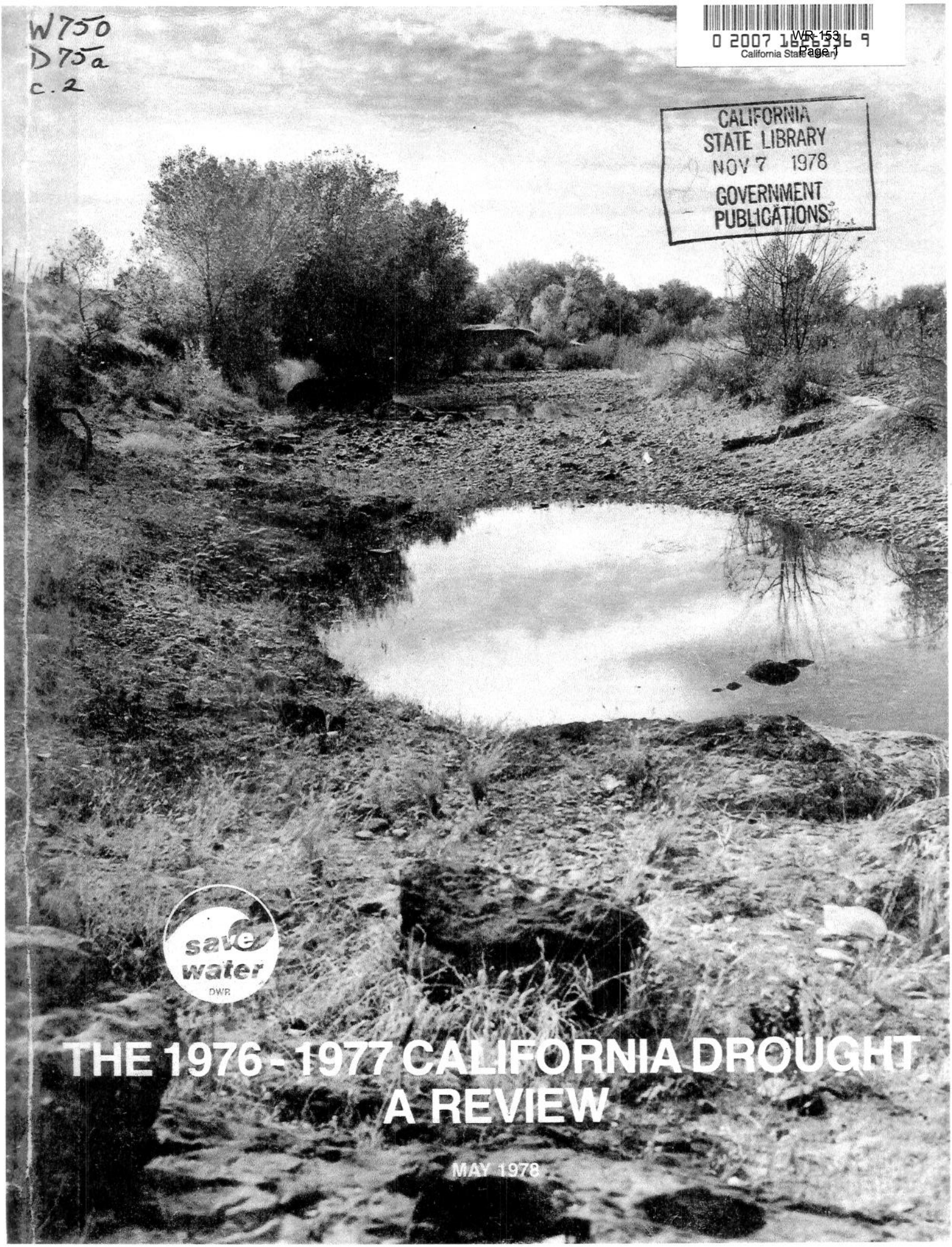


THE 1976 - 1977 CALIFORNIA DROUGHT A REVIEW

MAY 1978

State of California
The Resources Agency

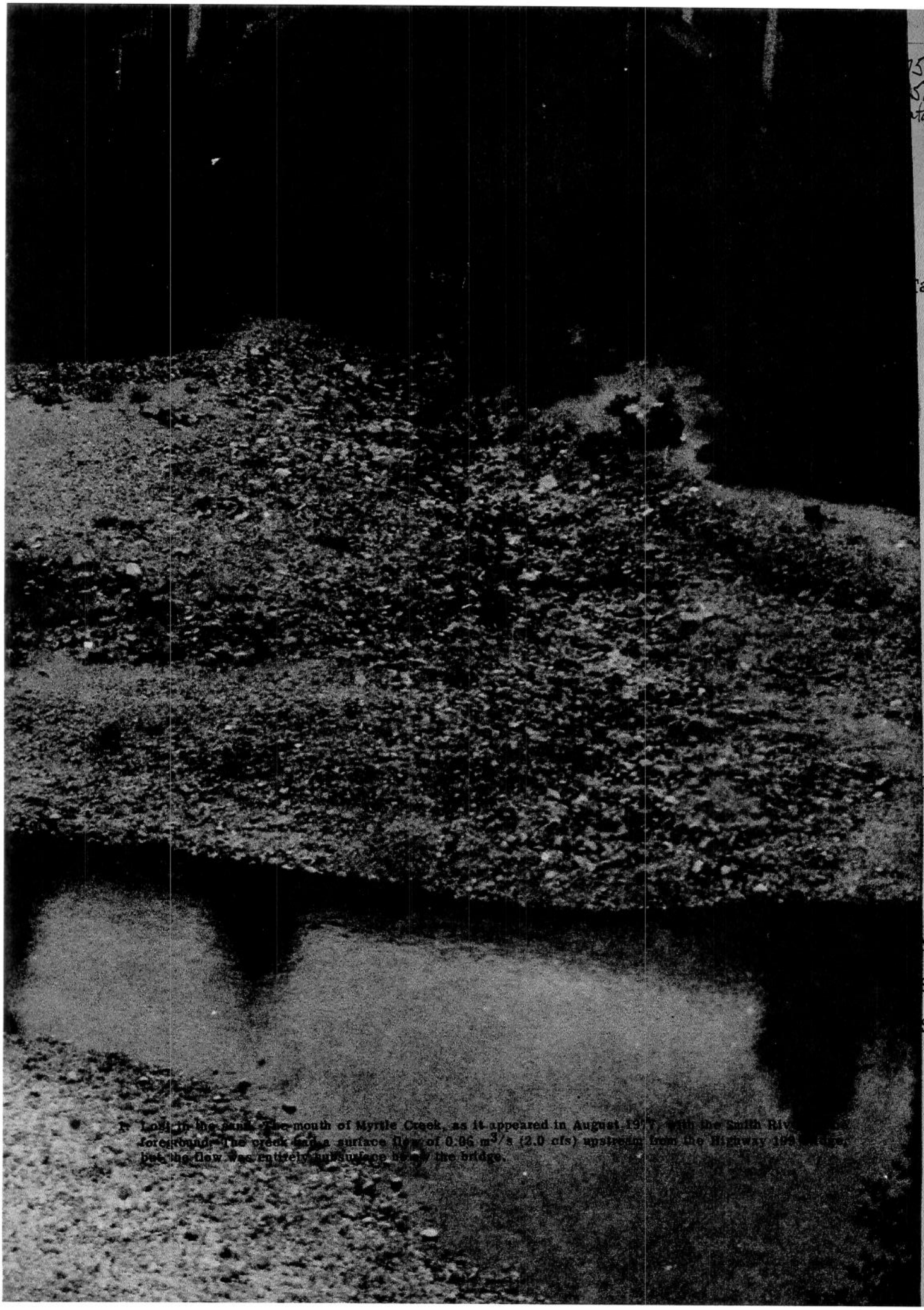
Department of
Water Resources

The 1976-1977 California Drought
A Review

May 1978

ON THE COVER

As the drought continued in 1977, many rivers, like the Cosumnes River pictured above, ceased flowing. When this photo was taken on November 17, 1977, there had been no flow in the Cosumnes River for almost five months.



Loss in the bank, the mouth of Myrtle Creek, as it appeared in August 19[illegible], with the Smith Riv[illegible] foreground. The creek had a surface flow of 0.06 m^3/s (2.0 cfs) upstream from the Highway 199 [illegible] but the flow was entirely subsurface below the bridge.

"The

Table 3

San Jo

Overd

Tulare

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Table 5

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Sierra V

South Ta
Valley

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Department of Water Resources
"The 1976-1977 California Drought--A Review"
May 1978

ERRATA

Table 3 - page 15

San Joaquin Basin - 1978

Overdraft should read -400*

Tulare Lake - 1978

	Should Read
Imported	3,600
Subtotal	10,200
Overdraft	-1,600*

*Accretion. Long-term overdraft condition still exists.

ADDITIONAL DATA

Table 5 - page 23

	Avg. Depth Spring 1978	Annual Change 1977-1978	Net Change 1970-78
Mohawk Valley	6.7	+0.5	+0.5
Sierra Valley	3.2	+1.5	-2.3
South Tahoe Valley	25.7	+1.8	-3.4

FOREWORD

This is the fifth and final Department of Water Resources' report on the 1976-1977 California drought, the worst in the State's history, which saw 1976, the fourth driest year of record, give way to 1977, the driest ever. These reports provide the most comprehensive documentation of a drought in history.

Now that the two dry years are past, we must not allow the abundant water supplies of 1978 to lull us into a false sense of security. Droughts do not recur in precise historical sequence or in equal severity. The years 1976 and 1977, together, far exceeded in dryness our historic prior two-year dry period of record. The experience of the worst earlier drought, covering the seven years from 1928-1934, should be reason enough for Californians not to let up in their water conservation efforts. In the 1928-34 drought, at least one year within the cycle provided near-normal rainfall. The year 1978 may turn out to be a temporary respite, also.

The 1976-1977 drought has again shown the finite nature of our resources and our limited ability to control nature. This report, prepared by the Department's Drought Information Center, updates the August 1977 report and places the entire two-year period in perspective. It documents the impact of the drought and details the response by federal, State, and local governments and the public. Californians can be justly proud of their individual and collective response to the drought.

This report also discusses lessons learned from the drought and suggests future actions to enable us to better use our State's limited water resources. We must take the opportunity now, while events are still fresh in mind, and we have the breathing spell provided by 1978 rains, to plan for coping with the next dry period. There is no assurance that the next drought is not just beyond the horizon. We can be assured, however, that drought will return, and, considering the greater needs of that future time, its impact, unless prepared for, will be much greater.

Ronald B. Robie

Ronald B. Robie, Director
Department of Water Resources
The Resources Agency
State of California

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MAY 1978

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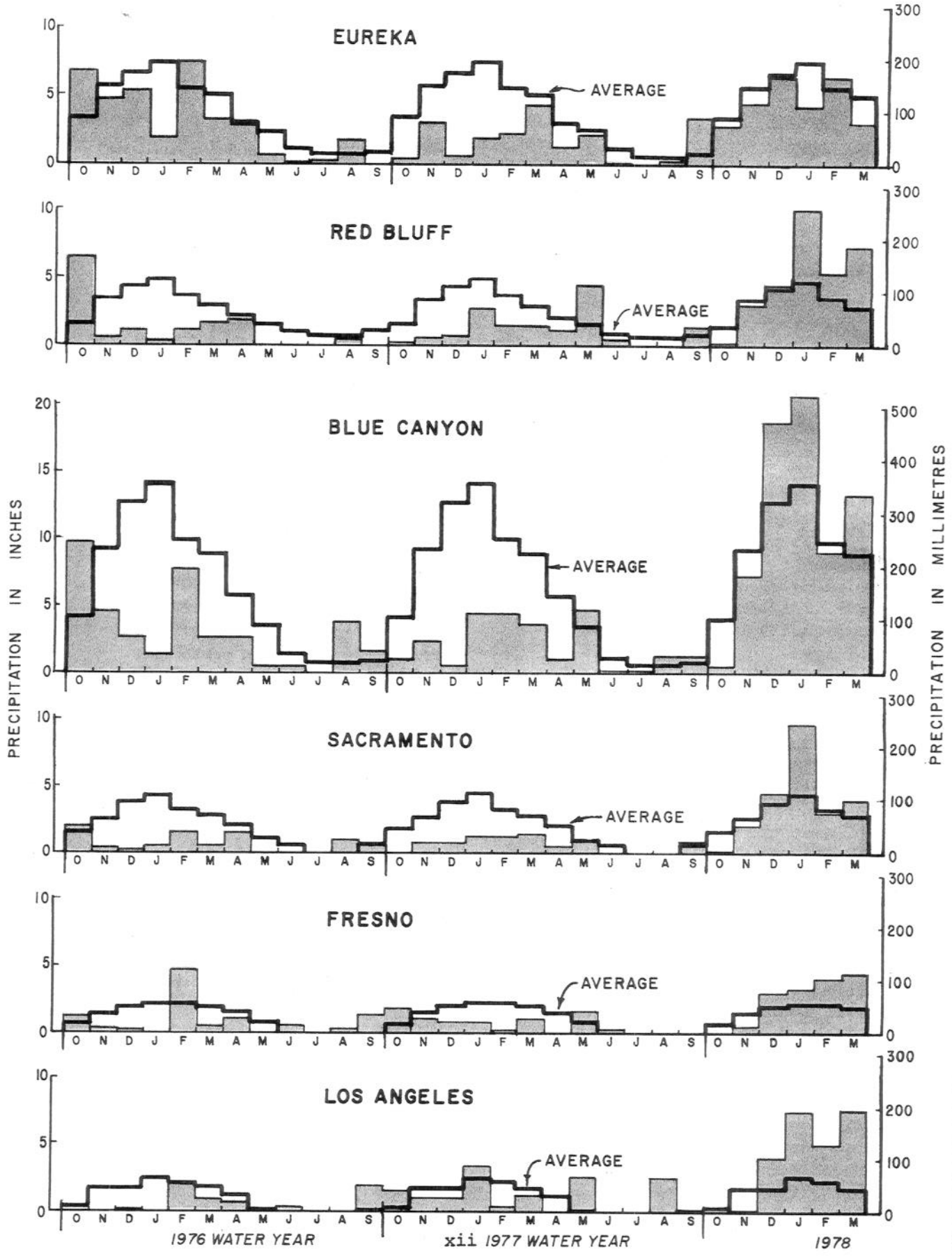
CONVERSION FACTORS

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)

Figure 1.

MONTHLY PRECIPITATION AT SELECTED LOCATIONS
October 1, 1975 - March 31, 1978



THE 1976-1977 DROUGHT - AN UPDATE

The year 1977 will be remembered as the driest year in the State's recorded history and as the second successive dry year of the worst drought California has experienced in over 100 years of record. It followed 1976, which now has the distinction of being the fourth driest year of record.

Two consecutive years with little precipitation left California with record low storage in its surface reservoirs and with ground water levels dangerously lowered.

Until January 1978, the low surface storage was viewed as especially critical since, in an average year, 60 percent of California's water supply is derived from surface water. In the absence of those supplies, greater dependence was placed on ground water, further depleting this resource. The heavy rains of January through March 1978 replenished surface supplies and provided a substantial snowpack, thus ending the threat of a third year of drought that would have had catastrophic consequences in many areas of the State.

Besides providing immediate relief for 1978, the substantial carry-over storage expected in the State's surface reservoirs in the fall of 1978 nearly guarantees averting a year of limited supplies in 1979 even if the coming year were to signal the beginning of a new drought.

The incredible recovery from the State's worst drought should not make us complacent, however. The 1976-77 drought has demonstrated the unpredictable nature of California's weather, and it behooves us to be increasingly careful with our water resources. Furthermore, the State's ground water basins must be recharged to provide anew the margin allowed us in 1977.

Precipitation and Runoff

Statewide, average precipitation in California is 250 000 cubic hectometres (200,000,000 acre-feet) annually. In the 1976 water year (October 1, 1975 to September 30, 1976), precipitation totaled 160 000 cubic hectometres (130,000,000 acre-feet), only 65 percent of average. In the 1977 water year ending September 30, 1977, precipitation totaled even less, 110 000 cubic hectometres (90,000,000 acre-feet), or 45 percent of average. The two years of limited rain and snow reduced runoff to streams and rivers to 47 percent and 22 percent for 1976 and 1977, respectively.

Figure 1 charts the monthly precipitation amounts recorded at selected stations during the drought period compared to the long-term average values. It illustrates the low precipitation levels throughout the State during 1976 and 1977 and the dramatic return to higher levels in 1978.

Figures 2 and 3 show California water year total precipitation, in terms of percentage of normal, for the 1976 and 1977 water years. Figure 2 (for the 1976 water year) pictures the central part of the State (shaded on the figure) as receiving generally less than 60 percent of normal rainfall. The extreme northern part of the State and the southern part of the Central Valley and coastal areas generally received above 80 percent of normal. The Colorado and Lahontan Deserts received amounts ranging up to 250 percent of normal.

Figure 3 (for the 1977 water year) indicates that the area receiving less than 60 percent of normal precipitation (shaded) had spread to encompass nearly the whole of the northern two-thirds of the State. A large part of the center

Figure 2.

WATER YEAR PRECIPITATION IN PERCENT OF NORMAL
October 1, 1975 - September 30, 1976

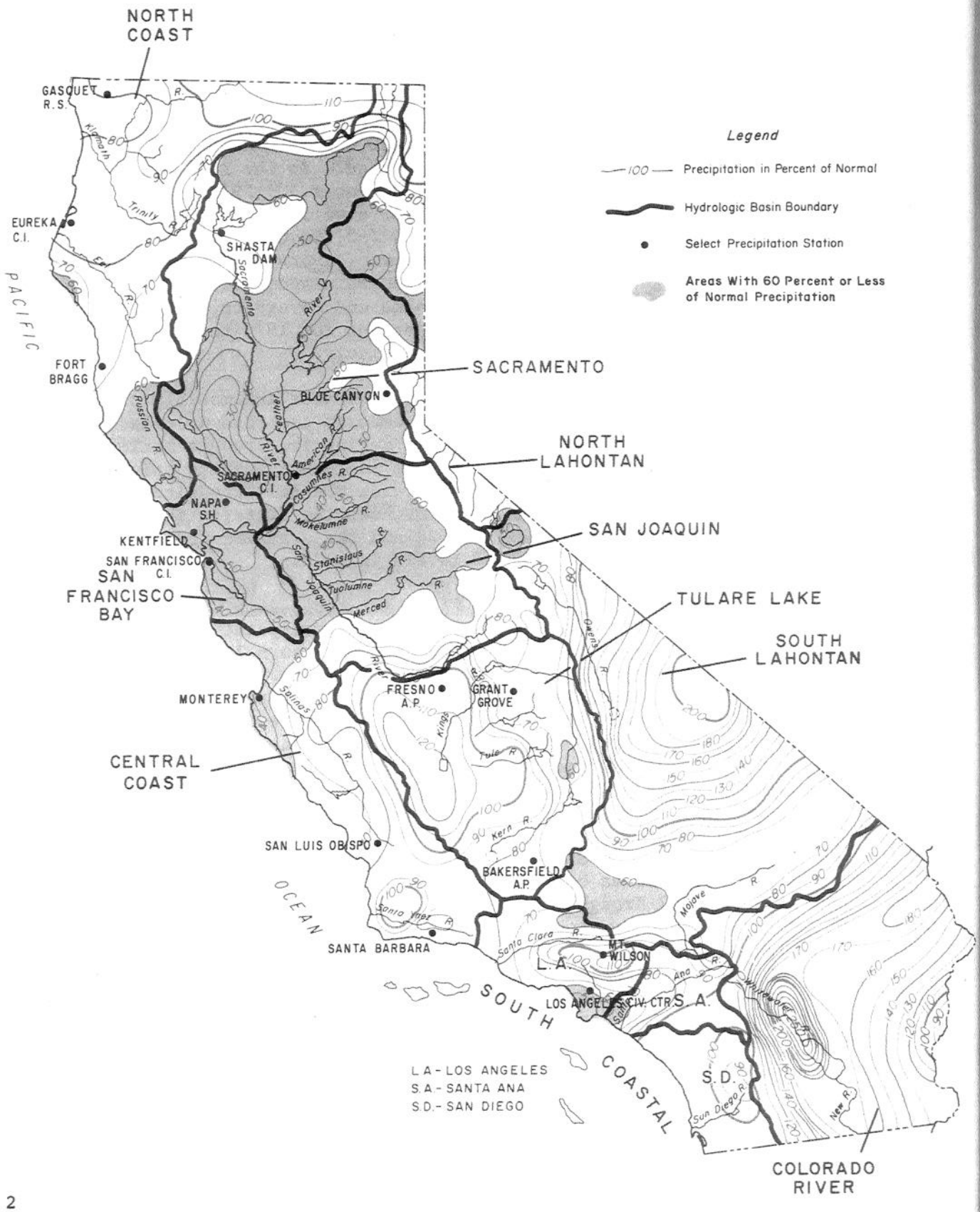
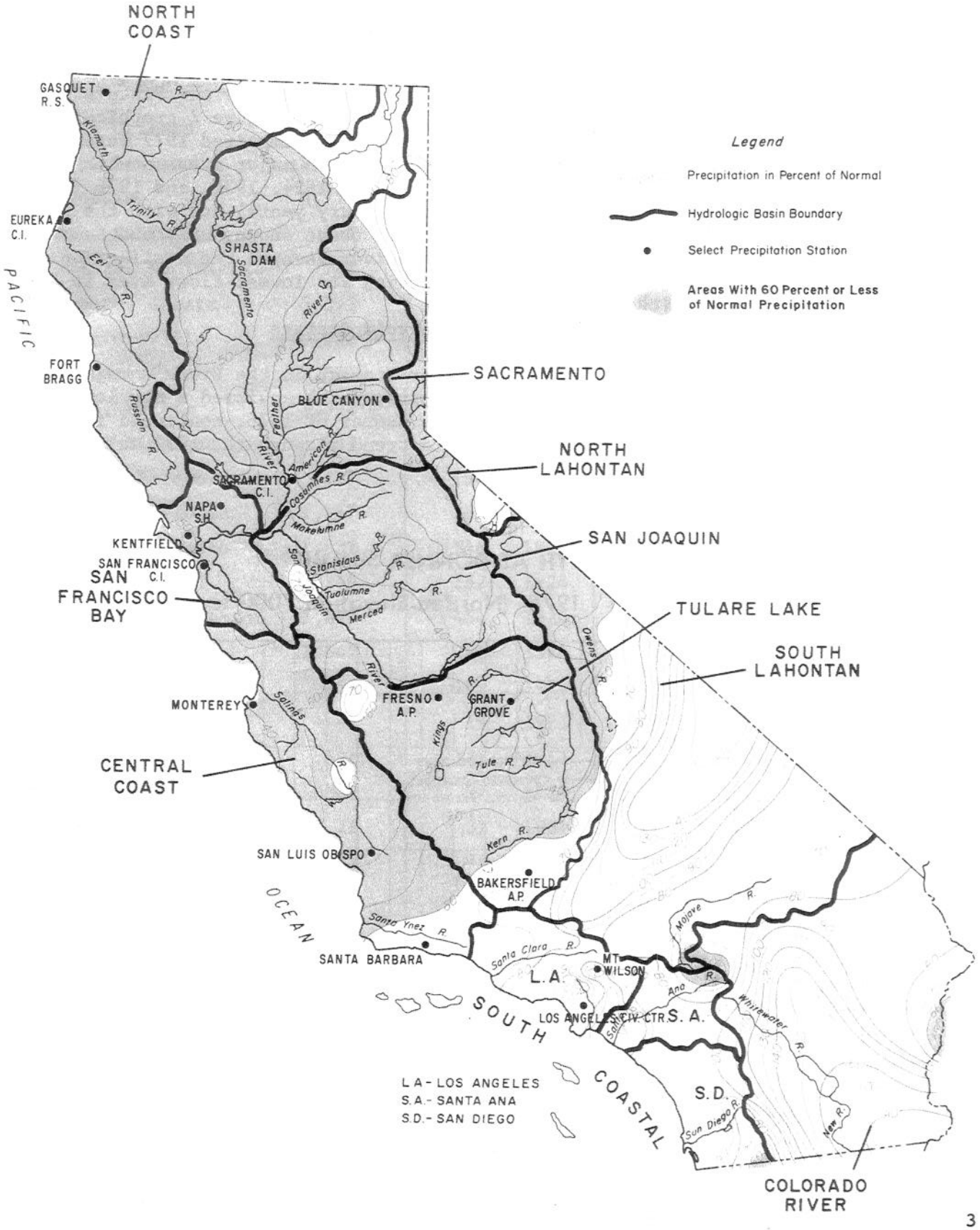


Figure 3.

WATER YEAR PRECIPITATION IN PERCENT OF NORMAL

October 1, 1976 - September 30, 1977



of the State received less than 50 percent in 1977. The record lows recorded for precipitation were reflected in record low snowpacks in 1977. The continuing lack of snowpack is exemplified by Figure 4, which shows conditions at Norden in the Sierra Nevada near Donner Summit during 1976 and 1977. (Also shown is the dramatic recovery brought about by the abundant snowfall of 1978.)

Runoff amounts in 1976 and 1977 were similarly low. In water year 1977, runoffs from interior basins ranged from a high of 48 percent of average for the Sacramento River to a low of 7 percent for the Cosumnes. On the Central Coast the situation was worse, with coastal streams registering mostly from 5 to 10 percent of normal. The Napa River had only 2 percent and the Russian 6 percent of normal runoff. Table 1 shows the 1976 and 1977 water year runoffs of selected streams compared to the minimums of record. It shows that 22 of 26 streams achieved new record lows for runoff in 1977. The Russian River had the dubious distinction of setting records for low annual runoff in two consecutive years, in 1976 and 1977. Figures 5 and 6 illustrate 1976 and 1977 water year runoffs, respectively, compared to the norm for the State's major upland basins. Figure 7 graphically compares the unimpaired 1977 water year flows of seven major streams with those recorded in 1924, 1934, and 1976 (three extremely dry years) and with the average. Of those shown, only the Sacramento River escaped the distinction of recording its lowest flows ever in 1977.

Reservoir Storage

Water storage in the State's major reservoirs, which achieved a new low in the late summer of 1976, continued its downward trend through the 1977 water year.

Figure 4.

SNOW DEPTH AT DONNER SUMMIT

Water Years 1976 - 1978 (Norden-Elevation 7000 feet)

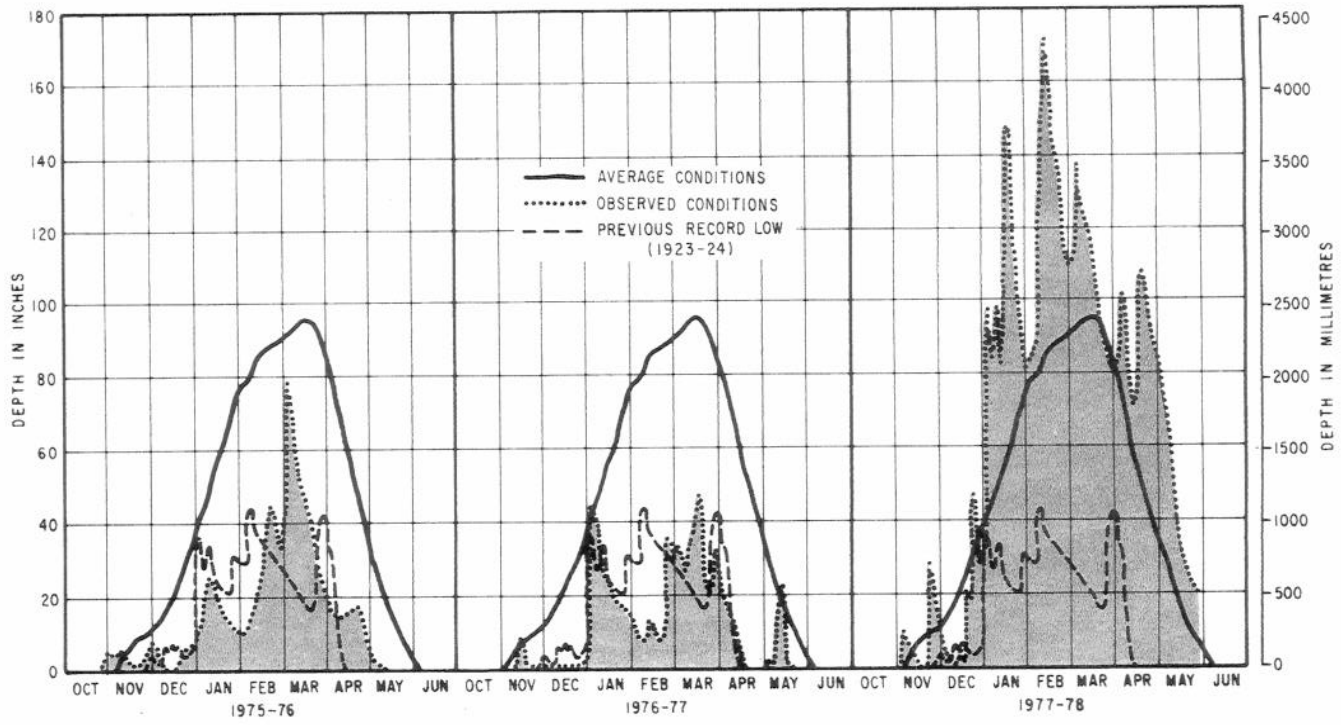


TABLE 1

WATER YEAR DROUGHT FLOWS
IN SELECTED STREAMS
(1,000 acre-feet)[1/]

Stream and Station	Median[2/] Flow	Prior Record Low	Year	1976 Flow	1977 Flow	1977 Flow as Percent of Average
Klamath, Orleans	4,295	1,772	1931	3,315	1,015*	23
Trinity, Lewiston	1,085	266	1924	672	198*	16
Eel, Scotia	4,720	878	1924	2,759	404*	8
Russian, Healdsburg	771	306	1972	120*	47*	6
Nacimiento, Nacimiento	141	15	1931	18	9*	5
Sacramento, Shasta	5,073	2,479	1924	3,613	2,628	48
Feather, Oroville	3,952	1,295	1924	1,862	1,013*	24
Yuba, Smartville	2,321	603	1924	690	339*	15
American, Folsom	2,594	543	1924	785	357*	14
Cosumnes, Michigan Bar	331	40	1924	55	26*	7
Mokelumne, Pardee	727	190	1924	236	134*	19
Stanislaus, Melones	1,117	261	1924	377	162*	15
Tuolumne, Don Pedro	1,832	546	1924	624	339*	19
Merced, Exchequer	919	252	1924	299	152*	17
San Joaquin, Millerton	1,679	444	1924	629	362*	22
Kings, Pine Flat	1,542	392	1924	536	386*	25
Kaweah, Terminous	352	102	1924	147	95*	24
Tule, Success	91	19	1961	42	16*	12
Kern, Isabella	528	175	1961	238	186	30
Truckee, Farad	387	97	1924	146	85*	22
West Carson, Woodfords	76	31	1961	32	19*	27
East Carson, Gardnerville	238	76	1924	115	63*	25
West Walker, Coleville	178	61	1924	80	47*	27
East Walker, Bridgeport	98	24	1924	40	27	25
Owens, Long Valley	147	73	1931	107	80	56
Colorado, Lake Powell	11,545	3,767	1934	8,441	3,575*	32

* New record low.

1/ Natural basin runoff. 1,000 acre-feet = 1.2335 cubic hectometres.

2/ Median flows are those expected to be exceeded half the time. (They are not necessarily equal to the average.)

Figure 5.

WATER YEAR NATURAL BASIN RUNOFF

October 1, 1975 - September 30, 1976

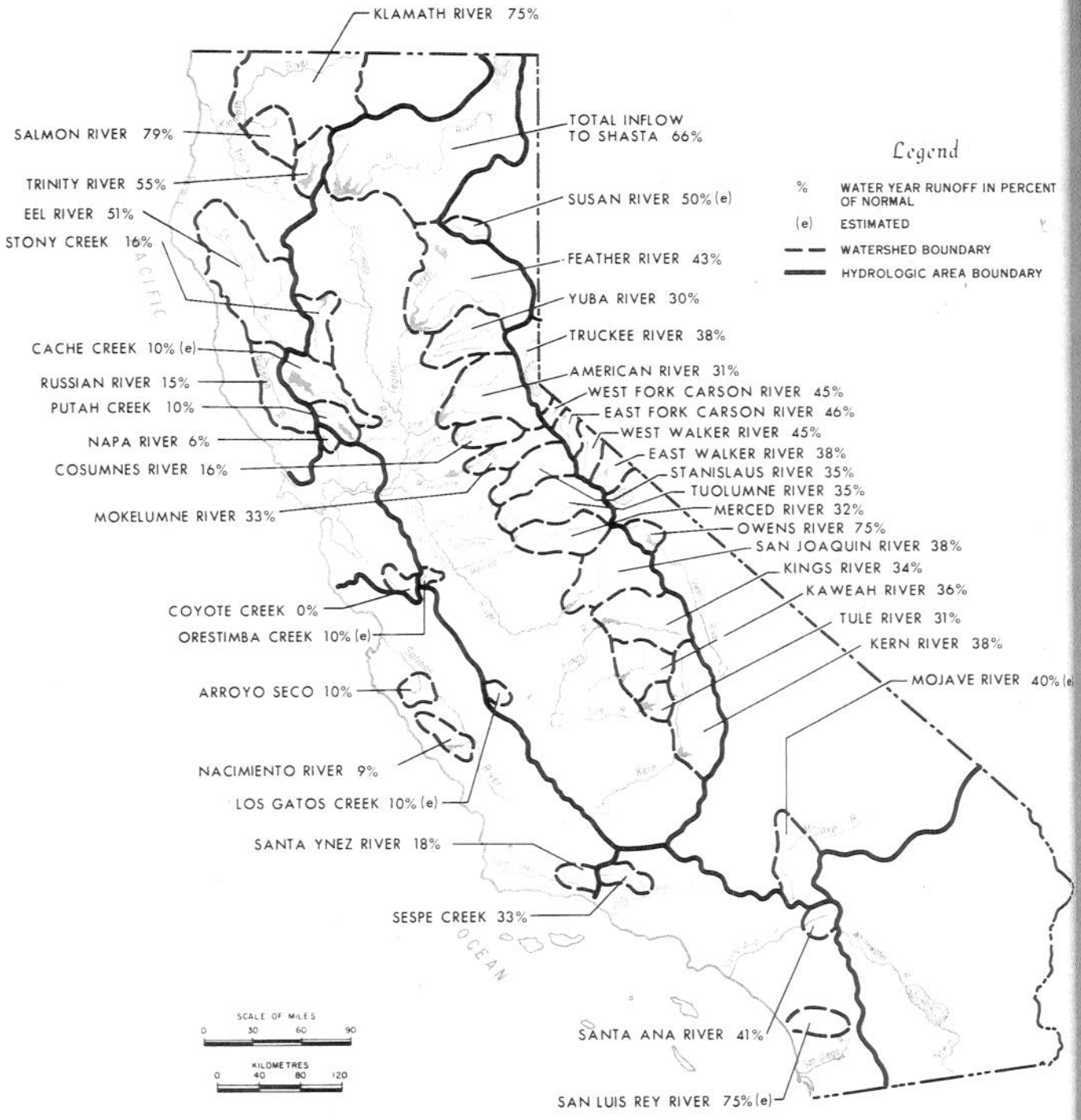


Figure 6.

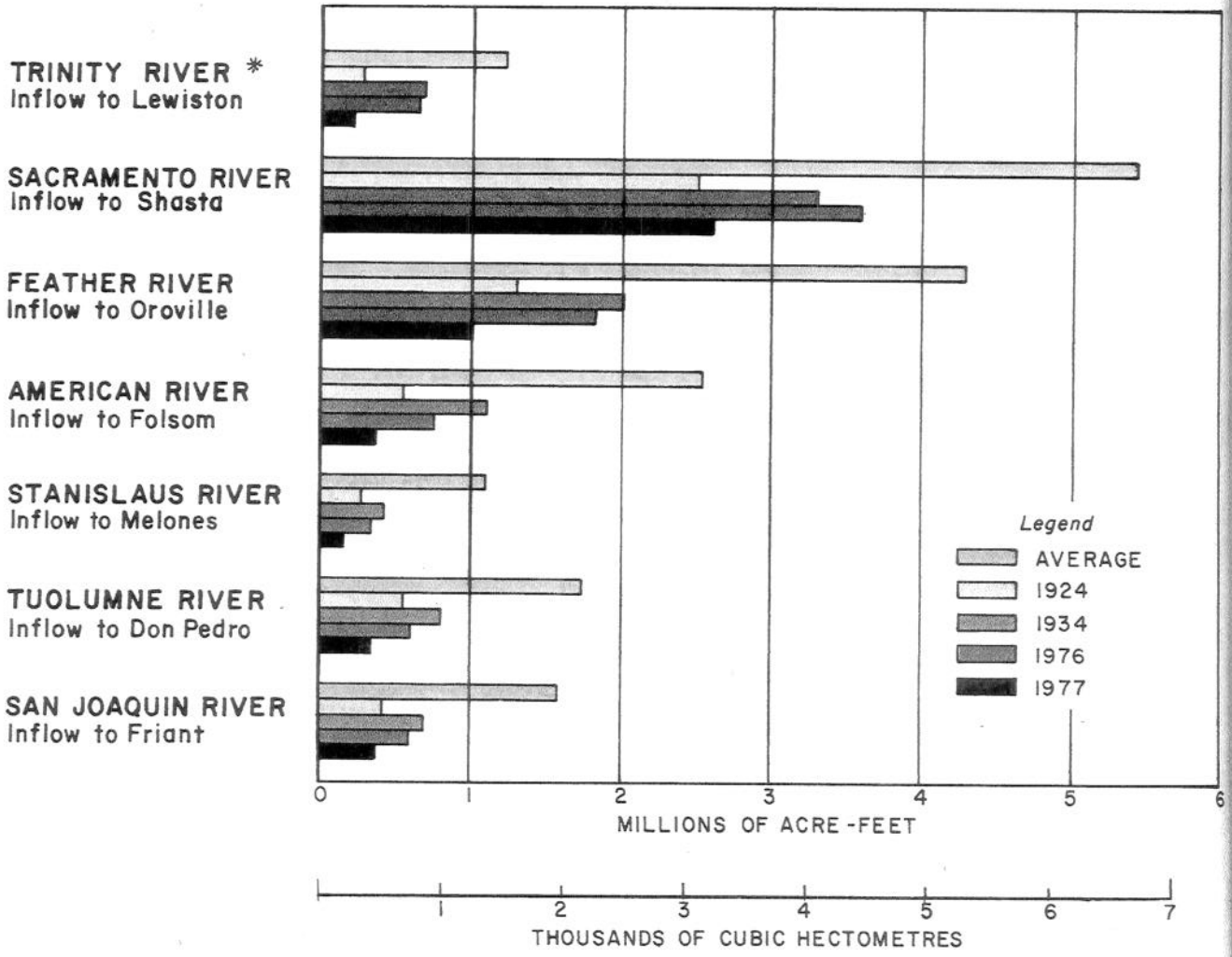
WATER YEAR NATURAL BASIN RUNOFF

October 1, 1976 - September 30, 1977

(e)

Figure 7.

UNIMPAIRED RUNOFF TO SELECTED CENTRAL VALLEY STREAMS DURING DRY YEARS



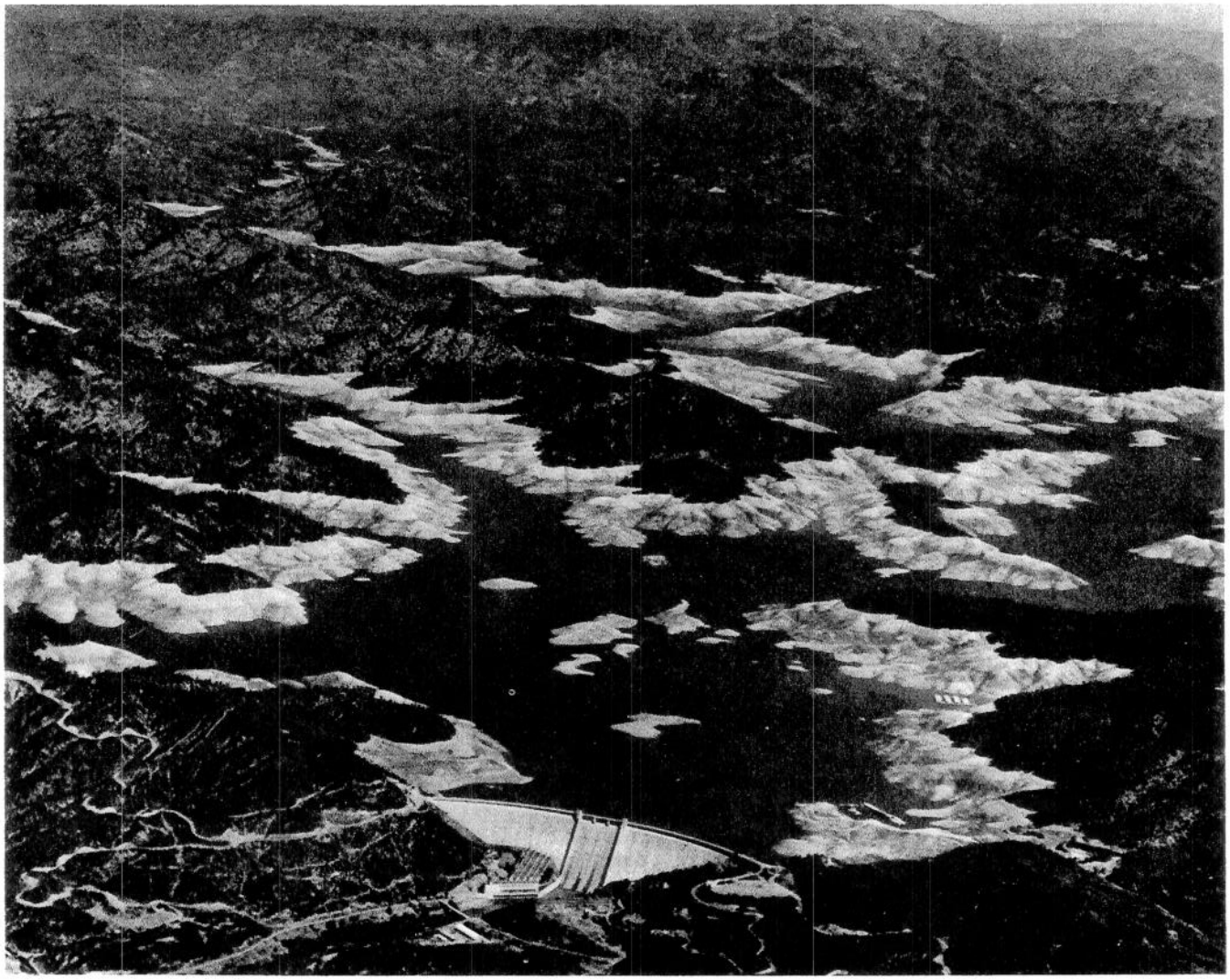
* CAPABLE OF EXPORTING WATER TO CENTRAL VALLEY

As of October 1, 1977, water storage in 143 major reservoirs comprising the bulk of California's storage capacity totaled around 9 530 cubic hectometres (7,725,000 acre-feet), compared to a ten-year average for that date of 25 580 cubic hectometres (20,740,000 acre-feet). This represented only 37 percent of average for the date and only 57 percent of that recorded one year earlier. Table 2 shows reservoir storage by seven hydrologic areas within the State and for additional reservoirs serving more than one state, including California. The table shows the progressive decline in surface storage from October 1, 1975 to October 1, 1977.

Figure 8, illustrating the drawdown at four major reservoirs, is representative of what occurred at larger reservoirs. At Lake Oroville, starting in April 1976, the storage level declined with each successive month through the 1976 water year and for 12 months straight in the 1977 water year. There was not even a mild resurgence during the normally big runoff months of spring and early summer. It was not until the December 1977 rains that recovery began.

The October 1, 1977, storage figure for Oroville was 1 130 cubic hectometres (915,000 acre-feet), compared to the norm of 3 040 cubic hectometres (2,461,000 acre-feet). Storage at Shasta for the same date was 780 cubic hectometres (631,000 acre-feet), compared to the norm of 3 890 cubic hectometres (3,153,000 acre-feet). Storage at Folsom was 180 cubic hectometres (147,000 acre-feet), compared to its norm of 830 cubic hectometres (676,000 acre-feet). Storage at Clair Engle was 300 cubic hectometres (242,000 acre-feet), compared to the norm of 2 290 cubic hectometres (1,860,000 acre-feet).

Similar drops in storage were recorded at all Central Valley reservoirs. On October 1, 1977, reservoir storage for the entire Central Valley was only 36 percent of average for that date, with the Sacramento Valley portion at 39 percent and the San Joaquin Valley at 31 percent.



2. Low point for California's largest. Lake Shasta, formed at the junction of the McCloud, Pit, and Sacramento Rivers, is the primary facility of the federal Central Valley Project. This aerial photograph was taken on September 30, 1977, when the storage was 780 cubic hectometres (631,000 acre-feet), or only 20 percent of capacity. The low point was reached on September 14, 1977, with only 690 cubic hectometres (563,000 acre-feet).

TABLE 2

RESERVOIR STORAGE BY HYDROLOGIC AREA*
CUBIC HECTOMETRES
(thousands of acre-feet)

Area	Number of Reservoirs	Total Capacity	10-Year Ave.1/ Storage	Storage Oct. 1 1975	Storage Oct. 1 1976	Storage Oct. 1 1977	1977 as Percent of Average
INTRASTATE							
North Coastal	6	3 456 (2,803)	2 493 (2,021)	2 743 (2,224)	2 030 (1,646)	363 (294)	15
San Francisco Bay	17	846 (686)	494 (400)	544 (441)	366 (297)	351 (285)	71
Central Coastal	6	1 210 (981)	699 (567)	955 (774)	613 (497)	280 (227)	40
South Coastal	28	2 603 (2,111)	1 292 (1,047)	1 280 (1,038)	1 245 (1,009)	1 016 (824)	79
Sacramento Valley	47	20 796 (16,866)	13 953 (11,312)	15 474 (12,545)	8 616 (6 985)	5 392 (4,371)	39
San Joaquin Valley	31	12 100 (9,814)	6 272 (5,085)	6 778 (5,495)	3 499 (2,837)	1 938 (1,571)	31
Lahontan	8	525 (426)	380 (308)	386 (313)	257 (208)	189 (153)	50
Subtotal	143	41 536 (33,687)	25 583 (20,740)	28 160 (22,830)	16 626 (13,479)	9 529 (7,725)	37
INTERSTATE							
North Coastal	3	1 486 (1,205)	729 (591)	910 (738)	783 (635)	464 (376)	64
Lahontan	5	1 338 (1,085)	884 (717)	981 (795)	494 (400)	44 (36)	5
Colorado River2/	4	66 006 (53,533)	41 596 (33,722)	52 189 (42,310)	51 813 (42,005)	47 342 (38,380)	114
Subtotal2/	12	68 830 (55,823)	43 209 (35,030)	54 080 (43,843)	53 090 (43,040)	47 850 (38,792)	111
TOTAL2/	155	110 366 (89,510)	68 792 (55,770)	82 240 (66,673)	69 716 (56,519)	57 379 (46,517)	83

1/ Average for the 10 years 1967-76.

2/ 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.

* The reservoirs used in this tabulation include most, but not all, of the storage capacity available in each area.

Figure 8.

WATER STORAGE IN FOUR MAJOR RESERVOIRS
1975 – 1978 Water Years

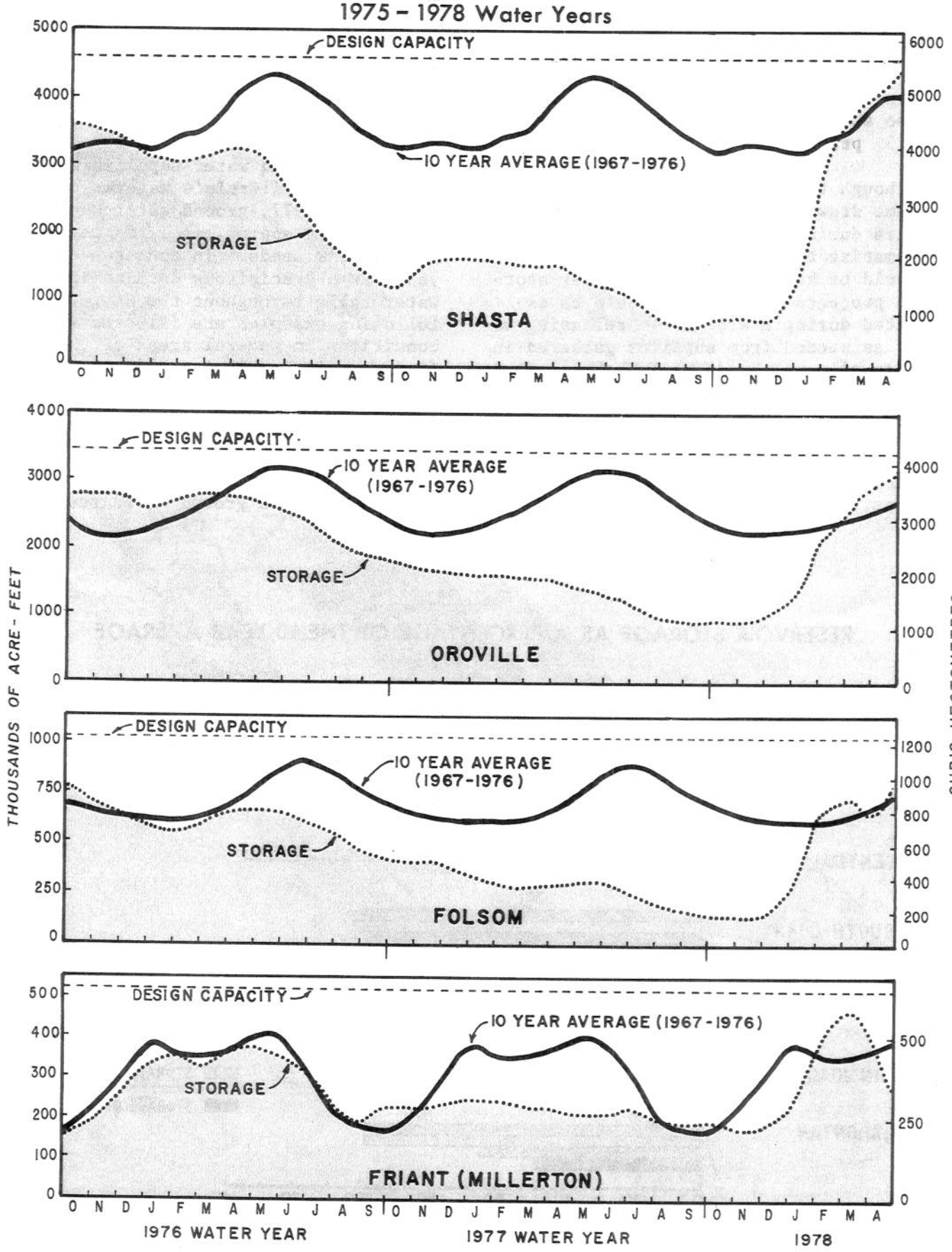


Figure 9 compares the October 1, 1977, storage in the State's seven major geographical areas with that of the same date in 1976, and the average for that date for the ten-year period 1966-1975. Also shown are figures for October 1, 1975, prior to the drought.

