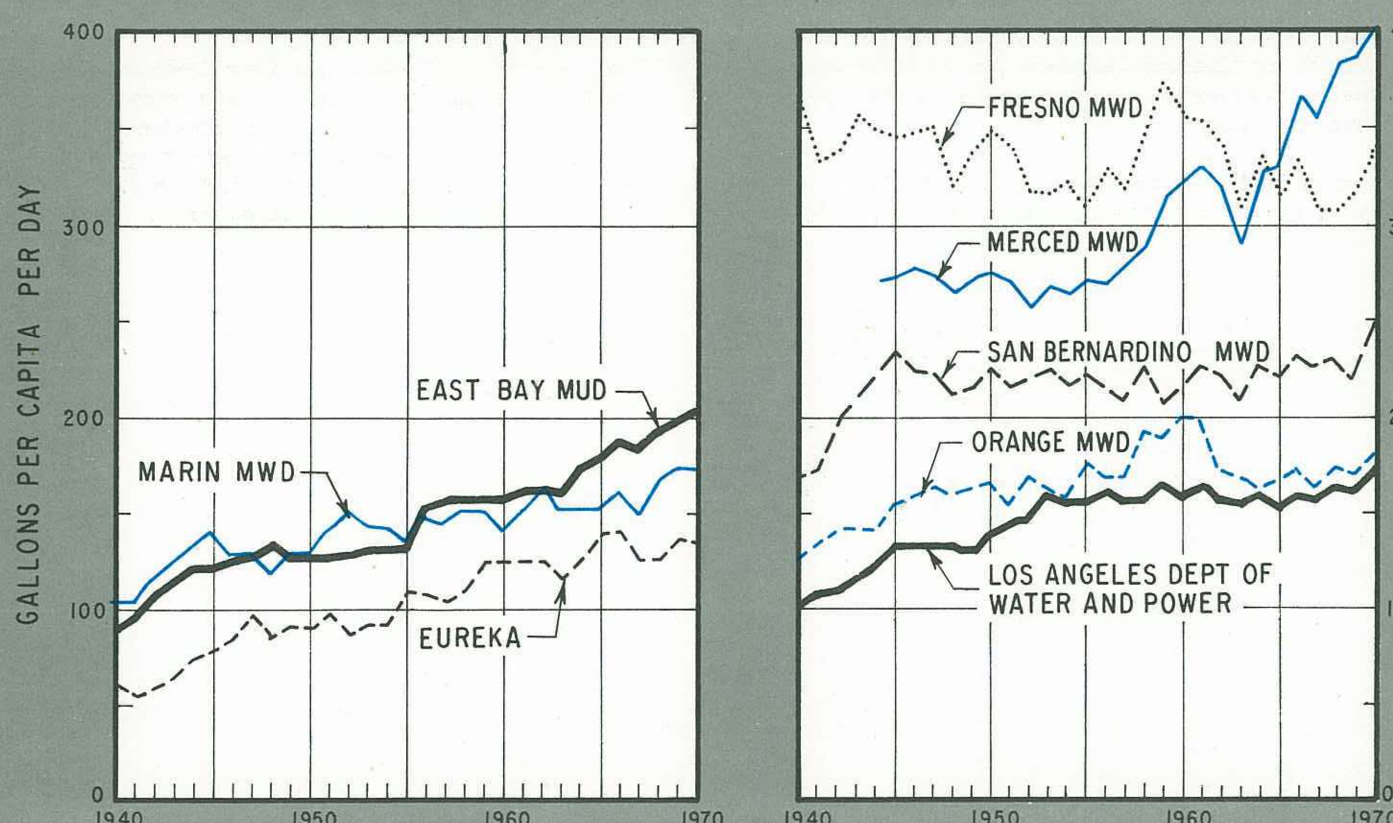


URBAN WATER USE

FIGURE 23. TRENDS IN URBAN WATER USE



URBAN UNIT WATER USE IN MAJOR HYDROLOGIC AREAS



TRENDS IN UNIT WATER USE, SELECTED AGENCIES

URBAN WATER USE

The term "urban water use" includes all urban applications of water; that is, residential, commercial, industrial, and recreational. It is interchangeable with the expression, "municipal and industrial water use." Such use of water has of course always existed but, as villages grew to towns, towns to cities, and cities to metropolitan areas or urban conglomerates, the amount of water used there became more and more significant. In California, urban water use accounts for about 13 percent of the total water used for all purposes. This equals about 200 gallons (757 litres) a day for each resident.

The trend in water use throughout most of the State since 1920 is shown at the top of Figure 23. Data are available for the North Coastal, San Francisco Bay, Central Coastal, and South Coastal hydrologic areas and for the Central Valley (which comprises the Sacramento Basin, Delta-Central Sierra, San Joaquin Basin, and Tulare Basin hydrologic areas). While there are data for certain cities, insufficient information exists at this time to show how trends are developing in the mountain and desert areas of the North Lahontan, South Lahontan, and Colorado Desert hydrologic areas. Much of the use in these areas is tourist-related and, in the case of the desert, tied to high temperatures.