Although these figures document the extreme drawdown of California's reservoirs during the two-year drought and dramatize the record lows reached, it should be kept in mind that water storage projects operated as would be expected during a drought -- releasing water as needed from supplies gathered in years of more abundance. The so-called "yields" of the State's water projects were put to the test, and most, but not all, performed well enough to withstand the two-year dry period. A third dry year, fortunately, was averted by 1978 rains.

Ground Water Levels and Water Use

The shortage of surface water in the 1977 water year necessitated the use of considerably more ground water than usual in agricultural and urban areas.

Normally, ground water supplies meet 40 percent of California's water needs. In water year 1977, ground water was called upon to meet approximately 53 percent of the State's needs. In consequence, the year saw a precipitous decline in the water table throughout the State. The following examples are illustrative of conditions in several areas of the State. (Refer to Figure 10 for locations of hydrologic regions noted.)

In the San Joaquin Valley, reduced imports and depleted carry-over storage in local reservoirs combined to put considerable strain on ground water resources.

Figure 9.

RESERVOIR STORAGE AS A PERCENTAGE OF THE 10 YEAR AVERAGE

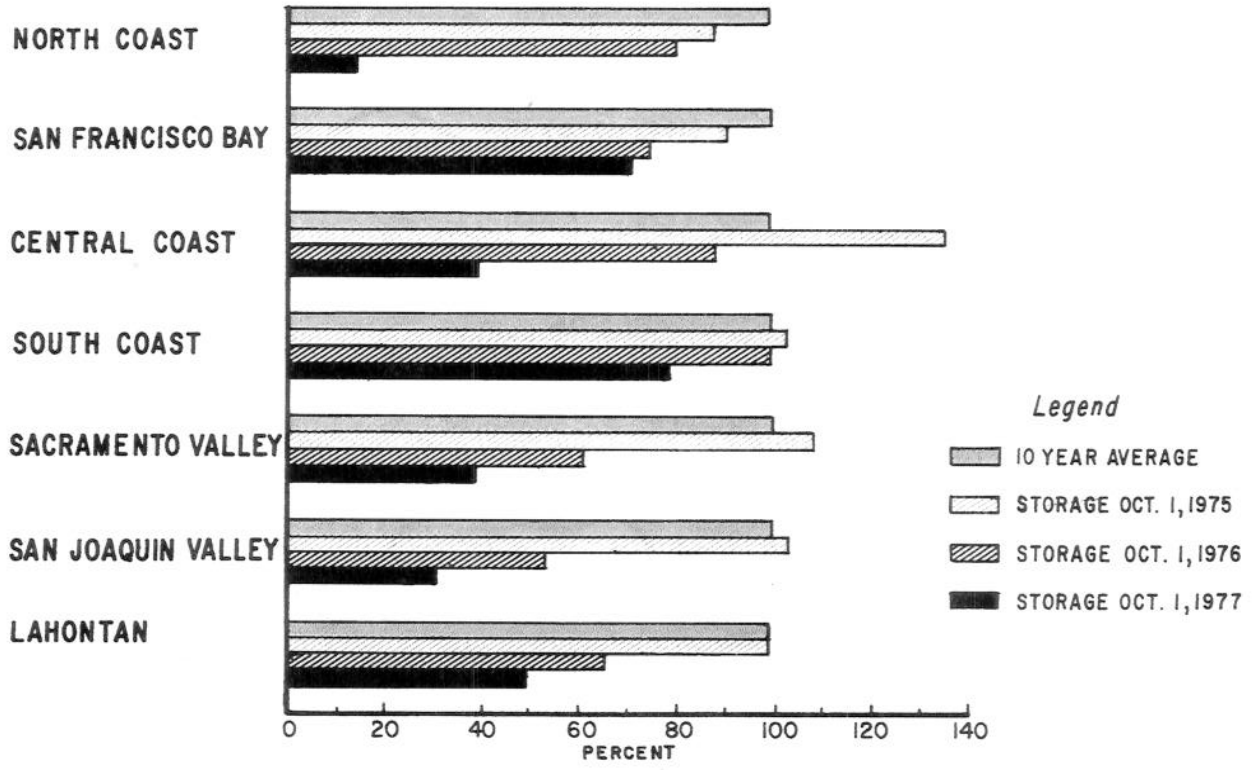
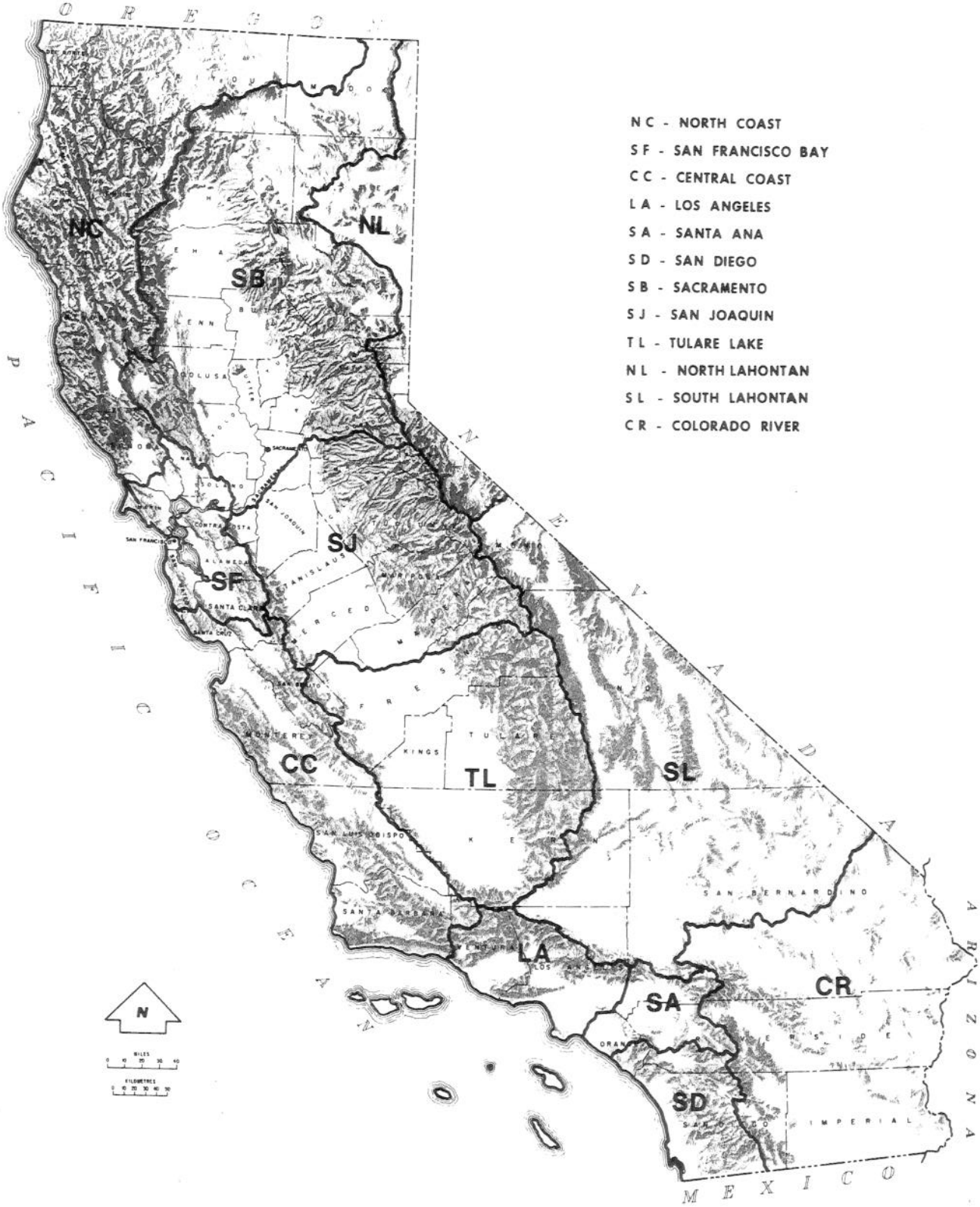


Figure 10.

MAJOR HYDROLOGIC REGIONS OF CALIFORNIA



Pumping capability was insufficient, in many instances, to maintain the same level of irrigated agriculture as in 1976. Table 3 indicates the relative amounts of water derived from the several sources in 1975 (a normal year) and in the drought years 1976 and 1977. Also shown are estimates for 1978.

In the west side of the valley, from Firebaugh to the vicinity of Kettleman City, hundreds of wells had been abandoned with the advent of surface imports. The reduced pumping capability, together with sharply curtailed imports, reduced applied water in 1977 to about 55 percent of normal. Ground water withdrawals increased.

In the east side of the valley, less dependent upon imports, applied water was reduced about 10 percent. In the Tulare Basin portion, 1977 ground water withdrawals approximated those of 1976. In the San Joaquin Basin, however, withdrawals were sharply higher due to greatly increased ground water extractions by the Merced, Turlock, Modesto, Madera, and Oakdale Irrigation Districts and the Chowchilla Water District.

Ground water depletion in the valley was estimated to approach 6 165 cubic hectometres (5,000,000 acre-feet) in 1977, nearly four times the normal values. Increased dependence on this resource was dramatic. In 1977, ground water accounted for over three-fourths of the total water used in the San Joaquin Valley, whereas in 1975 it had accounted for approximately one-half.

The shift in water sources is shown graphically on Figure 11. In the San Joaquin Basin, with local surface water sources accounting for most of the drop in total water supply, ground water use went up from 44 percent to 65 percent of the total.[1/] The Tulare Basin saw both its local surface water supply and its imported supplies cut drastically and, consequently, ground water use jumped from 56 percent to 82 percent of the total supply.

In terms of absolute numbers, the first year of the drought saw little reduction in the amount of water applied in the San Joaquin Valley. In 1976, the loss in surface water was balanced by an increase in ground water pumping, with no net change in total applied use. By 1977, however, ground water pumpage in the valley, which increased by more than 493 cubic hectometres (400,000 acre-feet) over 1976, still fell short of that needed to replace the larger quantity of absent surface supply. A net shortage of over 3 820 cubic hectometres (3,100,000 acre-feet) is indicated by the figures in Table 3. Some of this reduction was accommodated by reductions in demand due to conservation efforts, but the majority represents less than adequate supply for normal use.

On the Sacramento Valley floor, 1977 saw a major reduction in surface water supplies, but irrigated acreage did not exhibit a proportionate decrease. This was disclosed in a DWR study of land and water use for 12 major irrigation districts[2/] in the valley, stretching from Hamilton City in the north to Verona in the south. These particular districts ordinarily have large surface water supplies from the Sacramento and Feather Rivers. Surface water serves as their main supply, nearly all recapture drain water for reuse, and two have the capability to pump ground water.

The first year of the drought, 1976, was accommodated with little change in land and water use because water supplies carried over from previous years were adequate to maintain normal practices. By

1/ Based on net surface deliveries; i.e., surface diversions less conveyance losses and less water bypassed without use through the system.

2/ The 12 districts are shown in Table 4 and on Figure 12.

TABLE 3

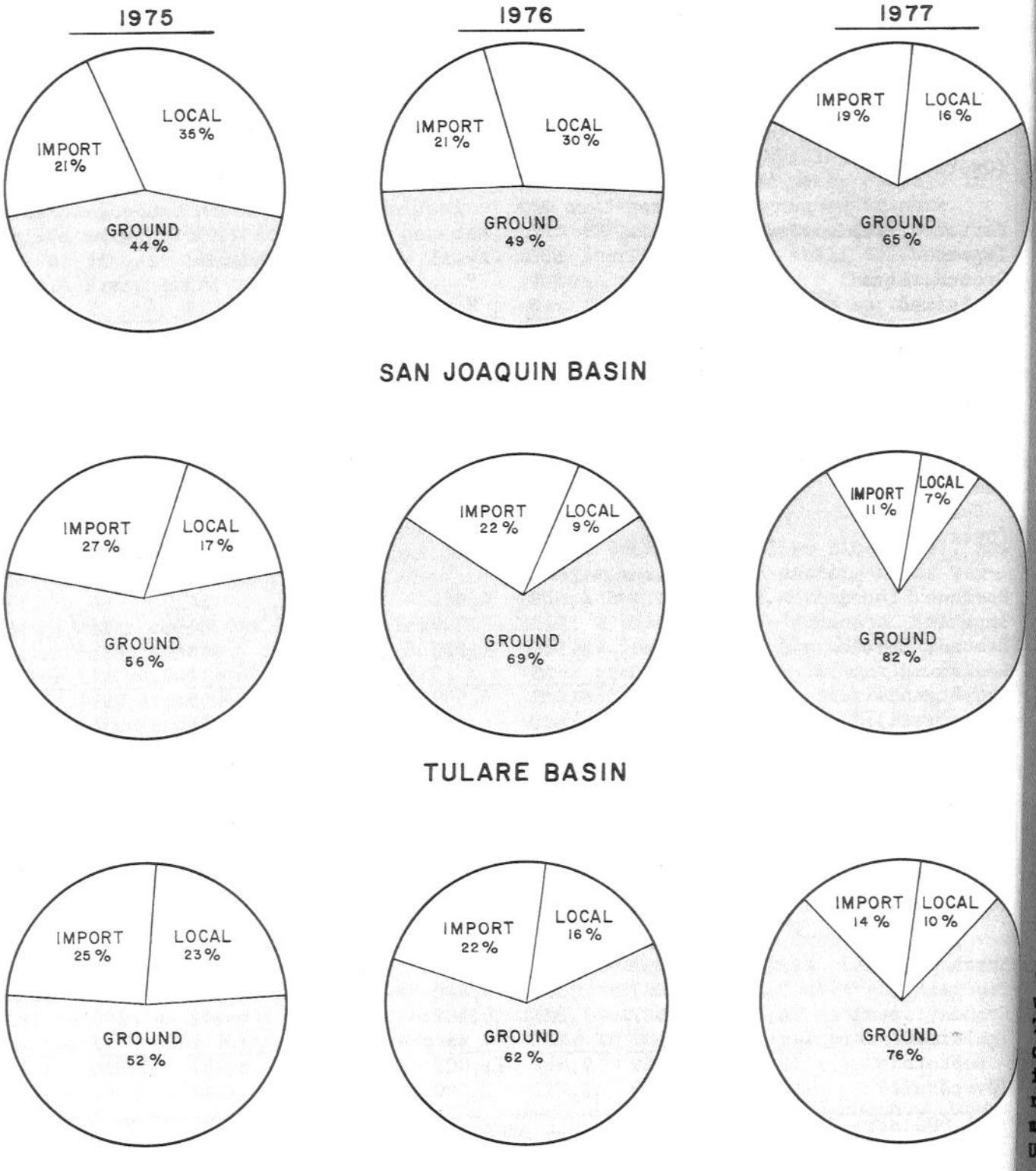
ESTIMATED WATER USE BY SOURCE
IN CALIFORNIA HYDROLOGIC REGIONS
in 1,000 acre-feet[1/]

Source	Region and Year 1975	1976	1977	1978	Region and Year 1975	1976	1977	1978
	North Coastal				North Lahontan[5/]			
Surface, Local	862	680	620	870	315	190	160	315
Imported	18	12	6	18	11	6	5	11
Ground, Local	187	200	220	200	61	80	90	80
Reclaimed	--	--	--	--	6	6	6	6
Subtotals	1,067	892	846	1,088	393	282	261	412
(Overdraft)	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-
	San Francisco Bay				South Lahontan			
Surface, Local	233	Not	100	Not	90	90	90	90
Imported	731	Avail.	554	Avail.	19	37	38	100
Ground, Local	255	"	298	"	361	345	347	276
Reclaimed	14	"	8	"	7	7	7	7
Subtotals	1,233	"	960	"	477	479	482	473
(Overdraft)	-0-	"	-0-	"	82	65	66	-0-
	Central Coastal[4/]				Los Angeles			
Surface, Local	44	52	40	50	49[2/]	41[2/]	34[2/]	61[2/]
Imported	--	--	--	--	873[3/]	930[3/]	851[3/]	917[3/]
Ground, Local	378	427	464	385	908[3/]	887[3/]	878[3/]	909[3/]
Reclaimed	5	5	5	5	6	6	6	6
Subtotals	427	484	509	440	1,836	1,864	1,769	1,893
(Overdraft)	50	84	114	43	139	199	264	-0-
	Sacramento[5/]				Santa Ana			
Surface, Local	4,962	4,788	4,502	4,962	75[2/]	84[2/]	66[2/]	117[2/]
Imported	9	6	2	9	264[3/]	306[3/]	258[3/]	259[3/]
Ground, Local	1,359	1,441	1,563	1,523	679[3/]	648[3/]	681[3/]	700[3/]
Reclaimed	15	15	15	15	17	17	17	17
Subtotals	6,345	6,250	6,082	6,509	1,035	1,055	1,052	1,093
(Overdraft)	100		600		83	67	154	-0-
	San Joaquin				San Diego			
Surface, Local	2,530	2,130	1,085	3,100	36	36	26	46
Imported	1,485	1,568	1,229	800	410	455	439	447
Ground, Local	2,524	2,824	3,308	1,500	117	86	101	115
Reclaimed	--	--	--	--	9	9	9	9
Subtotals	6,539	6,522	5,622	5,400	572	586	575	617
(Overdraft)	310	710	1,184	1,100	-0-	-0-	-0-	-0-
	Tulare Lake				Colorado River			
Surface, Local	2,462	1,255	850	2,500	--	--	--	--
Imported	3,796	3,047	1,307	4,400	4,077	4,002	3,733	3,947
Ground, Local	6,420	7,887	7,825	4,100	144	142	146	150
Reclaimed	--	--	--	--	7	7	7	7
Subtotals	12,678	12,189	9,982	11,000	4,228	4,151	3,886	4,104
(Overdraft)	1,029	2,959	3,791	2,500	41	41	42	45

1/ 1,000 acre-feet equals 1.2335 cubic hectometres.
2/ Excludes volume used for ground water replenishment.
3/ Includes extraction of imported replenishment water.
4/ San Luis Obispo and Santa Barbara Counties, only.
5/ Excluding Central District; information not available.

Figure 11.

WATER SOURCE DEPENDENCY DURING DROUGHT
SAN JOAQUIN VALLEY



1977, however, with spring reservoir storage at record lows, water agencies mandated severe cuts in water allotments. Concurrently, as a result of large carry-over surpluses of rice, federal allotments for this crop were cut 25 percent. The response was to greatly increase cereal grain plantings, up 55 percent over 1976. Other crops also replaced acreage previously planted to rice. The following tabulation indicates the shifts in land use from 1976 to 1977.

Irrigated Crops	1976 Acres*	1977 Acres*	Difference in 1977
Grain[1/]	46,270	71,897	+ 25,627
Rice	240,520	186,780	- 53,740
Field[2/]	66,314	72,783	+ 6,469
Alfalfa	5,355	7,557	+ 2,202
Pasture	13,974	12,706	- 1,268
Truck[3/]	20,783	27,406	+ 6,623
Orchard[4/]	22,938	22,665	- 273
Total[5/]	416,154	401,794	- 14,360

* One acre equals .40469 hectare.

1/ Includes barley, wheat, and oats. Does not include double-cropped grain.

2/ Includes safflower, sugar beets, corn, milo, sudan, dry beans, and sunflowers.

3/ Includes carrots, melons, squash, cucumbers, tomatoes, nursery and flowers.

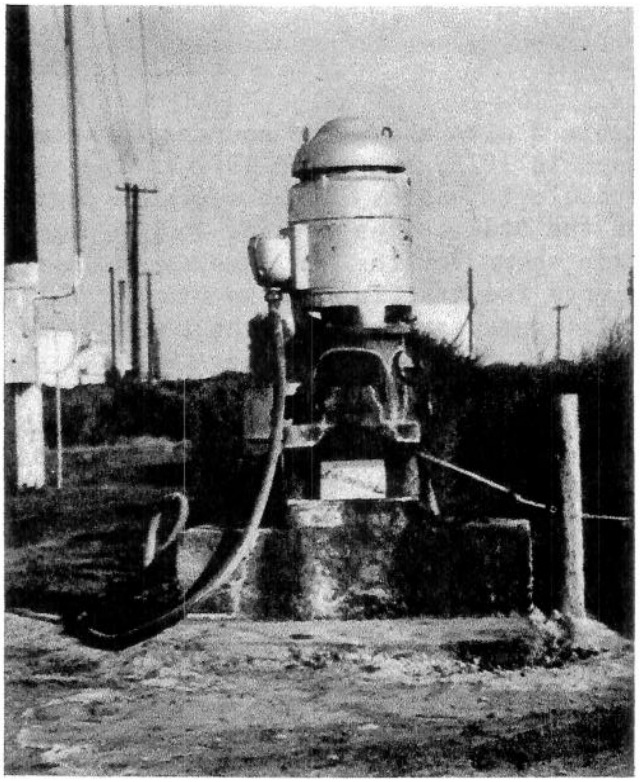
4/ Includes deciduous orchard, sub-tropical orchard, and grapes.

5/ Total area of districts surveyed was 477,940 acres.

The foregoing documents the major shift from water-intensive crops, such as rice, to those crops using moderate amounts of water, such as the cereals and row crops. Thus, net irrigated acreage decreased by only 3 percent in the 12 districts studied. This experience is believed representative of most areas of the Sacramento Valley, with the Orland Water Users Association in Glenn County as an exception.

Although irrigated acreage showed little decline from 1976 levels, water use in the 12 cited districts was down by 30 percent, by 990 cubic hectometres (805,000 acre-feet), as a result of reduced supplies. This is shown in Table 4.

Recaptured water, which had provided 16 percent of the total supply in 1976, showed a gain to 19 percent in 1977, reflecting an increased effort to reuse water within the districts. The gross figures for recaptured water, down from 1976, reflect the decrease in water availability during the year. Ground water use, although up in 1977, continued to play a rather minor role in organized districts' operations. It should be noted that individual ground water pumpage capability exists in addition to that shown. At this time, however, the extent to which it was relied on is unknown.



3. Lifesaver for a thirsty land. A typical irrigation pump installation in the San Joaquin Valley. With declining surface storage supplies, more and more farmers turned to ground water to supply their irrigation needs.

TABLE 4

WATER USE IN TWELVE SACRAMENTO VALLEY IRRIGATION DISTRICTS

Water Service Agency	1976 1/ Irrigated Acreage	1976 WATER SUPPLY (Acre-Feet)* 2/ Diversions	Recaptured	Ground Water	Total	1977 1/ Irrigated Acreage	1977 WATER SUPPLY (Acre-Feet)* 2/ Diversions	Recaptured	Ground Water	Total
Glenn-Colusa I.D.	133,470	824,000	214,700	-0-	1,038,700	118,963	557,799	135,200	-0-	692,999
Maxwell I.D.	4,717	5,935	27,301 3/	-0-	33,236	3,949	5,062	23,285 3/	-0-	28,347
Princeton-Codora-Glenn I.D.	11,058	57,259	22,572	-0-	79,831	10,945	46,805	21,845	-0-	68,650
Provident I.D.	13,802	49,462	23,180	490	73,132	14,860	35,088	23,747	2,385	61,220
Reclamation District No. 108	55,220	173,646	28,645	-0-	202,291	55,108	140,369	31,427	-0-	171,796
Reclamation District No. 1004	19,701	60,446	48,000 4/	-0-	108,446	19,352	51,248	43,000 4/	2,500	96,748
Sutter Mutual W.D.	49,207	231,761	26,857	-0-	258,618	48,532	180,942	34,104	-0-	215,046
Biggs-West Gridley W.D.	23,501	172,086	20,780	-0-	192,866	22,075	90,958	22,500	-0-	113,458
Butte Water District	24,344	129,377	-0-	-0-	129,377	23,944	68,588	-0-	-0-	68,588
Richvale I.D.	22,625	155,219	-0-	-0-	155,219	20,849	71,021	14,000	-0-	85,021
Sutter Extention W.D.	23,333	159,030	15,900	-0-	174,930	22,454	83,035	8,300	-0-	91,335
Western Canal Company	35,176	259,674	-0-	-0-	259,674	40,763	208,089	-0-	-0-	208,089
Totals	416,154	2,277,895	427,935	490	2,706,320	401,794	1,539,004	357,408	4,885	1,901,297

* 1,000 acre-feet equals 1.2335 cubic hectometres.

1/ Does not include double cropped grain.

2/ Includes only that water used for irrigation from April 1 to October 31.

3/ Most of recaptured water from outside of district.

4/ Part of recaptured water from Butte Slough.

Table 3 also shows the sources of water used in 1975, 1976, and 1977 in the six hydrologic basins in the southern part of the State. The decline in consumption shown for the Los Angeles Basin reflects the cuts in imports via the SWP's California Aqueduct and the Los Angeles Aqueduct from Owens Valley. Reduced usage in the Colorado River Basin is attributed to two factors: (1) conservation efforts taken by Imperial Irrigation District, user of two-thirds of the water used in the basin; and (2) reduction in need caused by the flooding of agricultural lands as a result of tropical storms in 1977. Overall, usage was reduced only 4 percent, from 10 630 cubic hectometres (8,620,000 acre-feet) in 1976 to 10 210 cubic hectometres (8,284,000 acre-feet) in 1977. Ground water extraction was up significantly in only one of the basins, the Central Coastal, where usage went up approximately 9 percent from 1976 figures and 23 percent from 1975.

Water supplies in the Salinas Valley are derived almost entirely from ground water. Water is released from two upstream reservoirs, San Antonio and Nacimiento, to recharge the ground water basin which provides for the agricultural needs of 75 000 irrigated hectares (185,000 acres), and the municipal use of urbanized areas such as the City of Salinas. During 1977, the average drop in ground water levels in the valley amounted to 1.3 metre (4.2 feet). This drop in water levels is within normal ranges, but during the same period, the combined upstream reservoir storage declined from 370 cubic hectometres (300,100 acre-feet) to 91 cubic hectometres (74,100 acre-feet). This drop in surface storage was the result of releases to maintain ground water levels. Normal storage on October 1 is 420 cubic hectometres (339,300 acre-feet).

Extraction of larger amounts of ground water during the drought had its effect

Figure 12.

WATER DISTRICTS INVOLVED IN DWR LAND AND WATER USE STUDY 1977

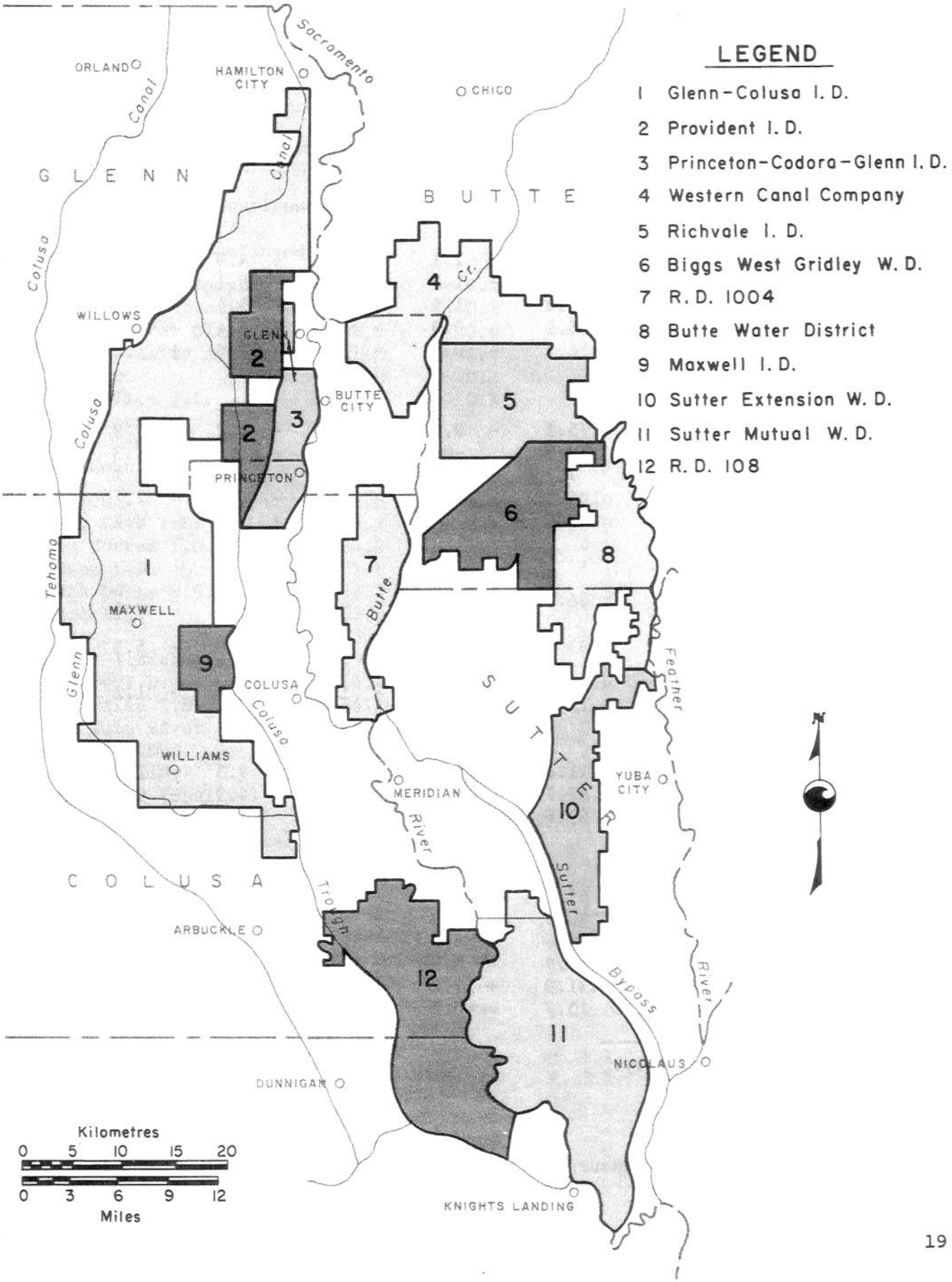


TABLE 5

GROUND WATER LEVEL CHANGES
FEET[1/]

District or Area	Average Depth Spring 1978	Average Annual Change 1970-75	Annual Change 1975 1976	Annual Change 1976 1977	Annual Change 1977 1978	Net Change 1970-78
San Joaquin Valley						
San Joaquin County:						
Mokelumne River Area	73.5	- 1.1	- 4.7	- 4.9	-0-	- 15.3
Calaveras River Area	93.1	- 1.5	- 3.8	- 5.1	-0-	- 16.4
Farmington-Collegville	87.8	- 1.6	- 4.4	- 5.4	- 0.7	- 18.5
South San Joaquin I.D.	35.9	- 0.9	- 1.6	- 4.4	- 5.4	- 15.7
Delta Area	14.7	- 0.4	- 1.0	- 2.0	+ 2.2	- 3.0
Stanislaus County:						
Oakdale I.D.	75.1	- 0.3	- 2.9	- 2.2	- 3.9	- 10.4
Modesto I.D.	18.9	-0-	- 1.7	- 2.3	+ 1.3	- 3.5
Turlock I.D.*	7.7	+ 0.1	+ 0.2	- 1.6	+ 2.1	+ 3.4
Area East of Turlock	105.5			- 6.5	- 2.2	
City of Modesto	52.6			- 2.4	- 8.1	
Merced County:						
Merced I.D. (Deep)	46.8	- 0.7	- 5.2**		- 9.7	- 17.6
(Shallow)		- 0.6	- 1.6**			
El Nido I.D.	93.1	- 2.7	- 0.9	- 7.0	- 5.3	- 26.9
Delta Mendota Area		+ 0.6	- 0.9	- 1.1		
Merced Bottoms	34.0	- 1.1	- 1.8	- 2.3	- 1.2	- 10.8
Madera County:						
Chowchilla W.D.	111.6	- 2.9	- 3.6	- 9.3	- 12.1	- 39.4
Madera I.D.	87.7	- 0.8	- 3.9	- 4.9	- 6.6	- 19.3
West Chowchilla Area	63.6	- 3.1	- 4.0	- 2.4	- 3.7	- 25.7
Fresno County:						
Fresno I.D.	69.0	- 0.8	- 1.4	- 6.6	- 7.0	- 18.8
City of Fresno	90.9	- 0.9	- 0.9	- 1.3	- 3.5	- 10.0
Fresno Slough Area	108.6	- 2.6	- 10.8	+ 0.6	- 7.6	- 30.8
Consolidated I.D.	56.9	- 0.9	- 3.6	- 5.3	- 6.1	- 19.3
Mendota-Huron Area[2/]	431.9	+ 13.2	+ 11.2	+ 10.2	-102.6	- 15.1
Poso Conservation District	13.7	- 0.2	- 1.3	0.0	- 4.4	- 6.9

* Shallow test wells, only.

** Fall 1976 measurements.

1/ 1 foot = 0.3048 metre.

2/ Reflects increase in pressure (not basin storage) in confined aquifer.

TABLE 5
(Continued)

GROUND WATER LEVEL CHANGES
FEET[1/]

District or Area	Average Depth Spring 1978	Average Annual Change 1970-75	Annual Change 1975 1976	Annual Change 1976 1977	Annual Change 1977 1978	Net Change 1970-78
San Joaquin Valley (Continued)						
Fresno County: (Continued)						
San Luis Canal Company	24.3	- 0.1	- 0.1	- 9.1	- 9.5	- 19.1
Centerville Bottoms	18.2	+ 0.2	- 5.3	+ 2.3	- 0.9	- 2.9
Garfield Water District	98.9	+ 0.4	- 3.4	- 1.4	- 4.9	- 7.6
Pleasant Valley Area	281.0	- 4.4	- 10.4	- 5.8	+ 5.3	- 32.9
James I.D.	116.0	+ 0.2	- 7.1	- 2.4	- 5.1	- 13.8
Tranquillity I.D.	46.4	+ 0.1	- 7.5	+ 2.2	- 3.0	- 7.8
Raisin City Area	142.7			- 1.6	- 21.1	
Tulare County:						
Alta I.D.	48.8	- 1.4	- 7.9	- 8.3	- 8.8	- 32.2
Orange Cove I.D.	35.2	- 0.4	- 3.9	- 4.4	- 5.9	- 17.0
Stone Corral I.D.	34.2	- 1.2	- 4.1	- 3.8	- 10.2	- 24.1
Ivanhoe I.D.	71.8	+ 0.3	- 4.1	- 9.0	- 6.3	- 17.7
Kaweah Delta W.C.D.	78.4	- 1.3	- 4.5	- 10.9	- 8.8	- 30.7
Tulare I.D.	102.1	- 1.3	- 3.6	- 14.9	- 10.8	- 35.9
Exeter I.D.	62.9	+ 0.7	- 6.0	- 3.0	- 10.1	- 15.7
Lindsay-Strathmore I.D.	59.1	+ 0.1	- 3.3	- 6.0	- 14.1	- 22.8
Lindmore I.D.	64.4	+ 2.2	- 3.4	- 5.7	- 9.8	- 7.8
Porterville I.D.	44.1	- 0.2	+ 1.4	- 10.5	- 9.0	- 19.2
Lower Tule River I.D.	93.7	- 1.3	- 0.4	- 8.8	- 9.5	- 25.2
Vandalia I.D.	137.5	-0-	- 2.1	- 3.4	- 9.3	- 14.8
Saucelito I.D.	155.8	+ 0.3	- 0.3	- 6.4	- 10.3	- 15.4
Pixley I.D. (Shallow)		***	- 4.7	- 5.0	) - 9.8	
(Deep)		+ 1.5	- 4.4	- 6.4	)	
Alpaugh-Allensworth Area						
(Shallow)		- 2.5	+ 9.8	+ 5.7		
(Deep)		- 10.6	- 5.8	- 2.5		
Delano-Earlimart I.D.	155.4	+ 0.7	+ 7.3	- 7.2	- 11.8	- 10.2
Terra Bella I.D.	137.1	- 1.3	NM	NM	- 12.0	
Kern County:						
Kern-Tulare W.D.	546.8	***	- 21.0	- 14.6	- 3.5	
South San Joaquin M.U.D.						
(Shallow)		+ 0.4	- 1.1	- 7.6	) - 7.0	
(Deep)		- 5.1	- 2.1	- 14.3	)	

*** Insufficient data.

1/ 1 foot = 0.3048 metre.

TABLE 5
(Continued)

GROUND WATER LEVEL CHANGES
FEET[1/]

District or Area	Average Depth Spring 1978	Average Annual Change 1970-75	Annual Change 1975 1976	Annual Change 1976 1977	Annual Change 1977 1978	Net Change 1970-78
San Joaquin Valley (Continued)						
Kern County: (Continued)						
North Kern W.S.D.						
(Shallow)	271.5	(- 10.4	- 6.8	- 1.8	) - 12.5	
(Deep)		(- 4.1	- 12.0	+ 0.3	)	
Shafter-Wasco I.D.	285.9	- 5.7	- 16.5	- 11.6	+ 15.5	- 40.9
City of Bakersfield	218.5	- 3.7	- 7.2	- 5.2	+ 2.6	- 28.2
Kern River Delta						
(Shallow)		- 1.9	- 7.3	- 2.0		
(Deep)			- 4.9	- 5.1		
Wheeler-Ridge - Maricopa	349.2			+ 2.4	- 11.8	
Edison-Maricopa	371.3	- 7.3	+ 0.6	- 6.0	- 7.0	- 48.9
Buena Vista W.S.D., North	111.4	- 2.7	+ 2.3	- 6.8	+ 13.9	- 4.1
Semitropic W.S.D.						
(Shallow)		- 0.6	+ 1.9	- 0.2		
(Deep)		- 6.5	- 4.2	- 8.2		
Arvin-Edison W.S.D.	391.2	- 1.1	- 9.6	- 7.6	+ 0.6	- 22.1
Kings County:						
Corcoran I.D. (Shallow)		+ 0.9	+ 7.8	- 7.7		
(Deep)		+ 3.0	- 21.8	- 36.2		
Lower Kings River						
(Shallow)		- 2.0	- 0.1	- 12.7		
(Deep)		+ 4.0	- 9.2	- 32.7		
Kings County W.D.						
(Shallow)	69.7	(- 1.7	- 3.5	- 13.3	) - 3.5	
(Deep)		(+ 1.1			)	
Sacramento Valley						
Sutter County	17.3	+ 0.1	- 5.1	- 3.3	+ 0.8	- 7.0
Yuba County	48.2	- 0.2	- 5.7	- 5.9	+ 1.2	- 11.6
Placer County	59.0	+ 0.6	- 2.8	- 4.2	- 5.7	- 8.8
Sacramento County	71.4	- 1.0	- 3.6	- 3.5	+ 0.2	- 11.8
Yolo County	36.6	- 0.2	- 7.9	- 6.4	+ 7.1	- 8.2
Capay Valley (Yolo)	22.4	+ 0.2	- 5.8	- 3.8	+ 6.9	- 1.6
Solano County	26.7	+ 0.2	- 4.8	- 4.1	+ 6.6	- 1.1
Tehama County	33.8	+ 0.2	- 6.5	- 2.7	+ 6.2	- 2.1
Glenn County	29.2	- 0.1	- 7.3	- 5.3	+ 8.8	- 4.5

[1/] 1 foot = 0.3048 metre.

TABLE 5
(Continued)

GROUND WATER LEVEL CHANGES
FEET[1/]

District or Area	Average Depth Spring 1978	Average Annual Change 1970-75	Annual Change 1975 1976	Annual Change 1976 1977	Annual Change 1977 1978	Net Change 1970-78
Sacramento Valley (Continued)						
Butte County	26.3	- 0.3	- 4.8	- 3.6	+ 4.7	- 5.2
Colusa County	34.8	+ 0.2	- 7.3	- 3.0	+ 7.2	- 2.3
Northern Interior Region						
Alturas Basin	15.6	- 0.1	- 1.4	- 1.5	- 0.6	- 4.0
Big Valley (Lassen)	16.1	- 0.1	- 2.1	- 2.0	+ 0.9	- 3.9
Fall River Valley (Shasta)	16.6	- 0.2	- 1.4	- 1.0	+ 1.4	- 2.2
Redding Basin	64.9	- 0.2	- 4.5	- 1.8	+ 2.1	- 5.4
Sierra Nevada Mountain Region						
Mohawk Valley (Plumas)	NA	+ 0.2	- 0.8	- 0.2	NA	NA
Sierra Valley (Plumas)	NA	- 0.2	- 1.8	- 0.8	NA	NA
South Tahoe Valley	NA	- 0.1	- 2.5	- 2.0	NA	NA
Lake County Basins						
Coyote Valley	12.5	+ 0.4	- 4.2	- 0.7	+ 3.5	+ 0.5
Upper Lake Valley	8.1	- 0.3	- 5.6	- 6.2	+ 11.9	- 1.5
Collayomi Valley	10.9	+ 0.5	- 2.8	- 2.4	+ 3.8	+ 1.1
Scott Valley	8.5	+ 0.2	- 4.2	- 23.0	+ 26.5	+ 0.3
Kelseyville Valley	15.4	+ 0.1	- 8.1	- 5.2	+ 7.6	- 5.0
High Valley	26.4	- 0.3	- 7.0	- 7.6	+ 7.6	- 8.4
Lower Lake Area	10.2	+ 0.4	- 6.5	- 1.7	+ 9.8	+ 3.8
Lahontan Region						
Surprise Valley (Modoc)	57.7	- 0.8	+ 0.1	- 3.5	- 6.7	- 14.2
Honey Lake Valley (Lassen)	16.9	- 0.5	- 2.0	- 2.5	- 0.9	- 7.9
Owens Valley						
Independence Area	50.0	- 4.2	- 4.0	-0-	- 9.0	- 34.0
Big Pine Area	89.0	- 4.4	- 12.0	- 4.0	- 13.0	- 51.0
Bishop Area	35.0	- 2.2	- 1.0	- 4.0	- 2.0	- 18.0
North Coastal Region						
Del Norte County:						
Smith River Plain	9.5	+ 0.5	- 0.2	- 3.3	+ 3.5	+ 2.5

1/ 1 foot = 0.3048 metre.

TABLE 5
(Continued)

GROUND WATER LEVEL CHANGES
FEET[1/]

District or Area	Average Depth Spring 1978	Average Annual Change 1970-75	Annual Change 1975 1976	Annual Change 1976 1977	Annual Change 1977 1978	Net Change 1970-78
North Coastal Region (Continued)						
Siskiyou County:						
Butte Valley	35.4	+ 0.2	- 1.6	- 2.2	- 1.4	- 4.0
Shasta Valley	27.9	+ 0.9	- 0.9	- 0.5	- 1.1	+ 2.1
Scott River Valley	6.0	+ 0.3	- 1.2	- 1.2	+ 3.0	+ 2.1
Humboldt County:						
Mad River Valley	5.7	+ 0.7	- 0.3	- 2.9	+ 3.0	+ 3.3
Eel River Valley	12.3	+ 0.6	- 1.2	- 2.7	+ 3.8	+ 2.7
Mendocino County:						
Round Valley	3.5	+ 0.1	- 1.2	- 7.7	+ 9.5	+ 1.0
Laytonville Valley	2.3	+ 0.7	- 2.8	- 5.6	+ 8.7	+ 4.1
Little Lake Valley	10.0	+ 0.8	- 1.2	- 5.7	+ 9.7	+ 7.0
Potter Valley	7.4	+ 0.4	- 1.2	- 1.3	+ 1.8	+ 1.1
Ukiah Valley	4.9	+ 0.7	- 4.8	- 2.6	+ 7.2	+ 3.2
Sanel Valley	6.3	+ 0.8	- 5.3	- 2.8	+ 5.9	+ 1.7
Sonoma County:						
Alexander Valley	5.9	+ 0.7	- 7.2	- 1.6	+ 7.7	+ 2.2
Santa Rosa Area	16.1	- 0.5	- 4.1	- 3.9	+ 5.6	- 4.7
Healdsburg Area	16.7	- 0.4	- 2.3	- 0.6	+ 2.1	- 2.9
Petaluma Valley	16.7	- 0.6	- 3.3	- 2.0	+ 6.3	- 2.1
Sonoma Valley	19.6	- 0.1	- 5.1	- 3.8	+ 8.0	- 1.5
Central Coastal Valleys						
Napa Valley	14.6	- 0.1	- 5.6	- 4.0	+ 9.0	- 1.0
Suisun-Fairfield Valley	5.6	-0-	- 2.2	- 0.7	+ 4.3	+ 1.3
Pittsburg Plain	33.2	-0-	- 0.4	- 0.1	+ 1.3	+ 0.7
Clayton Valley	17.7		- 2.1	- 1.9	+ 5.6	
Yqnacio Valley (Contra Costa)	17.0	- 0.1	- 1.2	- 1.1	+ 3.5	+ 0.7
North Santa Clara Valley						
East Bay	32.3	+ 1.4	- 4.9	+ 4.8	+ 2.0	+ 9.1
South Bay	89.3	+ 6.0	- 3.5	- 13.4	- 4.7	+ 8.3
South Santa Clara Valley				- 26.0		

1/ 1 foot = 0.3048 metre.

TABLE 5
(Continued)

GROUND WATER LEVEL CHANGES
FEET[1/]

District or Area	Average Depth Spring 1978	Average Annual Change 1970-75	Annual Change 1975 1976	Annual Change 1976 1977	Annual Change 1977 1978	Net Change 1970-78
Central Coastal Valleys (Continued)						
Livermore Valley	49.3	+ 2.4	- 1.6	- 4.5	+ 3.1	+ 9.1
Half Moon Bay Terrace	20.8	- 0.8	- 3.8	- 3.8	+ 6.1	- 5.3
San Gregorio Valley	7.3	- 0.5	- 2.4	- 1.6	+ 6.2	- 0.5
Pescadero Valley	4.5	- 0.5	- 3.5	- 0.8	+ 7.3	+ 0.3
Soquel Valley	65.3	- 0.6	- 0.9	- 2.4	+ 0.9	- 5.3
West Santa Cruz Terrace	79.7		- 3.1	- 3.1	+ 0.1	
Scotts Valley (Santa Cruz)	67.5		- 2.0	- 2.0	+ 4.7	
San Benito County				- 20.4*		
Salinas Valley			- 3.7	- 5.6		
South Coastal Region						
Los Angeles County:						
Monk Hill Area	283.9	- 3.3	- 1.6	- 16.1	+ 3.0	- 32.7
San Fernando Valley	110.5	+ 1.8	+ 2.4	- 11.2	+ 8.7	+ 13.7
Antelope Valley	284.7	- 1.5	- 0.9	+ 1.4	- 0.6	- 8.0
Baldwin Park Area	162.2	- 6.7	- 10.9	- 8.0	+ 19.5	- 33.0
Pico Rivera Area	94.5	- 0.8	- 14.3	- 18.7	+ 6.2	- 35.6
Fountain Valley (Orange)	30.1	- 4.0	- 3.0	+ 5.5	+ 4.2	- 14.5
Oxnard (Ventura)	25.6	-0-	- 1.5	- 11.1	+ 17.3	+ 6.0
West Las Posas (Ventura)	342.7	+ 0.6	- 0.3	- 7.5	+ 18.1	+ 11.4

* Range -1.0 to -54.2

1/ 1 foot = 0.3048 metre.

upon water levels. Table 5 lists the annual changes in spring water levels during the two drought years, 1975-76 and 1976-77, for 130 districts. Shown for comparative purposes are the changes for 1977-78 and the average annual change for the five years, 1970-75. In general, the drought years reflect a relatively large drop in water levels. A limited recovery during 1977-78 is exhibited by some, but not all, of the districts listed.

The increased dependence on ground water during the drought is illustrated by the greater activity demonstrated by the well drilling industry. The number of Water Well Drillers Reports received by the Department (and required to be submitted under Section 13751 of the Water Code) increased from 8,687 in 1974 and 8,275 in 1975, to 11,209 in 1976 and 20,115 in 1977. These figures do not include all new wells drilled, since historically not all work has been reported. However, the significant rise in filings justifies the conclusion that a large number of new wells were drilled, particularly in 1977. The greatest percentage increase (60 percent) occurred in the nine-county San Francisco Bay Area. In the ten San Joaquin Valley counties (Fresno, Kern, Kings, Madera, Mariposa, Merced, San Joaquin, Stanislaus, Tulare, and Tuolumne), about 6,800 reports were filed. Based on a compliance rate of 75 percent, it is estimated that approximately 9,000 wells were drilled or deepened in the valley. Even in the south, particularly in the South Coastal Basin, a substantial increase, 30 percent, was noted.

Another indicator of the greater dependence placed on ground water during the drought is the trend of electrical energy usage for agricultural customers. PG&E, the largest supplier of agricultural electric power in the State, showed a 35 percent increase in agricultural usage from 1975 levels to those of 1977.

State and Federal Water Projects and the Delta

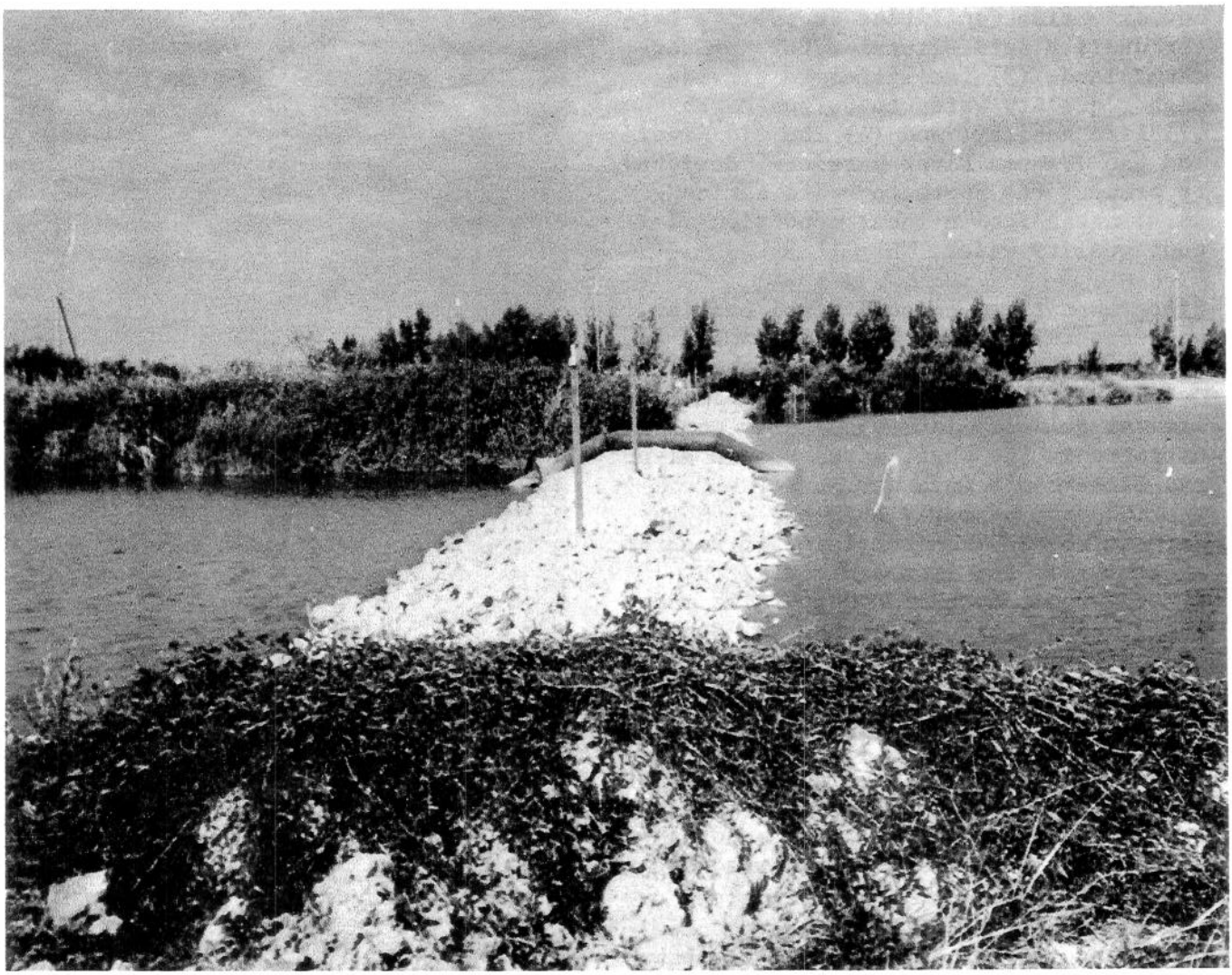
Operation of State and federal projects by the Department of Water Resources (DWR) and the U. S. Bureau of Reclamation (USBR) was complicated by the low storage in upstream reservoirs during 1977. The State Water Project (SWP) was operated to maintain Delta water quality objectives established by the State Water Resources Control Board (SWRCB), whereas the federal Central Valley Project (CVP) was operated to meet water quality standards required by some of its customers. In 1976 and 1977, coordinated federal-State action was complicated by the USBR's failure to provide sufficient releases to maintain accepted standards of protection for Delta users, exposing its Contra Costa County customers to levels of salt content judged hazardous to health. As a consequence, DWR was forced to take certain actions, described later, to protect those users.

In past years, including 1976, it was possible to provide sufficient upstream storage releases to meet the applicable water quality standards contained in the Water Quality Control Plans (Basin Plans) and the projects' water rights permits. By December 1976, however, it was clear that with the continuing drought, the State and federal water storage facilities would be dangerously low if the projects continued to be operated to meet the standards. After hearings, the SWRCB adopted an Interim Water Quality Control Plan on February 8, 1977, which modified the Delta standards to levels that could be met with smaller project releases. Since the USBR was no longer operating to protect the Delta, this modification of standards had the purpose and effect of reserving Oroville Reservoir storage for protection against the continuing drought.

A lawsuit was filed challenging the SWRCB's authority to modify the stan-

dards even though the modification had as one of its purposes the protection of the Delta against future loss of salinity control because of insufficient upstream storage. Before that suit could be tried, it was necessary for the SWRCB to hold an emergency hearing to deal with the fact that actual hydrologic conditions were very much worse than had been projected. Even under the Interim Plan's modified criteria, Lake Oroville no longer would be able to generate electricity by late summer and would end 1977 only 14 percent filled -- an insufficient amount of storage to protect the Delta if the drought continued into 1978.

In early June 1977, the SWRCB issued an emergency regulation which superseded the Interim Delta Quality Control Plan by temporarily eliminating most water quality standards and limiting SWP exports to unstored water. The regulation was necessary to preserve Oroville storage levels to the greatest extent possible. This emergency regulation was to have terminated no later than December 31, 1977, but with some modifications was extended in mid-December because of continued low reservoir levels.



4. Dams in the Delta. Two barriers, one at Rock Slough (shown) and the other at Indian Slough, actually saved water during the drought. By redirecting fresher water to the Contra Costa Canal Intake, less water had to be released from upstream reservoirs to maintain the same level of water quality.

On February 2, 1978, following substantial improvements in reservoir storage and snowpack occasioned by the heavy precipitation of January, the Board rescinded its emergency order governing Delta water quality. Standards contained in the prior Basin Plan and water rights permits now govern.

The August 1977 report[1/] detailed a number of efforts by the Department to mitigate effects of the drought upon water quality throughout the Delta. These included construction of (1) the Rock Slough and Indian Slough barriers, together with the Middle River Pumping Plant, designed to improve water quality at the Contra Costa Canal Intake; (2) new diversion facilities to provide better quality agricultural water to Sherman Island; (3) facilities to provide higher quality water to Suisun Marsh wildlife habitat; and (4) the Old River and San Joaquin River barriers, designed to protect the Southern Delta agricultural areas from a local condition of poor quality water.

Since that time, an additional barrier was constructed (completed September 22, 1977) across Dutch Slough in the western Delta to provide additional protection against salinity intrusion. Two more barriers in the west, across False River and Fisherman's Cut, were under consideration, and by early 1978 had even undergone the environmental impact report process, but the improved conditions brought about by the January rains made their construction unnecessary. Several of the completed barriers were removed at this time. All barriers were removed by April 1978.

Figure 13 shows the locations of the barriers and other facilities constructed by the Department in 1977, at a total cost of $3,300,000. (These costs were eventually funded by a federal grant under the authority of PL 95-18, the Emergency Drought Act of 1977.) Also shown is the location of the Sutter Slough barrier, which was completed August 31, 1976, to conserve additional water in 1976. The barrier was removed December 10, 1976, and, because of the differing conditions in 1977, was not reconstructed.

The effect of the low inflows during 1976 and 1977 was to lower water quality throughout the Delta. Figure 14 illustrates the generally lowering water quality as indicated by rising chloride measurements at selected west Delta sta-

5. Aid to Sherman Island. These pipes are siphoning water from Mayberry Slough, a source of irrigation water for Sherman Island farmers. Because of an increasing salinity problem, water from the central canal facilities was pumped into the slough, providing fresher water for those farmers along Mayberry Slough.

1/ DWR report, "The Continuing California Drought".

Figure 13.

DROUGHT MITIGATIVE FACILITIES CONSTRUCTED BY DWR SACRAMENTO - SAN JOAQUIN DELTA 1976 and 1977

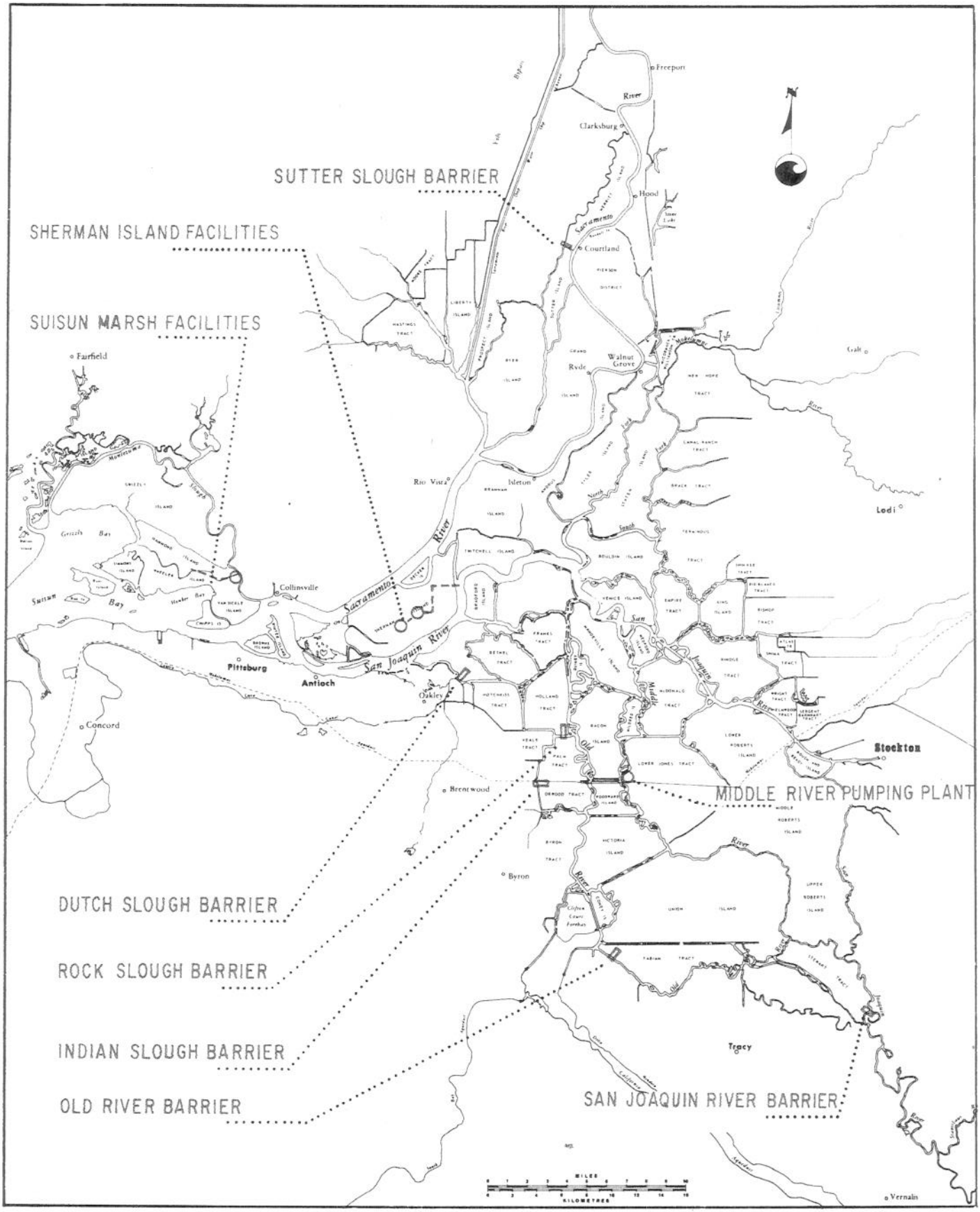
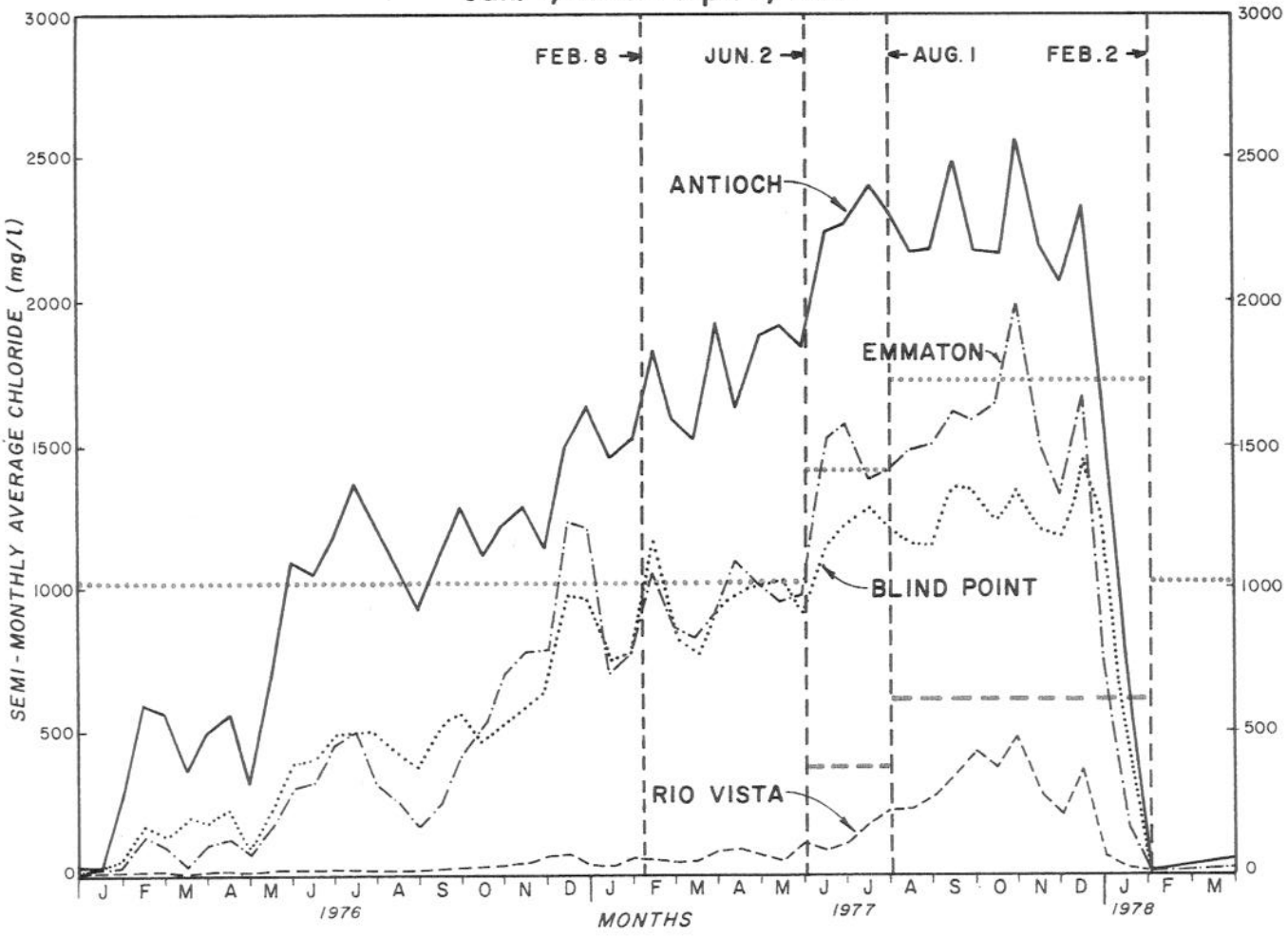


Figure 14.

WATER QUALITY MEASUREMENTS AT SELECTED WEST DELTA STATIONS
Jan. 1, 1976 - Apr. 1, 1978



SWRCB WATER QUALITY CRITERIA FOR BLIND POINT AND EMMATON

SWRCB WATER QUALITY CRITERIA FOR RIO VISTA

INTERIM WATER QUALITY CRITERIA EFFECTIVE FEB. 8, 1977 AND REPLACED WITH EMERGENCY CRITERIA EFFECTIVE ON JUN. 2, 1977. BASIN PLAN CRITERIA AGAIN EFFECTIVE ON FEB. 2, 1978.

Figure 15.

WATER QUALITY MEASURING STATIONS IN THE SACRAMENTO–SAN JOAQUIN DELTA

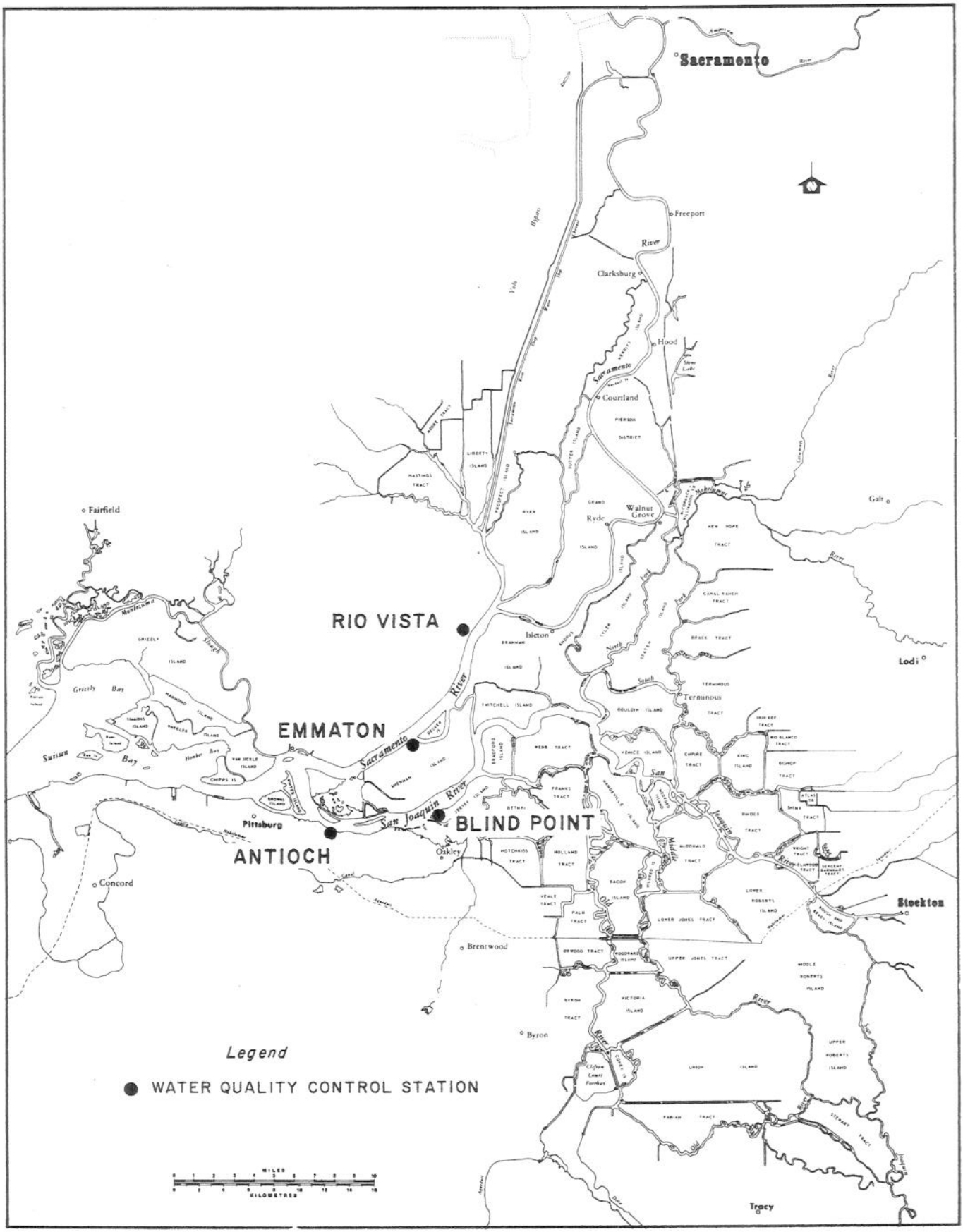
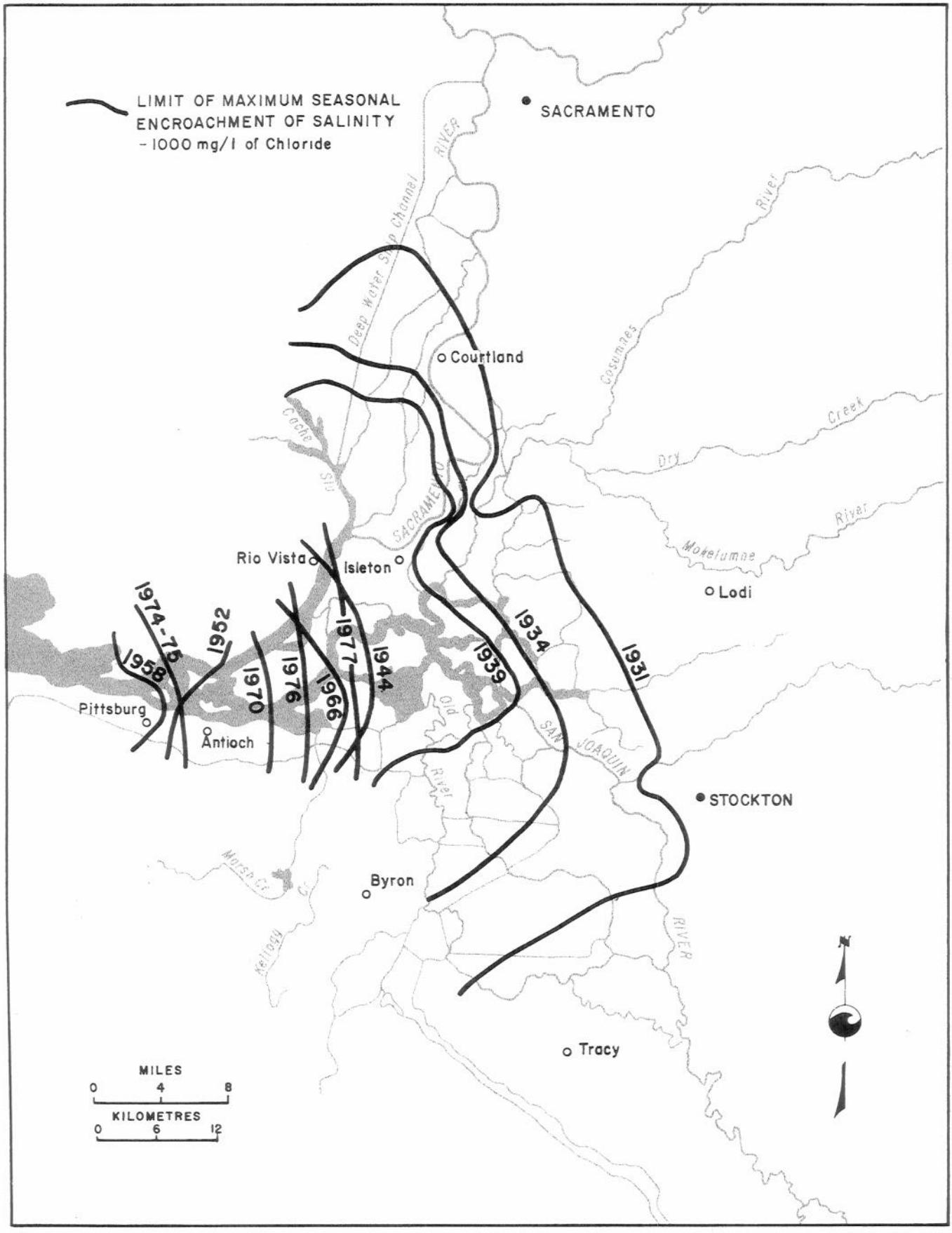


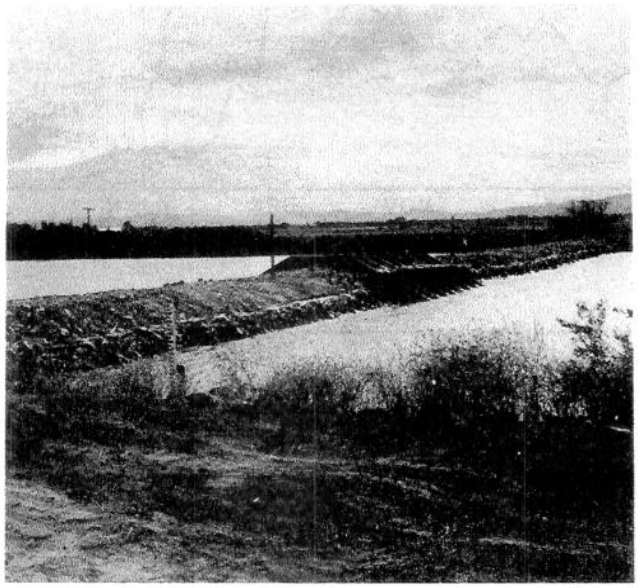
Figure 16.

SALT-WATER INTRUSION IN THE SACRAMENTO-SAN JOAQUIN DELTA



tions, at Antioch, Blind Point, Emmaton, and Rio Vista. (Refer to Figure 15 for locations of measuring stations.) An easterly progression of saline water into the interior Delta as a result of the rising salt content in the west was prevented by the DWR-constructed barriers, while at the same time water releases from upstream reservoirs were decreased to comply with SWRCB orders. It is estimated that 296 cubic hectometres (240,000 acre-feet) were saved in 1977 while Delta protection was maintained. This is in addition to the 62 cubic hectometres (50,000 acre-feet) conserved in 1976 by construction of the Sutter Slough barrier. Figure 16 indicates the maximum salt line penetration in 1977 (as measured by the high tide 1000 ppm level of chlorides) to be to a point near Rio Vista. As Figure 16 shows, salinity intrusion in 1976 and 1977 was much less than in 1931 (before the State and federal projects). Considering that 1977 was the worst water year of record, Delta salinity in 1977 compares favorably with that of other years, such as 1944, after Shasta was constructed.

Through the employment of barriers, substitute diversion points, overland facilities, and the Middle River Pumping Plant complex, users of water from the interior Delta were protected from quality degradation that could have rendered their sources unusable. The beneficial effect of measures taken can be demonstrated by comparing water quality of the unprotected sources to that of the protected, or, in some cases, new sources. These comparisons are shown in Figure 17 for the Contra Costa Canal Intake, Sherman Island agricultural uses, and the South Delta users near Dutch Slough.



6. Guardian of the South Delta. The Dutch Slough barrier, west of Antioch, prevented the inflow of salt water and kept the salt content at an acceptable level.

Extending a trend already evident in June, shortly after construction of facilities designed to improve its water quality, the Contra Costa Canal continued to exhibit substantially lower chloride measurements than in the adjacent Rock Slough which was unprotected by barriers. Figure 17 indicates that salt content was lowered on the order of 28 percent (from an average of 340 mg/1 to an average of 246 mg/1) during the months of June through December 1977. Because of improving conditions, use of the Middle River pumping plant was discontinued January 13, 1978, and the barriers were removed by April 1978.

Similar improvement in water quality was noted at Sherman Island where salinity measurements at the new diversion point averaged less than 900 mg/1 chlorides (except for several peaks of up to 1 500 mg/1) during June through mid-December 1977, whereas, for the same period, measurements at Emmaton (near the old diversion point at the intake to Sherman Island Central Canal) averaged about 1 600 mg/1. Also shown are the measurements taken at Antioch (roughly corresponding to the salinity of the old intake facilities to Mayberry Slough). Chloride measurements at the latter location for the same period averaged about 2 300 mg/1.

Mean daily chlorides at Dutch Slough also showed a decline after completion of its barrier on September 22, 1977, from about 1 100 mg/1 in mid-September to less than 700 mg/1 by October 1977. Between

Figure 17.

EFFECT OF MITIGATIVE FACILITIES UPON CHLORIDES IN DELTA DURING 1977-78

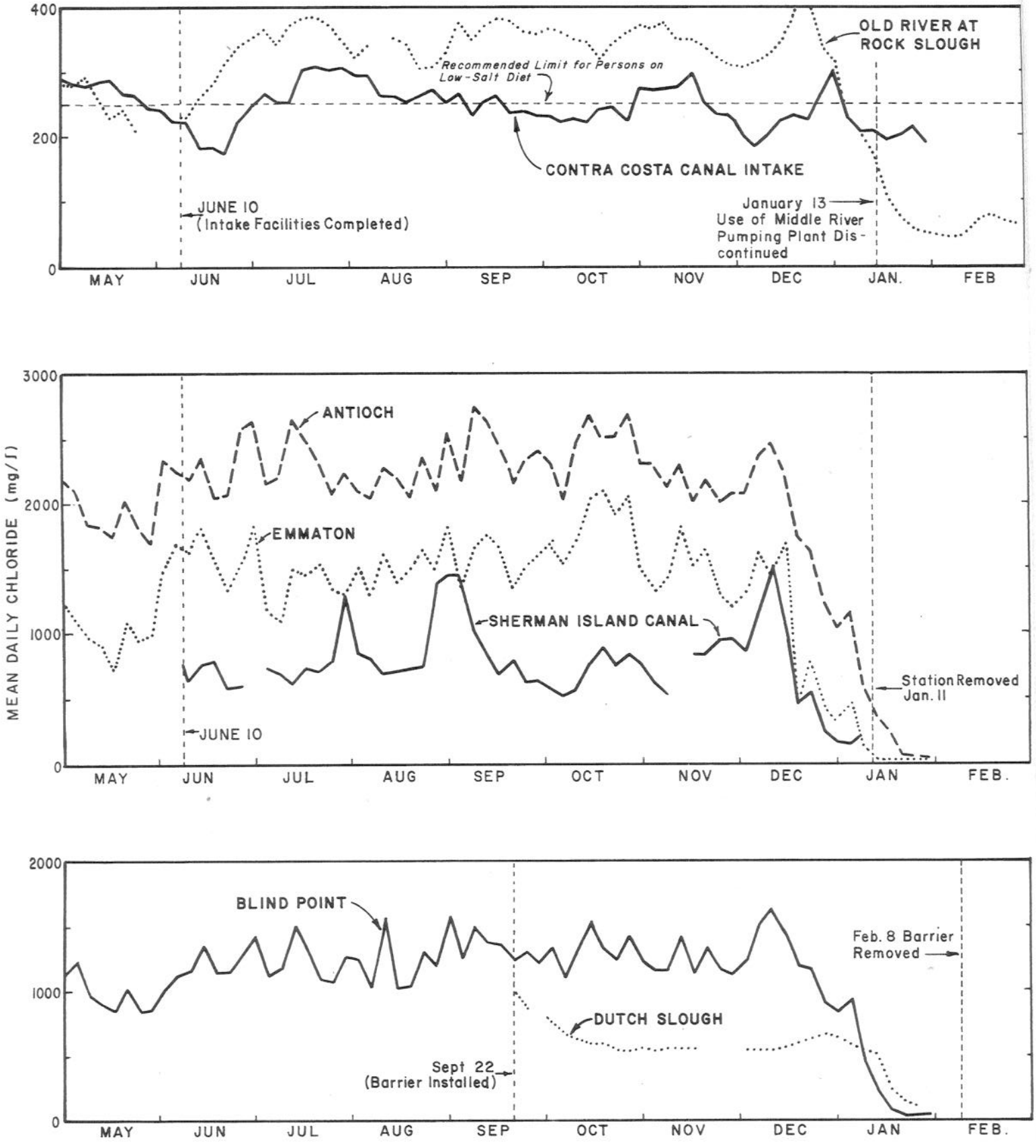
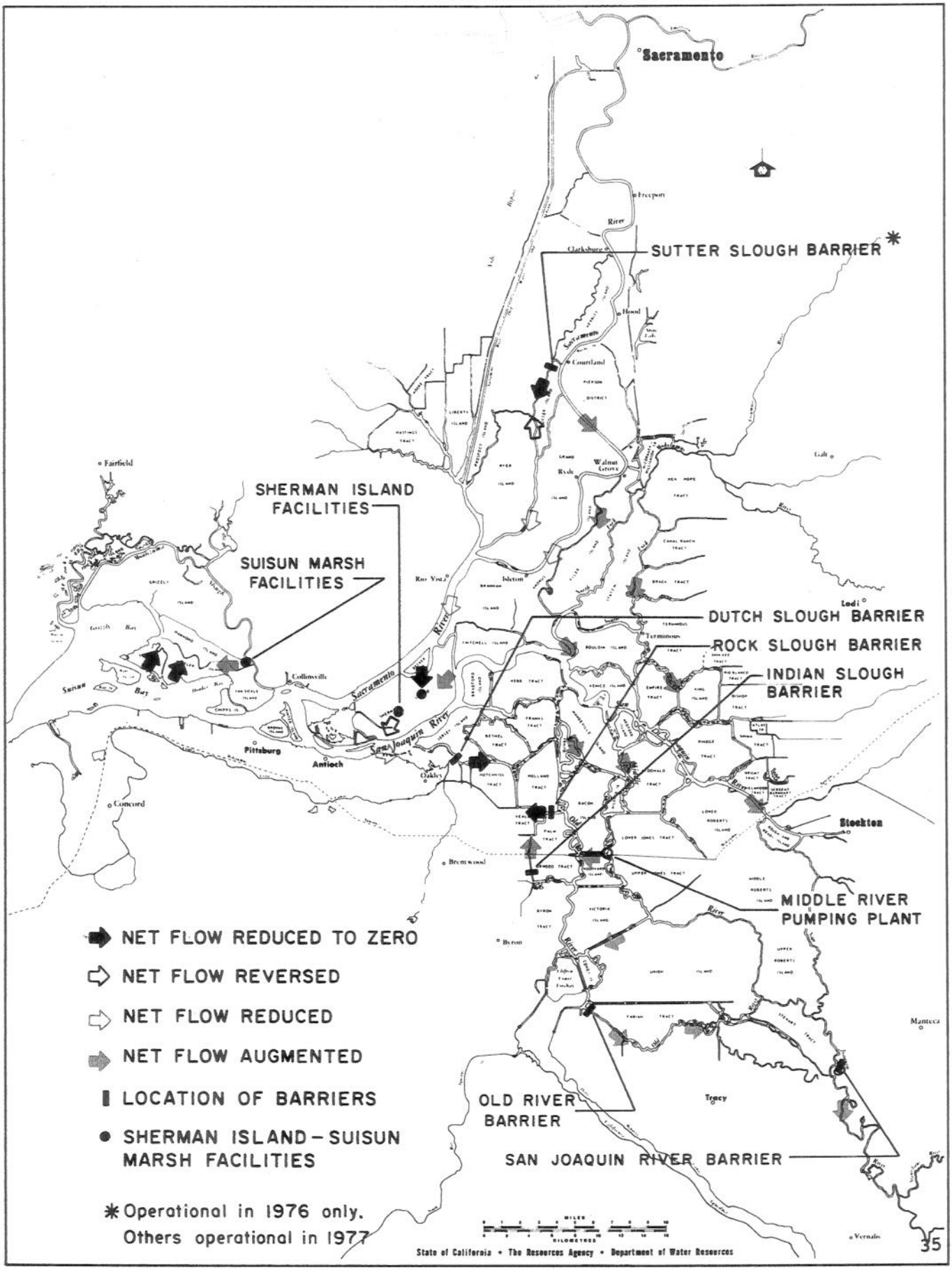


Figure 18.

INFLUENCE OF BARRIERS AND OTHER FACILITIES ON DELTA FLOW PATTERNS 1976 and 1977



October and mid-December chlorides averaged less than 600 mg/l. Plotted for comparative purposes are measurements taken at nearby Blind Point. The latter location continued to show high saline concentrations, with no corresponding improvement, averaging about 1 200 mg/l for the same period. The general improvement in Delta water quality as a result of early 1978 rains allowed removal of the barrier across Dutch Slough by February 8, 1978.

The temporary Delta barriers served the purposes for which they were intended and provided benefits in improved water quality and conserved water that far outweighed their cost. This is not to say that there were no detriments. In the Bethel Island area, bordered by Dutch Slough, residents expressed concern that sewage effluent dilution was adversely affected by the barrier on that waterway. This condition was closely monitored, however, and no health problems surfaced.

In this area, as well as in several other Delta waterways, flow conditions were affected. In some sloughs natural summertime low flows were decreased, some were increased, and in parts of the southern Delta, flows were reversed. (The effects on flows are shown in Figure 18.) There is currently no evidence of any ecological damage as a result of these activities.

In addition to the projects designed to improve water quality, another project was constructed to provide additional supplies from the Delta. The East Bay Municipal Utility District (EBMUD) constructed a second pumping plant in September 1977 to obtain emergency supplies from Middle River. This second connection to EBMUD's Mokelumne Aqueduct provided CVP water to EBMUD and additional SWP capacity for Marin County as part of the exchange agreement between DWR and the Metropolitan Water District of Southern California.

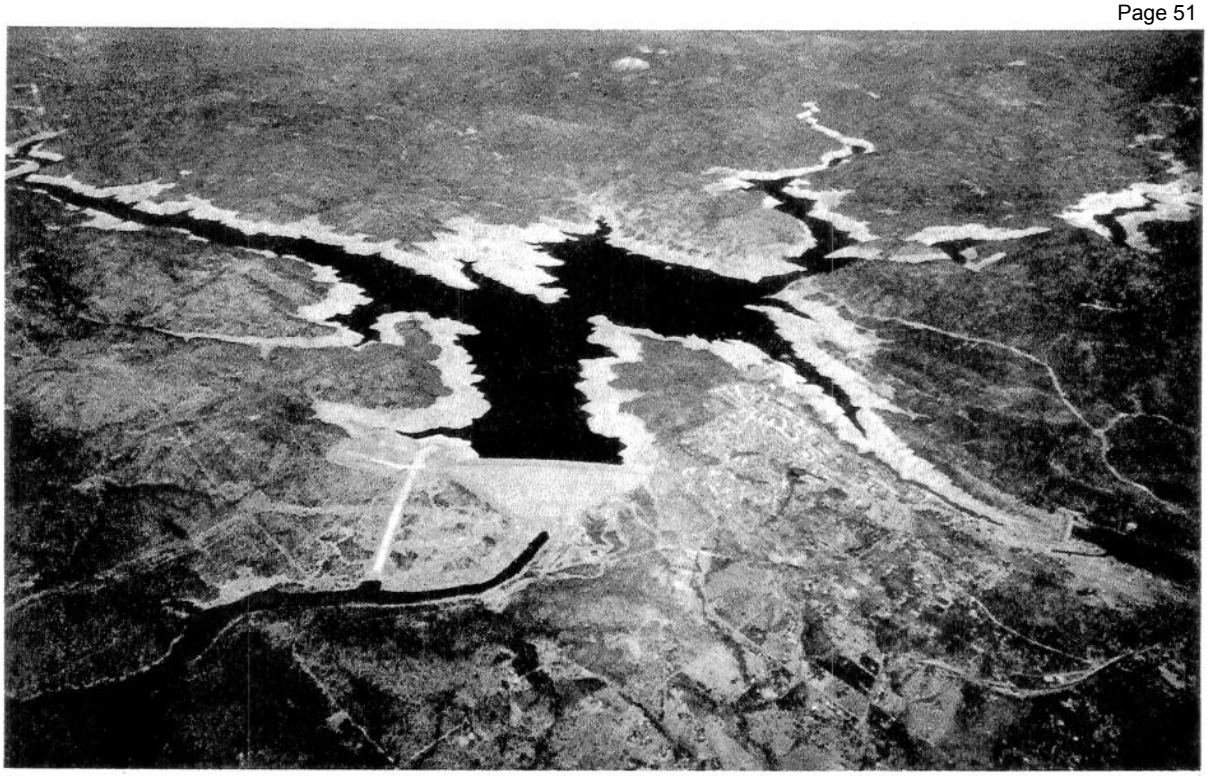
The foregoing has illustrated the problems facing Delta users and the State and federal water projects in their 1977 operations in the Delta as well as the efforts made in behalf of those relying on the Delta as a source of water. It is now very clear that the CVP-SWP operated to provide substantial improvements in water quality which prevented large losses of agricultural income during 1977.

Exactly how much savings accrued is subject to conjecture, but Figure 16 shows that salinity intrusion in the Delta was much less in 1977 than in 1931 (prior to the projects and the worst year of record). In 1931, 81 000 hectares (200,000 acres) were subjected to salinities exceeding 1 000 mg/l at maximum intrusion, while in 1977, only about 8 900 hectares (22,000 acres) were similarly affected. This reduction was accomplished by releases from upstream storage despite (1) a 1977 natural water supply 16 percent below that of 1931, and (2) a much earlier start of high salinities in the western Delta in 1977.

According to 1943 reports, the 1931 crop loss in the Delta amounted to $1,300,000, a 5.3 percent reduction in gross agricultural income for that year. Adjusted for 1977 prices, the 1931 loss becomes $6,600,000. Contrast this figure to the $1,200,000 loss estimated for 1977, amounting to a reduction of only 0.7 percent in gross income. It is obvious that without upstream reservoirs to provide a year-round supply to the Delta, crop losses would have been considerably higher than in 1931. In addition, the municipal water supply for about a million people would have been jeopardized.

State Water Project

During 1977, total deliveries to SWP customers amounted to about 1 110 cubic hectometres (898,099 acre-feet), down from the 2 410 cubic hectometres (1,953,112 acre-feet) delivered in 1976.



7. Low on reserves. Lake Oroville as it appeared on September 30, 1977. Storage on that date was only 1 100 cubic hectometres (915,000 acre-feet), or about one-fourth of capacity. Lake Oroville reached its lowest point on September 7.

Table 6 shows the amounts delivered to SWP customers in 1977 compared to those in 1976, and reflects the reduced allotments resulting from the drought and the effect of water exchanges among SWP customers. In addition, nearly 700 cubic hectometres (563,946 acre-feet) were released to satisfy upstream water rights of the Feather River users using water from Thermalito Complex, Palermo outlet, and Upper Feather. Some of this water returned to the system as return flows and was reused for downstream purposes, including 750 cubic hectometres (609,597 acre-feet) for downstream diverters and riparian users. A total of 1 160 cubic hectometres (940,176 acre-feet) were released into the river from Thermalito for all downstream purposes, including fish releases, water rights users along the Feather and Sacramento Rivers, Delta salinity control, and delivery to SWP customers. No separate releases were made for power generation, although some power was developed as an incidental use of releases for other purposes.

In carrying out those objectives, Lake Oroville, key storage reservoir for the SWP, was drawn down to 1 090 cubic hectometres (882,395 acre-feet), reaching its lowest level on September 7. The southern reservoirs, including San Luis, were called upon to furnish the bulk of SWP deliveries for the year and most showed drastic declines in storage. Total December 31 storage in the seven major project reservoirs amounted to 2 350 cubic hectometres (1,905,133 acre-feet), 52 percent of average storage for that date.

In the several months of the new year, marked by an above-normal precipitation pattern, Lake Oroville storage has increased at a record rate, totally recovering from the effects of the two-year drought. Storage on May 1 was about 3 910 cubic hectometres (3,170,000 acre-feet), or about 112 percent of the average storage for that date based on the 10-year period 1968-77.

4—77735

TABLE 6

STATE WATER PROJECT
DELIVERIES AND PROJECTED DELIVERIES
1976, 1977, and 1978
(acrefeet)[1/]

Contracting Agency	Contractural Entitlements 3/: 1976	1977	1978	Adjusted Entitlement Deliveries 4/: 1976	1977	1978	Surplus, Carryover, Deferred Entitlements and Exchanges 5/: 1976	1977	1978	Total Deliveries: 1976	1977	1978
1. City of Yuba City	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-
2. County of Butte	1,400	1,800	2,200	527	706	2,200	-0-	-0-	-0-	527	706	2,200
3. Plumas Co. F.C.&W.C.D.[2/]	590	620	650	382	303	650	-0-	-0-	-0-	382	303	650
4. Napa Co. F.C.&W.C.D.[2/]	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-
5. Solano Co. F.C.&W.C.D.	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-
6. Alameda Co. F.C.&W.C.D., Zone 7	17,200	18,400	19,600	17,131	12,575	10,613	3,636	69	3,387	20,767	12,644	14,000
7. Alameda Co. W.D.	21,300	22,200	23,100	21,300	18,840	23,100	4,147	1,094	1,140	25,447	19,934	24,240
8. Santa Clara Valley W.D.	88,000	88,000	88,000	88,000	76,220	88,000	24,705	-0-	11,718	112,705	76,220	99,718
9. County of Kings	1,600	1,700	1,900	1,600	1,530	1,900	-0-	-0-	170	1,600	1,530	2,070
10. Devils Den W.D.	11,700	12,700	12,700	11,700	5,075	12,700	5,727	6,836	7,300	17,427	11,911	20,000
11. Dudley Ridge W.D.	30,921	30,400	32,500	30,921	11,153	32,500	41,422	17,565	19,247	72,343	28,718	51,747
12. Empire West Side I.D.	3,000	3,000	3,000	3,000	738	3,000	3,457	1,617	1,262	6,457	2,355	4,262
13. Hacienda W.D.	3,900	4,200	4,600	3,900	1,680	4,600	3,720	2,156	2,520	7,620	3,836	7,120
14. Kern Co. W.A.	442,150	483,600	534,300	439,250	188,407	534,300	442,150	244,430	295,193	881,400	432,837	829,493
15. Oak Flat W.D.	4,039	3,700	3,900	4,112	1,472	3,900	3,840	1,898	2,155	7,952	3,370	6,055
16. Tulare Lake Basin W.S.D.	57,807	54,800	58,700	54,911	13,505	58,700	57,806	31,017	41,295	112,717	44,522	99,995
17. San Luis Obispo Co. F.C.&W.C.D.	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-
18. Santa Barbara Co. F.C.&W.C.D.	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-
19. Antelope Valley-E. Kern W.A.	44,000	50,000	57,000	27,782	12,177	57,000	-0-	22,152	42,372	27,782	34,329	99,372
20. Castaic Valley W.A.	9,500	11,400	13,400	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-
21. Coachella Valley Co. W.D.	7,600	8,421	9,242	7,600	-0-	9,242	-0-	[-7,579]	-0-	7,600	-0-	9,242
22. Crestline-Lake Arrowhead W.A.	1,740	2,030	2,320	1,002	1,109	1,800	-0-	-0-	-0-	1,002	1.109	1,800
23. Desert W.A.	12,000	13,000	14,000	12,000	-0-	14,000	-0-	[-11,700]	-0-	12,000	-0-	14,000
24. Littlerock Creek I.D.	640	730	920	589	111	69	-0-	-0-	181	589	111	250
25. Mojave W.A.	17,800	20,200	22,500	-0-	80	2,500	-0-	-0-	38	-0-	80	2,538
26. Palmdale W.D.	6,900	8,220	9,340	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-
27. San Bernardino Valley M.W.D.	55,000	57,500	60,000	12,273	24,833	24,000	-0-	[-16,000]	-0-	12,273	24,833	24,000
28. San Gabriel M.W.D.	14,000	14,800	15,700	6,071	8,996	15,700	-0-	-0-	-0-	6,071	8,996	15,700
29. San Gorgonio Pass W.A.	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-
30. Metropolitan W.D. of So. Calif.	655,600	755,900	856,300	628,951	189,755	492,200	[-10,500]	[-400,000]	90,000	618,451	189,755	582,200
31. Ventura Co. F.C.D.	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-
Total	1,508,387	1,667,321	1,845,872	1,373,002	569,265	1,392,674	580,110	328,834	517,978	1,953,112	898,099	1,910,652
Joint Water Districts Board	-0-			-0-			-0-			-0-		
Marin M.W.D.	-0-			-0-			4,594			4,594		
San Francisco	-0-			-0-			4,345[6/]			3,372		973
Skylonda Mutual Water Co.	-0-			-0-			10			10		
USBR	-0-			-0-			8,185[7/]			8,185		
Undelivered Exchange	-0-			-0-			95,176[7/]			-0-		

1/ 1,000 acre-feet equals 1.2335 cubic hectometres.

2/ Temporarily served federal water from Project facilities.

3/ From Table A of water supply contracts as of December 31, 1977.

4/ 1976-Adjusted by agreement between water contractor and DWR. Contractural entitlements of all contractors could have been delivered.
1977-Based on 60% cuts in agricultural and 10% cuts in municipal and industrial entitlement water and reductions due to exchanges.
1978-Certain entitlement water deliveries reduced by request due to the wet winter (1977-78).

5/ 1976-All surplus water except for 10,500 acre-feet of MWD exchange delivered to Dudley Ridge.
1977-All exchange water except 5,865 acre-feet of entitlement water which three contractors elected to carry over from 1976. Numbers in brackets [...] indicate water released for use by other contractors and not included in total.
1978-Includes 146,175 acre-feet of entitlement water which nine contractors elected to carry over from 1977 and 371,803 acre-feet of 1977 deferred entitlement deficiency replacement water.

6/ Includes final delivery of 973 acre-feet of exchange water made during January 1978.

7/ Composed of 75,689 acre-feet which was held in an unallocated reserve and 19,487 acre-feet which was allocated but not taken.

The following table summarizes SWP storage at the end of water years 1975, 1976, and 1977, and the estimated storage on October 1, 1978:

OCTOBER 1 STORAGE IN SWP RESERVOIRS (ACRE-FEET*)

Reservoir	1975	1976	1977	1978**
Oroville	2,857,500	1,827,900	915,160	2,700,000
Del Valle	35,191	31,900	32,130	34,000
Castaic	189,183	237,180	58,460	310,000
Pyramid	163,652	163,290	165,300	167,000
Silverwood	60,403	72,650	47,660	72,000
Perris	96,345	87,290	75,440	108,000
San Luis	629,747	468,732	195,839	974,000
TOTAL	4,032,021	2,888,942	1,489,989	4,365,000

* 1,000 acre-feet = 1.2335 cubic hectometres.

** Estimated.

Effect of Shortages Upon SWP Contractors

During 1977, the SWP was unable to deliver all the water needed by its contractors. Municipal users were required to take a 10 percent deficiency and agricultural users took a 60 percent cut in contract entitlement.

An example of drought impact is provided by the experience of the Kern County Water Agency (KCWA), whose 19 member districts accounted for 533 cubic hectometres (432,500 acre-feet) of SWP agricultural water entitlement and 63 cubic hectometres (51,100 acre-feet) of municipal, or a total entitlement of 596 cubic hectometres (483,600 acre-feet). By reason of the cuts, only 270 cubic hectometres (218,990 acre-feet) were deliverable in 1977. (Actual quantities delivered were somewhat less.) In contrast, 1 087 cubic hectometres (881,400 acre-feet) were delivered from the SWP in 1976, including 545 cubic hectometres (442,150 acre-feet) of surplus water available from reservoir storage resulting from prior years of above-average precipitation.

To provide a more nearly normal quantity for agricultural purposes, DWR arranged for the Agency to purchase water from four Southern California SWP contractors who agreed to forego all or part of their 1977 entitlements. (See Table 6 for participating agencies.) A total of 298 cubic hectometres (241,530 acre-feet) were purchased. Figure 19 illustrates the decreased availability to the Agency. Also shown is a bar indicating the amounts of water anticipated, but not received because of the drought, in 1977.