Records of urban water use in San Francisco Bay area reach back to the 1920s, when the principal utilities – East Bay Municipal Utility District, San Francisco Water Department, San Jose Water Works, and Marin Municipal Water District – served nearly one million persons. Most records for California, however, start in 1940, when the average daily use of water statewide was 114 gallons (431 litres) per capita.

Except in the Central Valley, the annual values of urban water use show a slow but steady increase, with some areas rising more sharply than others. Undoubtedly the growing popularity of water-using household appliances, including washing machines, dishwashers, and garbage disposal units, plus today's custom of frequent or daily bathing, are together responsible in part for the increase. At the same time, developers have made greater allowances for garden areas in new tract homes, nearly all of which are eventually fully landscaped. Roughly half of all domestic water is used to water gardens; most of this water is taken up by plant tissues, rather than being released through evapotranspiration to the atmosphere.

Fluctuations in urban use of water in the Central Valley do not appear to follow the trend of other areas, although there is a parallel overall rise, beginning about 1953. Values for the years before 1950 may reflect changes in operation and management of delivery systems as they grew, or the effects of unusually dry periods that occurred during the late 1940s.

The developments responsible for higher unit water use were slow in coming. Reversal of this trend may also take a long time. Per capita urban use can be expected to decline because of the growth of apartment buildings and condominiums. These multiple-unit structures have high resident density but relatively small garden areas. Since about 60 percent of urban water use is residential, this drop alone could help lead to a reduction in use. The added incentives to save water through conservation programs and revised pricing schedules should cause a more rapid reversal of the present overall trend toward increasing use of urban water.

The trend in unit water use since 1940 in selected localities throughout the State is shown in the graph at the bottom of page 58. Additional information about unit water use for 147 major water service agencies in California will be found in DWR Bulletin No. 166-2, *Urban Water Use in California*, October 1975.

CONVERSION FACTORS

English to Metric System of Measurement

Quantity	English unit	Multiply by	To get metric equivalent
Length	inches (in)	25.4	millimetres (mm)
		.0254	metres (m)
	feet (ft)	.3048	metres (m)
	miles (mi)	1.6093	kilometres (km)
Area	square inches (in^2)	6.4516×10^{-4}	square metres (m^2)
	square feet (ft^2)	.092903	square metres (m^2)
	acres	4046.9	square metres (m^2)
		.40469	hectares (ha)
		.40469	square hectometres (hm^2)
		.0040469	square kilometres (km^2)
	square miles (mi^2)	2.590	square kilometres (km^2)
Volume	gallons (gal)	3.7854	litres (l)
		.0037854	cubic metres (m^3)
	million gallons (10^6 gal)	3785.4	cubic metres (m^3)
	cubic feet (ft^3)	.028317	cubic metres (m^3)
	cubic yards (yd^3)	.76455	cubic metres (m^3)
	acre-feet (ac-ft)	1233.5	cubic metres (m^3)
		.0012335	cubic hectometres (hm^3)
		1.233×10^{-6}	cubic kilometres (km^3)
Volume/Time (Flow)	cubic feet per second (ft^3/s)	28.317	litres per second (l/s)
		.028317	cubic metres per second (m^3/s)
	gallons per minute (gal/min)	.06309	litres per second (l/s)
		6.309×10^{-5}	cubic metres per second (m^3/s)
	million gallons per day (mgd)	.043813	cubic metres per second (m^3/s)
Mass	pounds (lb)	.45359	kilograms (kg)
	tons (short, 2,000 lb)	.90718	tonne (t)
		907.18	kilograms (kg)
Power	horsepower (hp)	0.7460	kilowatts (kW)
Pressure	pounds per square inch (psi)	6894.8	pascal (Pa)
Temperature	Degrees Fahrenheit (°F)	$\frac{tF - 32}{1.8} = tC$	Degrees Celsius (°C)

DISTRICT OFFICES OF THE DEPARTMENT OF WATER RESOURCES

NORTHERN DISTRICT
P. O. Box 607
Red Bluff, CA 96080
(2440 Main Street)
916 527–6530

CENTRAL DISTRICT
P. O. Box 9137
Sacramento, CA 95816
(3251 S Street)
916 445–6831

SAN JOAQUIN DISTRICT
P. O. Box 5710
Fresno, CA 93755
(3374 East Shields Ave.)
209 488–5223

SOUTHERN DISTRICT
P.O. Box 6598
Los Angeles, CA 90055
(849 South Broadway)
213 620–4136

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Sacramento, CA 95802
916 445–9371