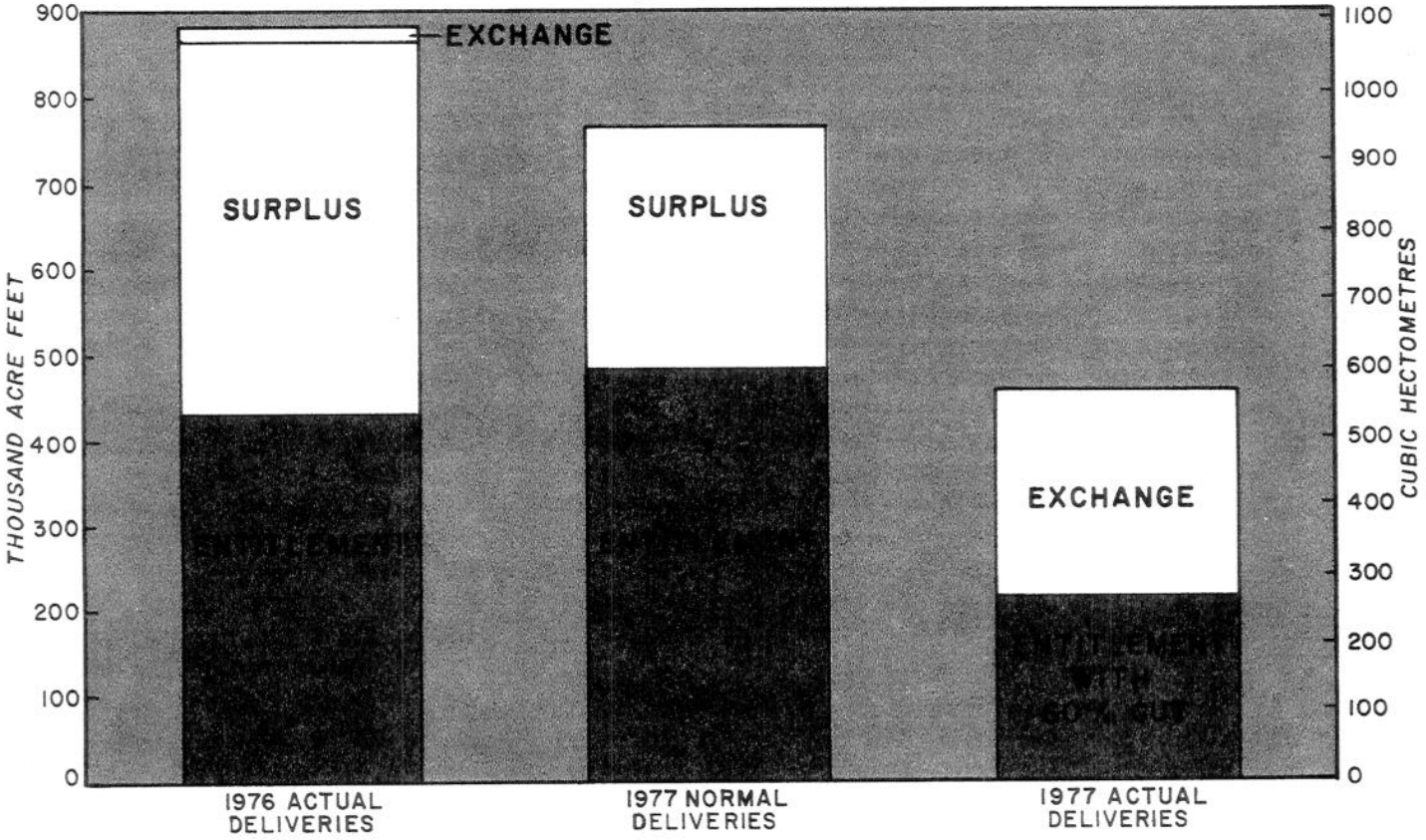
The low level of deliveries had its effect upon the Agency's customers, particularly in the economic area. Since annual payment of project costs includes a large fixed component, charges to the Agency (passed on to its member districts) did not proportionately reflect the marked decrease in deliveries experienced in 1977. As a result, unit costs of the delivered water were considerably higher than in past years.

Also shown in Figure 19 are the historic (since 1968) levels of delivery and average canal-side unit costs for SWP water (including water purchased from other SWP customers in 1977). It shows that until 1977 unit costs to member districts had remained relatively stable at about $.012 per cubic metre ($15.00

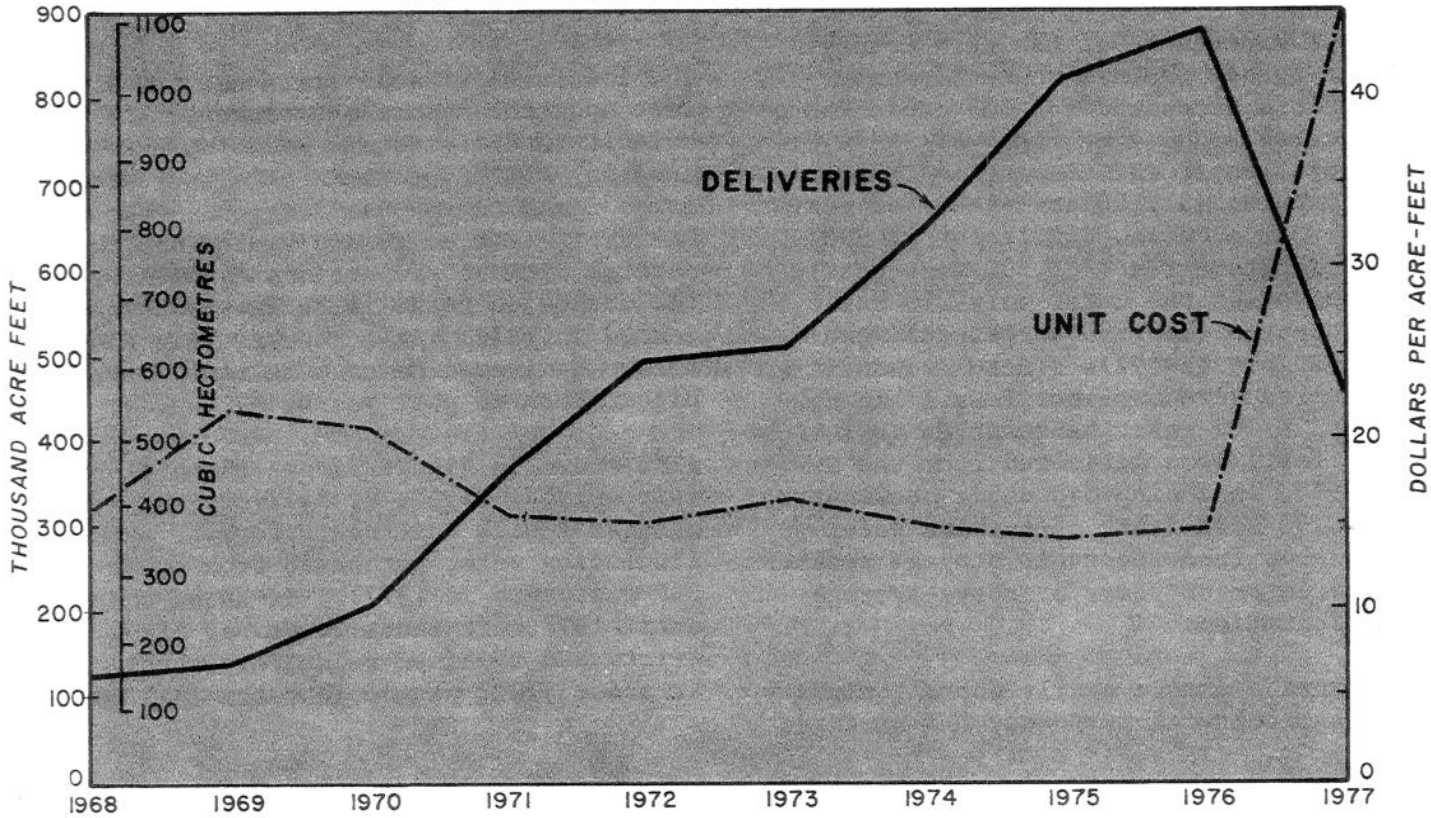
Figure 19.

KERN COUNTY WATER AGENCY

Normal vs. Dry Year Water Supplies



SWP Historical Deliveries and Unit Costs



per acre-foot). In 1977, however, average unit prices jumped to $.036 per cubic metre ($44.27 per acre-foot). The following table summarizes the 1977 sources of supply to KCWA and the unit costs of each:

Source	Quantity (acre-feet)[1/]	Unit Cost ($/A.F.)
SWP Entitlement	218,990	$54.73
MWD Exchange	199,766	30.88
Coachella Exchange	4,767	30.88
Desert WA Exchange	7,361	30.88
San Bernardino Exchange	10,044	30.88
USBR	10,903	79.08
MWD	8,689	79.08
Total	460,520	$44.27

[1/] 1,000 acre-feet = 1.2335 cubic hectometres.

Canal-side unit costs are those prices paid to the Agency by its member districts and are not the prices paid by the farmer. A poll of districts indicates that in 1977 the farmers paid from $44,590.00-$101,340.00 per cubic hectometre ($55.00-$125.00 per acre-foot), compared to previous year costs ranging from $20,270.00-$44,590.00 per cubic hectometre ($25.00-$55.00 per acre-foot).

To counteract the decrease in surface water supplies, additional dependence was placed on ground water. The Kern County Water Agency estimates that ground water furnished 3 700 cubic hectometres (3,000,000 acre-feet) of the County's 1977 water supplies, up from a normal pumpage level of about 2 470 cubic hectometres (2,000,000 acre-feet). The additional draft on the basin produced significant declines in ground water levels (from 10 to 60 feet in some areas).

Despite the measures taken to provide the additional supply, some Kern County cropland went out of production. The Agency estimates that 22 600 hectares (56,000 acres) of land, ordinarily irrigated by SWP water, were idled because of lack of project water in areas of limited ground water pumping capability. According to Agency figures, this represented 9 percent of the irrigated acreage and a gross farm income loss of $50 million.

The 1978 weather conditions have provided a dramatic turnaround from the situation facing KCWA in 1977. This is discussed more fully later in this report.

Central Valley Project

During 1977, the CVP, operated by the U. S. Bureau of Reclamation, delivered 4 070 cubic hectometres (3,300,000 acre-feet) of water to its users. This was down significantly from the 7 380 cubic hectometres (6,000,000 acre-feet) delivered in 1976 and the 8 630 cubic hectometres (7,000,000 acre-feet) ordinarily delivered. In addition to deliveries to its customers, water was also released to help maintain Delta water quality, generate power, and provide fish releases. A total of nearly 6 770 cubic hectometres (5,500,000 acre-feet) was released for all purposes in 1977 (based on releases from Keswick and Folsom Dams and to the Friant-Kern and Madera Canals).

CVP water users were faced with significant cuts in contract entitlement deliveries in 1977. These ranged from 25 percent to all users with water rights on the Sacramento and San Joaquin Rivers to 75 percent for all other agricultural users. Municipal and industrial users were cut back 50 percent. A comparison of diversions for use in each of the project's main aqueducts during 1975, 1976, 1977 is shown on the following table. Also shown are projected diversions for 1978.

Service Area, By Canal	Calendar Year Diversions, Acre-Feet[1/]			
	1975	1976	1977	1978*
Contra Costa	76,752	125,129	95,857	90,000
Delta-Mendota	1,512,962	1,652,915	983,911	1,290,000
San Luis	1,375,832	1,425,849	376,678	1,275,000
Madera	319,651	94,360	31,670	400,000
Friant-Kern	1,393,977	534,240	258,410	1,200,000
Corning	33,228	47,864	18,270	39,000
Folsom South	12,809	22,350	19,530	30,000
Tehama-Colusa	183,798	267,822	224,878	230,000
	4,909,009	4,170,529	2,009,204	4,554,000

[1/] 1,000 acre-feet equals 1.2335 cubic hectometres.

* Projected.

Total storage in the CVP's five major reservoirs (Shasta, Trinity, Folsom, San Luis, and Millerton) stood at 1 680 cubic hectometres (1,362,000 acre-feet) by water year's end. Major losses in storage were registered during the water year by Trinity and Shasta Lakes. Trinity Lake storage decreased from 61 percent of capacity to 10 percent, whereas Shasta fell from 28 percent to 14 percent.

Since December, storage in project reservoirs has increased substantially. Storage on May 1, 1978, was about 9 830 cubic hectometres (7,970,000 acre-feet), or 101 percent of the average storage for that date, and up considerably from the 4 040 cubic hectometres (3,273,000 acre-feet) registered one year earlier.

Compared with the three previous years, estimated storage at the end of water year 1978 shows a dramatic increase. The table below illustrates the steady decrease in CVP storage because of the drought, as well as the estimated storage for October 1, 1978:

OCTOBER 1 STORAGE IN CVP RESERVOIRS (ACRE-FEET*)

Reservoir	1975	1976	1977	1978**
Shasta	3,569,500	1,295,300	630,600	3,433,000
Trinity	2,040,700	1,502,800	242,400	2,022,000
Folsom	773,000	416,400	147,000	713,000
San Luis	401,813	209,081	78,339	521,000
Millerton	160,139	224,240	197,200	270,000
TOTAL	6,945,152	3,647,821	1,295,539	6,959,000

* 1,000 acre-feet = 1.2335 cubic hectometres.

** Estimated.

Hetch Hetchy Project

The San Francisco Water Department, operator of the Hetch Hetchy Project, delivers water directly to consumers in the City and County of San Francisco. It supplies either full or partial supplies on a wholesale basis to approximately 45 other agencies in San Mateo County, the portion of Santa Clara

County bordering the bay, and the southwestern portion of Alameda County. About 1.6 million San Francisco Bay Area residents rely on the water system.

All of the water delivered by the Hetch Hetchy System comes from system storage in Hetch Hetchy Reservoir, Lakes Lloyd and Eleanor in the Tuolumne watershed, and local Bay Area reservoirs. Total reservoir capacity is 1 068 cubic hectometres (866,000 acre-feet). The average water supply to the Hetch Hetchy system consists of about 312 cubic hectometres (253,000 acre-feet) from the Tuolumne watershed and 70 cubic hectometres (57,000 acre-feet) from local Bay Area watersheds.

The normal annual water need of the service area, based on use during 1975-76, is about 382 cubic hectometres (310,000 acre-feet).

In 1977, the San Francisco Water Department initiated a mandatory rationing program to reduce water use by 25 percent. Actual annual water use in the service area was reduced almost 35 percent, to about 254 cubic hectometres (206,000 acre-feet).

Besides mandatory rationing, other steps to conserve or develop water during 1977 included the purchase or exchange of water from the Presidio of San Francisco (Lobos Creek) to be treated by the Presidio, an analysis of the potential for reactivating wells in the Sunset area, the purchase of 4 cubic hectometres (3,372 acre-feet) of Metropolitan Water District exchange water from the Department of Water Resources, and the continued use of reclaimed water in Golden Gate Park. Seventy-five percent of the use within the park presently comes from reclaimed water and wells. Additional service from other waste water treatment plants is being considered to expand use of such water in Golden Gate Park and other parks.

Mokelumne River Aqueduct

The East Bay Municipal Utility District (EBMUD) delivers water through its Mokelumne River Aqueduct to northwestern Alameda County and western Contra Costa County for municipal and industrial purposes. The EBMUD also delivers raw water under water rights settlements to Amador, Calaveras, and San Joaquin Counties. Most of its municipal and industrial water supply is imported from Pardee Reservoir via the Mokelumne Aqueduct. A small amount of water is developed in local reservoirs within the District service area. The District uses no ground water; however, there are private wells in the service area. The District's Camanche Reservoir is operated almost solely for local water rights settlement and does not form a source of water for municipal and industrial use.

Normal annual water use in the EBMUD service area is 300 cubic hectometres (243,000 acre-feet).

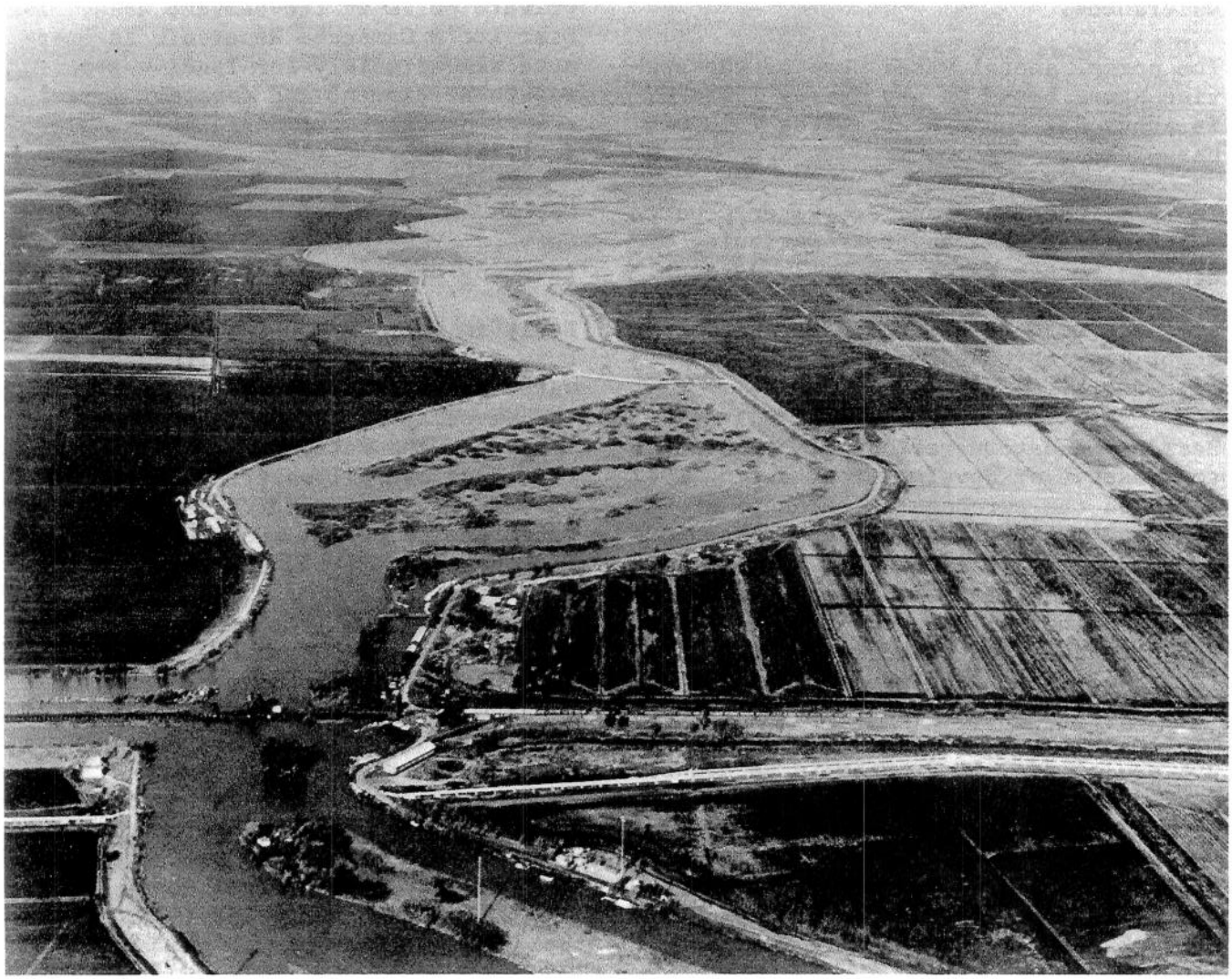
Early in 1977, EBMUD initiated a mandatory rationing program to reduce total water use by 25 percent. Later, after the severity of the drought became more apparent, the rationing was increased to reduce overall water consumption by 35 percent. District figures show 1977 water use to be 184 cubic hectometres (149,000 acre-feet), 61 percent of normal.

During 1977, the District, in cooperation with the Department of Water Resources, developed a new diversion point at Middle River in the Delta to pump a portion of its American River CVP contract allocation into its service area. Approximately 31 cubic hectometres (25,000 acre-feet) were pumped in the period of operation, from September 1, 1977, through January 15, 1978.

A 43 800 cubic metres (1,000,000 gallons) per day advanced waste water treatment plant at Special District No. 1 was put into operation in 1977 to reclaim waste water for process water and irrigation. Waste water reclamation on a larger scale also is being planned by the District. The District reclaimed water at six of its seven water treatment plants during the drought and completed construction of facilities to conserve water at the remaining plant. The amount of water conserved varies from about one to two percent of the water filtered.

The District was one of the key participants in a complex water exchange program coordinated by the Department of Water Resources to assist Marin Municipal Water District obtain up to 13.3 cubic hectometres (10,800 acre-feet) of Metropolitan Water District exchange water. The program, described later, also involved the San Francisco Water Department and the City of Hayward.

In addition, EBMUD made its Mokelumne Aqueduct No. 1 available to deliver water (pumped into it at Middle River) to permit the water quality standards in the Sacramento-San Joaquin Delta at the Contra Costa Canal intake at Rock Slough



8. Before the drought. The Mokelumne Aqueduct is seen crossing Middle River. This photograph was taken before the drought necessitated the construction of the Middle River pumping facilities.

to be maintained with less fresh water Delta outflow.

Los Angeles Aqueduct

The City of Los Angeles ordinarily receives 80 percent of its water supply, 580 cubic hectometres (470,000 acre-feet) via the Los Angeles Aqueduct from the Owens River and Mono basins. Local ground water sources usually provide the remaining 20 percent of the total normal demand of 720 cubic hectometres (584,000 acre-feet).

During 1977, precipitation in the Owens and Mono Basins was only 54 percent of normal, providing a runoff into surface reservoirs of only 380 cubic hectometres (310,700 acre-feet), or 54 percent of normal. A portion of this flow was reserved for use within Inyo and Mono Counties.

As a result of low runoff, the City was able to deliver only 340 cubic hectometres (276,960 acre-feet) from its east Sierra Nevada sources in 1977. Of this, 44 percent was derived from pumped ground water and the remainder from surface water. Local ground water sources in the Los Angeles area provided an additional 170 cubic hectometres (137,300 acre-feet). Because traditional sources provided an insufficient supply, additional water amounting to 150 cubic hectometres (119,370 acre-feet) was purchased from MWD.

Thus, the total water delivered by the City in 1977 amounted to 660 cubic hectometres (533,630 acre-feet), down 9 percent from the normal.

Early in 1977, recognizing the growing seriousness of the water shortage, City officials called for voluntary conservation on the part of the residents. This was changed later, on July 1, to mandatory conservation of at least 10 percent. Litigation brought against the City over ground water sources in the Owens Valley area served as an additional impetus to the conservation effort.

Through conservation efforts and increased purchases from MWD, the City was able to get by in 1977. The new water year has seen considerable improvement in surface water storage.

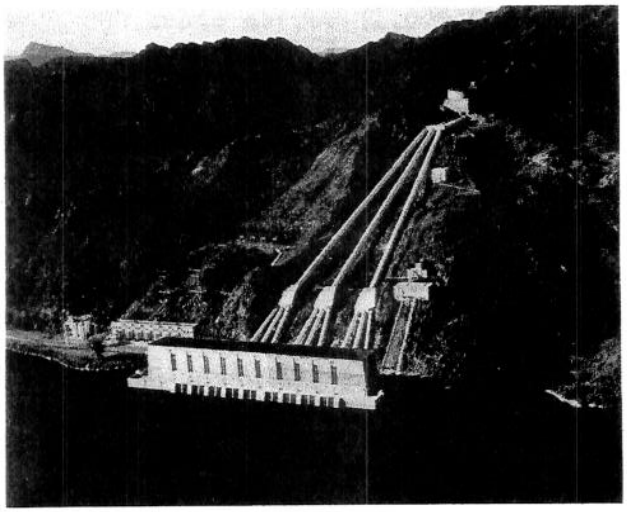
Metropolitan Water District of Southern California

The Metropolitan Water District of Southern California (MWD) provides full or partial supplies on a wholesale basis to 27 member public agencies in the Counties of Los Angeles, Orange, Riverside, San Bernardino, San Diego, and Ventura. Over 11,000,000 Southern California residents rely, in whole or in part, on the MWD system.

The water delivered by MWD comes from two sources. They are: (1) State Water Project (SWP) reservoirs in Central and Northern California whose waters are conveyed through the California Aqueduct, and (2) federally owned reservoirs on the Colorado River with delivery through MWD's Colorado River Aqueduct.

There are no local MWD sources except for minor runoff into terminal reservoirs. However, within MWD's service area there are many ground water wells and six of its participating agencies practice conjunctive use (storing water underground during periods of abundant supply and withdrawing it later by pumping). Four of the six ordinarily receive ground water replenishment supplies from MWD; of the other two, one uses local runoff, while the other (LADWP) uses local runoff and replenishing with water imported from the eastern slopes of the Sierra Nevada.

MWD, which supplies approximately one-half of the water used in its service area, currently delivers 1 936 cubic hectometres (1,570,000 acre-feet) annually. Since SWP water became available in 1972, increasing reliance has been placed on this higher quality source with a consequent decrease in use



9. Helping hands across the State. The Colorado Aqueduct Pumping Plant, shown here pumping from Lake Havasu into the Colorado River Aqueduct for delivery to MWD, was the keystone in the complicated water exchange which allowed additional water to be retained for use in Northern and Central California.

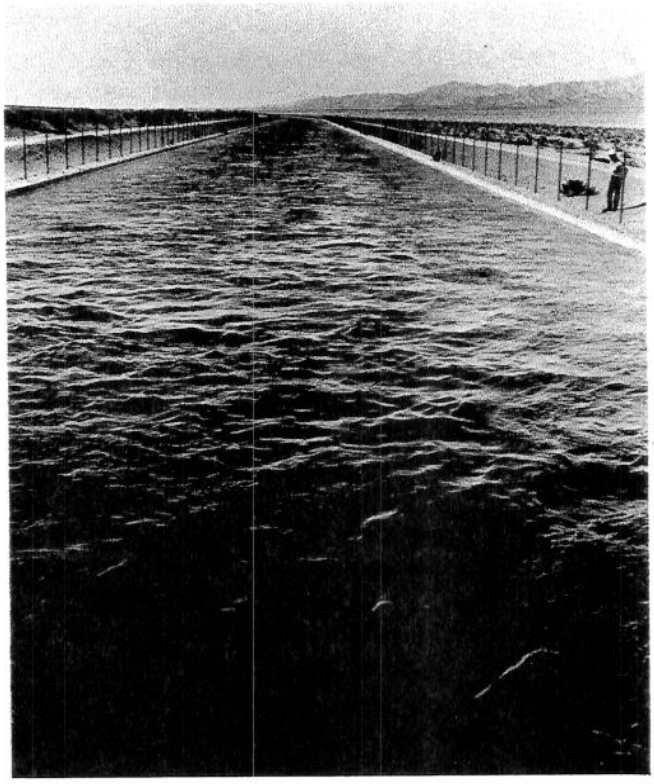
of the Colorado River supply. By 1976, SWP supplies accounted for nearly 45 percent of MWD's total deliveries, or 787 cubic hectometres (638,051 acre-feet). During 1977, however, SWP deliveries to MWD were reduced to 234 cubic hectometres (189,755 acre-feet).

Early in 1977, MWD, recognizing the seriousness of the situation facing California, agreed to a reduction in its SWP deliveries. This action released the much-needed water for use in the more severely stricken Northern and Central California areas. MWD then began operating its Colorado River Aqueduct to provide full capacity flows. By year's end, 1 591 cubic hectometres (1,289,590 acre-feet) had been pumped from the Colorado River. This supply, after accounting for changes in reservoir storage, comprised 86 percent of the total MWD deliveries. The other 14 percent represented SWP deliveries.

To aid other areas of the State, the District called for its member agencies to conserve water, requesting a 10 percent cut in their 1976 usage. To enforce conservation, the District imposed a rate surcharge, beginning April 1, on all usage in excess of 90 percent of 1976 use. In addition, no water was made available for ground water spreading operations, and a rebate was given to all member agencies who decreased their demand below 90 percent.

Voluntary conservation was requested by most member agencies. The City of Los Angeles imposed a mandatory cut of 10 percent, beginning July 1. Other member agencies and subagencies imposing a 10 percent mandatory cut in usage included the Cities of Fullerton, Santa Monica, and El Segundo; Western MWD[1/] of Riverside County; and Rainbow MWD[1/], Valley Center MWD[1/], and Yuima MWD[1/], member agencies of the San Diego County Water Authority.

Total MWD water deliveries in 1977



10. Replacement water for Southern California. The Colorado River Aqueduct transports water from the Colorado River to Los Angeles, Riverside, Orange, and San Diego Counties. The aqueduct saw near-capacity use in 1977 in order to free SWP water for use in Northern and Central California.

1/ Municipal Water District.

amounted to 1 622 cubic hectometres (1,314,863 acre-feet), compared to 1 729 cubic hectometres (1,401,924 acre-feet) in 1976, a 6 percent reduction when the effects of growth are not considered. However, a reduction of 13 percent was achieved for the period from April 1 through December 31, 1977, compared with the same period in 1976. This reflects the time in which the District's conservation incentive program was in effect.

Lower Sacramento, American, and Cosumnes Rivers Service Area

The City of Sacramento, the largest municipal and industrial purveyor in the area, has two water treatment plants on the Sacramento River and one on the American River, and extensive distribution pipelines. The San Juan Suburban Water District diverts water from Folsom Lake and distributes it for sale to Fair Oaks Irrigation District, Citrus Heights Irrigation District, Orangevale Mutual Water Company, part of the City of Folsom, and other small areas in Sacramento and southern Placer Counties. The City of Folsom also diverts water from Folsom Lake. The Carmichael Irrigation District pumps water from the American River and also receives surface water from San Juan Suburban. These surface water suppliers also have supplemental wells.

Storage in Folsom Lake was about 315 cubic hectometres (255,000 acre-feet) on July 1 and dropped to 180 cubic hectometres (147,000 acre-feet) by October 1, 1977. The U. S. Bureau of Reclamation (USBR) reduced lower American River flows from 31 to 23 cubic metres per second (1,100 to 800 cfs) on July 5 and, after a series of additional reductions, on October 1, 1977, finally reduced flows to 7 cubic metres per second (250 cfs). This flow was maintained through the rest of 1977. (Mandatory flood releases began on January 19, 1978, as a result of the extraordinary rains of early 1978.)

Actions taken by urban water suppliers included conservation efforts and restrictions on outside use. As available supplies continued to decrease, both urban and irrigation water purveyors having dual ground and surface water supplies increased ground water pumping when necessary to compensate for reduced surface water.

Napa and Solano County Communities

The City of St. Helena in Napa County added two wells to its system, giving it ample supplies for 1977 and 1978. The City of Calistoga also added a well to its system.

The City of Vallejo in Solano County, long time diverter of water from Cache Slough, was informed by the State Water Resources Control Board in 1977 that water from that source would be unavailable because of low flows during the summer. Eventually, diversions were allowed to continue on the condition the City come up with a satisfactory alternate supply. This condition is being met by a project to increase the capacity of its Solano Project supply.

Contra Costa Canal Service Area

All of the water obtained from the USBR's Central Valley Project via the Contra Costa Canal is distributed by the Contra Costa County Water District (CCCWD), which serves Antioch, Clayton, Concord, Martinez, Pacheco, Pleasant Hill, Pittsburgh, and Walnut Creek. The District also takes a fraction of its water from the San Joaquin River. Industry in the area, at times, takes a small percent of its water directly from the river.

Normally, the CCCWD receives up to 154 cubic hectometres (125,000 acre-feet) of water from the Contra Costa Canal and the remainder of its total annual demand of 160 cubic hectometres (130,000 acre-feet) from the San Joaquin River.

In 1976, the district obtained 148 cubic hectometres (120,000 acre-feet) from these sources and in 1977 cut back to approximately 120 cubic hectometres (97,000 acre-feet).

11. The Delta, an endangered species. An aerial view of some of the 1 100 kilometres (700 miles) of meandering waterways in the Sacramento-San Joaquin Delta, a fragile ecosystem and farming area threatened by salinity intrusion.

For much of the first half of the year, water at the Rock Slough intake to the Contra Costa Canal exceeded the maximum mean daily standard of 250 mg/l chlorides as a result of the USBR's failure to provide sufficient water releases to protect water quality at the intake. By late June, however, the water met standards set up by the State Water Resources Control Board. This resulted from construction of the $3 million Middle River exchange facilities, consisting of rock barriers constructed by DWR across Indian and Rock Sloughs, and a pumping plant at Middle River designed to provide higher quality water at the intake channel of the canal. These facilities are discussed earlier in this report and are shown on Figure 12.

In 1977, to counter the decreasing supply of water, cities in the District instituted mandatory programs to ration water and restrict outside water use. The rationing was not as severe as that of other Bay Area water districts. In Martinez, for instance, each household was cut to 1 374 litres (363 gallons) per day, industrial and commercial users were cut to 90 percent of normal use,

apartments to 70 percent, and parks to 50 percent. In Richmond, also in Contra Costa County, but served by EBMUD, residential water use was cut to 852 litres (225 gallons) per household per day, industry use to 80 percent, commercial to 70 percent, parks to 40 percent, and apartments to 65 percent of normal use.

Russian River Service Area

The area includes Marin and Sonoma Counties and the Russian River drainage area in Mendocino County. The major source of supply is Lake Mendocino, which stores runoff of the upper Russian River area and Eel River flows transferred through the Potter Valley power tunnel from PG&E's Lake Pillsbury. Major users are the North Marin County Water District (NMCWD) and the Sonoma County Water Agency (SCWA). Other sources of supply are ground water and local runoff conserved in six smaller reservoirs owned and operated by the Marin Municipal Water District (MMWD).

Because of low storage in Lakes Mendocino and Pillsbury, surface water supply to NMCWD and SCWA in 1977 was less than normal. To conserve water for human use, fish flows to the Pacific in the area were eliminated.

Each of the seven communities within the SCWA adopted conservation programs, most involved mandatory restrictions with rationing. To meet deficiencies within its area, the SCWA drilled deep, high-capacity wells, which by year's end were satisfying a significant part of the urban demand. The SCWA moved the ground water via aqueducts to all major urban areas in Sonoma County and northern Marin County. This permitted 1977 delivery of 31 cubic hectometres (25,462 acre-feet), down 22 percent from 1976 use.

The North Marin County Water District, the City of Petaluma, and the City of Rohnert Park are to receive ground water from Rohnert Park via the Sonoma County Water Agency aqueduct. Rohnert Park drilled wells especially for this arrangement, with the costs being paid by the other two agencies. First deliveries from the wells were made in 1977.

In southern Marin County, MMWD obtained some relief from its extreme water shortage (the worst in the State for a major urban area) through the reallocation of water from Southern California and conveyance of the water from the Delta to Richmond through existing aqueducts and from Richmond to Marin by construction of a pipeline across the San Rafael bridge. The exchange water began to enter the County on June 7, 1977, and by December 31, 1977, 5.7 cubic hectometres (4,594 acre-feet) of the exchange water had come across the bridge. As a result, MMWD was able to provide 14 cubic hectometres (11,500 acre-feet), about 36 percent of normal.

Santa Cruz County

Ground water supplies take care of most of the County's water needs. No water import projects for domestic use exist, and the only surface reservoir which contributes significantly to the area water supply is Loch Lomond Reservoir on Newell Creek. It ordinarily supplies approximately 4.7 cubic hectometres (3,800 acre-feet), about one-third of the annual demand of the City of Santa Cruz. Two other major purveyors are the San Lorenzo Valley County Water District and Citizen's Utilities Company, both of which rely on stream diversions and ground water.

During 1977, streamflows were very low and the ground water level in the City's wells dropped about 0.3 metre (1.0 foot) in 1977. In the lower end of the Pajaro River fan, the overdraft is expected to increase salt water intrusion.

A countywide water conservation program was implemented in 1977, funded as follows: Federal (CETA Title VI) $401,053, State (AB 380) $100,000, and County, $40,000. Under this program, described elsewhere in this report, the County

distributed free toilet dams and showerheads to County residents.

The City of Santa Cruz and San Lorenzo Valley Water District enacted rationing programs. The City reduced use in 1977 to 63 percent of that used in 1975 with the water district program reducing consumption to approximately 60 percent. During the period when the City's program was in effect (March-November), however, water consumption was reduced by 54 percent.

Central Sierra Foothills Region

For this report, the region includes the foothill portions of the Counties of Amador, Calaveras, and Tuolumne. A number of communities in the three counties receive their water from ditch systems from the Mokelumne, Cosumnes, and Stanislaus Rivers or their tributaries, plus wells.

Because of limited supplies available from PG&E's Amador Canal, Amador communities including Amador City, Drytown, Ione, Jackson, and Sutter Creek resorted to rationing which saw a 25 percent cut to metered customers and 50 percent to others. In Plymouth, served by PG&E's Arroyo Ditch, rationing reached 50 percent. Pine Acres, Pine Grove, and Pioneer, with their own wells or surface storage, saw cuts ranging from 30 percent to 65 percent.

In Calaveras County, Angels Camp and Altaville saw their water supplies from the North Fork Stanislaus River and PG&E's Utica Ditch reduced by 35 percent. About eleven other communities served by Calaveras County Water District and Union Public Utility District recorded 25 percent cuts.

In Tuolumne County, Columbia, Jamestown, Sonora, Tuolumne City, and Twain Harte, served by PG&E's Tuolumne Ditch, were forced to reduce usage by 35 percent.

In most instances, the affected communities restricted outside usages, such as watering landscaping, and imposed rationing.

Other Foothill and Sierra Communities

In Butte County, many communities obtain most of their water from wells, although some water is obtained from PG&E's Miocene and Hendricks Canals, and from the Paradise and Magalia Reservoirs on Little Butte Creek. Both reservoirs were very low in 1977.

To meet the deficit, the various Butte County communities began strict rationing as early as April 1. Individual hauling of water was instituted in some cases. Paradise Irrigation District, among the hardest hit of the urban areas, responded with one of the most effective conservation programs in the State, achieving a 65 percent reduction in usage for 1977.

In Placer County, Auburn, Lincoln, Loomis, Newcastle, Penryn, and Rocklin receive water from the Placer County Water Agency's reservoirs on the Middle Fork American River. Storage on February 1, 1977, was only 36 percent of normal, necessitating action to conserve water. Rationing was instituted. In mid-year the Placer County Water Agency became the recipient of an interest-free loan by the USBR under the Emergency Fund Act of 1948. Money was used to provide canal repairs and for installing canal water measuring and recording devices to monitor losses.

Through voluntary and mandatory rationing, 50 percent savings were realized by the Agency's customers in 1977. District officials feel that future savings will continue at least 15 percent.

The Plumas County communities of Quincy and East Quincy obtain their water from wells and springs. Because of reduced supplies, outside uses of water were restricted in 1977.

Agriculture

Losses to California agriculture in 1977,

during the second year of the drought, are estimated at $566.5 million, according to the California Crop and Livestock Reporting Service. Of the $566.5 million total loss to California agriculture in 1977, livestock producers sustained by far the largest loss at $414.5 million. An additional $112 million in losses were suffered by field crop producers (including fallow cropland), and $40 million by fruit and nut producers.

Earlier estimates of drought losses beginning in the fall of 1975 through the end of 1976 totaled $510 million. Accumulative drought-associated losses for California agriculture from November 1975 through December 31, 1977 are an unprecedented $1.07 billion.

These and other conclusions are contained in a December 31, 1977 report titled, "Drought Damage to California Agriculture", produced by the California Department of Food and Agriculture and the Governor's Drought Emergency Task Force.

Range and pasture conditions throughout 1977 were the worst of record, reflecting extreme drought with poor forage conditions throughout the year. The poor conditions existing in California throughout 1977 are confirmed by the U. S. Department of Agriculture and the National Weather Service, whose late summer maps of Palmer Index[1/], a measure of drought severity, and pasture and range feed conditions are reproduced here as Figure 20. Examination of the maps leads to the conclusion that California conditions were among the worst in the nation, with extreme drought and lack of pasture and range feed a condition common to the greater part of the State. Graphically demonstrated is the drought's heavy hand on the Central Valley and Central Coastal areas. The drought forced cattle and sheep producers to move to summer pastures and some out-of-state pastures much earlier than normal. Range forage was virtually nonexistent in many areas of the State, and with heavily depleted stock water supplies, range cattlemen were forced to haul hay and water to their livestock. In numerous cases, early or forced sale of stock for pen feed or slaughter occurred.

The increased marketings and culling of herds resulting from over two years of drought and four years of low prices caused a decline in the California cattle inventory to 4.43 million head by January 1, 1978, down 7 percent from the 4.75 million head on California farms and ranches a year earlier. Cattle numbers in California have now declined 16 percent, or 820,000 head from the peak inventory of 5.25 million head recorded on January 1, 1974. Declines in cattle inventory during 1977 ranged from 3 percent in the northeastern part of the State to 17 percent in the north coastal area.

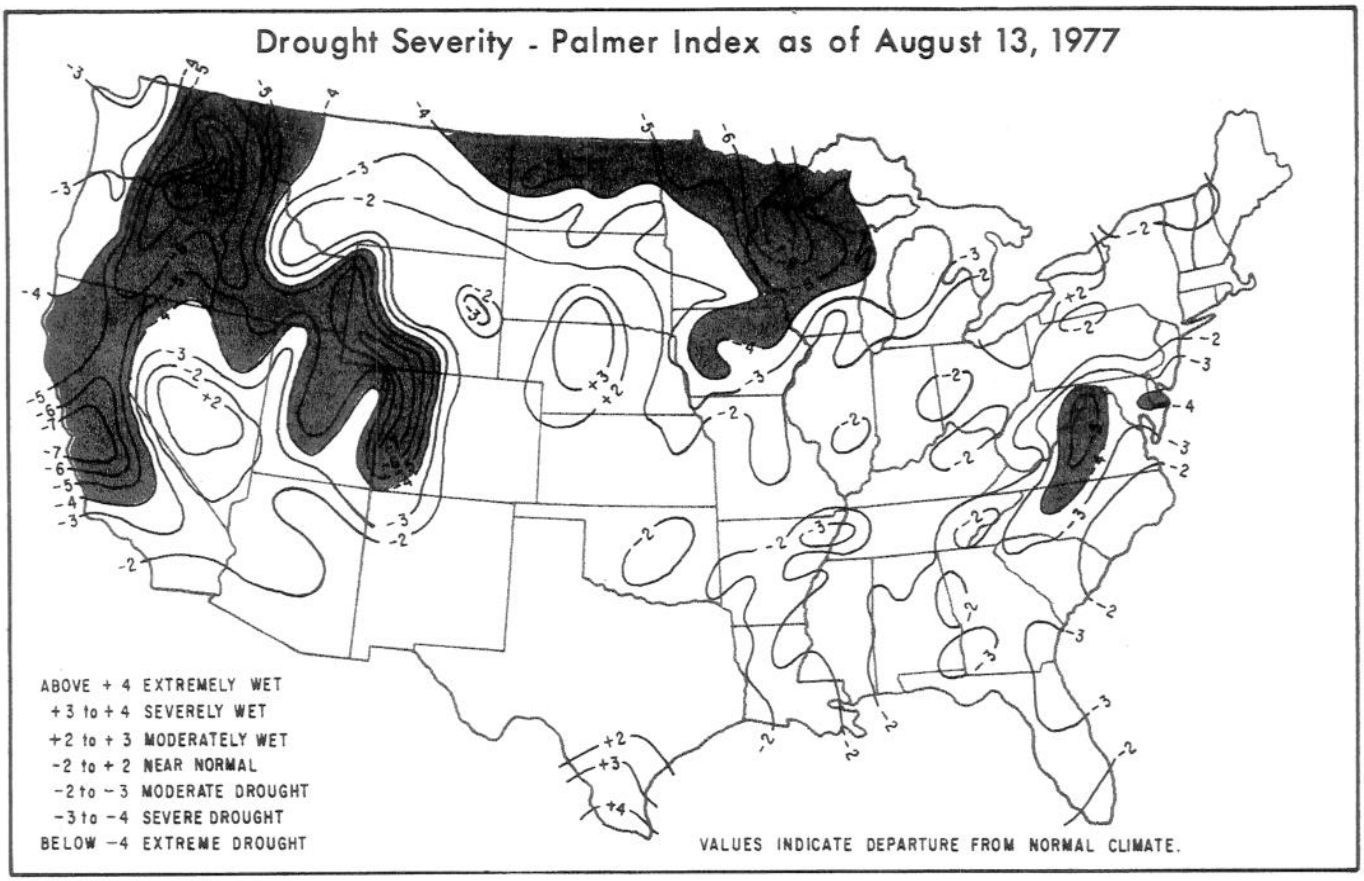
The direct impact of the drought upon the livestock industry has been hard to measure since the U. S. cattle industry, including California, has also been in the liquidation phase of the cattle cycle. The cyclical movement of breeding cattle to market, along with the liquidation of herds due to the lack of feed and pasture, has held cattle prices below the cost of production for over three years.

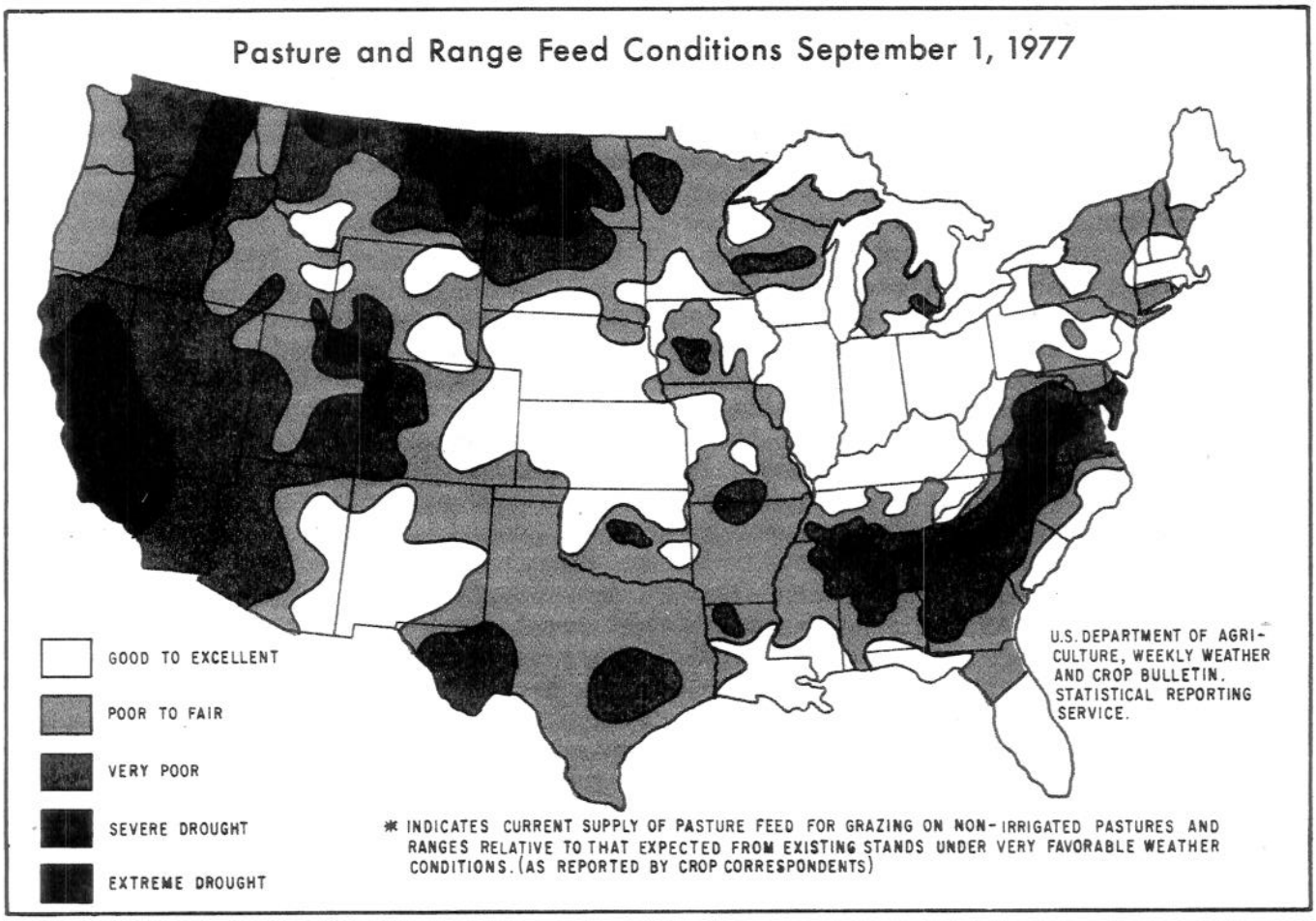
The following table presents the 1976 and 1977 California range and pasture conditions in percent compared to the 10-year average.

1/ Palmer Index depicts drought severity, and is computed in a manner designed to consider the intensity and duration of abnormally wet or dry periods using the parameters of temperature, precipitation, evaporation and transpiration, runoff, soil moisture, and time. Its single index number normally falls between +6 and -6.

Figure 20.

MEASURES OF THE DROUGHT'S SEVERITY AND EFFECT ON AGRICULTURE





Year	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Season Ave.
1965-75	82	79	78	78	77	76	75	74	--	78
1976	49	48	46	46	47	47	55	57	56	50
1977	37	35	41	42	38	39	43	38	38	39

(Percentages of 35-49 represent severe drought, 50-64 is very poor, 65-79 is fair, and 80 and over is good to excellent.)

The following discusses the drought's effect upon the cattle raising areas of the State. The North Coast, North Central, and North East regions comprising the Counties of Mendocino, Humboldt, Del Norte, Trinity, Siskiyou, Shasta, Modoc, Lassen, and Plumas are areas where the continued drought impact was not as seriously felt, except in a few local areas, until 1977. Consequently, the prolonged effect of the drought has been considerably less than in other areas of the State. Range and pasture conditions in the northern counties were in the 50-64 percent range in 1977, but were still considered very poor; however, these reported conditions were still much higher than in other districts in the State. Very little irrigated pasture exists in these counties; consequently, the poor range conditions generally reflected a larger percentage decrease in cattle numbers. Stock water supplies were available in these areas with minimal hauling.

Losses in the northern counties were generally measured in reduced breeding herd weight losses, reduced feed availability on ranges, and increased feed costs, for hay and supplements. Dry feed was in short supply in early 1977, but became available as the season progressed; however, most herds received supplemental feed throughout the year.

In the Central Coast, Sacramento Valley, and Sierra regions, range and pasture conditions during 1977 ranged from 33 to 38 percent (lowest of record) indicating severe drought and extremely poor conditions. These regions include the Counties of San Luis Obispo, Monterey, San Benito, Santa Cruz, Santa Clara, San Mateo, San Francisco, Alameda, Contra Costa, Marin, Sonoma, Napa, Lake, Yolo, Colusa, Glenn, Tehama, Butte, Yuba, Sutter, Sacramento, Sierra, Nevada, Placer, El Dorado, Amador, Alpine, Calaveras, Tuolumne, Mariposa, Mono, and Inyo.

Shortages of stock water existed since early 1975 and many herds were maintained by producers hauling water. Forced liquidations of herds began in early 1976 and continued through 1977, particularly as it became apparent that the spring 1977 rains were not forthcoming. Many producers tried to maintain herd sizes in order to keep open lines of credit, but in many instances were forced by creditors to lower inventory levels in an effort to cut overhead costs. Most herds were moved off stressed and overused irrigated pastures early in the season to take advantage of what feed existed at higher elevations. These herds were still being supplemented to maintain condition. The ratio of calves born to cows on hand January 1 slipped slightly, but would have been lower if very heavy culling of cows had not taken place during 1976.

Ground protection in the Central Coast, Sacramento Valley, and Sierra regions did not exist for new range seedlings in early 1977. Consequently, most new grass died almost immediately after germination because of no moisture. Most counties reported almost 100 percent loss of grazing capacity during 1977 in these districts. Many sheep and lamb producers either moved flocks or liquidated.

The San Joaquin Valley region comprising the Counties of San Joaquin, Stanislaus, Merced, Madera, Fresno, Kings,

5—77735

Tulare, and Kern saw range and pasture conditions averaging only 28 percent during 1977, the lowest of any region in the State, and 11 points below the State average. This region suffered some of the most severe effects of the drought and felt the impact over two years, being the first to feel the impact of continued drought. Stock water supplies dried up in early 1976. Dry feed was nonexistent and dry roughage was in short supply until the 1977 hay crop was harvested. Pasture leases were almost nonexistent during 1977. The San Joaquin Valley is the only region in California where the number of cattle being fattened for slaughter market on January 1, 1978 was below a year earlier. Breeding herds were in generally poor condition. Reports indicate that herd reductions in 1976 came about by culling cows and older breeding stock, but in 1977 the numbers disappearing were the younger stock. Producers attempted to hold onto cows and springer heifers in hopes of being in business in 1978.

The Southern California and Desert regions comprising the Counties of Santa Barbara, Ventura, Los Angeles, San Bernardino, Riverside, Orange, San Diego, and Imperial maintain a large part of their cattle inventory either in feed lots or on irrigated pastures, the same being true for sheep flocks. Because they are not greatly dependent upon nonirrigated rangelands, water availability was not a serious problem in 1977. Livestock in these areas were generally in good condition and little affected by the drought, except as it affected feed prices and market conditions. Feedlot placements were up during 1977. Dairies in this area are all dry lot and continue to hold the demand for feed stuffs relatively high.

Relief to producers from drought relief programs, long-term, low-interest credit, feed purchases, and tax relief programs have helped, but many producers still face serious financial problems.

The number of cattle in the areas affected by the drought are in excess of 3.0 million head. Losses to the cattle industry in 1977 are estimated as follows:

	Millions
North Coast, North Central, North East	$ 30.9
Central Coast, Sacramento Valley, Sierras	121.6
San Joaquin Valley	206.0
Southern California and Desert	50.0
TOTAL	$ 408.5

Besides cattle, there are nearly 900,000 stock sheep in the areas affected by the drought. Losses to producers in these areas included forced liquidation or major culling, reduced grazings on public lands, loss of irrigated pasture, higher supplemental feed costs, and increased costs of leases. The 1977 loss to the sheep industry in additional costs and reduced production is estimated to be in excess of $6.0 million.

California's small grain producers suffered from a second year of drought in 1977 with substantial abandonment of planted fields and poor yields on much of the dryland grain brought to harvest. While wheat growers shifted acreage to irrigated ground wherever possible, final estimates show that 27 percent of the planted wheat acreage was not harvested, nearly three times the normal loss. Similarly, some 17 percent of the barley acreage was not harvested. Dryland grain losses in 1977 due to abandonment and yield reduction are estimated at $11.5 million for wheat, nearly $10 million for barley, and $1.5 million for oats.

The sharp curtailment in surface water availability for irrigation also forced field crop producers to leave a substantial acreage of cropland idle. It appears that nearly 50 600 hectares (125,000 acres) of irrigated cropland was out of production during the 1977 season, with most of the idle land in

Fresno and Kern Counties. Using gross values per acre for crops normally grown on this land, it is estimated that field crop producers lost nearly $89 million of income from land idled in 1977.

Other major field crop acreages were also affected by the continued drought and sharply curtailed irrigation water. Both rice and sugar beet acreage declined, but it is difficult to separate economic factors from reductions due to the drought. In any event, much of the displaced rice and sugar beet acreage was planted to other crops, including safflower and small grains.

Cotton acreage in 1977 was increased substantially in the face of sharply curtailed water supplies, since expected crop returns at the time of planting were very favorable. Cotton yields were much better than expected in the San Joaquin Valley, but well below normal in the Imperial Valley due to factors which were not drought related, largely insect problems, and a tropical storm which hit the area in August 1977.

Total field crop losses due to the drought in 1977, including idle irrigated cropland, are estimated at $112 million.

The overall effect of the drought on fruit and nut crops in 1977 was much less than had been expected since producers turned to water-saving techniques such as drip irrigation and more efficient sprinkler systems. (DWR has begun a study to determine the extent to which these changes in irrigation practices contributed to water savings.) Record crops were realized for almonds, plums, and nectarines. Favorable spring weather resulted in excellent pollination for most fruit and nut crops, thus increasing yields. However, the principal reason for the record almond crop was the continued increase in new bearing acreage. In spite of a sharp reduction in clingstone peach acreage, a large crop was still harvested due to the sharp increase in the yield per acre. While walnut yields were favorable in early season varieties, meat weights were well below normal in the late season varieties, particularly the important Hartley variety.

Raisin grape yields were well below average due to light bunch weights at harvest. Wine grape yields were also below average, although they were higher than in 1976 when the crop was damaged by untimely rains in September. Table grape yields were more favorable due to the unusually large Tokay crop in the Lodi area where production was not adversely affected by the drought.

The State drought loss of raisin variety grapes is estimated in the neighborhood of 150,000 tons,[1/] with many vineyards reporting light bunch weights at harvest. Drought loss in wine grapes is probably in the neighborhood of 50,000 tons[1/]. Most of this loss was in the premium wine producing areas which are largely nonirrigated. Allowing an average value of $180.00 per ton[1/] for all grapes, the total loss would amount to $36 million.

The drought loss in walnuts, resulting in light kernel weights late in the season, is placed at 5,000 tons.[1/] Allowing an average value of $750.00 per ton,[1/] the loss would amount to $3,750,000. There was also some production loss in pears resulting from the lack of irrigation water in Lake, Mendocino, and El Dorado counties.

Total loss to fruit and nut crops, largely in grapes and walnuts, was in excess of $40 million.

The effect of the two-year drought on 1978 production of tree and vine crops is largely unknown at this time. However, the 1977-78 crop season production of Navel oranges in the San Joaquin Valley is expected to be below average due

1/ One ton equals 0.90718 tonne.

to a spotty set and below average fruit size which is related to tree stress caused by last year's drought.

In general, there were no significant overall losses in vegetables. However, canning tomato acreage was reduced in some areas of the San Joaquin Valley, particularly Fresno and Kern counties, with compensating increases in coastal areas and the Sacramento Valley. There were also significant shifts in lettuce and melon acreage in the San Joaquin Valley, and 1977 melon yields were lower. In contrast, lettuce supplies were larger during the summer months resulting in low returns to producers.

There were other costs to California growers besides those associated with reduced income. The cost of applying irrigation water rose sharply in 1977 with increased power bills to pump ground water to replace surface water supplies. In addition, there were added bills caused by increased well drilling to provide ground water.

While well costs vary greatly depending on their depth and the size of the casing, it is estimated that the cost of well drilling for agricultural use totaled $300 million in 1977. Statewide, the extra energy associated with the required lift and additional ground water extraction is estimated to have required about one billion kilowatthours of energy in 1977 at a cost of over $25 million.

Following are comments on the conditions faced by the agricultural community (chiefly that segment dependent on irrigation) in selected counties of the State as a result of short surface water supplies in 1977.

Alameda County. Irrigated agriculture on the bay side of the County had an adequate water supply and the ground water remained relatively stable throughout the drought years. Winter preirrigation with water from the SWP and summer irrigation with ground water enabled growers in the Livermore Valley to maintain their vineyards.

Rangeland feed was reduced drastically. The County Farm Advisor reported the numbers of range cattle were reduced 80 percent. The largest financial losses were experienced by those who did not reduce their herds quickly enough to match range conditions.

Amador County. Approximately 50 percent of the irrigated land (mostly in Ione and Jackson Valleys) is pasture with the remainder in row and deciduous orchard. The Jackson Valley Irrigation District in 1977 delivered 6.9 cubic hectometres (5,600 acre-feet), down from the 13.6 cubic hectometres (11,000 acre-feet) distributed in 1976. To meet the deficit, the district allocated the available supplies and changes were made in crop patterns. The major change was the complete absence of sugar beet plantings. The remaining area is served by ground water where the drop in the water table required many pumps to be lowered.

Butte County. The Feather River Service Area consists of the valley floor lands in Butte, Sutter, and Yuba Counties which are served water diverted from the Feather River after storage in DWR's Oroville Reservoir. The diversions are primarily for agricultural use in organized districts, of which the Joint Water Districts Board (an amalgamation of four districts) is the largest. Other agricultural districts are the Western Canal Company of PG&E, Tudor Mutual Water Company, Garden Highway Mutual Water Company, Plumas Mutual Water Company, and Oswald Water District. Rice is normally the major crop, but orchards, alfalfa, and pasture comprise about 40 percent of the total irrigated acreage. Feather River diversions normally total about 1 230 cubic hectometres (a million acre-feet) annually.

Ground water is a negligible supply source for these agricultural diverters. It is, however, a major source for urban areas, such as Oroville, Yuba City, and

Marysville, and for individual farmers having orchards along the Feather River.

For 1977, DWR imposed a 50 percent reduction of the normal appropriative diversion entitlements for agriculture. The 1977 reduced entitlements total 550 cubic hectometres (443,745 acre-feet). Local actions to cope with the reductions consisted of reducing the acreage of rice and other annual crops by about 50 percent, reducing the number of orchard irrigations, and increasing the use of drainage water. Only a slight increase in ground water pumping by individual farmers was needed to make up for the surface deficiencies. In addition, voluntary conservation efforts in the urban areas achieved significant water savings.

Calaveras County. Agriculture in the County is on a small scale. The water agencies serving surface water are Calaveras County WD, Calaveras PUD, PG&E, and Union PUD. The only other source for the County is a limited supply of ground water with some wells going dry in 1977. Customers of the districts incurred an estimated 50 percent reduction; irrigated pasture was reduced by two-thirds. The dry land pasture occupying the lower elevation incurred a substantial loss of feed. Those of higher elevation (above 900 metres, or 3,000 feet), however, fared much better.

12. A transfusion for Contra Costa. Shown is the Contra Costa Canal, the major source of water for industrial, agricultural, and urban uses in Contra Costa County. With the construction of the barriers at Rock and Indian Sloughs and the Middle River facilities, CCCWD received higher quality water than would have otherwise been possible.

Contra Costa County. Reduced flows in the Delta resulted in increased salinity intrusion and a reduction in irrigation water quality. Growers, particularly of the lower Delta islands, either curtailed irrigation or incurred some crop damages.

With the installation of a barrier on Middle River to reduce the amount of salinity, East Contra Costa ID and Byron-Bethany ID had an adequate supply for the irrigation season. The drought had only a slight impact on the crops grown in these districts with some almond orchards indicating salt burn in 1977. (Its severity may show up in the 1978 crop year.)

Dry-farmed lands in the County did not produce a crop, although some losses of the nonirrigated grain and hay crops were recovered by grazing to sheep. The rangeland, in general, fared poorly.

Del Norte, Humboldt, and Mendocino Counties. Throughout the entire north coastal area, along the Eel River and in the coastal valleys, a limited amount of irrigation occurs. Evapotranspiration rates are low due to dense cloud and fog cover. As a consequence, crop suitability is reduced to grass pasture and a few acres of nursery stock, mainly bulbs. Serious irrigation is supplied mainly from ground water. Those on ground water had normal supplies during 1977.

Round Valley had little surface water available. The main irrigated areas of the valley, however, are on ground water and Round Valley has experienced a

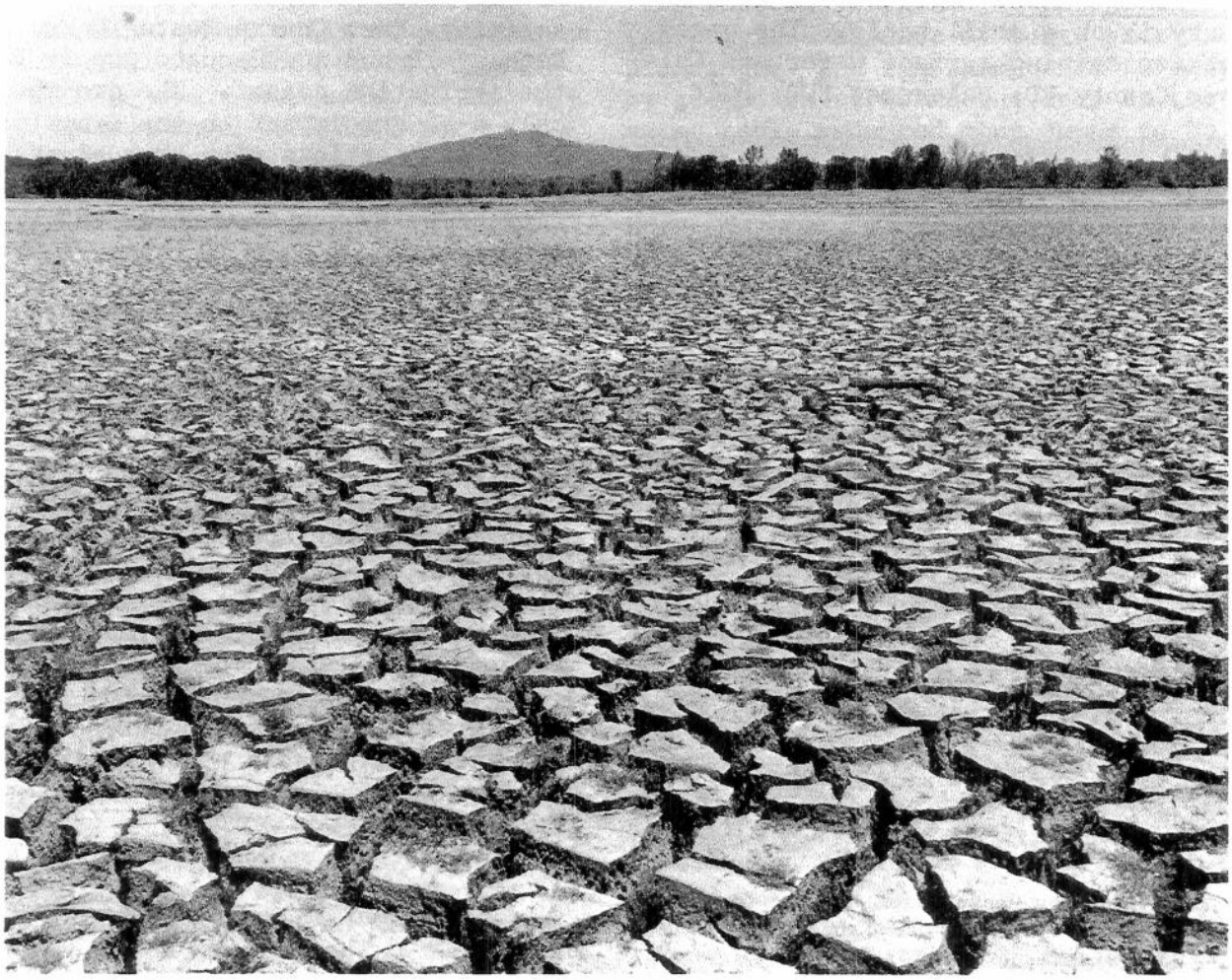
general rise in the water table over the past five years.

Further south, the Willits area experienced a large deficit in both surface and ground water supplies. Little or no irrigation water was applied.

Redwood Valley, located in the upper reaches of the Russian River, had some loss from lack of water and cold spring weather. A 10 percent crop loss in grapes can be attributed to the drought. Pear orchards also had some loss because of insufficient deep soil moisture.

Potter Valley farmers, east of Redwood Valley, have entitlement to a full supply from Lake Pillsbury which they used. The creek passing through the Valley to Lake Mendocino had some flow of water throughout the year. Drainage water produced from irrigated pasture and other irrigated crops added to the small stream flow.

El Dorado County. Irrigated agriculture in El Dorado County is concentrated in the western one-half of the County with the major crops grown being deciduous orchard, pasture, and a few vines and Christmas trees. Irrigation water is supplied primarily by the El Dorado Irrigation District (EID) and the Georgetown Divide Public Utility District (GDPUD). Two wholesalers in this area which furnish water to EID are Pacific Gas and Electric Company (PG&E) and the United States Bureau of Reclamation (USBR). The USBR operates Jenkinson Lake (Cosumnes River Basin) to furnish all of its yield to EID. Some water comes from



13. One picture tells it all. Bass Lake in El Dorado County held only a small puddle when this photo was taken on March 2, 1977.

wells and on-farm reservoirs.

During 1977, the irrigation water supplied by the two districts was curtailed by 30 percent. Despite this curtailment, growers were able to produce an average tonnage, but with slightly smaller fruit size.

The American River watershed above Folsom Lake has a normal unimpaired runoff of 3 174 cubic hectometres (2,573,000 acre-feet). In 1977, runoff was only 14 percent of normal, whereas 1924's was 21 percent.

The EID, whose normal demands are 36 cubic hectometres (29,000 acre-feet) could deliver only 15 cubic hectometres (12,200 acre-feet) in 1977 and rationing was imposed. Other steps taken in 1977 included reductions in irrigated acreage served, a moratorium on annexations, and the institution of "lifeline" rates. Irrigated areas served were reduced from 2 400 hectares (6,000 acres) to 1 700 hectares (4,200 acres) by providing agricultural supplies only to commercial agricultural customers. 1977 was the second consecutive year of scarcity for the District. Faced with low supplies in 1976, the District initiated conservation activities and engaged in the Irrigation Management Service program, described elsewhere in this report. It is estimated the total 1976 conservation program conserved 5 cubic hectometres (4,350 acre-feet). Thus, the 1976 savings provided a large fraction of the 1977 supplies.

The GDPUD normally uses 10 cubic hectometres (8,000 acre-feet) per year. In 1977 a normal supply was available.

Rangeland fared better in El Dorado County than other adjacent foothill counties because the higher elevation of the County's rangeland provides for slower grass maturity and a longer grazing period.

Fresno County. The eastern 60 percent of Fresno County, two-thirds of whose growers normally use surface water, had few problems with the drought. Virtually every grower in this part of the County has wells to augment short surface supplies. Fresno Irrigation District's (FID) irrigation run in 1977 was the shortest ever, extending only from June 1 to August 1. Ground water levels in July for FID were down an average of just over 2.1 metres (7 feet) compared to the previous year. Wells in the Consolidated Irrigation District (CID) were also down an average of just over 2.1 metres (7 feet) when compared to the previous summer. For the second year in a row, CID did not deliver surface water. During the first nine months of the year 1,800 wells were drilled in the County.

The most serious problem in the County was experienced in the Westlands Water District where most of the wells had been put out of service with the arrival of CVP water. Part of the reduced federal water supply, cut 75 percent in 1977, was replaced with water made available from MWD and the USBR's water transfer program. Despite these actions, 28 100 hectares (69,500 acres) remained unplanted in the federal service area portion of Westlands. In 1977, a very high acreage of cotton was planted, mostly due to an expectation of a favorable price, but to some extent, due to its lower water requirement. Some Westlands acreage was diverted from sugar beets, which use more water, and from processing tomatoes. 1977 was the first year since the introduction of imported water in the late 1960s that land had to be left out of production because of lack of water.

Estimated pumping in Westlands for 1976 was less than 370 cubic hectometres (300,000 acre-feet) and for 1977, 503 cubic hectometres (408,000 acre-feet). The latter figure is still less than that developed annually from this source before surface supplies became available.

Current information indicates that the reduction in gross farm income in Westlands as a result of the drought was in excess of $100,000,000. In addition,

farmers spent an estimated $7,700,000 for new and rehabilitated wells, and more than $7,000,000 for tailwater return systems and sprinkler and drip irrigation systems. Employees were laid off because of the reduced acreage in the District.

In 1977, Fresno County had a gross farm income of over $1 billion for the third year in a row. Income was down, however, from the record 1976 level of $1,170,800,000.

Irrigation practices used in Westlands and in the rest of Fresno County to stretch water supplies included skip-rowing of cotton, simply applying less water (in some cases only a preirrigation of cotton), alternate row irrigation of deciduous fruits and vines, and the installation of return flow systems. Many farmers applied for federal financial assistance to convert open ditches to pipelines.

Imperial and Riverside Counties. Water is imported from the Colorado River by the Coachella Valley County Water District (CVCWD) and Imperial Irrigation District (IID) to serve the agricultural areas of the Coachella and Imperial Valleys. The All-American Canal, a 129-kilometre (80-mile) canal originating at Imperial Dam and extending westerly along the Mexican border, is the primary conveyance facility for importing Colorado River water to the Coachella and Imperial Valley areas. The Coachella Canal branches off the All-American Canal west of Yuma and extends northwesterly to the service area of CVCWD. East Highline, Central Main and Westside Main Canals branch off the All-American Canal and extend northerly to serve the Imperial Valley area.

Because storage in the Colorado River system was above normal during 1976 and 1977, there was no effect on water supplies to these areas because of the recent drought.

The CVCWD presently serves an area totalling about 26 710 hectares (66,000 acres) in eastern Riverside County, an area immediately northwest of the Salton Sea. In addition, undeveloped irrigable land within the District's boundaries totals about 90 650 hectares (224,000 acres). In 1977, the District diverted 681 cubic hectometres (551,970 acre-feet) from the Colorado River to meet its need.

In 1976, losses to nonirrigated lands in Riverside County were small because rain, while inadequate, came at the right time for small grains. The drought of 1977 resulted in substantial losses as the yield was reduced by half. Irrigated grains are mainly in the eastern part of the County. In the western end (Santa Ana Basin), there are nearly 10 100 hectares (25,000 acres) of dry-farmed grain, chiefly wheat.

The Imperial Valley, a predominantly agricultural area, is served by IID, which was formed in 1911. The District's service area covers 429 898 hectares (1,062,290 acres), of which 273 166 hectares (675,000 acres) are considered arable lands. In 1977, the District diverted 3 670 cubic hectometres (2,975,650 acre-feet) of water from the Colorado River to serve its area.

Inyo-Mono Counties. Due to reduced precipitation and deliveries of water from Owens River for irrigation, agricultural production in 1977 dropped to about 50 percent of normal. Some land previously irrigated was not irrigated in 1977, so production of alfalfa decreased. Grazing was poor and could not support the usual number of livestock. Estimated losses for 1976-77 are $2 million for Inyo and $2-1/2 million for Mono County.

Kern County. Cotton acreage in the County was greatly increased over 1976, but the effects of the drought were still to be seen in the form of reduced yields and quality because of less than optimum amounts of applied water and, in some cases, poor ground water quality.

Western Kern County, where the entire water supply must come from the SWP's California Aqueduct, was most severely affected by the drought. Some of the water service agencies in that area requested deferral of about $6,000,000 in 1977 payments to the SWP. This became unnecessary as federal funds became available to some of these districts. Berrenda Mesa Water District, located in this area, had its proposal to buy 72 cubic hectometres (58,000 acre-feet) of ground water from a farming organization in Yolo County turned down by the State Water Resources Control Board.

In the entire SWP service area, an estimated 22 700 hectares (56,000 acres) of row crops remained unplanted because much of the available surface water was allocated to save permanent crops and much of the area has no ground water supply. There was a reduction in double cropping throughout the County, greatly reducing the grain sorghum acreage. Some alfalfa fields were allowed to dry up.

Some Kern County wells had water level drops of 4.6 metres (15 feet) or more in 1977 instead of the normal 0.6- to 0.9-metre (2- to 3-foot) drop.

Gross farm income in the County was down by $70,000,000 from the 1976 level of $873,655,800. In addition, production costs increased due to increased water and power rates.

Kings County. Farmers in this County were able to make up deficiencies in the surface water supply by pumping. County districts also received some of the water given up by MWD and other Southern California State water contractors. This was very helpful in the westside and Tulare Lake areas which normally depend on federal and State water.

Field crop acreages were generally down. About 6 070 hectares (15,000 acres) of field crop land was left unplanted. There was an increase in barley acreage and a decrease in wheat acreage which reflects the lower water requirement for barley. Gross farm income in Kings County was reduced about 5 percent below the 1976 level of $403,002,100.

Lassen County. In the northern part of the State, the most severely impacted area was located in Lassen County and included the Madeline Plains, the Upper Honey Lake Basin, the Susan River Drainage area, and the Herlong area. It is estimated that out of the 20 600 hectares (50,800 acres) normally irrigated, 3 040 hectares (7,500 acres) received no irrigation during the 1977 growing season. Of the remaining acreage, perhaps only one-third received a full irrigation supply. This area did not get the benefit of the mid-May and early June 1977 thundershowers that aided the Pit River basin to the north. It is estimated that the majority of the lands irrigated by surface water in this area received 60 percent or less of the water required to meet a normal irrigation requirement. Ground water pumping increased from 17.0 cubic hectometres to 20.4 cubic hectometres (13,800 to 16,500 acre-feet). Like most of northeastern California, where irrigated mountain pasture is supplied by natural runoff, not all the land receives a full irrigation supply, even in wet years, with the timing of runoff, more than the amount of runoff, the critical factor. Cloud cover and thundershowers, low snowmelt rate, and the timing of rainfall can quickly turn a low rainfall year into a good grass year for the cattleman. Such was not the case in the area in 1977.

Los Angeles County. The drought was felt mainly in the Antelope Valley and losses were primarily in the form of cancelled plans for agricultural expansion. There were minor losses on foothill rangelands and in the Newhall area; some marginal land in alfalfa was abandoned as water levels went down and farmers hesitated to invest in deeper wells. However, the main cause of the loss was the unavailability of surplus SWP water which was to be used for ex-

panding potato and vegetable production in the western part of the Antelope Valley and for alfalfa on lands purchased by the City of Los Angeles (to be used later for the Palmdale Intercontinental Airport).

Madera County. About 60 percent of the County's growers receive CVP water through the Madera Canal from Millerton Lake. In 1977, deliveries from this source were only about a third of the 1976 figure and about 10 percent of the 395 cubic hectometres (320,000 acre-feet) delivered in 1975. Ground water pumping made up the difference.

Gross farm income in 1977 was $219,640,000 -- an increase of just over 10 percent compared to 1976. There were no drastic shifts in crop acreages that could be attributed to the drought, even though the effects were felt in Madera County as everywhere else.

Chowchilla Water District received an emergency drought loan of $4,000,000 which was allocated to individuals who will repay the district. The general disbursement of this money was as follows: $2,000,000 for 50 new wells, $1,000,000 to deepen existing wells, and $1,000,000 for tailwater return systems.

Marin County. Marin County had 200 hectares (500 acres) of irrigated pasture in the western portion of the County. The pasture was not irrigated during the drought year in order to reserve water for livestock. Additional livestock water was hauled by truck from North Marin WD for 23¢ per cubic metre (65¢ per 100 cubic feet).

Merced County. Nearly 40 percent of the County's irrigated acreage east of the San Joaquin River is in the Merced Irrigation District which in 1977 received just 50 percent of its normal surface supply. Much of the irrigated lands west of the river are within districts that receive replacement water from the Mendota Pool, operated by the USBR. These districts received 77 percent of their normal supply. Ground water pumping made up the difference in these two areas.

The San Luis Water District on the extreme westside received only 1 830 cubic metres per hectare (0.6 acre-foot per acre) from the federal San Luis Canal. About 90 percent of the District's service area has no ground water and significant reductions in crop acreage occurred.

Gross farm income in Merced County in 1977 was $506,770,000 -- an increase of $41,000,000 over 1976. This was accomplished as growers shifted to crops with lower water requirements. The acreages of high water using crops such as rice, alfalfa hay, sugar beets, silage, and pasture all decreased.

Many new wells were drilled in the County with a total of 500 permits for drilling received by the middle of July in 1977, as compared to 391 received during the same period in 1976.

Modoc County. Big Valley, partially located in Lassen County, receives its main water supply from the Pit River, Ash Creek, and several smaller tributaries. In 1977, runoff during the irrigation season was estimated to be 75 percent of normal, or 74.5 cubic hectometres (60,400 acre-feet). In addition, 6.4 cubic hectometres (5,200 acre-feet) were pumped from ground water. Irrigated land was reduced by 1 000 hectares (2,500 acres).

The North Fork Pit River area, whose normal applied water requirement for its 6 680 hectares (16,500 acres) is 60.8 cubic hectometres (49,300 acre-feet), sustained a 1977 surface supply deficit of 10.5 cubic hectometres (8,500 acre-feet).

In the South Fork Pit River area and Warm Springs Valley, irrigated acreage remained about the same at 15 100 hectares (37,400 acres). However, a 5 percent decrease in surface water supply

resulted in a 6.9-cubic-hectometre (5,600 acre-foot) deficit in the normal applied water requirement.

Surprise Valley, in the far northeast area of the State, was more severely impacted. During a normal year, approximately 130 cubic hectometres (105,000 acre-feet) is used to meet irrigation demands. Surface water ordinarily supplies 96 cubic hectometres (78,000 acre-feet) with ground water supplying the remainder. In 1977, with surface supplies down by 35 percent, ground water use was nearly doubled, to an estimated 63 cubic hectometres (51,000 acre-feet). Records show 70 new wells in the area during the last four years. Net deficit in applied water in the valley is estimated at 27 cubic hectometres (22,000 acre-feet), resulting in an irrigated acreage decrease of 1 200 hectares (3,000 acres).

Monterey County. Monterey County's two reservoirs on tributaries of the Salinas River were full at the beginning of 1976, and, including runoff for early 1977, there was enough water to meet the 1977 agricultural water needs for the Salinas Valley.

Unlike most areas of the State where water stored in surface reservoirs is used, there is no distribution system; instead, water is released from the reservoirs into the Salinas River. Most of the water percolates into the ground and replenishes the ground water basin so growers can pump from their wells. On the average, ground water levels in the Salinas Valley fell 1.3 metre (4.2 feet) in 1977.

Monterey County farmers may have lost up to $10,000,000 on their dry farm barley crop because of the drought.

Napa County. Ground water replaced Napa River water usually used for frost protection. In some instances, domestic wells were hooked to drip irrigation systems to save small acreages of young vines. In general, the vineyards in Napa County were helped tremendously by the late May 1977 rain.

One group of farmers on Suisun Creek appealed to the Solano ID and DWR for a supplemental water supply. A portable pipeline intertie with the Solano ID was made possible with help from DWR.

Secondary treated sewage effluent was trucked to approximately 40 hectares (100 acres) of young vineyard. A further expansion of the use of treated sewage water on vineyard and pasture in the southern portion of the County was proposed.

Nevada County. The upper Yuba River watershed, lying east of the Yuba River and Bear River service areas discussed under Yuba County, has a normal unimpaired runoff at Smartville of 2 805 cubic hectometres (2,274,000 acre-feet). The Yuba's 1977 runoff was only 15 percent of normal, much drier than 1924's 26.5 percent. The Bear River watershed has a normal unimpaired runoff of 414 cubic hectometres (335,800 acre-feet) into Camp Far West Reservoir. The Bear's 1977 runoff was only 15 percent, less than in 1924 when there was 20 percent of normal inflow.

There are two main water purveyors in this area of the County -- Nevada Irrigation District (NID) and the Pacific Gas and Electric Co. (PG&E),

The NID, whose normal demands are 173 cubic hectometres (140,000 acre-feet), distributes water for urban and agricultural use in the southwestern part of Nevada County and the northern portion of Placer County. Sources of supply are NID and PG&E reservoirs in the Yuba and Bear Rivers systems.

The southwestern portion of the County is served by the Nevada ID (which also serves the northern portion of Placer County). Approximately 3 200 hectares (8,000 acres) of pasture and some orchard land are served from the Yuba and Bear Rivers. In 1977, irrigated pasture took a 50 percent reduction in water

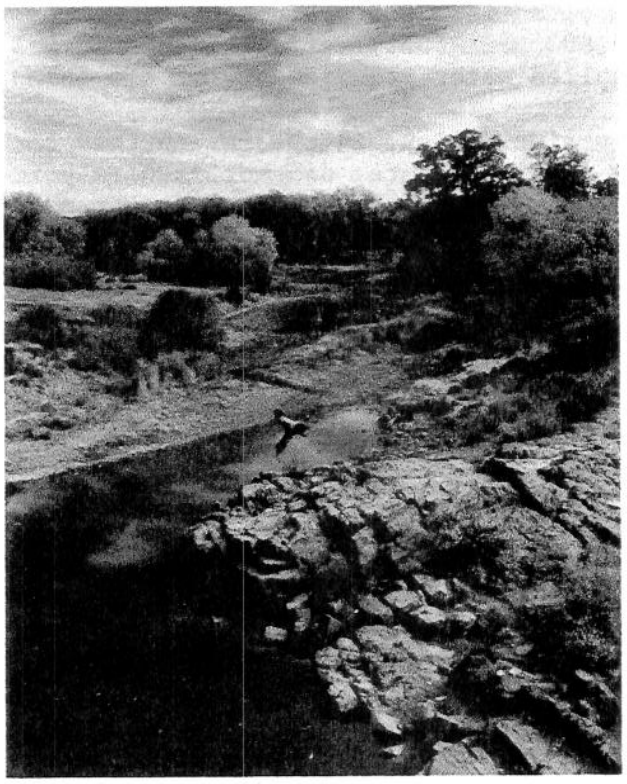
supply while orchards were cut by approximately 25 percent.

To meet the 1977 deficit, NID participated in an exchange with Placer County Water Agency (PCWA), PG&E, and the USBR, which brought water from the North Fork American River to the Gold Hill area. The District also rationed water and limited outside use. It used only 93 cubic hectometres (75,000 acre-feet), a 46 percent reduction.

PG&E's normal demands are 173 cubic hectometres (140,000 acre-feet), with 123 cubic hectometres (100,000 acre-feet) ultimately being furnished to PCWA, 25 cubic hectometres (20,000 acre-feet) to NID, and the remaining 25 cubic hectometres (20,000 acre-feet) for retail to Colfax and other communities in Placer County. Total use for 1977 was limited to 93 cubic hectometres (75,000 acre-feet). Savings in 1977 were about 50 percent as a result of rationing.

Orange and San Diego Counties. These counties suffered least from the drought. Grazing was, of course, poorer, but this is of relatively little importance. Water was used a little more carefully and drip irrigation gained in popularity.

Placer County. The Placer County Water Agency (PCWA), which normally receives water for the northern half of its service area from PG&E, currently has demands of 99 cubic hectometres (80,000 acre-feet). In 1977, water use was reduced by about 50 percent by rationing. The PCWA reinstalled its pumps in the American River Canyon and pumped about 6 cubic hectometres (5,000 acre-feet) of its stored water released from French Meadows and Hell Hole Reservoirs on the American, reservoirs ordinarily used by PCWA only for power generation. Part of this was exchanged with NID to avoid lifting water more than 122 metres (400 feet). If 1978 had continued dry, PCWA would have released its stored water from French Meadows and Hell Hole, lifting American River water into the PCWA tunnel and substituting it for NID water as in 1977.



14. No water for downstream. A view of the Cosumnes River in November 1977. This river was among the first to stop flowing in early 1977.

Old wells in the County's South Sutter Water District were cleaned and repaired, and others were drilled to meet irrigation needs (for additional details refer to Sutter County).

The Nevada ID supplies water to approximately 400 hectares (1,000 acres) of deciduous orchards in the County, where, in 1977, supply was reduced 30 percent.

PCWA's deliveries of irrigation water to approximately 400 hectares (1,000 acres) of deciduous orchard and to a small acreage of pasture was reduced 25 percent in 1977.

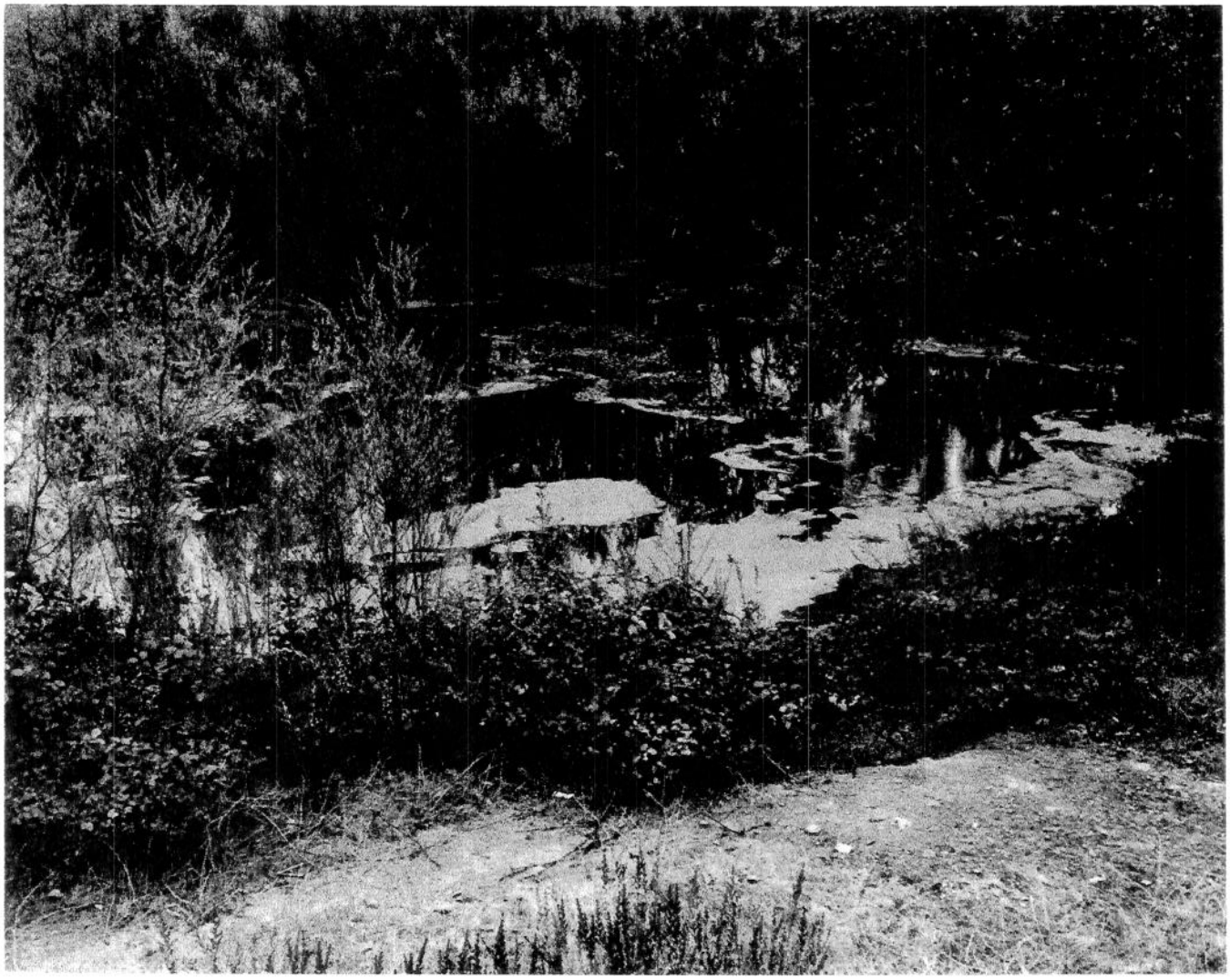
The grain, rice, and pasture grown in the Sacramento Valley portion of the County relied on ground water in 1977.

Sacramento County. Water supplies for this area, primarily in Sacramento Coun-

ty, consist of locally pumped ground water and local surface water diversions from the Sacramento, American, and Cosumnes Rivers. Normal water use accounts for more than 990 cubic hectometres (800,000 acre-feet) annually, with 54 percent derived from surface water and the remaining 46 percent from ground water sources.

The 1977 crop production in the County was reduced with most of the reduction occurring in field crop categories such as corn, grain, sorghum, rice, and wheat. Pasture also experienced a reduction. Other crops either retained the same acreage or showed an increase. The overall harvested acreage for 1977, according to figures reported in the Sacramento County Agricultural Crop and Livestock report of 1977, shows a reduction of 5 870 hectares (14,500 acres) compared to that of 1976. Crop yields for 1977, on the other hand, more often than not exceeded that of 1976.

One area in the County for which the crop losses can be related to the drought is the lower end of Sherman Island where irrigation water was affected by salt water intrusion from the bay. Although preirrigation practiced in the Delta, together with the installation of an added facility to divert



15. The Mokelumne River in November 1977. This river is the water source for EBMUD, numerous Sierra foothill communities in Amador and Calaveras Counties, and agricultural users in San Joaquin County.

water from Threemile Slough, helped to minimize crop losses, Sacramento River water, the usual irrigation source, deteriorated with the progression of the irrigation season. Some corn and milo fields located at the lower end of the island are reported to have received only preirrigation water, but managed to produce almost a normal yield. However, many of the small grain fields observed in the same area at the end of June 1977 showed signs of crop failure or, at best, an extremely poor yield.

San Bernardino County. Some losses because of drought were observed in dry farming and grazing, but they were minor.

San Joaquin County. The East Bay Municipal Utility District's Lake Camanche on the Mokelumne River provides surface water supplies to riparian landowners and to the Woodbridge Irrigation District in San Joaquin County. The Mokelumne River diversions supplement individual wells in Woodbridge's Service Area. Woodbridge has prior rights to 74 cubic hectometres (60,000 acre-feet) annually and purchases interim supplies to provide normal diversions of about 140 cubic hectometres (116,000 acre-feet) annually. Major crops in Woodbridge's Service Area are vineyards, corn, alfalfa, and fruits and nuts. Rice is usually grown, but not in 1976 because its Mokelumne River supplies were reduced to 74 cubic hectometres (60,000 acre-feet).

Storage in Lake Camanche was about 150 cubic hectometres (119,000 acre-feet) on June 1, 1977, and was down to about 67 cubic hectometres (54,000 acre-feet) by October 1, 1977. Again in 1977, planting of rice was curtailed and ground water pumping had to be increased to compensate for reduced surface water deliveries.

Most of the irrigation supplies for the agricultural lands to the east of Stockton are obtained from ground water. The Stockton area is notable for its ground water overdraft condition and salt water intrusion from the west. The ground water supplies are supplemented by surface water furnished by the Stockton-East Water District from the U. S. Corps of Engineers' New Hogan Reservoir on the Calaveras River. Calaveras County also has entitlements to the New Hogan supplies and the USBR has overall responsibility for the use of the reservoir's water supplies. Stockton-East normally diverts about 83 cubic hectometres (67,000 acre-feet) annually from the Calaveras River, Mormon Slough, and Mosher Creek. The crops grown in the agricultural areas are orchards, vineyards, and a variety of field crops.

Stockton-East Water District recently completed a project to provide treated water to the Stockton area from its New Hogan supply and thereby help preserve the ground water basin. The treatment plant became operational on June 1, 1977.

Storage in New Hogan Reservoir was only 510 cubic hectometres (41,600 acre-feet) about June 20, 1977, and fell below minimum pool level of 18 cubic hectometres (15,000 acre-feet) by late summer. The limited New Hogan supplies were used for irrigation and for delivery to the new treatment plant. Because of the reduced surface water supplies, ground water use was accelerated.

Stockton-East appealed to the USBR for use of the minimum pool water to the 4-cubic-hectometre (3,000-acre-foot) level. Calaveras County interests protested this because of the detriments to recreation and concern over conditions in 1978. The USBR ruled against Stockton-East. Thus, no further surface water was available to the irrigation customers when minimum pool was reached. This also caused problems for Stockton-East with respect to operation of the treatment plant.

Overall, the drought year did not have an adverse impact on irrigated agriculture in San Joaquin County because the lack of surface water and deficient soil moisture were compensated for by in-

creased ground water pumpage, and by preirrigating during the winter months.

Local farm advisors encouraged all farmers using Delta water to preirrigate and leach lands with high salt concentration during the winter months. The preirrigation and leaching practice is required to remove salts that accumulate during the growing season and to provide adequate soil moisture for spring planting. Some Delta farmers also found it necessary to increase the irrigation requirement during the growing season to compensate for increased water salinity.

San Luis Obispo County. There were no appreciable reductions in acreages or yields in irrigated agriculture in the County during 1977. Dry farming and livestock production on ranches suffered about equal substantial losses. Numbers of cattle have dropped probably by 50 percent since 1975 with animals being sold before attaining normal weight. Others were not purchased to be fed or pastured in 1977. Extra feed had to be purchased to supplement grazing. This increased the cost of meat production; losses amounted to $3-4 million in the two-year period.

Yields of dry-farmed small grain dropped to less than 50 percent and on some farms to 30 percent of normal. Production losses for barley were about $1-1/2 million, and for wheat and hay $1 million each. Total losses due to drought are estimated at $7 million.

San Mateo County. The main irrigation supply is from runoff with a very small amount of ground water pumped. The short surface supply created heavy financial losses for flower and truck farmers. The grain crop was helped by the May rain, but range grasses were already stunted and the additional moisture was not of great help. The range supported 20 to 40 percent of the normal stocking capacity.

All tailwater was recycled. Water supplies from reservoirs on small watersheds were increased by installing diversions to capture runoff as much as possible.

Santa Barbara County. The main impact of the 1976-77 drought was on numbers of cattle grazing on Santa Barbara County ranches. The reduction amounted to about 15-20 percent in 1976 and by another 15 percent in 1977. The current numbers of livestock are about one-third below normal. There was a reduction of about 50 percent in dry-farmed acreages of beans and small grains, and the yield of cultivated dry crops was about one-third lower than normal. There was no reduction of yield or reduction of the area of irrigated crops. On the contrary, there was a small increase in acreage, as some farmers irrigated lands which in a wet year would be cultivated without irrigation. Some previously abandoned or not fully used sources of local water supplies were used. Total losses in income have been roughly estimated at around $10 million. Some 14 200 hectares (35,000 acres) were affected.

Santa Clara County. The County's irrigated agriculture is restricted to the Santa Clara Valley which is separated into north and south portions by a natural ground water and surface water divide occurring in the vicinity of Morgan Hill.

The North Santa Clara Valley is undergoing the third major land-use change in the past century. First the cattle industry grew rapidly, then crops began replacing cattle, and now cities are replacing crops. As of 1976, approximately 11 700 hectares (29,000 acres) remained in crop production, of which less than 30 percent was irrigated and the remainder was dry farmed. Over 50 percent of the dry-farmed land comprises deciduous orchards.

The north portion of the Valley is served by the Santa Clara Valley Water District (SCVWD) which obtains surface water supply through the SWP to supple-

ment the ground water supply through recharge of the ground water basin. Ground water pump tax is used as a means to recover ground water recharge cost. Agricultural water is expensive; therefore, sprinkler irrigation is commonly practiced in attaining efficient water use. As a result of efficient irrigation practices, together with the conjunctive use of surface and ground water supplies, the 1976-77 drought had a relatively minor effect on crop production and the amount of irrigation water applied.

The south portion of the valley presently does not receive imported surface water and locally developed surface and ground water sources are adequate in meeting irrigation needs as long as the farmers practice water conservation. Sprinkler irrigation systems have replaced furrow and basin check type methods.

Santa Cruz County. Ground water is the main agricultural supply. The overdraft in the 1977 dry year accelerated depletion of the ground water, increasing sea water intrusion. In general, all irrigated crop needs were met, but at the expense of overdrafted ground water supply sources.

Shasta County. Irrigated agriculture in the County is located in the upper reaches of the Sacramento Valley and in other smaller valleys. In the drainage area of Cow and Bear Creeks, the majority of the 4 730 hectares (11,700 acres) normally irrigated received at least one irrigation in the 1977 season, but the area still received only an estimated 60 percent of the water normally available. Under the lowered water supply, irrigation efficiencies are estimated to have increased to near 70 percent from the normal 50 percent range.

In the Shasta Lake and lower Pit River areas, there are about 5 750 hectares (14,200 acres) normally irrigated with an applied water requirement of 63 cubic hectometres (51,000 acre-feet). It is estimated the area sustained a 25 percent deficit in 1977 water supply, but late spring rains greatly reduced drought impacts.

In the Hat Creek area, the 1976-77 drought had little effect on irrigated acreage, since Hat Creek, the local source, emanates from deep volcanics little affected by drought. Burney Creek, on the other hand, experienced a deficit up to 50 percent of normal supply. As much as 30 percent of the land normally irrigated received no water in 1977.

The drought presented only minor problems in Fall River Valley, where irrigated acreage normally receives a total water supply of 113 cubic hectometres (91,500 acre-feet) of which all but 4.3 cubic hectometres (3,500 acre-feet) is from surface sources. Fall River Valley is similar to the Hat Creek area in that surface supplies are derived from a large volcanic forebay area. The valley is thought to have had only a 10 percent reduction in 1977 surface supply.

Siskiyou County. Irrigated acreage in the County occurs primarily in several small valleys, not all of which depend upon surface runoff. In Butte Valley, for example, ground water supplies most of the irrigated acreage. Ground water resources have shown a decline over the past few years, and in 1977 Butte Valley received about 5.0 cubic hectometres (4,000 acre-feet) less than a full supply.

Scott and Shasta Valleys were judged to have received about 80 percent of a full water supply during 1977. Ground water pumpage made up for some of the losses in surface supply. Net deficits in total supply were estimated at 32.6 cubic hectometres (26,400 acre-feet) in Shasta Valley and 16.7 cubic hectometres (13,500 acre-feet) in Scott Valley.

In the Lost River Valley (partly in Modoc County), as a result of large

diversions from the Klamath and Lost Rivers, 1977 surface applied water supplies were only 5 percent less than normal. Total deficits amounted to only 6.0 cubic hectometres (13,000 acre-feet).

Solano County. The Solano Irrigation District (SID) distributes the largest supply of irrigation water in the County, derived from Lake Berryessa. SID, although enjoying ample supplies, conducted a conservation program aimed at reducing use. Due to lack of precipitation, the irrigation requirement during 1977 was higher than normal, but the overall irrigation needs were met with a small reduction in use.

During 1976 and 1977, the District made a special effort to correct any inefficiencies in its distribution system. Individual farmers gave more time to irrigation water control. Tailwater return systems were employed to recirculate the water, and increased use of sprinklers gave additional water savings. The District increased ground water pumpage by 18 cubic hectometres (15,000 acre-feet). New wells were constructed and old or abandoned wells were revamped. In total, the supply was adequate to give two good crop years.

According to the 1977 Agricultural Crop Report of Solano County, the gross value for agricultural crops exceeded $100 million, or an increase of $11 million over 1976. Tomatoes, fruit, and nut crops showed an increase, whereas field crops, including small grain and hay crops, showed a decrease.

Overall, the drought had only a minor impact on irrigated agricultural crop production. Dry land growers and livestock producers, on the other hand, incurred a substantial loss.

Sonoma County. Reduction in crop yields from lack of irrigation water apparently was not a problem for 1977. Water ordinarily used for vineyard frost control was made unnecessary by the relatively frost-free spring weather. On the negative side, applied nitrogen fertilizer tended to promote vine growth and reduced flower set because the desired level of nitrogen, usually reached as a result of leaching, was higher than normal.

Stanislaus County. Turlock Irrigation District, one of the largest of the County's 19 districts, was expected to be especially hard hit as its 1977 reservoir storage in Don Pedro Reservoir was extremely low. It was allowed to draw water from below minimum pool, however, and ground water supplied the remainder of that needed.

Despite the drought, an increase in gross farm income from $424,885,000 in 1976 to $500,042,000 in 1977 was experienced in the County. Farmers were able to supplement the short surface water supplies by ground water pumping. Many new wells were drilled and old wells reactivated.

Much of the increase in gross farm income was due to new almond trees coming into production with the biggest impact of the drought being felt by beef producers because of the poor range conditions.

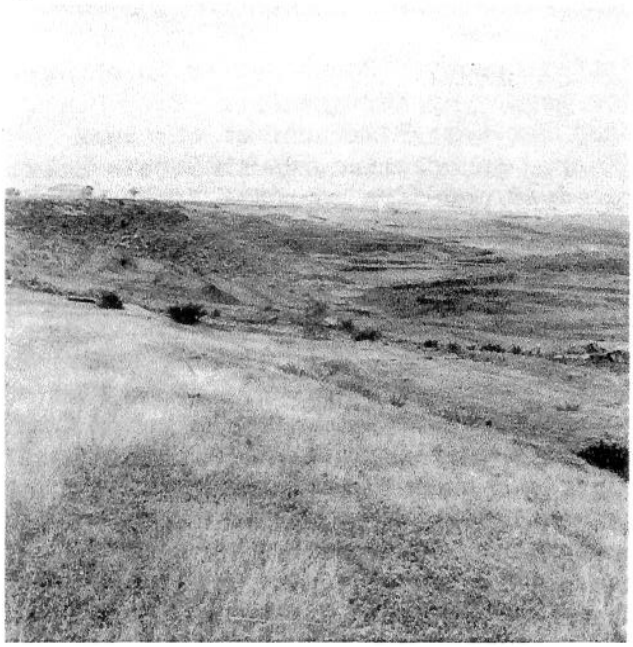
Sutter County. South Sutter WD obtains its source of surface water from the Camp Far West Reservoir on the Bear River. On occasion, South Sutter has received non-firm supplies from the Nevada Irrigation District. The District encompasses about 22 300 hectares (55,000 acres), of which 16 000 hectares (40,000 acres) are normally supplied with surface water and the remainder are supplied with ground water only. Its operation is based on the concept of conjunctive use of ground and surface water supplies; therefore, deep wells are maintained in the event surface supply is curtailed. During the 1977 year, water was not available from the reservoir. Therefore, farmers served by the District reverted to pumping from the ground water source.

The lack of surface supply entailed changes in crop pattern and on-farm irrigation efficiency. In 1977, rice acreage went down and about 4 000 hectares (10,000 acres) were left idle. Irrigation water was watched more closely to avoid excess drainage outflow.

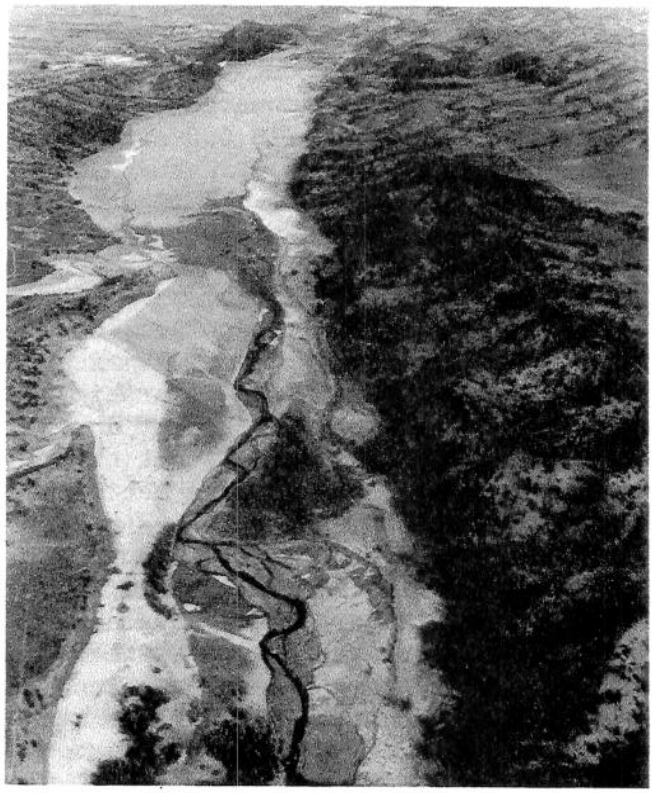
The Sutter Extension WD and the portion of Butte WD in Sutter County have rights to Feather River water, normally resulting in use of 284 cubic hectometres (230,000 acre-feet) to serve 12 000 hectares (30,000 acres), mainly rice. In 1977, 167 cubic hectometres (135,000 acre-feet) were taken to irrigate 7 890 hectares (19,500 acres).

For the 1977 drought year, the other water agencies in the County (Oswald WD, Tudor Mutual Water Company, Inc., Garden Highway Mutual Water Company, and the Feather River District) were required to take a 50 percent deficiency from the SWP. The deficiency was compensated for by increasing ground water pumpage, reducing rice acreage, and employing better water management techniques.

Tehama County. One of the hardest hit agricultural areas in the State was the



16. Camp Far West Reservoir in Yuba County, which normally supplies water to the South Sutter WD, saw its supplies dwindle to the small pool shown.



17. Stony Creek and Stony Gorge Reservoir in Glenn County, one of the major sources of water for the Orland Water Users Association, as it appeared on March 2, 1977.

Orland Unit Water Users Association (OUWUA) which obtains most of its irrigation supply from Stony Gorge and East Park Reservoirs on Stony Creek. Capacity of these two reservoirs is 124 cubic hectometres (101,000 acre-feet). Normal annual water demand for OUWUA is 149 cubic hectometres (121,000 acre-feet). However, in 1977 OUWUA was only able to deliver 22.0 cubic hectometres (17,800 acre-feet) from this source.

In order to save "permanent" crops, the Association purchased 17.9 cubic hectometres (14,530 acre-feet) from the U. S. Bureau of Reclamation, 10.5 cubic hectometres (8,500 acre-feet) of which came from Black Butte Reservoir, and 7.4 cubic hectometres (6,030 acre-feet) from the Tehama-Colusa Canal. Landowners drilled 40 new wells in 1977 to augment their deficient surface supplies. Some orchardists purposely let their older orchards go dry. Because of these efforts, OUWUA was able to irrigate 4 185

hectares (10,341 acres) of their total 7 892 hectares (19,723 acres).

Tulare County. With the CVP's Friant-Kern Canal deliveries decreased to 25 percent of Class I entitlements, serious problems were expected in the County, particularly in the citrus growing area east of the valley floor. The USBR, through water transfer programs, and the farmers themselves, by drilling wells and purchasing water from other farmers who could pump into the Friant-Kern Canal, developed a sufficient water supply to allow for nearly normal production.

The rush to drill irrigation wells was most prevalent in the citrus area and water levels there dropped drastically. For example, in Exeter Irrigation District, the water level dropped from 14.6 metres (48 feet) in February 1976 to 22.3 metres (73 feet) in October 1977. In 1950, another drought year, it had declined to 33.2 metres (109 feet) before rebounding with the advent of Friant-Kern Canal deliveries.

18. Little help for the valley farmer. This photograph, taken below Stony Gorge Reservoir, shows Stony Creek on August 31, 1977. Storage upstream in both Stony Gorge and East Park Reservoirs, serving the Orland Water Users Association, was depleted early in 1977.

Tulare County experienced a very slight decrease in gross farm income -- from $743,327,000 in 1976 to $734,755,000 in 1977. There were some drastic shifts in crop acreages, however. Cotton acreage was up, as it was everywhere. The acreage of alfalfa hay, field corn, grain sorghum, barley, wheat, and sugar beets all showed marked decreases. The aggregate decrease was much larger than the increase in cotton, reflecting a substantial decrease in double cropping.

Ventura County. County agriculture depends primarily on local wells for water supply. Cost of pumping was a little higher as the water level went down due to drought, grazing on the hills was poorer, and some supplemental feed had to be purchased in greater than normal quantities. Salt may have accumulated due to lack of leaching by rain. Some grain was not planted in 1977 but, on the whole, income losses due to drought were rather minor. Farm income in the County was down chiefly due to lower prices of lemons and oranges.

Yolo County. The Yolo County Flood Control and Water Conservation District (YCFC&WCD) serves water to approximately 42 500 hectares (105,000 acres) of irrigable land in western Yolo County. Smaller water districts, reclamation districts, and private wells serve the remainder of the County. The source of supply for YCFC&WCD is Clear Lake, Indian Valley Reservoir, and ground water. In 1977, the reservoir system yielded no water and ground water became the only available supply. The smaller water districts and reclamation districts obtained water from the Sacramento River and wells.

Within the YCFC&WCD, water was shared by neighbors on approximately 1 600 hectares (4,000 acres); new wells were con-

structed to serve another 1 600 hectares (4,000 acres); and 1 600 hectares (4,000 acres) were planted but not harvested because of lack of water. Rice acreage was reduced by 75 percent and fallow land increased by an estimated 6 000 hectares (15,000 acres). The cost of a well in Yolo County to serve 32 hectares (80 acres) in 1977 approximated $37,500, an increase of approximately 30 percent from the previous year.

Crop yields were good on those lands with adequate irrigation water. The ground water supply was adequate as a source for supplemental water. Rangeland and dry farming operations, on the other hand, performed poorly.

Yuba County. Valley floor lands in Yuba County depend mainly upon water diverted from the Yuba River. The diversions are entirely for agricultural use. Major purveyors on the valley floor are the Cordua Irrigation District and the Hallwood Irrigation Company, which together normally divert about 190 cubic hectometres (155,000 acre-feet) annually. Brown's Valley Irrigation District also obtains partial supplies from the Yuba River. The diversions are under both prior rights and contracts with the Yuba County Water Agency, operator of New Bullards Bar Reservoir. Rice is the predominent crop. There is no ground water pumping in these service areas.

In 1977, Cordua ID, Hallwood Irrigation Company, and Browns Valley ID had a 37 percent reduction of water supply from the Yuba River source. Browns Valley ID's second source, Merle Collins Reservoir, was also in short supply. The BVID, serving 4 450 irrigated hectares (11,000 acres), has a normal demand of 59 cubic hectometres (48,000 acre-feet), about 65 percent of which comes from storage in Collins Reservoir. In 1977, it was only able to furnish a total of 33 cubic hectometres (27,000 acre-feet). Customers served by the District out of Collins Reservoir were cut back 67 percent. Irrigated acreage for pasture and rice was decreased.

19. No contribution from Clear Lake. Shown is the Clear Lake outlet channel at the head of Cache Creek near Clearlake Highlands on September 2, 1977. Since Clear Lake releases were halted, Yolo County farmers were forced to rely on ground water. Recreational uses downstream were severely curtailed, also.

Other valley floor lands in the County are irrigated from Camp Far West Reservoir on the Bear River. The Camp Far West Irrigation District has rights to the first 16 cubic hectometres (13,000 acre-feet) from storage, while the South Sutter Water District in Sutter County uses the remainder, normally about 140 cubic hectometres (110,000 acre-feet) annually. The major crops are rice, pasture, orchards, and corn. Ground water is also a major source which has been supplemented and replaced by the Camp Far West supplies.

Storage in Camp Far West Reservoir was only 15 cubic hectometres (12,200 acre-feet) on June 1. The Camp Far West District, therefore, used all the available reservoir supplies, leaving none for the South Sutter Water District.

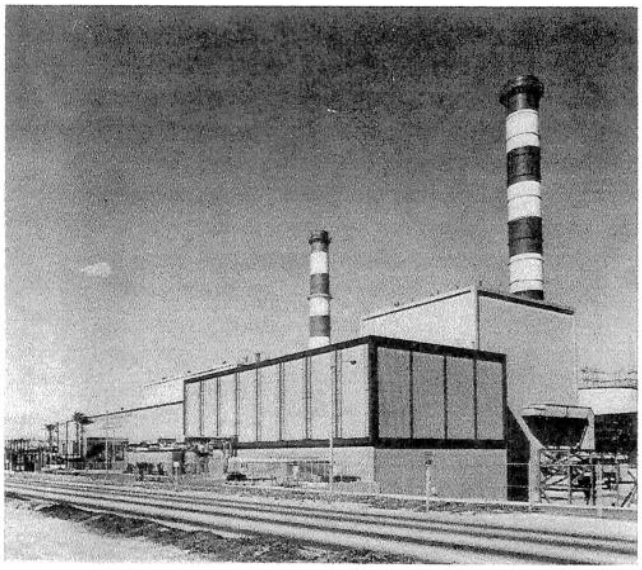
The water shortage was compensated for by reducing rice acreage, increasing ground water pumpage, and changing irrigation techniques to reduce drainage water outflow with the result that all crops received an adequate water supply. Grain and tomato crops generally replaced the reduced rice acreage.

Energy

With two successive dry years, California's utilities have had to make some major operational changes to ensure adequate supplies of energy.

The Pacific Gas and Electric Company (PG&E) service area, comprising most of Northern and Central California, has been seriously affected by the drought. Normally, PG&E relies on hydroelectric power for one-third to one-half of its total electric requirements.

During a normal rainfall season, California's hydroelectric output is about 32.6 billion kilowatthours (kWh), or 20 percent of the State's total electrical energy supply. During the first year of the drought in 1976, hydroelectric production was reduced to about 15.9 billion kWh. The 1976 hydrolectric energy deficit was made up by importing 12.5 billion kWh from the Pacific Northwest, and the remainder was generated by burning high-cost oil and by drawing down water levels behind hydroelectric generating dams to below normal storage levels.



20. Replacement energy. The Scattergood Powerplant, owned and operated by the Los Angeles Department of Water and Power but idled for lack of clean burning fossil fuel, was put into service to meet the critical energy demand in the summer of 1977. (LADWP photo.)

In 1977, with continuing drought conditions, hydroelectric generation totaled only about 12.6 billion kWh. This represents 7 percent of California's energy production for the year. The 20 billion kWh deficit was made up largely through fossil fuel steam generation, requiring 33 million barrels of oil at a cost of $500 million.

The electrical utilities approached the summer of 1977 with projections that Northern California's electrical energy demand would be approximately 75 billion kWh, an increase of 3.2 percent over 1976, and an area peak demand of 14,650 megawatts (MW), an increase of 4.4 percent over the summer of 1976. Unfortunately, PG&E was unable to rely on imports from the Pacific Northwest as that area was suffering similar effects of the drought. As a result, Northern California could only import about 4 billion kWh from the Pacific Northwest during 1977. In addition, reservoir levels, already reduced to below normal levels in 1976, were insufficient to allow the utilities to use the option of additional reservoir drawdown to produce more energy during 1977.

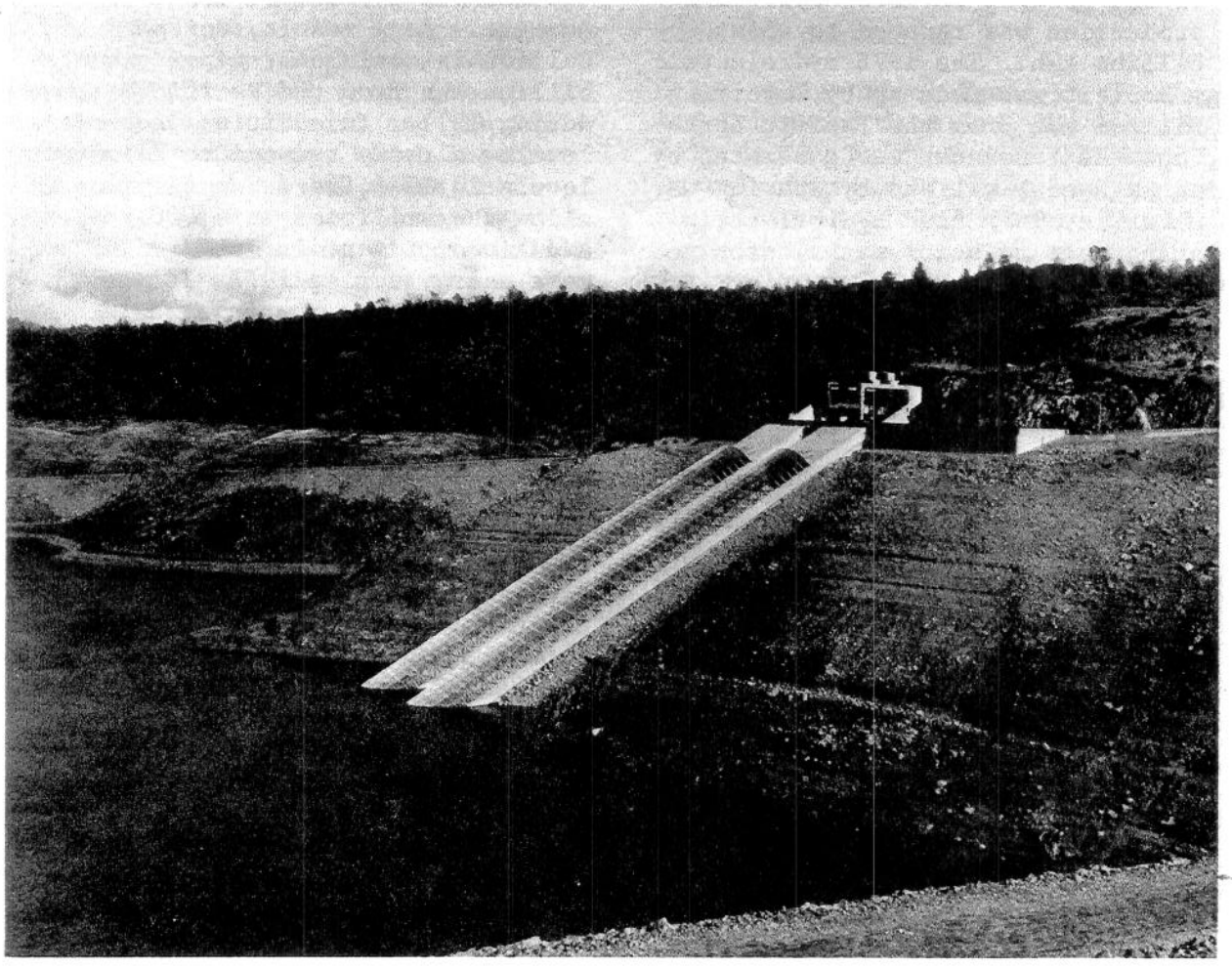
However, Southern California's capability to supply electrical energy is considerably better than that of the remainder of the State. While Northern California suffered a 2 percent energy deficit, Southern California utilities averaged a 24 percent margin over their expected demand. About 2.5 billion kWh were purchased and transmitted from the Southern California area to PG&E via the intertie lines. PG&E also was able to purchase 1.5 billion kWh from utilities in Arizona and Nevada. The increased 1977 production costs to PG&E as a result of the drought amounted to approximately $326,000,000. This followed 1976 with its added costs of $144,000,000.

In addition to the shortage of hydroelectric energy, the decrease in surface water available for irrigation precipitated an increase in the amount of agricultural pumping. By mid-summer, 1977,

PG&E had already made more than 4,700 new agricultural connections (an increase of 67 percent over 1976). In 1977, an additional (in excess of normal) 4 200 cubic hectometres (3.4 million acre-feet) was withdrawn from ground water basins. The increased pumping used about 1 billion kWh of energy at a cost of $25,000,000. Increased costs continue in 1978 because of the additional energy required to lift water from lower levels and the higher costs of energy.

The Los Angeles Department of Water and Power's (LADWP) Scattergood III powerplant is designed to operate using natural gas as its fuel. Because of the diminishing availability of natural gas, particularly for low priority electrical generation purposes, this 300 MW had been idled.

But on July 12, 1977, the Public Utilities Commission (PUC) ordered PG&E to effect a transfer of natural gas supplies to Southern California to allow LADWP to generate additional energy to replace the lost hydro-generation with as clean a fuel as possible, thereby minimizing the amount of air quality degradation resulting from burning fossil fuels. This measure would have allowed LADWP to bring Scattergood III into service during the critical summer months. However, gas supplies were obtained from Southern California Gas Company, and the PG&E transfer was not required.



21. A weakened giant. The intake structures to the Hyatt Powerplant at Oroville Dam as they appeared in mid-February 1977. The photo illustrates the decreased volume of water and lowered energy head available for hydroelectric generation in 1977.

Other utilities throughout California faced energy shortages as water for hydroelectric power became scarce. In the Turlock Irrigation District (TID), which supplies both water and power, farmers relied on ground water when surface supplies became scarce. TID sold more than 120 million kWh to agricultural customers in 1977, an increase of 55 percent over 1976. The district normally supplies two-thirds of its power from the hydroelectric generating facilities at Don Pedro Dam, but because of the low reservoir levels, TID was able to generate only 7 percent of its power needs in 1977 with 3 percent coming from Hetch Hetchy and the remainder from PG&E.

The Sacramento Municipal Utility District (SMUD) had no serious problems, although total energy production was reduced by more than one-third because of a loss of hydroelectric power from SMUD's upper American River projects. Hydroelectric production in 1977 amounted to only 186 million kWh compared to the normal of 1,900 million kWh. Fortunately, SMUD's Rancho Seco nuclear plant was able to operate at near capacity most of the year.

The reduced amount of water delivered by both the State Water Project and the Central Valley Project during 1977 had a large effect on the amount of energy required by SWP and CVP pumping plants.

It had been estimated that 5,685 million kWh of electrical energy would be required by SWP pumping plants during 1977. SWP recovery generating plants were expected to supply 1,257 million kWh and 4,428 million kWh were to be purchased. Because of the reduced deliveries to Southern California, actual pumping, recovery, and purchased energy quantities in 1977 were only 1,240 million kWh, 227 million kWh and 1,013 million kWh, respectively. An additional 884 million kWh, however, was required to pump 489 cubic hectometres (400,000 acre-feet) from the Colorado River through the MWD's Colorado River Aqueduct.

The CVP also cut its power requirements in half. Project pumping used 1,395 million kWh in 1976, but after cutting water deliveries, the CVP used only 708 million kWh.

The electrical utilities in cooperation with the Energy Commission formulated a plan to share surplus energy and capacity during critical periods. The plan was designed so that the State would be treated as a single service area for purposes of reliability. The utilities followed this suggestion and, by March 1977, a comprehensive plan to exchange and sell electricity had been developed by the utilities.

To ensure that the Commission was prepared to meet the possibility of an electrical shortage, a monitoring system was developed requiring utilities to report to the Energy Commission should their reserve margin reach 5 percent. This warning enabled the Commission to assess the problem on a statewide basis and, if necessary, assist in pooling reserve electrical supplies from another utility. After prompt notification, the Commission could request that the Governor inform the public about the potential energy shortage situation and to ask all citizens to do their share to conserve electricity, particularly during peak demand periods.

Fortunately, California had no serious summer outages; however, two California utilities did approach the 5 percent reserve margin.

The first occasion was on July 26 when San Diego Gas and Electric (SDG&E) reported a "worst case" margin of 6.5 percent when its 220 MW South Bay Unit #4 was taken out of service due to a breakdown. To alleviate any potential shortages, SDG&E contacted its 16 largest customers to warn them about the low reserve margins. In addition, SDG&E alerted the news media which informed the public that San Diego was having an "energy alert". The unexpected cooler

temperatures that day combined with SDG&E's media campaign were sufficient to reduce electrical demand, and, as a result, SDG&E was able to reduce its peak by over 3 percent.

The second occurrence was on September 6 when PG&E reported a 6.9 percent reserve margin with both the 870 MW Rancho Seco and the 720 MW Pittsburgh #7 power plants out of service. PG&E then notified its major interruptible customers that service could be curtailed the following day should the temperatures increase or should the generation reserve situation deteriorate further.

The following morning, PG&E predicted a 9.9 percent reserve margin for the day, expecting Pittsburgh #7 to be returned to service in time for the peak hours. However, Pittsburgh #7 went out of service again, lowering the projected reserve margin to only 5.8 percent. PG&E then issued releases to the news media requesting every customer to eliminate the use of unnecessary appliances during the peak period of 12 p.m. through 7 p.m. In addition, the Bureau of Reclamation and DWR responded by bringing online the San Luis pump storage facility and Oroville-Hyatt generators, and Southern California Edison (SCE) assisted PG&E by transferring 300 MW of extra capacity into the Northwest intertie line.

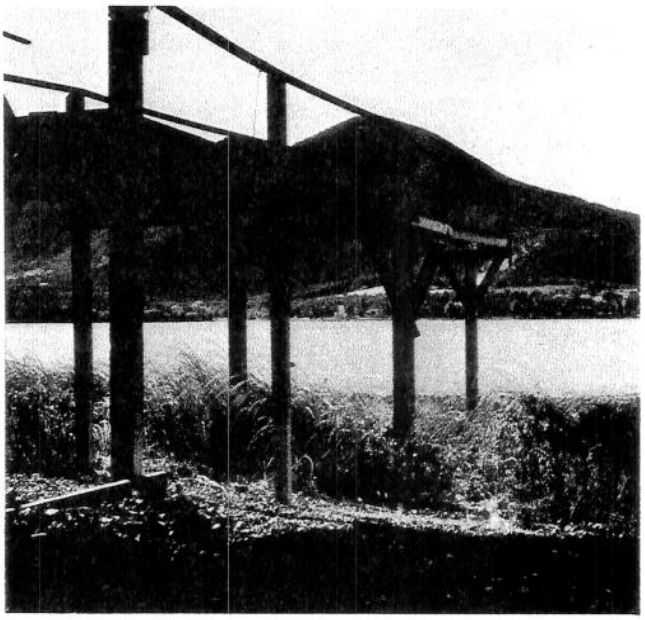
Fortunately, by September 8 Pittsburgh #7 had returned to service and produced approximately 360 MW during the peak period. With a reduction in peak usage of 237 MW, PG&E reported a reserve margin of 9.6 percent for September 8. Peak usage dropped 1,144 MW on September 9 due to a State holiday and the cool breezes that moved into the Central Valley.

Two additional incidents occurred during the summer when the interties experienced problems. On June 27, one of three major transmission lines linking PG&E with SCE failed. The problem was relatively minor and the transmission line was back in service by June 29.

Another outage occurred in early August as a result of drought-aggravated forest fires in Modoc County. The combination of smoke and heat caused the two 500 kilovolt Northwest Transmission Intertie lines to go down intermittently, five times in one week. Service returned to normal after the fire had been controlled.

Recreation

Like the 1975-76 winter sports season, the 1976-77 season was short and financially devastating for most of the State's winter resorts. The poor performance demonstrated by this segment of the recreation industry began in November 1975 and continued as few storm clouds deposited snow in the early season from November through January 1976. Some snow falling in February and early March provided a temporary respite, but the remainder of the 1975-1976 season was nearly dry. Most resorts reported abbreviated seasons with marked decreases in patronage. Exceptions to the poor skiing year in 1976 occurred in Southern California where at least one resort in the San Bernardino Mountains registered a record year.



22. A useless mooring. This boat pier on the northeast shore of Clear Lake is typical of the many boat launching facilities rendered unusable as a result of the drought.

The 1976-1977 season was even worse as nearly every location in Northern and Central California suffered from record scarcity of snow. Some Northern California ski resorts never opened and others opened only for short period of time.

The effect of the drought upon winter sports is best illustrated by resort attendance figures. The following table, compiled from data supplied by the Sierra Ski Association, representing 38 ski areas in Northern, Central, and Southern California, shows the number of skier-days recorded during the drought seasons of 1975-1976 and 1976-1977. Also shown for comparative purposes is the figure for 1974-1975, a predrought year, and the projections for the current season.

Season	Skier-Days
1974-75	5,100,000
1975-76	3,800,000
1976-77	2,500,000
1977-78	6,000,000 plus

There is considerable evidence that the overall impact upon the State's winter sports industry was ameliorated somewhat by the mobility of the skiing public. Thus, although Northern and Central California registered large declines in attendance, there was a considerable increase in Southern California ski resort patronage, particularly in 1976. Nevertheless, the visitor-day figures show a net attendance decline (from 1974-75 figures) of 1,300,000 in 1975-76 and 2,600,000 in 1976-77. It is estimated that this sector of the recreation field suffered an economic loss of approximately $50 million for the two years.

Fortunately, the 1977-78 winter sports season got off to a more promising start. The first snow for the central Sierra Nevada fell just before Thanksgiving and resorts at Donner Summit and at Lake Tahoe opened at that time. A few weeks passed before the next snow came, but the weather remained cold enough to operate snow-making equipment so that the larger resorts stayed open. December 1977 and January and February 1978 storms deposited enough snow to ensure good ski conditions for the remainder of a normal season while mid-April snowfall guaranteed an extended season.

Mammoth Mountain resort areas on the east side of the Sierra Nevada recorded excellent early season conditions and the large snow depths resulting from January and February 1978 storms made for an exceptional year.

In Northern California, conditions varied. Ski resorts at Horse Mountain, Shasta, and Cedar Pass had snow and were open in time for the Christmas holiday. Shasta, shut down for the last two seasons due to lack of snow, was plagued by too much snow in early 1978, as an avalanche rendered ski lifts inoperable.

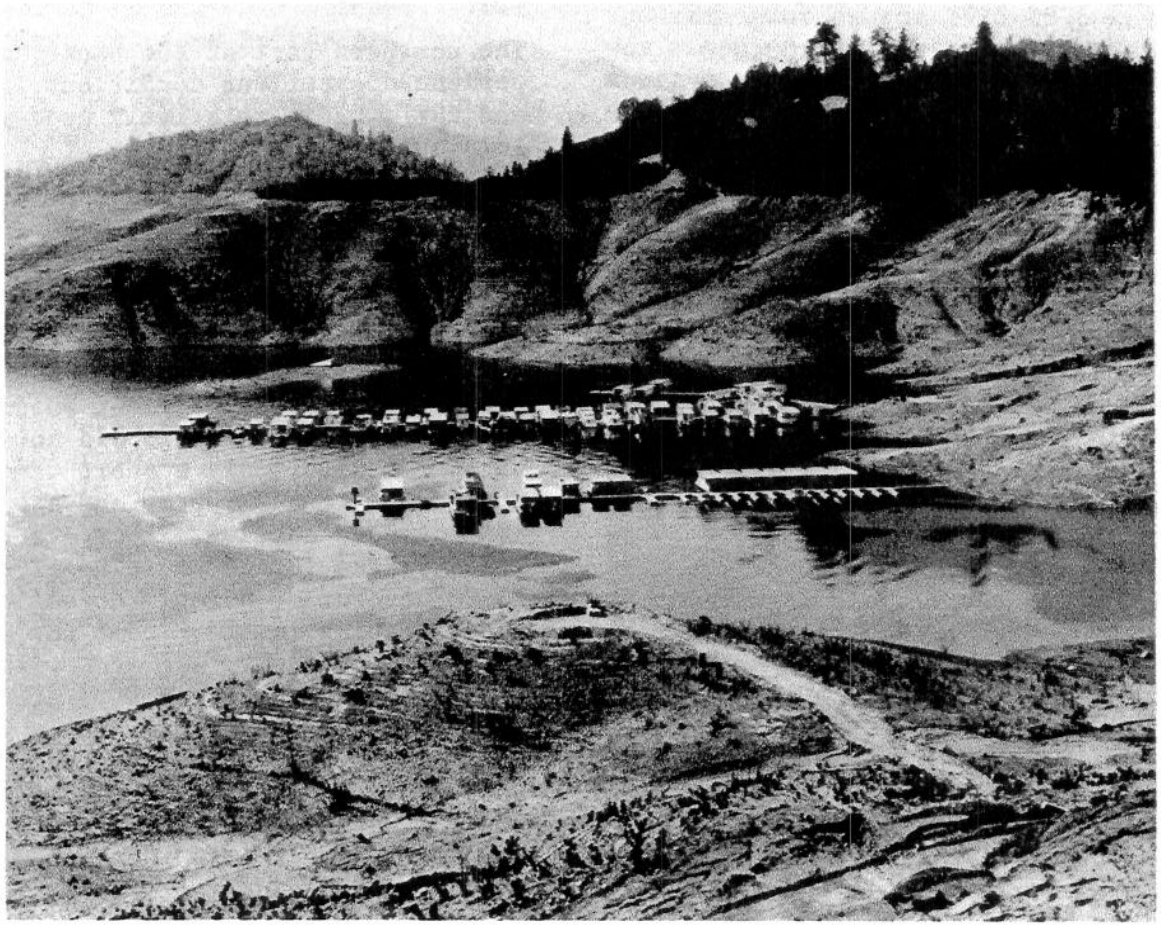
The southern part of the State, which experienced excellent conditions in 1976 and 1977, had a relatively good year in 1978 despite a late start.

Lake recreation in 1977 was severely impacted by record low reservoir levels. Recreation use at Shasta Lake in 1977 was considerably less than normal, falling even below the low usage registered in 1976. Bridge Bay was the only Shasta resort with any significant business. Most resorts on the lake did not operate or operated for only a short time. Many were close to bankruptcy and applied for SBA loans to survive. Recreation at Trinity Lake (Clair Engle Reservoir) was 10-20 percent of normal recreational use, creating little income for its resorts. Conversely, use at Lewiston Reservoir was above normal. Attendance at Whiskeytown Reservoir was up for the year. According to the National Park Service, use would have been even higher, but the water level at Whiskeytown dropped 2.4 metres (8 feet) in mid-August, which made many facilities (beaches, ramps, etc.) less desirable. The water elevation at Whiskeytown was back up to normal by October 1977.

At large natural lakes, like Eagle Lake, Clear Lake, and Lake Tahoe, drought impacts on recreational activities were negligible. In fact, due to the unavailability of other popular resorts, visitation at these lakes actually increased. The afterbays and forebays of major reservoirs also enjoyed an increase in usage in 1977. Their water levels remain relatively constant although fluctuations in the main reservoir may occur. Recreational activities on Colorado River reservoirs, along the Sacramento River, and in the Delta were similarly unimpaired by the drought, but no recreational use data is available.

The experience of the State Water Project (SWP) and Central Valley Project (CVP), comprising the two largest systems of reservoirs in the State, serve as an example of water-oriented recreation in most of the State. Attendance figures, in visitor-days, are contained in Table 7 for facilities operated in connection with each project. Comparisons are made for three years, 1975, 1976, and 1977. Table 7 shows that SWP attendance figures actually rose slightly from 4,189,000 in 1975 (predrought) to 4,242,000 in 1976, then dipped somewhat to 3,959,000 in 1977. CVP project attendance declined steadily from 12,677,000 in 1975, to 10,761,000 in 1976, and to 9,170,000 in 1977.

As with winter sports, lake-oriented Californians demonstrated considerable mobility, shifting their attention to other previously lesser visited lakes as some of the more popular fell victim to the drought. This is illustrated by the 1976 experience in the Shasta-Trinity-Whiskeytown complex in Northern



23. The traveling marinas. As levels at Shasta Lake began to drop, these floating docks had to be moved farther downslope. At the right is the temporary road leading down to the disappearing reservoir.

TABLE 7

RECREATION USAGE AT
SWP and CVP FACILITIES
1975, 1976, 1977
(in visitor-days)

SWP Facility	Attendance in Visitor-Days		
	1975	1976	1977
Frenchman Lake	148,000	147,000	122,000
Antelope Lake	100,000	80,000	15,000
Lake Davis	271,000	252,000	263,000
Lake Oroville Complex	539,000	463,000	411,000
Lake Del Valle	117,000	229,000	313,000
Clifton Court Forebay	2,000	11,000	5,000
San Luis Reservoir	199,000	153,000	194,000
O'Neill Forebay	203,000	195,000	165,000
Los Banos Reservoir	34,000	26,000	61,000
Lake Castaic	1,013,000	964,000	833,000
Silverwood Lake	426,000	412,000	375,000
Lake Perris	788,000	880,000	782,000
Pyramid Lake	276,000	330,000	321,000
Fishing Access Sites	36,000	20,000	23,000
Walk-In Fishing	26,000	61,000	57,000
Bikeway	11,000	19,000	19,000
SWP Subtotals	4,189,000	4,242,000	3,959,000
CVP Reservoir			
Shasta Lake	2,161,000	1,176,000	726,000
Trinity Lake	174,000	153,000	31,000
Whiskeytown Reservoir	1,274,000	1,632,000	1,617,000
Lake Berryessa	1,834,000	900,000	798,000
Folsom Lake	2,403,000	1,839,000	1,337,000
Millerton Lake	642,000	819,000	702,000
CVP Subtotals	8,488,000	6,519,000	5,211,000
TOTALS	12,677,000	10,761,000	9,170,000

California. In 1976, Lake Shasta visitation fell by 46 percent (from 1975 levels) and that for Clair Engle (Trinity) Lake fell by 12 percent, each reflecting significant declines in lake elevation. However, Whiskeytown Reservoir, with a relatively stable water surface, registered record use with an increase of 28 percent for the year.

As lake levels fell even lower in 1977, visitation generally continued to drop. Shasta's use was only 34 percent of 1975 use and Trinity's use fell to 18 percent. Whiskeytown, however, held to the record level of 1976 use.

There were major efforts made by the news media, the DWR Drought Information Center, and the Department of Parks and Recreation to counteract the negative psychology engendered by dropping lake elevations and to redirect public interest to alternate locations. Without these efforts, there undoubtedly would have been an even larger decline in lake and waterways visitation.

Many lake resort operators and public agencies took the opportunity afforded by low lake levels to extend boat launching ramps. Other innovative methods were developed for coping with the receding shoreline. Pre-cast concrete ramp sections and metal landing mats were employed as temporary expedients which were relocated to follow the water. The U. S. Forest Service constructed several floating launch ramps which were used at Trinity and Shasta Lakes. Similar ramps were provided by the Department of Navigation and Ocean Development at Lakes Oroville and Folsom.

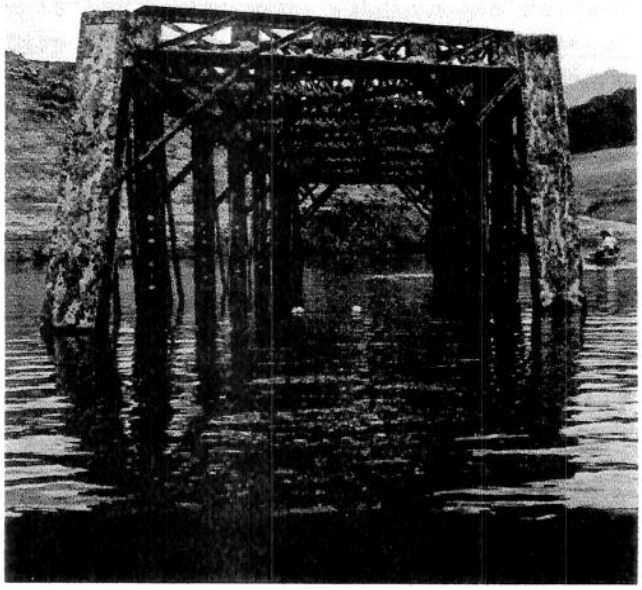
Two consecutive dry winters hindered river boating throughout the State. Except in a few places, boating on California's rivers and streams was very poor the entire summer of 1977. White-water rafting conditions never really existed on the State's waterways. By the end of the boating season, less than a dozen of the popular boating stretches had adequate flows for any type of boating.

Ironically, while drought in the State ruined most popular river boating places, dry conditions were directly responsible for opening up a usually inundated section of the North Fork Feather River. As water in Lake Oroville receded to record low levels, the stretch became available to boaters for a few weeks in August.

When rain finally fell on the North Coast in late September, rivers again began to rise, but by then the popular boating season had already passed.

Angling enthusiasts found many of their favorite reservoirs and streams with less than adequate water for good fishing. Some major fishing streams saw extremely low or nonexistent flows in 1977. For example, flow in the American River below Folsom Dam was reduced in stages to 7 cubic metres per second (250 cfs), down from its usual summertime

24. Where can I launch? The question was asked often in 1977 as reservoirs receded to record lows. This boat ramp at Rollins Reservoir in Nevada County was left high and dry. When this photograph was taken, the water level was another 30 metres (100 feet) down the slope.



25. Relic from the past. An old railroad bridge that disappeared when Shasta Lake was first filled reappeared to provide a new navigational hazard in late 1976. The photograph was taken from the entrance of a partially submerged tunnel.

minimum of 42 cubic metres per second (1,500 cfs). This condition existed from October 1, 1977 to January 1978. The Truckee River outlet from Lake Tahoe was dry from September 22, 1977 to January 5, 1978. The Cosumnes River, although not a major fishery, stopped flowing in the early summer of 1977.

Despite the negative points, fishing was still generally considered fair. Much of this was due to efforts by the Department of Fish and Game, which rearranged planting schedules to place fish in waters still available.

Most national forest recreation areas in Northern California were open for use during the summer of 1977. Some campgrounds were without water by summer's end, and the fire hazard was extreme throughout the summer season.

In August 1977, a series of lightning storms started several major fires on high elevation forest lands. Closures and fire restrictions were implemented as necessary. Due to dry conditions in the forests, a statewide "Stage-1" fire restriction was issued for all national forests in July. "Stage-1" prohibits open campfires outside of designated campground areas.

The conditions which existed in 1977 at specific forests are discussed in the following paragraphs.

Six Rivers National Forest - Patrick's Creek, Tish Tang, Fish Lake Bailey Canyon, and Fur Cove Campgrounds were without water, along with numerous rustic campsites. Closures occurred only at Patrick's Creek, Bailey Canyon, Fur Cove, and for a short time at Tish Tang. Despite water supply problems, visitation was near normal. River rafting, which is popular in Six Rivers Forest, was curtailed by the low flows in the rivers.

A "Stage-2" fire restriction was declared on August 5. "Stage-2" prohibits all open campfires, and all fires outside of developed campground areas. No fire closures were necessary. Hazardous fire conditions ended in September with the coming of rain to the North Coast.

Klamath National Forest - No closures occurred because of depleted water supplies; however, six campgrounds were without water for a short time. Closures occurred near the Forks of the Salmon area when fire broke out in August.

Modoc National Forest - Drought impacts in this forest were minimal. No changes in the number of visitors were reported. Medicine Lake, the major recreation spot in the forest, remained in good shape throughout the summer. Water supplies for one small campground and the fire station dried up.

On August 3, 1977, 27 separate fires were started by lightning. Eventually they merged to form seven and then one. Nicknamed the "Scarface Fire", the blaze burned 32 375 hectares (80,000 acres). Although closure of the forest was never implemented, in some areas "Stage-2"

26. River lost to the drought. The Truckee River as it appeared in November 1977. The Truckee, a stream popular with fishing and rafting enthusiasts, stopped flowing in September when its source, Lake Tahoe, dropped below its rim.

fire restriction was ordered.

Shasta-Trinity National Forest - Drought impacts in the Shasta-Trinity forest were substantial. Only about two-thirds of the campgrounds were open due to low use, especially at Shasta and Trinity Lakes. There were several closures required because of water supply problems. Fawn Campground near Weaverville closed right after Memorial Day for lack of water and Antlers Campground at Shasta Lake was closed by mid-summer.

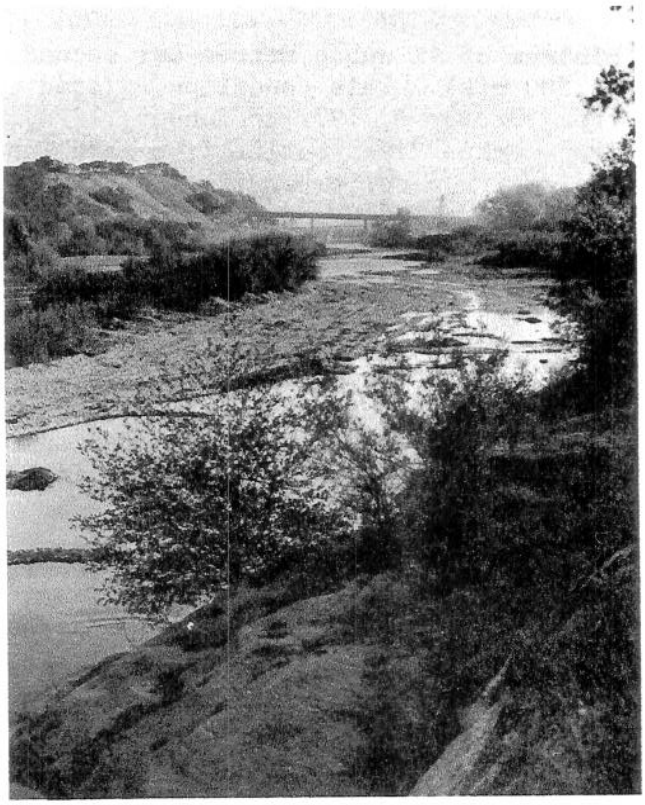
Extreme fire hazard also caused closures of campgrounds. A "Stage-2" fire restriction was declared in August.

Mendocino National Forest - Although no general closures were implemented in the Mendocino National Forest, the number of visitors to the area was low when compared to a normal year's usage. The low usage is attributed to the diminished water supply. An estimated one-third of the available campgrounds were without water by August.

The fire season in the Mendocino Forest passed without incident. Low visitation and greater public awareness of the increased fire hazard are responsible, in part, for the good fire season.

Lassen National Forest - At Lassen National Forest, the fire danger was high and the water supply low, but there were no special closures for either of those reasons last summer. The water level at Lake Almanor was low, but Eagle Lake remained full for the recreation season.

Some closures occurred during the summer because of an increase in the incidence of bubonic plague in animals. Plague, which is transmitted by fleas to animals and humans, is endemic to the area. Two dry winters have aggravated the situ-



27. No rafting here. When this photo of the American River was taken in November 1977, Folsom Reservoir releases to the river were at a record low of only 7 cubic metres per second (250 cfs).

ation however, by forcing animals to concentrate near permanent water supplies. The Little Crater Lake area and the Eagle Lake area were both closed for two weeks in order to control the disease. Negative publicity surrounding the rise in disease resulted in a substantially lowered usage of the forest.

Lassen National Park - No serious problems occurred in Lassen National Park. Butte Lake opened a little later than normal, but remained open for the rest of the summer.

Like Lassen National Forest, Lassen Park had some problems associated with the spread of bubonic plague. Manzanita Lake was closed toward the end of August for vector control, but was reopened in time for the Labor Day weekend.

Sierra National Forest - Closures occurred in all areas of the Sierra Forest except for high elevation wilderness areas. The closures were a result of the extreme fire hazard which existed in the forest. The lower elevation forest area was closed for most of the summer. The mid-elevation forest was closed in August and in September. Camping in the lower and mid-elevations was restricted to developed campgrounds. Usage of the wilderness areas was equal to or greater than that of previous years. Visitation at campgrounds and picnic areas, which are at low and mid-elevations, was down by 30 percent.

Both camping restrictions and low water supply were factors in reducing usage. Almost all campgrounds dependent on streams and springs for their water were dry, and a few campgrounds using wells also went dry.

Fishing and off-road vehicle recreation in the forest was low, mainly because of the restricted use of the forest. Hunting did not appear to be affected because rain had fallen by the start of the season and fire restrictions relaxed.

Because of the inavailability of water

28. A picnic by the water. This is what picnickers and campers faced at Rollins Reservoir.

to operate snow-making equipment, China Peak, the forest's main ski resort, had to depend on natural snow. Lack of precipitation delayed the 1978 seasonal opening of the resort for three weeks past the normal opening time. Plenty of snow fell by late December 1977, however, and the remainder of the season was good.

The economic impact of the drought on the recreation industry is not yet fully known. Rough estimates put direct losses to recreation at $16 million, with another $40 million from indirect losses. Economic losses could have been a great deal larger, had Californians not switched their attention to different resort locations and different activities.

Fish and Wildlife

The impacts on fish and wildlife after two years of drought were most severe in the lower and mid-elevation streams and foothills of the Coast Range and the western slopes of the Sierra Nevada. Low flows and higher water temperatures affected fish spawning and migration, and wildlife, especially waterfowl, faced a reduction in forage quantity and quality. Problems south of the Tehachapi Mountains and in the Colorado Desert were relatively minor.

The drought adversely affected fish spawning activity in 1977, but the impact was not as great as anticipated. The DFG was unable to quantify effects of the drought upon juvenile survival rates of salmon and steelhead. However, it is known that elevated water temperatures in the Sacramento system and the Trinity, coupled with low flows, impaired the spawning success of all species of salmon. In the Sacramento River system above the Feather River, the four runs of king salmon were down 25 percent from 1976. Salmon spawning runs in the Feather and Yuba Rivers were up slightly and those in the American were equal to runs in 1976.

Low spring outflow jeopardized survival of juvenile outmigrant salmon and steelhead, but it will take several years to determine the effect on the numbers of returning adults.

Production of wild brown and rainbow trout populations in the Truckee River from Lake Tahoe to the state line was depressed to a significant extent, probably for years to come, as river flow became nonexistent in September 1977. Normal flow for September is 9 cubic metres (326 cubic feet) per second.

In the Sacramento-San Joaquin Delta, there was little spawning by striped bass in the spring of 1977, probably because of negative response to higher than normal salinities. It is not known yet if this was offset by possible increased spawning in the Sacramento River above the Delta.

The index of young striped bass survival through mid-summer 1977 was the lowest measured since annual surveys began in 1959. Apparent survival was only 10 percent of the 1959-1976 average.

It was estimated that in both 1976 and 1977 the number of opossum shrimp was only about 20 percent of average. This was apparently due to habitat loss from salinity intrusion and low food supplies caused by low flows. The opossum shrimp is the major food of young striped bass and other fish in the Delta. Other crustacean foods were at lower abundance than normal.

Due to low production in two successive years, there probably will be reduced catches when the young fish return as adults. However, fish populations and fishing success should increase once more as typical flow conditions return.

Although not quantified, salinity encroachment also resulted in reduced numbers of freshwater fish in the Suisun Marsh and Bay.

Low water levels in a number of mid- and high-elevation lakes and reservoirs permitted the use of chemicals to remove rough fish which were depressing trout populations. Meanwhile, vegetation began growing on exposed shorelines of large reservoirs and this should improve the survival and future growth of game fish. In addition, several fishing clubs took advantage of the drought by placing brush in the bottoms of dry reservoirs to provide future nesting sites.

Wildlife, exclusive of fish and crustaceans, was relatively unharmed by the drought in 1977, this despite the drying up or reduction to record low levels of valley and foothill water impoundments and the lack of normal forage.

In a water-short year there was, nevertheless, enough spring rain to produce ample nesting cover and food for quail, chukars, turkeys, and rabbits. Sage grouse and tree squirrel populations were high, and band-tailed pigeon numbers continued to rise. Because growers plowed fields and cleaned up drainage and irrigation ditches early -- actions also related to the drought -- there was little cover for pheasants, and production of the species was poor.

In an annual survey of waterfowl food production in the Delta-Suisun Marsh, the DFG found severely limited seed pro-

29. Fishing from a bridge. This bridge, actually part of an abandoned highway, was put to good use temporarily when uncovered as the water level at Lake Shasta declined.

duction in the area's alkali bulrush, a favorite food for Delta waterfowl. At nine of the twelve stations sampled, seed production was less than 100 pounds/acre,[1/] compared with 1,550 pounds/acre recorded for well-managed stands. The reduction is attributed to relatively high salinities resulting from the drought.

The expected depredation of crops by waterfowl did not occur, however, largely because of the late fall in western Canada. When the birds, ducks, and geese finally migrated southward into California, most crops had already been harvested.

The DFG reports, however, that the drought led to an outbreak of hoof rot in Modoc County deer, and the increase in the reuse of irrigation water led to concentrations of pesticides in canals and ditches which subjected waterfowl and animals to disease.

The full economic impact on the State's fisheries and industries dependent on wildlife is unknown; however, a measure of this is found in the loss of revenue from fishing license sales -- estimated at $1,600,000 in 1977. In addition, emergency expenditures on drought-related salmon programs exceeded $600,000.

Forests and Wildlands

The severe moisture stress caused by lack of precipiation in 1976 and 1977 took its toll in an increased number of trees lost to insects, disease, and fire.

Information on tree loss, in terms of numbers of trees and volume, resulting from the two-year Northern California drought, was gathered by the U. S. Forest Service, a division of the U. S. Department of Agriculture, in a combination aerial-ground survey of 12 national forests in Northern California. The results are contained in a staff report titled, "1976 and 1977 Drought Pest-Caused Tree Mortality in National Forests of Northern California', dated December 20, 1977. The report portrays the drought loss situation as of May 1977 on 2.5 million hectares (6.3 million acres) of commercial Forest Service land in Northern California.

Findings reported include:

1. Total Mortality Losses. An estimated 5.3-7.7 million trees, with a volume of 2.4-3.8 billion board feet, died during the two-year (1976-1977) drought. The estimated one-year loss, from May 1976 to May 1977, was 3.7-5.3 million trees with a volume of 0.9-1.5 billion board feet.

2. Loss by Site. The highest tree mortality was in southfacing, low-elevation, and marginal sites. But, in terms of volume, the greatest losses in both the two-year drought period and the year ending in May 1977 were on the higher sites, where up to 68 to 74 percent of the total volume lost was located.

[1/] One pound equals 0.45359 kilogram, one acre equals 0.40469 hectare.

3. Loss by Forest Type. The greatest tree and volume loss during the drought occurred in the mixed conifer and red fir types of forest (65 percent of the trees and 78 percent of the volume). Loss estimates by type for 1977 alone (May 1976 to May 1977) are being computed but are not yet available.

4. Loss by Species. In the year ending May 1977, the greatest tree and volume loss was in ponderosa and Jeffrey pines. An estimated 80 percent of the tree and volume loss occurred in four tree species: ponderosa and Jeffrey pines and the red and white firs.

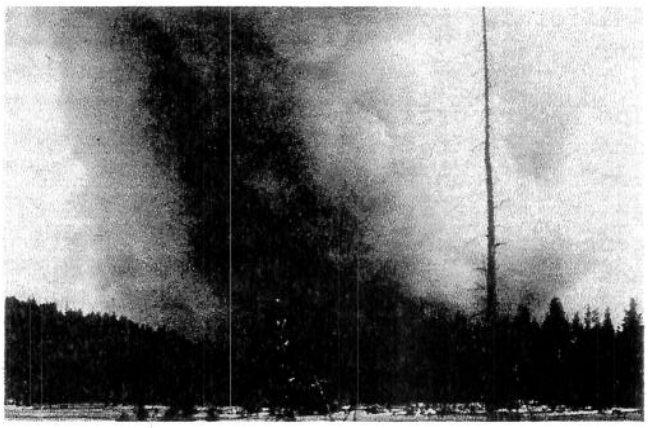
5. Pest-Associated Losses. Although the current drought was a major factor contributing to these losses, forest insects and diseases were involved in the majority of losses. For the one-year period May 1976 to May 1977, pests were associated with and diagnosed as important contributors to death in 95 percent of the dead trees, containing 98 percent of the volume lost. In 70 percent of the killed trees, a combination of an insect and a disease working together under drought conditions was the cause of death. This type of insect-disease complex was responsible for 67 percent of the volume loss (see Figure 21). Insects alone killed 24 percent of the trees, and diseases alone were responsible for 1 percent of the tree deaths. The major insects involved were bark beetles (scolytids) and to a lesser degree, but above normal, the flatheaded and round-headed borers. The most damaging diseases were the dwarf mistletoes and root diseases.

   These pests played one of two roles in tree mortality. The long-term debilitative diseases (such as root diseases and dwarf and true mistletoes) operated by weakening the hosts, predisposing them to drought stress. The bark beetles and flatheaded borers attacked and killed trees that were sufficiently stressed by the drought, pests, and other factors.

The report concludes that the drought of 1976 and 1977 has triggered a sharp increase in pest-caused tree mortality in Northern California which has occurred on all sites and forest types. The mortality continued to increase in the fall of 1977 and the spring of 1978 and is expected to continue to occur this summer.

For additional details on tree mortality, please refer to the referenced U. S. Forest Service report.

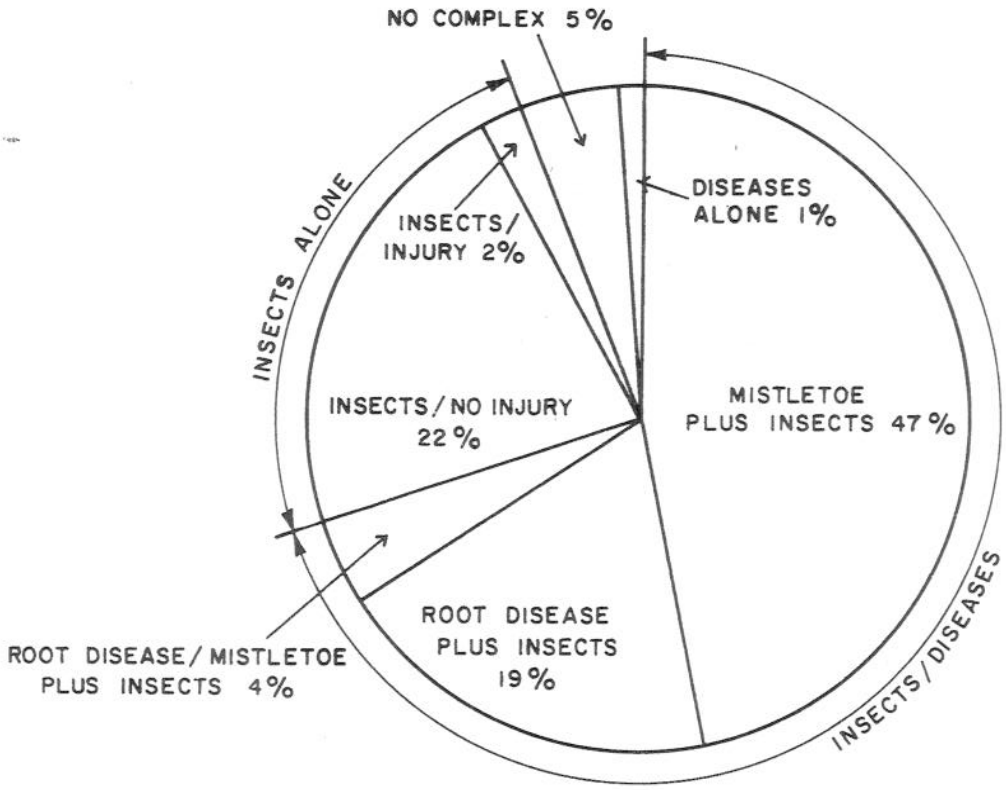
Besides the increased mortality caused by disease and pests, the summer of 1977 saw a marked increase in the number of trees lost to forest fires. From August 1 to August 10, a series of lightning storms ignited about 1,400 wildland fires in Northern and Central California. Ten of those fires burned more than 2 000 hectares (5,000 acres) each; and the largest fire of the year, the "Marble Cone" near Monterey, covered 70 800 hectares (175,000 acres). Other major fires included the "Scarface" fire in Modoc County and the "Forks of Salmon" in Siskiyou County. During 1977, wildland fire control agencies in California spent about $30,000,000 fighting



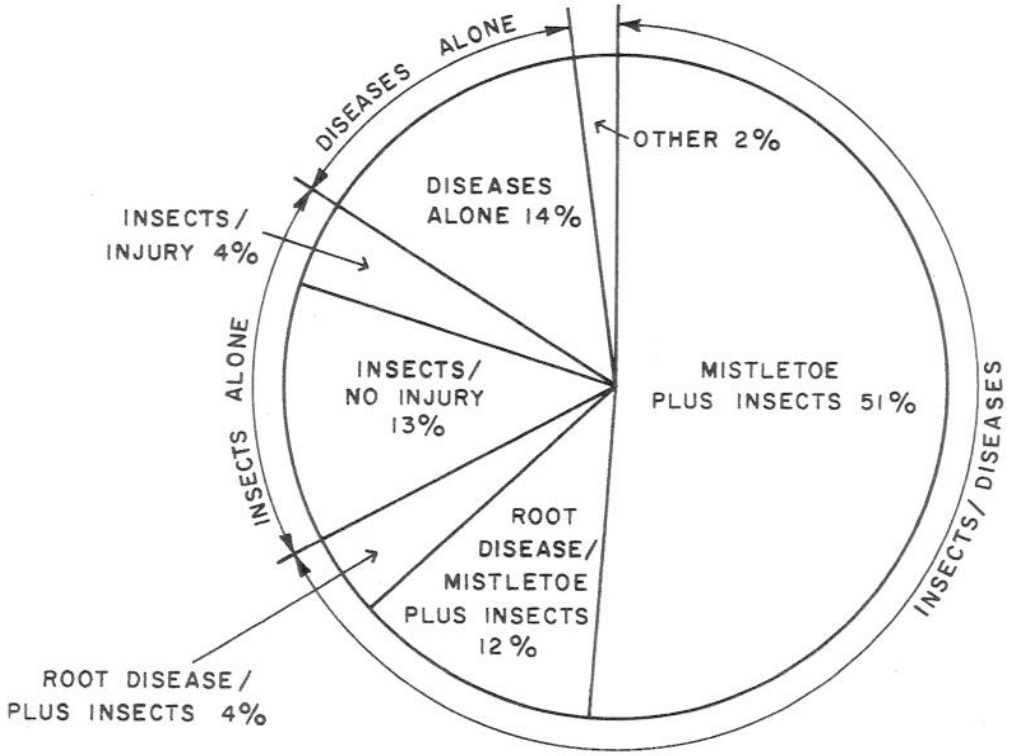
30. Forest fire! A convection column rises from the 8 100-hectare (20,000-acre) Pondosa fire in Modoc County in August 1977.

Figure 21.

TREE MORTALITY CAUSES DURING YEAR ENDING May 1977



Percentage of Total Number of Trees



Percentage of Board-Feet Volume

major fires, and damage to forest and watershed land amounted to about $280,000,000. A comparison of 1976 and 1977 losses to fire to the five-year average (1971-1975) for all California wildland protection agencies is:

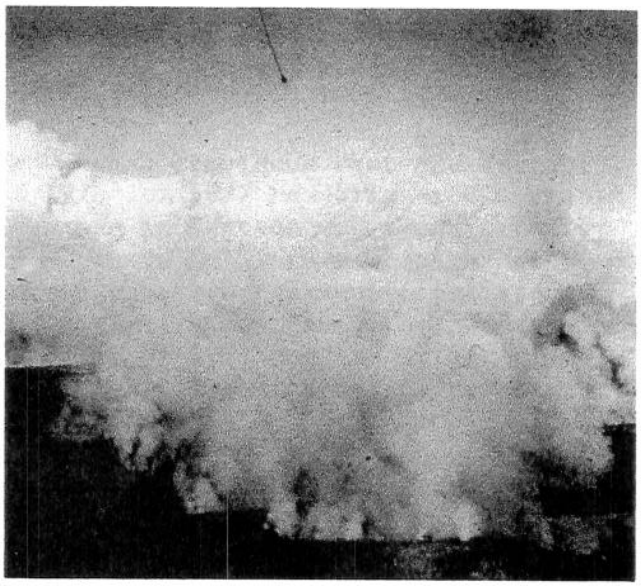
Year	No. of Fires	Hectares(Acres)
Average	12,524	83 000(205,000)
1976	13,339	78 500(194,000)
1977	11,923	181 700(449,000)

Economic Assessment

The staggering economic impact of the drought has been reviewed in preceding sections of this report as it touched the separate sectors of the economy, including agriculture, energy, recreation, forests, and industry. The largest losses were sustained in the agricultural, energy, and forest fields. The following table summarizes current estimates of drought losses in dollars:

Economic Area Affected	Drought Loss Millions of Dollars 1976	1977
1. Agriculture		
a. Livestock	467.4	414.5
b. Grains	22.8	23.0
c. Irrigated Crops	0.0	89.0
d. Fruits, nuts	19.3	40.0
e. Power Costs	25.0	25.0
f. Well Costs	40.0	300.0
2. Energy	144.0	326.0
3. Recreation	20.0	40.0
4. Forests		
a. Loss by fire		280.0[1/]
b. Loss by insects	150.0[1/]	237.5[1/]
5. Industry	(Unknown)	(Unknown)
Totals	$888.5	$1,775.0

1/ Based on average "onsite" value of $125 per 1,000 board-feet.



31. A scar across the land. Part of the huge 36 000-hectare (89,000-acre) Scarface forest fire in Siskiyou and Modoc Counties which started as a result of August 1977 lightning storms.

The foregoing tabulation is an estimate of the direct economic losses resulting from the drought and measures the drought's effect in terms of losses to the producers of livestock, farm produce, energy, recreation activities, and trees. Because there are many other segments of the economy dependent upon the products of these basic industries, the total impact is multiplied. The Department of Food and Agriculture estimates, for example, that for each dollar lost in the food and fiber producing sectors there is an additional two dollars lost in agriculture-related industry. Some, but not all, of the other primary industries listed above may be affected by a similar "multiplier" effect.

Earlier estimates of anticipated drought loss were much higher, particularly in the agricultural industry where surface water supplies for irrigated agriculture were known to be extremely deficient. Those estimates did not adequately reflect the flexibility of the farmer and the ability of the well drilling, pump manufacturing, and energy-producing industries to provide a substitute supply from ground water. Without those efforts, losses would have been much

greater.

It was not possible to include loss figures for other segments of the economy, including nonagricultural industry. DWR is currently working on a study to define those losses. Results will be available later this year.

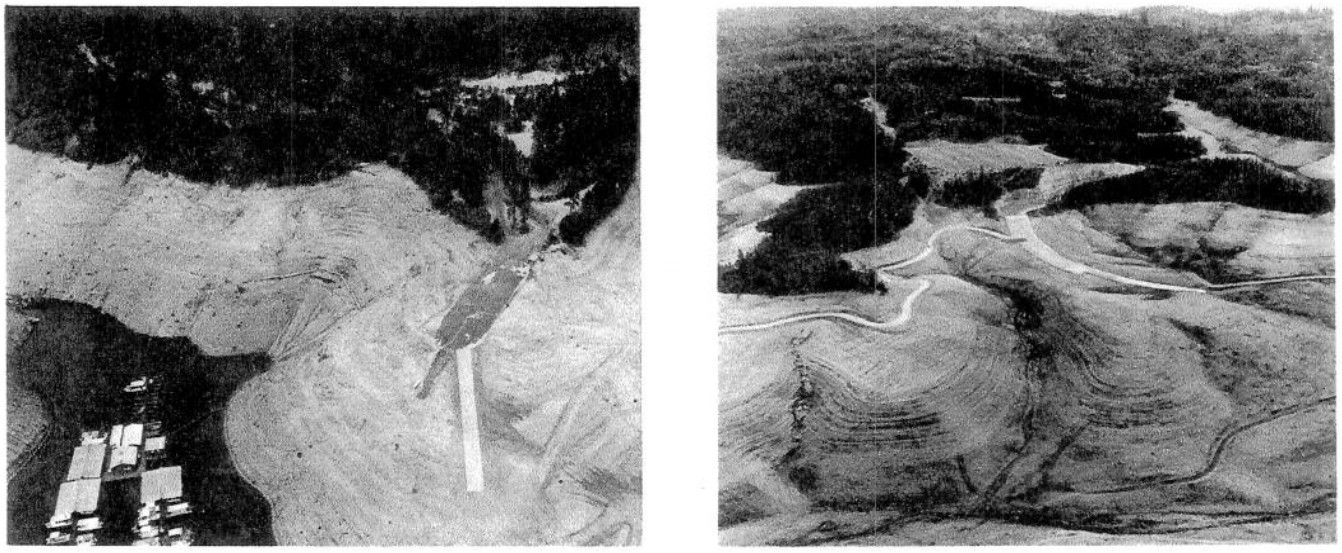
It should be noted that some increased costs were offset by increased economic activity in an associated field (an example is the increased well drilling activity countering some of the agricultural losses) and certain direct losses were in fields that have the capacity to absorb some of those losses by deferring their impact. (For example, the lumbering industry can switch to other timber areas while regrowth renews the resource.)

In a separate move to assess the drought's current and potential impact upon nonagricultural industry, DWR contracted with the Marketing Services Division of Dunn & Bradstreet, Inc., to conduct a survey of California's high water-using industries -- those using large amounts of water in production processes, or with large labor forces requiring substantial quantities of water for sanitary or cooling purposes. About 6,000 industries were contacted. Results indicated that 58 percent felt no impact from the drought, about 8 percent felt a substantial or critical effect, and about 6 percent indicated layoffs due to drought.

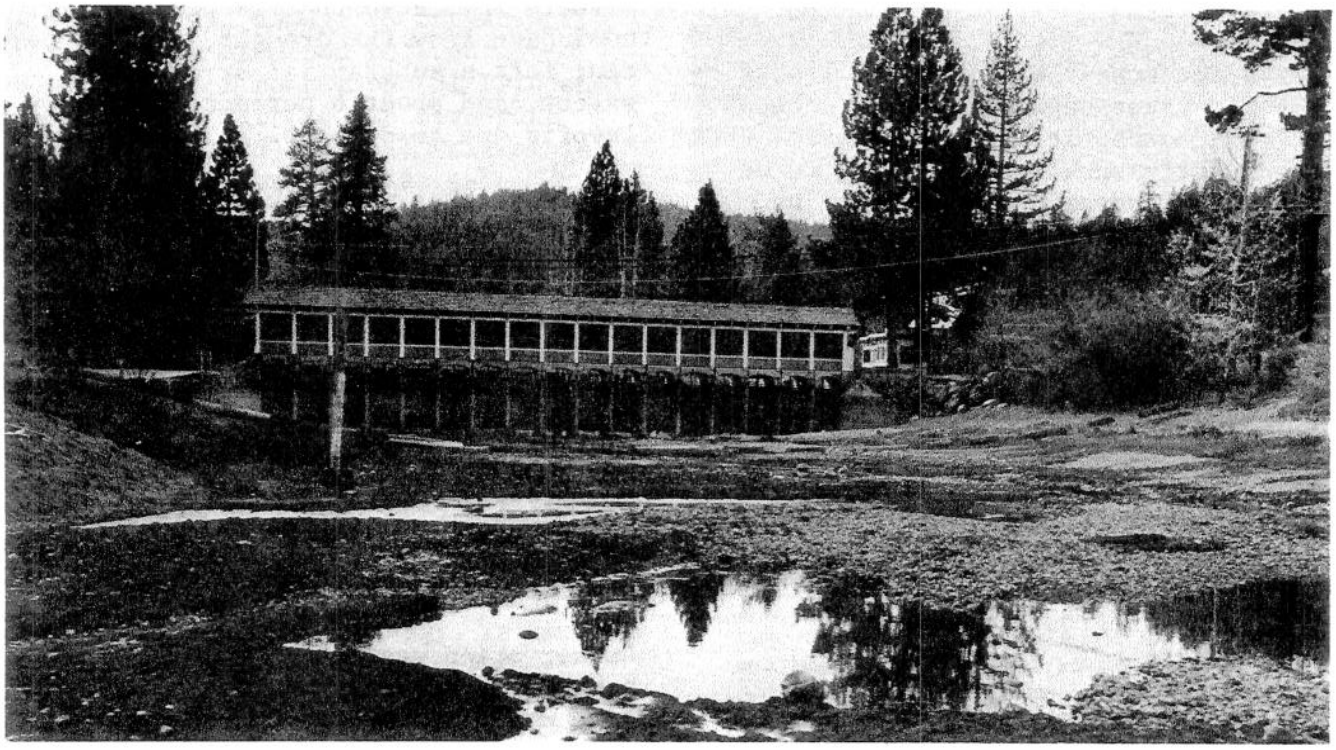
The industries were asked to indicate the anticipated effect of various levels of reduced water supply. Most (79 percent) reported that a 25 percent cut would involve no reduction in production; none felt such a cut would trigger moves to shut down or relocate. At a 50 percent cutback level, 34 percent of the industries felt decreased production would result, and 4 percent felt that shutdowns or relocations would occur. At 75 percent cutback levels, these figures became 44 percent and 7 percent.

Conservation was cited by the largest number (55 percent) as the most effective way for industry to meet present and future water shortages. Recycling and reclamation (34 percent), increased storage facilities (15 percent), and new sources such as desalted seawater, seawater, and new wells (9 percent) were also cited.

Approximately 70 percent of those responding indicated that additional funds would be spent for water conservation in 1978.



32. O'Brien's Marina and Jones Valley Ramp. The drought's impact upon this segment of the recreation industry at Shasta Lake is dramatized by these two photographs.



33. The Lake Tahoe Outlet near Tahoe City. The Truckee River ceased flowing when the level at Lake Tahoe dipped below that of the outlet. The photographer was standing within Lake Tahoe's ordinary pool.

34. The mighty Eel bows to the drought. This is the confluence of the Eel River and the Middle Fork of the Eel River as it appeared on August 23, 1977. No surface flow appears in the Eel River; the Middle Fork flow is 0.02 m^3/s (0.75 cfs). Normal summer flows for the Eel River and its Middle Fork are about 0.14 m^3/s (5 cfs) and 0.42 m^3/s (15 cfs), respectively.

THE DROUGHT RESPONSE

Response was remarkable as the people and their elected representatives reacted in a variety of ways to cope with the drought and to devise, plan, and carry out measures intended to blunt its effects. State and federal legislation was enacted, task forces were created and staffed, administrative rules were devised or simplified, institutional requirements were changed, technical and financial aid was made available, and physical works were constructed. All this was done with one objective in mind -- to make the best use of a scarce resource. Water conservation and exchanges played a large part in the success of the effort. The attempts and accomplishments are detailed on the following pages.

Legislation at the Federal Level

There were three major federal laws enacted in 1977 designed to assist victims of the drought.

The Emergency Drought Act of 1977 (P.L. 95-18) was enacted by the Congress and signed by President Carter on April 7, 1977. The Act (attached as Appendix A) gave the Secretary of the Interior temporary authority to institute emergency actions for mitigating the impacts of the 1976-77 drought and appropriated $100 million to augment, utilize, and conserve water supplies for irrigation farming operations on projects constructed or funded under reclamation law, on Indian irrigation projects constructed by the Secretary, and on irrigation projects financed with nonfederal funds. It also authorized grants to state water resource agencies and fish and wildlife conservation agencies. Sections 10(b) and (c) of the Act, providing for state grants, were included at the request of the California Resources Agency.

There were two subsequent amendments to PL 95-18, both sponsored by DWR. The first, signed into law August 17, 1977, extended the Act's deadline for construction activities from November 30, 1977 to January 31, 1978, and gave the U. S. Bureau of Reclamation the flexibility needed to channel appropriations to the Act's most effective programs, including those of state water resources agencies. The second amendment, signed in January 1978, provided another deadline extension which enabled the State to recoup expenses incurred after January 31, 1978, including those for barrier removal, cloud seeding, and the Governor's Drought Emergency Task Force.

The Community Emergency Drought Relief Act of 1977 (P.L. 95-31), the second piece of major legislation, was enacted by the Congress and signed by the President on May 23, 1977. The Act authorized $225 million for the Economic Development Agency's (EDA) drought program. The appropriation was $175 million, with $109 million to be used for loans and $66 million to be used for grants. It is estimated that for each $100.00 of federal funds, $19.00 of state or local funding was stimulated.

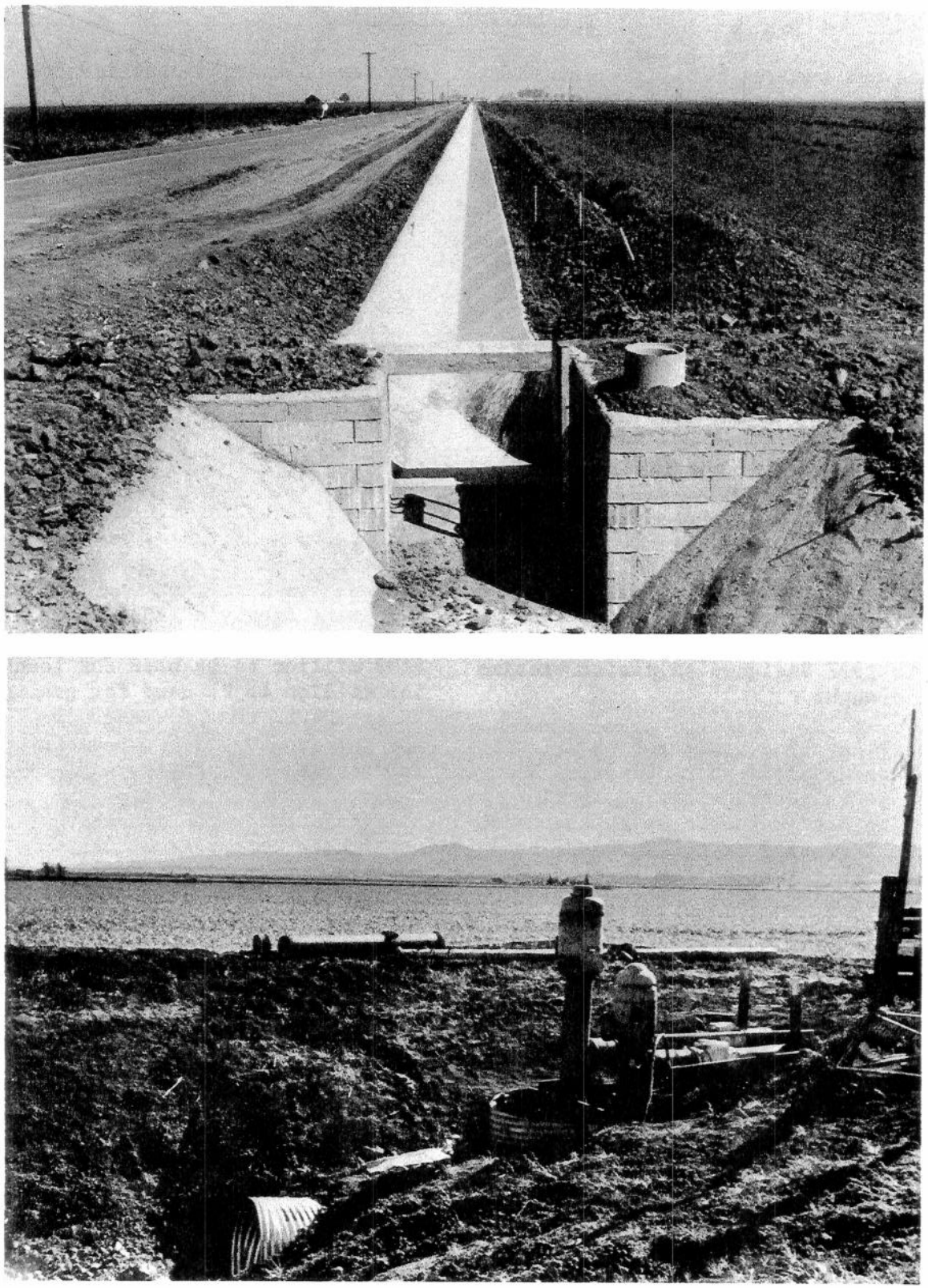
Eligibility for the grants and loans was restricted to cities and communities with populations of 10,000 people or more, Indian tribes, and nonprofit organizations including water districts.

The basic goals of the program were:

- to augment community water supplies by improving water systems.
- to aid in the purchase and transport of water.
- to promote water conservation.

Additional objectives were:

- to complement other federal and state drought assistance programs.



35. Drought aid to farmers. During the drought, several programs were made available to implement soil and water conservation practices. The photographs show a newly lined ditch (to prevent seepage loss) and a tailwater return system. (Soil Conservation Service photos.)

- to assist communities in dealing with health and safety problems caused by the drought.

- to assist in the response to other serious problems (i.e., adverse economic impact).

First priority projects, as defined by EDA Community Drought Relief Regulations, were those responding to severe health and safety hazards. These projects were primarily water supply augmentation, maintenance and repair of existing water systems, and fire protection in populated areas.

Second priority projects were directed toward alleviating economic stress, furnishing fire protection in nonpopulated areas, and resolving threatened, but not immediate, water shortages.

The third item of drought-related legislation passed by the Congress and signed by the President was the Supplemental Appropriations Act of 1977 (P.L. 95-26). This Act provided funds to supplement several existing emergency assistance programs administered in California by the USBR, the Farmer's Home Administration (FmHA), and the Agricultural Stabilization and Conservation Service (ASCS).

The existing USBR assistance programs provide for loans to aid in projects such as conservation, pumps, dikes, lining, pipelines, and water banking programs in nonfederal irrigation projects. Grants are available to states for water resource agency programs.

Existing programs administered by the FmHA provide for (1) low-interest loans to cover farmers' and ranchers' prospective losses, and (2) loans and grants to rural communities of less than 10,000 population for short-term water supply assistance.

The ASCS's existing programs provide grants to help farmers and ranchers implement soil and water conservation practices, such as well drilling and rehabilitating and reorganizing irrigation systems. Also included are the emergency livestock feed and cattle transportation programs.

The Small Business Administration (SBA) also offers disaster assistance, and in 1977 House Resolution 692 amended the authorizing acts to improve the terms of loans made under SBA's physical disaster and economic injury disaster programs.

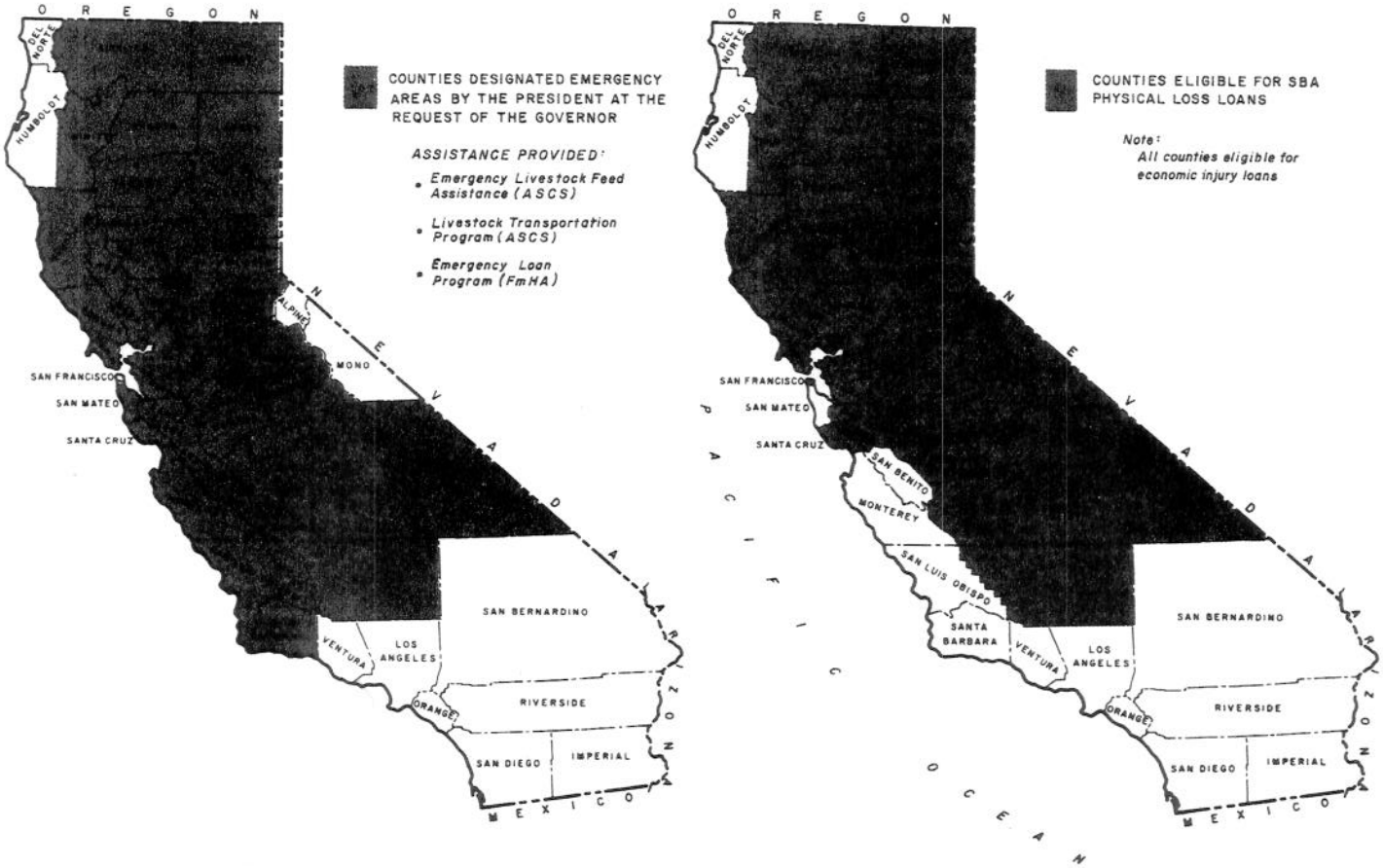
To be eligible for assistance under the various federal programs, an individual, business, or community must be located in a county designated as a "disaster or emergency area" or in an "Emergency Drought Impact Area". The former designations are made by the President at the request of the Governor and in 1977 included the 46 counties shown on Figure 22. "Drought Impact Area" designations are made by a federal interagency committee and in 1977 included all 58 California counties. However, individual federal agencies elected to restrict some of their programs to particular counties. Areas eligible for SBA assistance are shown on Figure 22. Businesses in all 58 California counties were eligible for SBA's economic injury loans, but physical loss loans were available in only the 44 counties indicated. The ASCS elected to restrict its programs to those 46 counties designated emergency areas by the President. All other programs were applicable statewide.

In addition to the federal programs discussed above, Appendix B lists other federal drought-related laws and programs available in 1977. For a more detailed listing of federally sponsored drought programs, see the Directory of Federal Drought Assistance: 1977 (also listed in the Bibliography).

EDA Grants and Loans

The Community Emergency Drought Relief Act (P.L. 95-31, administered by the EDA) proved to be a popular source of funding for drought relief projects.

Figure 22.
COUNTIES ELIGIBLE FOR FEDERAL DROUGHT ASSISTANCE



The total investment from all sources for EDA drought projects reached approximately $213 million throughout the country. This included $66 million in EDA grants, $109 million in EDA loans, $4 million in other federal agency funds, and $34 million in funds provided by State and local governments.

California, the hardest hit by drought in the country, received the lion's share of the EDA drought money. Forty-one percent of all the funding and 40 percent of all the approved EDA drought projects were claimed by California communities. Grants and loans amounting to $79,174,969 were used in the implementation of 106 separate California programs ($24,448,810 in grants and $54,726,159 in loans).

Appendix C lists the California communities which received EDA financing and describes how the funds were used.

USBR Drought Loans and Grants

As part of the program authorized under P.L. 95-18, Appendix A of this report, the U. S. Bureau of Reclamation (USBR) was provided funds to be used for loans, grants, and water purchases designed to alleviate drought impacts in California. The water purchases are covered under a following section of this report and are not discussed here.

Besides the new authority provided by P.L. 95-18, the USBR used existing powers available under an old law, the Emergency Fund Act of 1948. Together,

the two laws provided the source of funds for $18,489,146 worth of drought mitigative measures (exclusive of water purchases under the USBR's water bank, discussed later) employed in 1977.

Appendix D shows the entities receiving USBR loans and grants, the legislative authority for each transaction, and how the funds were used.

Loans to individual districts and water companies for assistance in water supply and conservation practices accounted for $11,440,043 of the total expended. There was one large grant -- $3,604,103 -- to the DWR for Delta barriers and other costs, and several other grants totaling $1,001,000 for mitigating damage to fish and wildlife. Loans totaling $2,444,000 went to four agencies for purchasing water supplies from other sources.

The biggest loan -- $4,500,000 -- went to the Chowchilla Water District, mostly for the drilling of wells. Other loans were made for such things as wells, effluent treatment, materials, pipelines, canal repairs, pumps, control gates, dredging, piling installation, and ditch measuring devices.

The largest grant -- $3,604,103 -- went to the State of California for building rock barriers and temporary water delivery facilities in the Delta, weather modification, and the costs of the Governor's Drought Emergency Task Force.

USBR Water Bank

One of the primary functions of the Emergency Drought Act, described previously in this report, was to establish a water bank to assist water users in purchasing water from willing sellers. Rules providing guidelines on the implementation of the Act were published in the Federal Register on April 14, 1977. Responsibility for administration of the water bank was placed with the USBR.

Early in 1977, after evaluating needs of its water contractors, the USBR determined that water bank supplies, as they became available, were to be allocated first for survival of permanent crops, second for maintenance of crops necessary to support foundation dairy and cattle herds and other breeding stock, and third for use in achieving maturity on other crops. After securing firm commitments from San Joaquin Valley entities to purchase water bank water, the USBR looked for prospective water sellers.

The first source of water was the State Water Project (SWP) which made 10.1 cubic hectometres (8,185 acre-feet) available through an exchange agreement with the Metropolitan Water District of Southern California.

Additional water was needed, but the USBR was constrained by legal restrictions, including requirements that any water transferred must be identified as Central Valley Project (CVP) water. Once water was legally identified as CVP water, the permit process allowed its transfer to other areas within the USBR's permitted place of use. To achieve optimum flexibility in the transfer process, the USBR elected to use existing permits for the Trinity River Division, which cover extensive land areas in both the Sacramento and San Joaquin Valleys.

The Sacramento River CVP contractors appeared as a likely second source of water supplies for the water bank. During the negotiations for purchase of CVP water, several important factors surfaced. They included:

1. Identification of available CVP water;

2. Ability, in some cases, to pay willing sellers;

3. Credit for return flow; and

4. Wheeling or conveyance of the water.

Central Valley Project water is identified in the Sacramento River contracts

as a base supply, project water supply, and total supply for the irrigation period of April through October. The base and project water supplies are negotiated values based on water rights and two water supply studies covering the 31-year hydrologic period 1924-54.

The USBR was somewhat limited in its attempt to purchase the Sacramento River contractors' project water supply for several reasons, including complexities brought about by internal requirements of the Sacramento River Water Contractors Association, a group counting numerous members as potential water bank suppliers. Furthermore, there was no way under the Emergency Drought Act to pay an individual farmer for his water if he had assigned his water rights to a water district under contract with the USBR.

Faced with these restrictions in purchasing contracted project water, the USBR looked to the possibility of purchasing base water supply which, during 1977, was obviously from CVP storage. The State Water Resources Control Board determined that, beginning in May 1977, there would be no natural flow water for Sacramento River appropriators above Sacramento, and that from June through August only about a 50 percent water supply would be available for riparians. It was apparent, therefore, that the only water available during May through October to Sacramento River contracts associated with appropriative water rights was entirely from CVP storage. Because limited water supplies were available for riparian rights, and because of uncertainties in riparian water requirements which could affect the available water supply, it was decided not to purchase project water allocated for those rights despite offers to sell.

The first USBR purchase of CVP-stored water from the contracted base water supply was from the Pleasant Grove-Verona Mutual Water Company. The company's shareholders had not made an assignment of their rights to the company, and because of this and the organizational setup, the company could, in turn, pay each of its participating shareholders. (The company's water rights included a small land area covered by the riparian right.) To complete the purchase transaction, the company transferred most of its project water supply to the association, retaining the total water supply allocated to its riparian right, and selling all of its remaining base water supply to the water bank. As a condition of the purchase contract, the company was required to leave fallow a land area based on the water quantities transferred and sold. Similar purchases were made from other Sacramento River contractors.

The second method of acquiring CVP water for the water bank was based on the potential for serving Sacramento River contractors' lands from ground water. When a contractor had wells capable of serving some or all of his lands, it was possible for him to cut back on diversions from the Sacramento River by increasing his ground water use. Surface water so conserved was identified as "conservation water" for purchase under the contracted base water supply. The first such contract was with the Pelger Mutual Water Company. Similar purchases of this type were made from other Sacramento River contractors.

Late in the irrigation season, the Sacramento River Contractors Association determined that 7.2 cubic hectometres (5,797 acre-feet) of project water was not needed by its association members, and this was also purchased for the water bank.

Altogether, the USBR was able to buy a total of 47.2 cubic hectometres (38,253 acre-feet) of CVP water. Coupled with the purchase from DWR, this brought total purchases to 57.3 cubic hectometres (46,438 acre-feet). The quantities of water purchased, the unit costs, and the total costs are reflected in Table 8.

In cases where suppliers let the land

TABLE 8

WATER SUPPLIED
TO
USBR WATER BANK
Acre-feet*

Supplying Agency	County of Origin	Amount Provided	Unit Cost	Total Cost
Department of Water Resources	Butte	8,185	$87.00**	$ 623,988
Chaplin-Lewis-Lewis	Sutter	1,279	$35.00	$ 44,765
Pelger Mutual Water Company	Sutter	4,425	$25.00	$ 110,625
Pleasant Grove-Verona Mutual Water Company	Sutter	15,752	$70.00	$1,102,640
Natomas Central Mutual Water Company	Sutter and Sacramento	6,000	$15.00	$ 90,000
Reclamation District No. 108	Colusa	5,000	$25.00	$ 125,000
Sacramento River Water Contractors' Association	Various	5,797	$15.00	$ 86,955
TOTALS		46,438		$2,183,973

* 1,000 acre-feet equals 1.2335 cubic hectometres.

** Estimated maximum unit cost, final costs will be determined in 1978.

lay fallow, CVP return flows were reduced and thus the amount of water available for reuse by the CVP was reduced as well. This decrease in return flow was charged against the water bank program, reducing the available water bank supply by an estimated 4.8 cubic hectometres (3,882 acre-feet). The estimate of 1977 return flow was based on measured 1976 return flow values as modified for anticipated 1977 conditions.

In summary, the water bank's brief but successful history saw some 57.3 cubic hectometres (46,438 acre-feet) of water purchased. After deducting 4.8 cubic hectometres (3,894 acre-feet) of return flow and wheeling losses, 52.5 cubic hectometres (42,544 acre-feet) of water were delivered to qualified Emergency Drought Act recipients.

The program proved successful in satisfying all requests for water used for survival of permanent crops and maintaining crops to support dairy and cattle herds; some water was left over for use in achieving maturity on other crops.

Governor's Drought Emergency Task Force

Executive Order No. B-27-77, signed March 4, 1977, by Governor Brown established a Drought Emergency Task Force

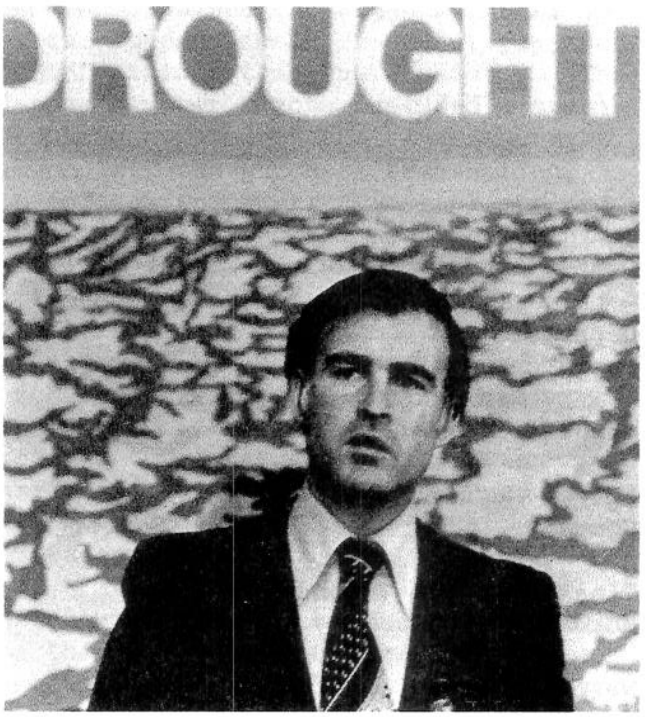
and named the Commander of the California National Guard as its Director. The Task Force was charged with the direction and coordination of all State efforts to alleviate drought-caused problems and the provision of public information regarding the nature and extent of the drought and means available to combat it.

Membership in the Task Force included the State Departments of Food and Agriculture, Water Resources, Forestry, and Military, the Office of Emergency Services, Public Utilities Commission, Energy Resources, Conservation and Development Commission, and the State Water Resources Control Board. Federal agencies participating included the Department of Agriculture's Soil Conservation Service, the Bureau of Reclamation, the Corps of Engineers, and the Geological Survey. Other participants were the University of California, Farm Bureau Federation, Association of California Water Agencies, and the Pacific Gas and Electric Company.

In discharging its duties, the Task Force attacked the problem on several fronts -- utilizing the educational, legislative, and direct assistance approaches.

On March 7, the Task Force Director chaired the Governor's Drought Conference held in Los Angeles. The Conference, attended by representatives of local, State, and federal governments, business, industry, labor, and consumers, stressed the need for and methods of conserving water in agriculture, urban areas, recreation, and landscaping.

Subsequent to the Drought Conference, letters were sent by the Governor to all California water suppliers strongly urging them to enact strict conservation measures. Additionally, the Task Force sent mailgrams to all counties requesting the identification of local drought problems and proposed solutions. This opened a communications channel for the exchange of drought information among all levels of government.



36. Governor Edmund G. Brown Jr. at the Drought Conference on March 7, 1977.

Early in the year, the Task Force conducted regional conferences in Modesto, Bakersfield, Redding, Santa Rosa, and San Diego to gather first-hand information on the seriousness of the drought in each local area, and to provide a forum for public input on ways to solve local problems.

Based on the input from those meetings, the Task Force began working with the California Congressional Delegation, through the State of California's Washington office, to help formulate federal drought legislation.

Testimony was presented before several congressional groups, including the House Committee on Small Business. Briefings were also conducted for the California Congressional Delegation and individual congressmen.

Task Force staff also met with the Western Regional Drought Action Task Force (formed by the Western Governor's Conference in February 1977 with membership from all western States) to develop a

unified voice at the federal level. As a result of efforts of all the states affected, the Community Emergency Drought Relief Act of 1977 was enacted providing aid to drought-stricken communities. The Task Force worked closely with the Economic Development Administration to identify drought-related problems and expedite relief measures. Subsequent meetings with federal agencies have resulted in recommendations for improvement in drought programs.

State legislation directly related to financial assistance for California's agriculture and livestock operators in drought-affected areas was also introduced. This legislation, described elsewhere in this report, provided moneys for property tax relief for rangeland and grassland ranchers, as well as exemption of livestock from head-day tax during drought emergency periods. Additional State legislation waived the requirements for special bond elections and environmental impact reports in order that drought relief projects could be undertaken immediately.

The Task Force had a direct hand in State legislation, providing briefings to members of the Legislature and testimony before legislative committees, including a joint hearing before the Assembly Agriculture and Water Committees.

Educational activities occupied much staff time. The Task Force provided the keynote speaker at the annual Conference of the Associated Drilling Contractors and stressed the importance of their assistance in helping to solve immediate emergencies.

Members of the Task Force made presentations at community water resource management workshops sponsored by DWR and the Office of Emergency Services.

Task Force members served as panel members at an Education Conference sponsored by the California State University and Colleges to advise teachers of materials and methods available to incorporate water and energy conservation into curricula where appropriate. It also met with the deans and presidents of the California university and college system to develop appropriate study programs in connection with the drought.

A letter was sent to various water agencies/associations requesting that they consider water banking and water pooling practices to avoid undue hardships and/or penalties on users already practicing maximum conservation.

The Task Force met with the Northern California Turf Grass Council to develop information for the public on proper care and types of plants to be used in drought areas, the League of California Broadcasters to discuss the use of a multimedia public eduation and water conservation program, and addressed the Pacific Coast Builder's Conference in San Francisco to discuss the effects of the drought on the building industry and to urge development of new ideas which would provide long-term benefits in the area of water and energy conservation.

The Task Force distributed to local government a document prepared by the Western Regional Drought Action Task Force outlining the various federal programs available, the basic eligibility requirements, and a list of persons to contact.

The Task Force also developed and released a directory of State Agency Drought Assistance Responsibilities. This document, distributed to county boards of supervisors, emergency services directors, and agricultural commissioners, outlined the types of problems and the assistance needs found or anticipated, and at the same time identified alternative measures to meet those needs and the agencies responsible for the service.

In cooperation with the Department of Food and Agriculture, a "Projected 1977 California Agricultural Drought Report"

was released detailing the economic outlook in agriculture due to drought conditions.

In January 1978, it released its "Alternative Drought Strategies for 1978", a comprehensive report detailing the impacts of the drought, discussing alternative strategies to deal with its continuation, and summarizing assistance programs available.

In direct assistance efforts, the Task Force:

1. Ordered the National Guard to move ten 3,000-gallon collapsible, fabric water tanks to various locations in Northern California to be readily available to assist small communities in case of emergency. These tanks were subsequently used by the Department of Forestry and several communities to provide emergency water supplies.

2. Coordinated the loan of additional State water trucks to several counties for emergency water hauling.

3. Met with members of the Soboba Indian Tribe to solve an emergency drought problem on the reservation.

4. Arranged for Caltrans to make front-end loaders available to assist the Department of Parks and Recreation in cleaning up damage from the forest fires in Big Sur and Santa Barbara.

5. Worked with the U. S. Bureau of Reclamation to procure funds for a winter cloud seeding program.

6. Requested National Guard water tank trucks be sent to Marin and Sonoma Counties to assist dairy farmers in hauling water to cattle until more permanent measures could be implemented.

7. Issued regulations governing the use of state vehicles in order to maximize their effectiveness in assisting in drought-related emergencies.

8. Coordinated the movement of a cylindrical steel filter tank from Niland, California, to the Feather River Fish Hatchery in Oroville, used to improve fish production capacity at the Oroville station.

9. Arranged for a summer cloud seeding program aimed at lessening fire danger and priming watersheds to allow earlier winter runoffs.

10. Met with representatives of the electric and gas utilities to formulate sharing and conservation plans.

Interagency Agricultural Information Task Force

In February 1977, at the request of the Department of Water Resources, a number of agriculturally oriented agencies assembled to address foreseeable drought-related problems.

Objectives of the group were to mobilize available information and resources of various agencies into a cohesive action program to (1) immediately develop and disseminate information to aid farmers in 1977 planting decisions, and (2) provide an ongoing source of information for prudent irrigation management and for other related agricultural problems.

Following a series of meetings, the group, now designated the Interagency Agricultural Information Task Force, formed a number of subcommittees staffed with individuals knowledgeable about a wide array of agricultural activities, ranging from crop evapotranspiration predictions to evaporation suppression on stockwater ponds.

Agencies providing this expertise included the Federal Soil Conservation Service; Bureau of Reclamation; Geological Survey; Agricultural Research Service; State Departments of Water Resources, Food and Agriculture; Water Resources Control Board; Geology and

Mines; University of California at Davis; UC Extension Service; and the Farm Bureau and Pacific Gas and Electric Company.

Approximately 325,000 leaflets, brochures, and booklets were distributed to the California farming community, principally through the Soil Conservation Service, UC Extension Service, Drought Information Center, and numerous county fairs. Some 19 publications are listed in the accompanying Bibliography under State of California, Interagency Agricultural Information Task Force. Several examples are contained in Appendix E.

Governor's Commission to Review California Water Rights Law

The two-year drought has underscored weaknesses in California's present laws governing use of water. California's water rights laws have undergone little change since the mid-1800s. The current legislation, much of it based on English common law riparian rights and appropriative water rights based on mining customs, and, after 1872, compliance with provisions of the Civil Code, is not only an obstacle to optimal water management practices, but also contributes to the waste of the State's scarce water resources.

On May 11, 1977, Governor Brown announced appointment of the Governor's Commission to Review California Water Rights Law. The Commission is reviewing current laws and is expected to recommend legislative changes in the laws governing water rights in California by December 31, 1978.

The staff of the Commission has prepared a series of reports presenting background material and water rights issues to assist persons who may lack detailed knowledge of California's water rights law and procedures. A total of six staff reports (which are listed in the Bibliography) have been prepared covering such topics as ground water rights and the legal aspects of water conservation.

In addition, the Commission held seven public workshops throughout the State:

- "Appropriative Water Rights in California", July 14, Sacramento.
- "Groundwater Rights in California", August 12, Los Angeles.
- "Legal Aspects of Water Conservation in California", September 13, Oakland.
- "Groundwater Rights in California", November 10, Chico.
- "Riparian Water Rights in California," December 8, Stockton.
- "The Transfer of Water Rights in California", January 12, Fresno.
- "Legal Aspects of Instream Water Uses in California", February 16, San Francisco.

Legislation at the State Level

In the California Legislature, by the end of 1977, over 50 proposals for drought-related legislation were introduced, and about one-third eventually became law.

A number of legislative measures were introduced to strengthen local water-saving measures and give the State authority, in some circumstances, to augment those measures.

A State emergency loan program -- first funded in 1976 as AB 3793 (Keene), Chapter 709, Statutes of 1976 -- was expanded through 1977 legislation, AB 395 (Gualco), Chapter 86, Statutes of 1977. The program provides loans to public agencies for emergency water supply facilities needed to relieve drought situations.

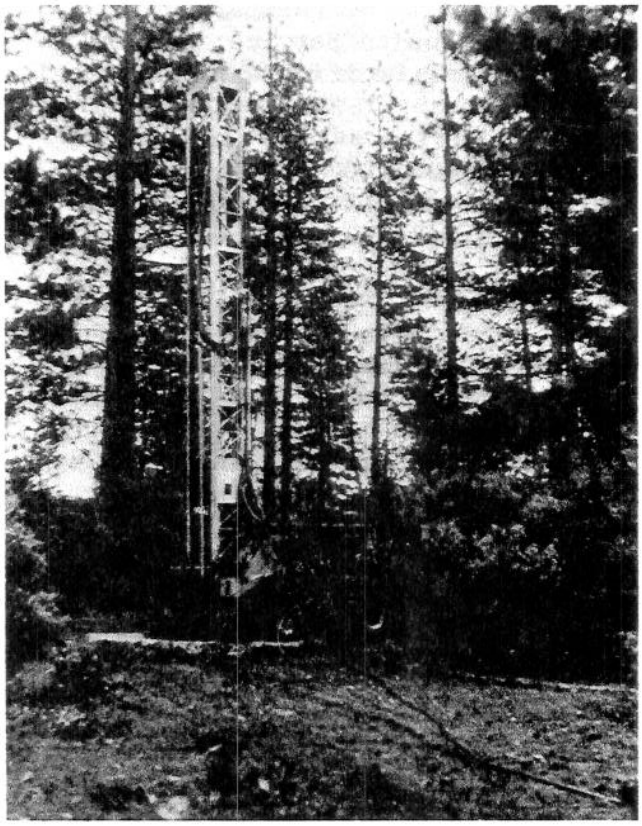
The 1977 legislation extended the program's authorization through calendar

year 1978, increased to $200,000 the maximum amount of a loan to a public agency with a maximum population of 200,000, and ended the $2 million loan limit on the total amount of loans. It is estimated that about $4.5 million will be available for drought-related emergency loans. The other bills enacted in 1977 are described as follows:

AB 127 (Fazio), Chapter 233, Statutes of 1977 -- Provides funds for construction of temporary rock barriers in the Delta. The program of barrier installations and consideration of their effectiveness is described in other sections of this report. (The funds provided were not used when federal funds became available.)

AB 314 (Chappie), Chapter 78, Statutes of 1977 -- Authorizes irrigation districts and California water districts which do not have volumetric measuring facilities to measure substantially all agriculture water to be delivered to determine the annual requirement for water to grow each crop grown or likely to be grown in the district. Applies to allocations in years of inadequate water supply, such allocations based upon crop acreage and proposed crops to be grown. Provides a means of measuring the allocation of water to land based on the type of crop grown and does not authorize a district to designate the crops to be grown on such land.

AB 380 (Gaulco), Chapter 28, Statutes of 1977 -- Appropriates $600,000 from the General Fund to the Department of Water Resources to undertake a pilot water conservation program to determine the feasibility and public acceptance of certain water conservation devices. Requires the study to be undertaken in at least three communities selected by the Director of Water Resources. Requires the funds to be commingled with other federal, state and local funds. The Department of Water Resources estimates that at a 30 percent installation rate, the pilot program would save energy worth $1,050,000 per year and would save 5.4 cubic hectometres (4,380 acre-feet) of water with a value of about $175,000 per year. The program actually undertaken and the preliminary results are described elsewhere in this report.



37. Emergency aid to a small community. Shown are the well drilling operations for Lime Saddle CSD, recipient of a low-interest loan under the Davis-Grunsky drought program.

AB 394 (Gualco), Chapter 18, Statutes of 1978 -- Provides authority to extend, until September 30, 1978, the dates for completion of projects financed by emergency federal drought loans without local elections or environmental impact reports.

AB 446 (Fazio), Chapter 169, Statutes of 1977 -- Gives the Governor explicit authority to declare a state of emergency due to a "sudden and severe energy shortage." Gives local authorities the power to declare a

"Local Emergency" due to an energy shortfall. This measure is designed to render the State capable of taking the quick and decisive actions which may be required to deal effectively with an energy shortage.

AB 776 (Fazio), Chapter 476, Statutes of 1977 -- Appropriates $10 million from the General Fund to provide property tax assistance on nonirrigated land used for producing livestock or planted crops in areas declared to be in a state of disaster due to drought conditions.

This direct property tax relief program is administered by the Director of the Department of Food and Agriculture. Eligibility for this program, which ends June 30, 1978, is based upon an average gross income from farming of at least $5,000, but not more than $500,000. This income must represent at least 75 percent of the average total gross income from all sources.

Assistance granted will not exceed the lesser of 75 percent of the property taxes on the land for the 1977-78 fiscal year or $.50 per acre[1/] of unplanted rangeland and $1.00 per acre[1/] for land on which grain or other crops were planted. AB 776 applies to both Williamson Act and non-Williamson Act land.

Any assistance granted to an owner based on the use of a lessee would be transmitted by the owner to the lessee either in the form of a reduction in rental payments or a cash refund.

AB 1784 (Papan), Chapter 1032, Statutes of 1977 -- Prohibits the use by public agencies of potable domestic water for the irrigation of greenbelt areas where reclaimed water is found by the State Water Resources Control Board to be available for such use under specific conditions.

AB 1954 (Gualco), Chapter 634, Statutes of 1977 -- Authorizes public water entities which supply water at retail for the benefit of the inhabitants of the public entity to adopt and enforce, by ordinance or resolution, conservation programs in order to conserve water during normal water supply periods as well as during emergency periods. Requires the public entity to hold a public hearing prior to adoption of the water conservation program. Violation of the adopted program is a misdemeanor, punishable by a fine and/or imprisonment.

ACR 16 (Gualco), Resolution Chapter 10, Statutes of 1977 -- Requests all local government agencies which supply water to immediately evaluate their local water supplies and needs and institute all appropriate water conservation methods. Requests the Department of Water Resources to provide technical assistance to public agencies in evaluating water supplies and demands and in implementing water conservation programs.

Twenty-one water conservation methods which should be considered are listed in ACR 16.

SB 358 (Nejedly), Chapter 581, Statutes of 1977 -- Adds "drought" and "sudden and severe energy shortages" to the list of specific conditions which constitutes a "state of emergency" and a "local emergency" as defined in the California Emergency Services Act.

With respect to regulated energy utilities, a "severe and sudden energy shortage" would be such that it would require extraordinary measures beyond the authority vested in the California Public Utilities Commission.

1/ One acre equals 0.40469 hectare.

SB 469 (Zenovich), Chapter 1235, Statutes of 1977 -- Appropriates $1,000,000 for preventive measures and emergency repairs needed as a result of damage to watersheds by forest fires.

SB 795 (Stiern), Chapter 188, Statutes of 1977 -- Under existing law, water storage districts may issue revenue warrants maturing not more than 5 years from the date of issuance, sold at less than par or face value to yield not more than 7 percent per annum, and in an amount not in excess of $1,000,000 in any one fiscal year. SB 795 changes the yield on sales at less than par or face value to 8 percent and, if issued prior to August 1, 1978, extends the maturity to 10 years and increases the amount in any one fiscal year to $4,000,000.

SB 1033 (Vuich), Chapter 173, Statutes of 1977 -- Existing law provides for the imposition of a tax on certain livestock in lieu of the property tax, and allocates the revenue derived from such tax to local agencies on the basis of the number of days livestock are within each jurisdiction.

SB 1033 exempts qualified livestock owners from livestock head-day tax during any period declared by the Governor, or by the President or a federal official at the request of the Governor, to be a drought emergency. Such exemption would apply for specific periods, unless extended due to a declaration by the Governor that the drought emergency still exists.

Provides for reimbursement by the state for the loss of revenue that would result from this exemption. Under current law, a tax of $.005 per day is imposed on certain bovine animals and $.00055 per day on sheep, in lieu of the property tax. During 1976-77 the livestock head tax produced $2.4 million for local governments.

SB 1034 (Vuich), Chapter 1100, Statutes of 1977 -- Allows authorized taxpayers a credit against the bank and corporation tax and personal income tax equal to the lesser of 10 percent of the cost, or $500, for the installation of any water application or distribution equipment. The equipment must be used in the production of income and its use should result in the improvement of agricultural irrigation efficiency through the reduction of water usage. This credit is available to taxpayers meeting specific income requirements and only for the year in which the equipment is installed. The agricultural land so affected must be owned and controlled by the taxpayer and have been cultivated and irrigated during any growing season from January 1, 1971 to December 31, 1976. This credit would be in addition to any deduction to which the taxpayer otherwise may be entitled. SB 1034 will be in effect only with respect to taxable and income years ending on or before December 31, 1980, at which time it is repealed.

State assistance in the form of livestock head-day tax relief under SB 1033 and property tax relief under AB 776 was made available in all but six counties of the State. (See Figure 23 for areas eligible.)

Water Conservation

On January 3, 1977, as public agencies became increasingly concerned with dwindling water supplies and the continuing sunny skies carrying little promise of replenishment, these concerns and their factual basis were conveyed to the people in Governor Brown's State-of-the-State message. This was followed on February 11, 1977, by a rare telegram message from the Governor to over 1,000 local water agencies requesting their plans for dealing with the impending

Figure 23.
COUNTIES ELIGIBLE FOR STATE SPONSORED ASSISTANCE

shortage. Urban response was immediate as urban areas throughout the State demonstrated a surprising awareness of the need for conservation. Voluntary conservation programs were instituted in virtually every community, and, by April, many of the cities, towns, and hamlets, including nearly all of the major Northern California communities, were under some form of mandatory conservation.

Mandatory conservation generally took either one of two forms: (1) a mandated reduction from the previous year's use, in percent; or (2) a quota, usually expressed in gallons per day per person or per household. Almost all programs placed restrictions on the outdoor uses of water, such as car washing, hosing off sidewalks and driveways, and watering lawns and shrubs. Landscape use, if not banned altogether, often was limited to early morning or early evening hours on certain specified days of the week. Table 4 in the February 15, 1977,

"Update" listed examples of specific actions taken by communities in 1976.

In 1977, actions were generally similar but considerably more extensive. It was estimated that over 150 communities were involved in some form of mandatory conservation at the height of the problem. Approximately 6-1/2 million, or nearly one-third of all Californians, were participating in mandated programs. Voluntary programs were engaged in by nearly all other Californians.

That the conservation programs were effective cannot be denied. In its February 15, 1977, report, "The California Drought-An Update", DWR had observed that 1 233 cubic hectometres (1,000,000 acre-feet) of water could be conserved in 11 of the State's major urban areas (accounting for 80 percent of the State's urban use) simply by cutting back 25 percent -- then believed to be, as now, an achievable goal. Final figures for 1977 indicate that California urbanites saved, on the average, over 20 percent. When adjusted by total urban population, this figure translates to a total saving of over 1 233 cubic hectometres (1,000,000 acre-feet) -- a remarkable achievement.

Table 9 documents the savings achieved in 1977 compared to 1976 use in terms of volume, per capita consumption, and percentage in 38 of the State's population centers. It illustrates another point made in the February 1977 "Update" -- that water conservation depends upon user motivation. It is clear from Table 9 that the higher conservation rates were achieved in those communities closest to the spectre of emptied reservoirs. The category included those communities served by East Bay MUD, Marin MWD, El Dorado ID, and Paradise ID. Other communities in the same general area as those most impacted usually showed high conservation rates also. Those areas farthest from the immediate problem of nearly emptied reservoirs, including large population centers in the south State such as Los Angeles and San Diego, showed a less strong response.

Just as the water conservation effort was strongest in those areas most impacted by the drought, public reaction also varied according to the availability of water. Few people felt inconvenienced at the request to decrease consumption, and most people voluntarily reduced their consumption just by modest habit changes.

Residents of Southern California had mixed feelings about the drought. With three water importation systems (Los Angeles Aqueduct, Colorado River Aqueduct, and SWP) and ground water supplies, water demands were met and many people did not believe that a drought actually existed. A few of their comments are listed below:

- "Agriculture uses most of the water, what I save in my home won't help any."
- "Why should I use less water? It's not going to save me money; the rates are going to be higher."
- "I don't mind spending extra cash for water, and I don't have to conserve. There's no drought anyway."

However, the greater majority of Southern Californians recognized that they live in an arid land and there is a lot more to meeting water needs and sustaining life than turning on a water tap or flushing a toilet. As a result, people wholeheartedly supported water conservation programs which curtailed and restricted water uses, and many offered helpful water conservation ideas and suggestions.

In the San Francisco Bay Area, where water supplies were limited, people responded so well that water conservation took on a fashionable trend. Many residents expressed outright anger at Southern California, accusing them of stealing precious water from the north and wasting it to maintain lush yards

TABLE 9
WATER USE BY MAJOR URBAN AGENCIES

Agency	Water Use (1,000,000 gallons)*			Per Capita Consumption (gallons per day)		
	1976	1977	% change	1976	1977	% change
Northern California						
Alturas	330	351	+6	303	323	+7
Eureka	1,265	1,150	-9	141	129	-9
Redding	2,142	1,939	-9	153	139	-9
Subtotal	3,737	3,440	-8	156	143	-8
Bay Area						
Alameda Co. WD	10,077	7,325	-27	158	115	-27
Contra Costa Co. WD	39,036	29,228	-25	179	134	-25
Daly City	2,888	1,988	-31	116	80	-31
East Bay MUD	81,185	48,407	-40	212	127	-40
Hayward	5,802	3,946	-32	170	115	-32
Marin MWD	7,778	3,744	-52	126	60	-52
Monterey Bay	4,231	2,770	-35	167	106	-37
North Marin WD	2,503	1,585	-37	144	91	-37
San Francisco	37,704	26,417	-30	155	109	-30
San Jose	42,407	33,622	-21	182	144	-21
San Mateo	4,646	3,046	-34	133	87	-35
Santa Clara	7,812	6,253	-20	236	189	-20
Santa Cruz	3,492	2,210	-37	174	110	-37
Santa Rosa	4,766	3,051	-36	163	104	-36
Sunnyvale	8,053	5,942	-26	207	153	-26
Subtotal	262,380	179,534	-32	180	123	-32
Central Valley						
Bakersfield**	15,764	13,990	-11	322	256	-20
Chico**	5,271	4,480	-15	324	275	-15
Fresno**	22,158	18,075	-18	307	245	-20
Merced**	4,410	3,745	-15	355	292	-18
Modesto**	11,391	9,594	-16	354	284	-20
Sacramento**	28,441	23,865	-16	299	238	-20
Stockton	10,372	8,268	-20	191	153	-20
Subtotal	97,807	82,017	-16	295	237	-20
Sierra Foothill						
El Dorado ID	3,179	992	-69	314	78	-75
Paradise	1,849	640	-65	264	92	-65
Sonora-Jamestown	587	449	-24	201	148	-26
Subtotal	5,615	2,081	-63	280	91	-68
Southern California						
Anaheim	18,287	16,347	-11	249	218	-12
Long Beach	22,444	19,251	-14	173	149	-14
Los Angeles	198,059	166,377	-16	196	165	-16
Oxnard	5,756	5,735	0	183	171	-7
Riverside	14,595	13,494	-8	250	209	-16
San Diego	53,566	51,993	-3	190	180	-5
San Luis Obispo	2,151	1,994	-7	169	150	-11
Santa Barbara	4,725	4,153	-12	179	157	-12
Santa Maria	2,631	2,416	-8	215	195	-9
Ventura	6,864	5,944	-13	257	219	-15
Subtotal	329,078	287,703	-13	198	171	-14
Total Reported	695,438	553,783	-20	199	157	-21

* 1,000,000 gallons = 3.07 acre-feet = 3 785.4 cubic metres..

** Predominantly unmetered.

and gardens.

Generally speaking, the drought made people more aware of the complexities of getting water to their faucets, and they became more water conscious. They found, too, that saving water saves energy, and that the use of drought-tolerant and native vegetation around the home can prevent expensive losses in the event of another drought.

Figure 24 shows the 1977 monthly water usage, in terms of per capita consumption, compared to 1976 use for eight selected urban areas. In nearly all cases, the greatest reduction occurred in the summer months. This is believed to be occasioned by the greater savings possible then by reduced outside-the-home uses. Since little such use ordinarily occurs in the winter months, most wintertime savings must be accomplished by reductions within the home -- necessarily of somewhat more limited scope. Comparisons, such as Figure 24, also show the effect of variations in weather from year-to-year. A cold, rainy month such as May 1977 shows usages much lower than its counterpart in 1976 which was relatively warm and rainless.

The news media took an active role in informing the public and supporting conservation efforts. Hardly a day went by without some mention of the drought in newspapers, radio, and television. In fact, the "Drought" was voted top-rated California news story for 1977, following a near-top rating in 1976. Examples of support of the conservation ethic are shown in water conservation charts and figures appearing regularly in local newspapers and reproduced here. The old adage that, "A well-informed public can make its own decisions" was adequately demonstrated by results achieved.

Citizen acceptance of the conservation ethic in many communities was so extensive that unit prices of water had to be raised to prevent water dispensers from losing money. In some communities, rationing programs were relaxed in an effort to help the dispensing agencies financially. The Department publicly protested any relaxation of water-saving efforts, pointing out that they were an illogical solution to the problem as long as the scarcity of water existed. It was noteworthy in 1977 that even in those communities which relaxed their rationing demands the customers continued to pursue water-saving practices.

Sixty-one agencies of the State initiated conservation programs on State-owned or supervised properties, both to conserve water and to serve as examples to communities and the general public.

The Department of Parks and Recreation, for instance, reduced water use at Cal-Expo. At its State parks, it restricted landscape watering, installed low-flow showers, spring-loaded or self-closing faucets, low-flush toilets, and toilet dams. In some areas, it closed restrooms and substituted chemical toilets.

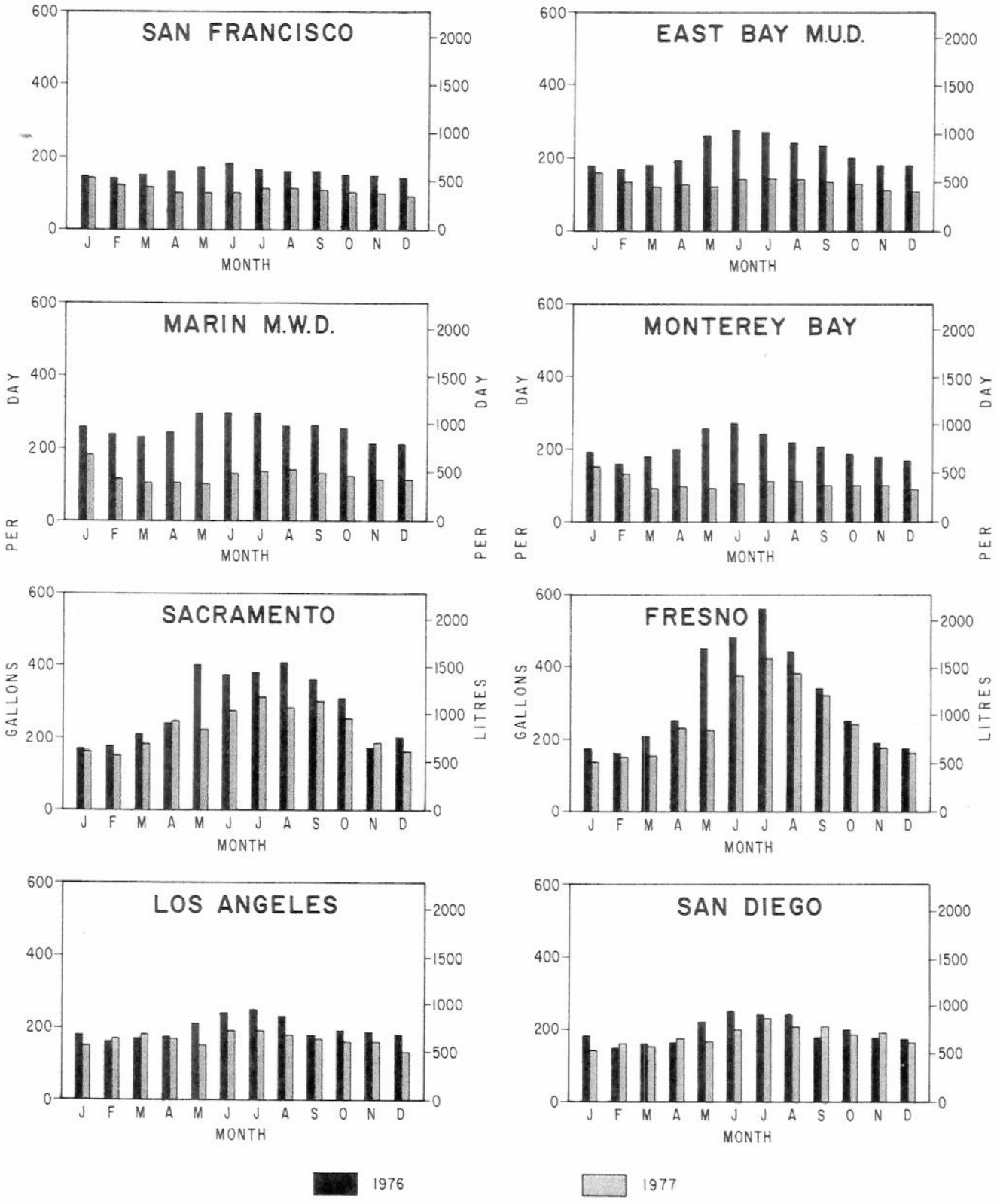
The Governor's Office of Emergency Services (OES) conducted community water resource management workshops in various locations around the State. Financed under a federal grant, the program was for community water managers and local officials and dealt with the technical, managerial, and physical aspects of developing and operating local water conservation and community water management programs. The workshops were sponsored by DWR, Valley Regional Training Center, County Supervisors Association of California, League of California Cities, and the Association of California Water Agencies, in addition to OES.

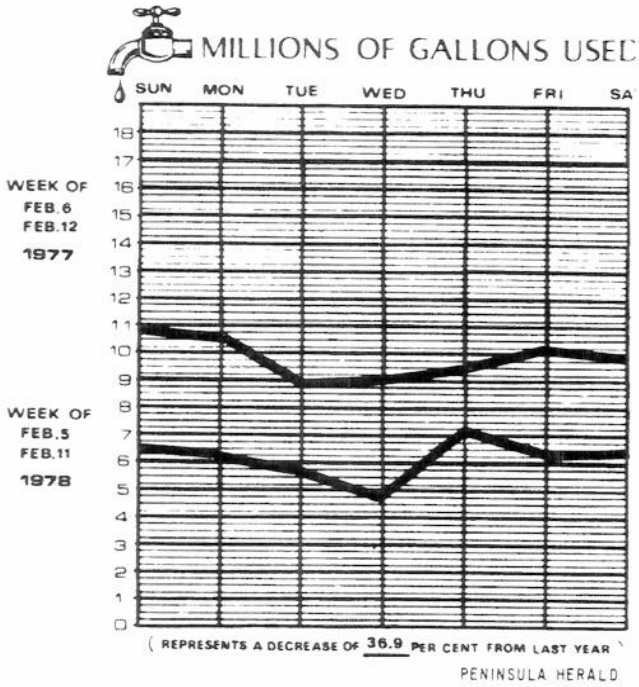
An industrial drought conference bringing together State and local officials, water and sanitary agencies, and representatives from industry and manufacturing was held in late July. Two conference sections, one in Northern California (Concord) and one in Southern California (Los Angeles), convened to discuss on a statewide level strategies for water conservation and responses to the drought

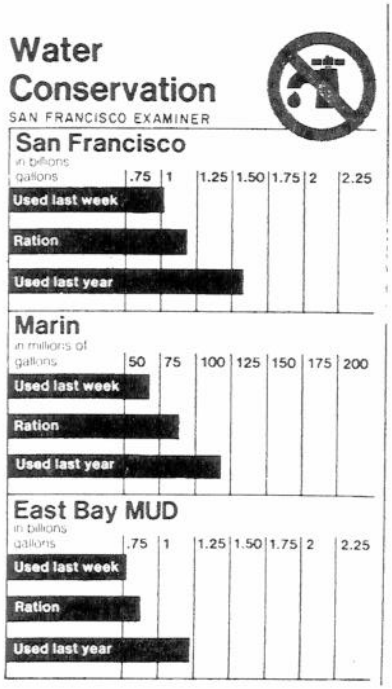
Figure 24.

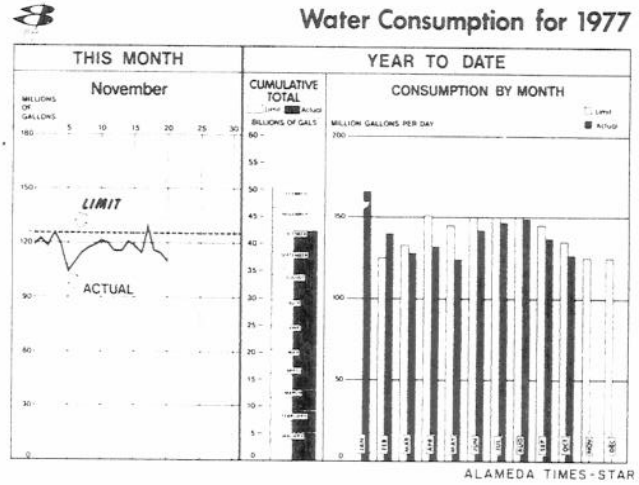
URBAN WATER USAGE IN 1977 COMPARED TO 1976

(Gallons or Litres per Capita per Day)





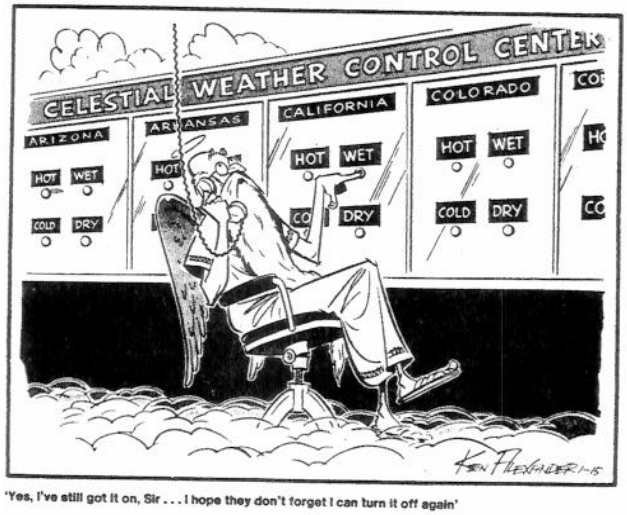




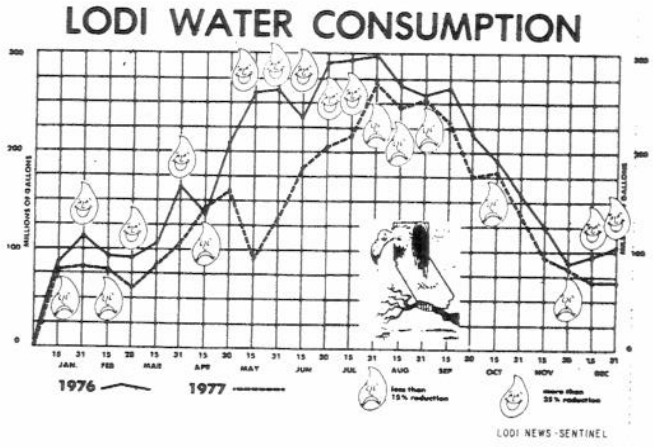
38. The media campaign for water conservation. Shown are examples of information provided by local newspapers.

Page 2 Section B ☆☆☆ Jan. 15, 1978 S.F. Sunday Examiner & Chronicle

Opinion / San Francisco Examiner

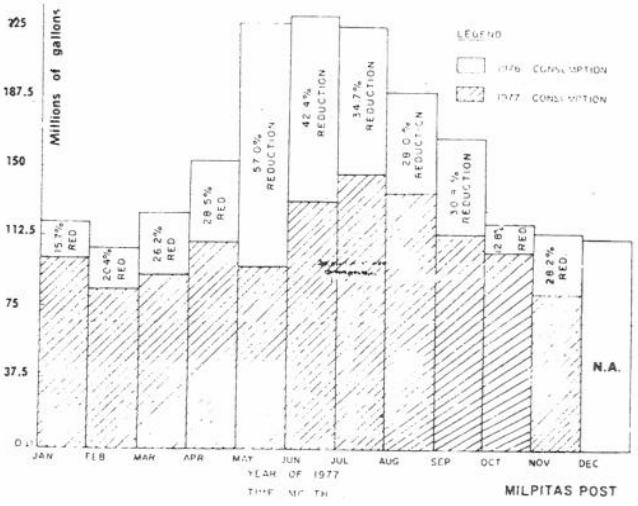


'Yes, I've still got it on, Sir . . . I hope they don't forget I can turn it off again'



AMY R., WHOM YOU SEE HERE CLUTCHING HER WATER BILL, JUST TOPPLED UNCONSCIOUS INTO AN OPEN-FACED BLT. WHY? HER FOUR YEAR OLD DAUGHTER LEFT THE GARDEN HOSE RUNNING AFTER FILLING HER JACK AND JILL SAND AND WATER PAIL THAT WAS BEFORE THEY LEFT FOR THE THREE-DAY WEEKEND AT WHAT REMAINS OF LAKE PILLSBURY. AMY, WHO LIVES IN MARIN, WENT BEYOND HER WATER ALLOTMENT BY A FACTOR OF NINE.

San Francisco Examiner



situation to prevent economic dislocations and loss of jobs. Technical information regarding water conservation was shared among those in attendance, and some new and innovative water conservation methods were discussed. The sponsoring agencies were OES, DWR, and the California Manufacturers Association.

About 10 percent of the water users in the State do not have their water metered, although a study conducted by the SWRCB in 1974 indicated metering would cut consumption in those areas by 20 to 55 percent. Metering advocates say metering provides the means for both effective urban water conservation programs and establishment of equitable pricing systems.

Several bills were introduced in the Legislature to mandate water metering; some would provide part of the costs from the General Fund. To date, none of these bills have been passed.

These measures are controversial, primarily because of the money involved. The major opponents of the bills are the municipalities in the Central Valley area where flat rate service is predominant. In Sacramento County alone, it has been estimated that the cost of installing meters would exceed $15,000,000.

Agriculture, continuing a trend begun before the drought, in 1977 made some changes to drip and sprinkler irrigation from flood and row irrigation to effect an unmeasured amount of water conservation. As part of its "Economic Drought Impact Study", DWR is developing information on the extent to which agriculture shifted its water management practices during the drought. Results of the study will be available late in 1978.

It is expected that the study will show that, among other steps taken, there were varietal changes (switching to field crops requiring less water), some well reactivation, increased interest in Irrigation Management Scheduling (IMS), activation of the year-long fallow in some irrigated pasture areas, tilling to decrease weeds and preserve moisture, and increased interest in drip irrigation.

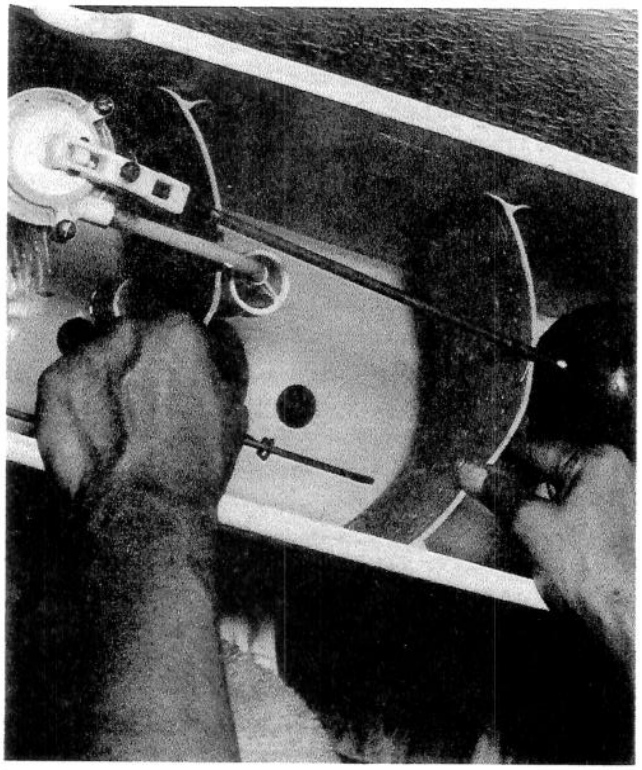
Some large irrigation districts in the southern part of the State took advantage of the drought to implement long-standing programs of water conservation, since many farmers were more receptive during this period. These programs will continue to benefit the farmers for many years to come by increasing irrigation efficiency.

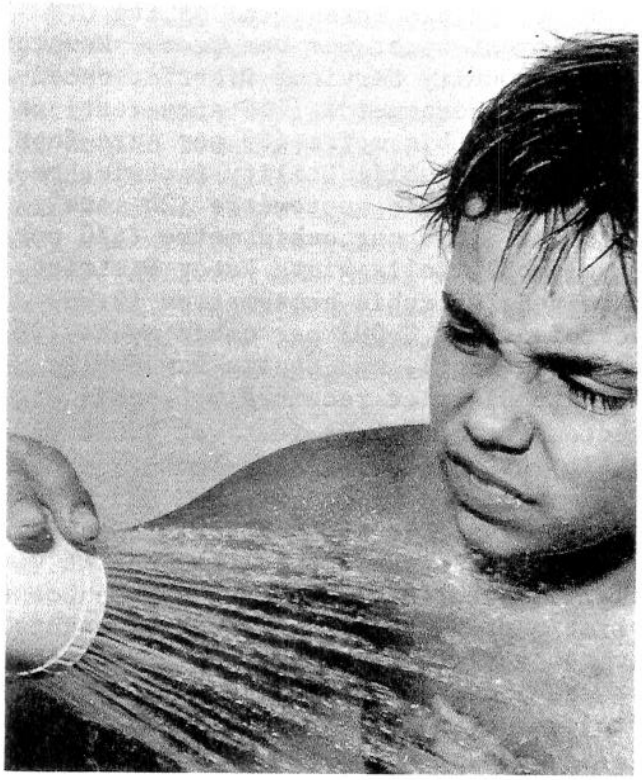
For example, Imperial Irrigation District initiated a fine which in effect tripled the normal water price to users when surface water runoff exceeded 15 percent of the water delivered each 24 hours. This created a multiplier effect encouraging farmers to repair leaks in field laterals and pipelines. IID also allocated $2 million a year for the concrete lining of irrigation canals to reduce water loss and erosion.

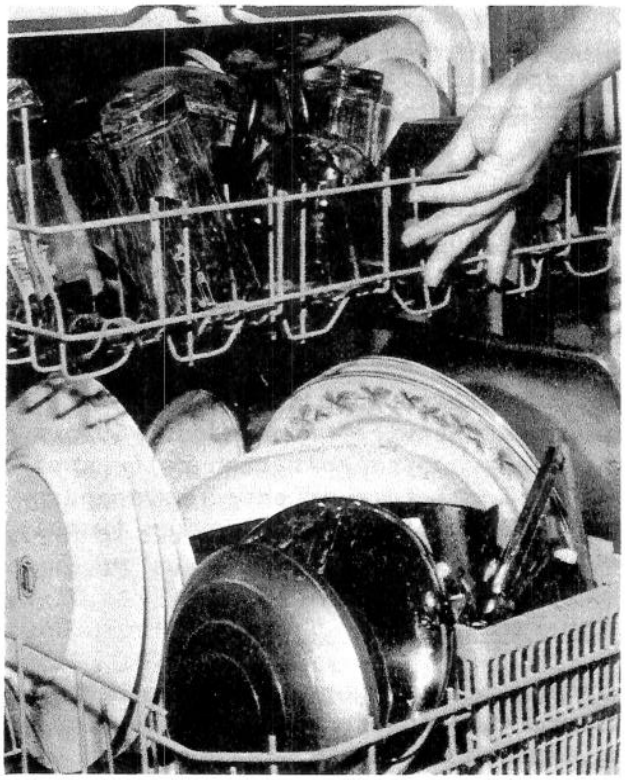
Coachella Valley County Water District also assumed this rate structure and extended its use of tensiometers. District farmers continued upgrading from furrow to sprinkler systems. More frequent land leveling was urged, and, in areas where land leveling was not actively practiced, the District stressed increased use of farm tailwater recycling systems.

Avocado farms within DeLuz Heights Irrigation District also increased their use of tensiometers and have installed a completely closed irrigation system. Hay was used extensively for mulching avocado and citrus trees to prevent erosion and evaporation. Tree counts were made continually to make sure that District water users did not decrease the spacing of trees beyond the Soil Conservation Service guidelines for maximum efficient water use.

One ingenious farmer in the San Pasqual







39. Water savers in action. These photos show the variety of water conservation practices and devices used by water-conscious individuals during the drought. Shown are: installation of toilet dams, brooming off a driveway instead of hosing it off, showering with a low-flow showerhead, and washing a full load of dishes.

Valley developed a soil compaction scheme on his sandy soil which he reported saves 50 percent of his water and increased his crop yield measureably.

Larger districts increased their public information programs, aiming at both the farmer and the general public. Many farmers took advantage of various loans made available through the State and Federal Governments and upgraded stock ponds, wells, irrigation equipment, and initiated tile drainage in areas where the cost would normally be prohibitive.

Irvine Water Company has an ongoing program to reclaim waste water and resell it to agricultural users at a 20 percent discount. Oceanside also has such a plan when the San Luis Rey plant is completed. Its treated waste water can be used both on tree crops as well as for grasses. Finally, South Laguna has used the publicity of the drought to aid it in implementing a similar program.

Although the irrigation districts served by Colorado River supplies reduced water usage, there was an overall increase in irrigated acreage to offset the reduction of irrigated lands in the San Joaquin Valley.

In 1977, greater emphasis was placed on providing information useful to the individual farmer in assessing water needs and in conserving that which was available. The USBR, DWR, and the University of California Agricultural Extension Office cooperated with the Irrigation Management Service to make such information as evapotranspiration rates available to local farm-oriented newspapers and radio stations on a regular (weekly) basis.

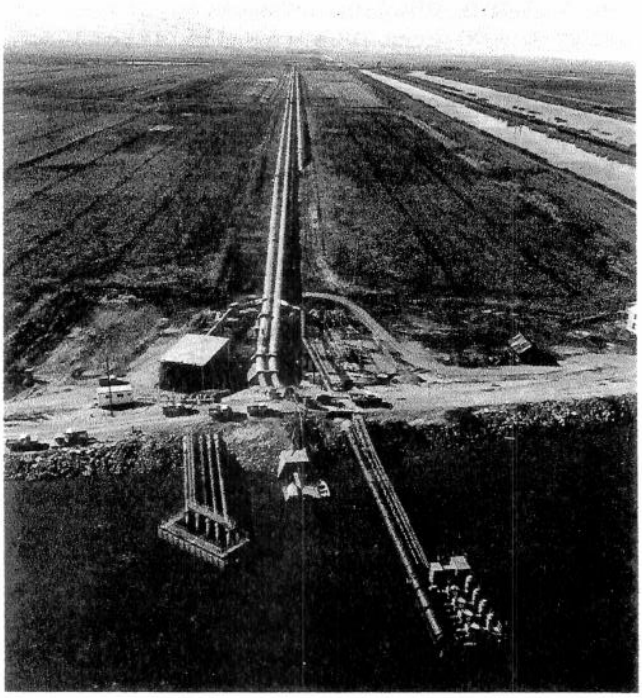
Water Exchanges and Transfers

Existing water rights law and other institutional requirements provide serious impediments to the free transfer of water in California, and it is believed by some that the obstacles have hampered the efficient use of the resource. This is discussed in Staff Paper No. 5, "The Transfer of Water Rights in California", by the Governor's Commission to Review California Water Rights Law and the reader is directed to that paper if background material is desired.

Despite the difficulties imposed by existing constraints, there were a number of successful water exchanges during the drought, whereby regions with sufficient water shared that water with those less fortunate. Among the largest were those in which the Department of Water Resources participated, notably the release in 1977 by four Southern California water agencies of 537 cubic hectometres (435,279 acre-feet) of SWP entitlement so that the water could be used in the San Joaquin Valley and Central California. These and other DWR-sponsored exchanges are discussed elsewhere in this report.

There were other successes in this area. On March 17, 1977, the City of Redding signed agreements with four local water districts for the sale of 3.2 cubic hectometres (2,626 acre-feet) of its CVP entitlement water for one year. Mountain Gate Community Services District received 0.1 cubic hectometre (100 acre-feet) at $.007 per cubic metre ($9 per acre-foot), Summit City Public Utility District received .03 cubic hectometre (26 acre-feet) at $.016 per cubic metre ($20 per acre-foot), Bella Vista Water District received 2.5 cubic hectometres (2,000 acre-feet) at $.007 per cubic metre ($9 per acre-foot), and Shasta Dam Public Utility District received 0.6 cubic hectometre (500 acre-feet) at $.016 per cubic metre ($20 per acre-foot).

Redding was able to avoid legal problems facing other transferrers because it claimed water under federal CVP appropriations. The terms of federal rights to appropriate water contain broad place of use provisions which allow use of its project water throughout the Central Valley. Thus, the City of Redding and the U. S. Bureau of Reclamation (USBR) did not need to obtain a change of place of use order from the State Water Resources



40. An emergency water supply. This aerial view shows the two newly constructed pumping plants in the Sacramento-San Joaquin Delta at Middle River. EBMUD facilities are on the left and DWR's pumping plant appears at the right. Both plants were constructed in 1977 to provide emergency supplies of water pumped from the Delta into EBMUD's Mokelumne Aqueduct, shown stretching west with Mt. Diablo in the distance.

Control Board (SWRCB) before selling water to the local districts. The City avoided return flow challenges to the sale because the original use by the City did not create return flow claimed by any parties. The USBR, which has the authority to disapprove all sales of its water outside of the boundaries of its contractors, encouraged and approved this transaction.

Another successful 1977 exchange involved the Paradise Irrigation District (PID) and several other agencies. In May 1977, Butte County, the Pacific Gas and Electric Company (PG&E), and the California Water Service (CWS) negotiated an exchange agreement with PID involving an exchange of up to 0.7 cubic hectometre (540 acre-feet) of water. CWS holds appropriative rights to water from PG&E's Miocene Canal. For 1977, PG&E agreed to divert the CWS entitlement to PID and, in turn, CWS obtained replacement water through the purchase of a portion of Butte County's 1977 SWP entitlement. PID agreed to pay $11,205 to PG&E for the loss of water that could have been used for power purposes. CWS received $10,800 for the SWP charge, the administrative charge, and an additional pumping cost imposed by the exchange. Butte County obtained $5,211 for the loss of its SWP entitlement. As with the Redding transfer, the absence of return flow from original uses reduced the potential challenges to the agreement.

The problems attendant with water rights to return flows is illustrated by the proposed City of Roseville transfer which ended in failure. On August 10, 1977, the City of Roseville executed an agreement with four water users along Dry Creek for the sale of .01 cubic hectometre (8 acre-feet) per day of treated effluent discharged into the creek between April 1 and October 31 of each year. The City's water supply is imported water, purchased from the USBR. Under a one-year agreement, the City would sell the water to downstream users for $.0004 per cubic metre (fifty cents an acre-foot) with the option for annual renewal.

The SWRCB obtained a temporary restraining order enjoining the proposed four downstream users from using the water of Dry Creek under this agreement. The SWRCB noted that the City has discharged effluent into the creek since 1925 and that 32 downstream users currently hold licenses to appropriate the effluent. The SWRCB contended that the agreement would sell water that the City cannot properly claim. The court extended the temporary restraining order until December 10, 1977, to allow all parties to reach a private settlement. On November 30, 1977, all parties to the sale mutually agreed to terminate the agreement.

This litigation indicates the difficulties facing water rights holders who seek to sell their return flow. Clarity

as to the property rights in return flow could ensure a more efficient use of the resource.

The adjudication of ground water basins in Southern California has provided the basis for the development of an extensive ground water transfer market. Basin adjudication involves a negotiated agreement, spurred by litigation, which results in the allocation of pumping rights. Sellers transfer their rights by reducing pumping to the extent of the transferred amount, thus allowing the buyer to increase his pumping production.

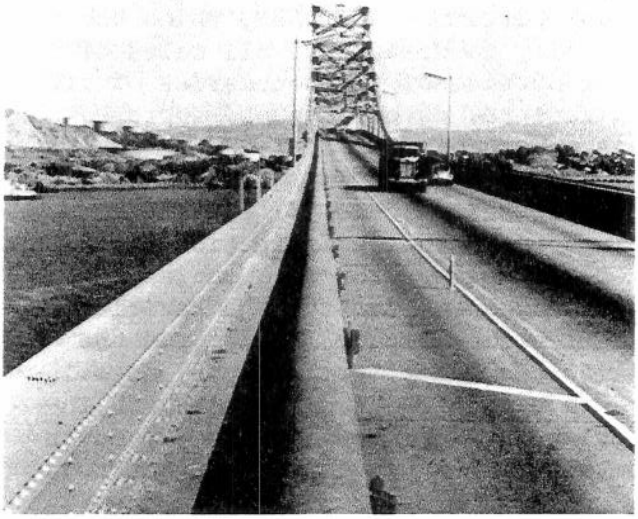
In 1965, the users of the Central Basin of Los Angeles County reached agreement as to the distribution of "Allowed Pumping Allocations" from the basin. In 1975, ground water users executed 246 transfers, primarily involving sales or leases, totaling 33.6 cubic hectometres (27,208 acre-feet). Such transfers accounted for over ten percent of the 268 cubic hectometres (217,367 acre-feet) allocated in the basin.

Ground water users of the West Basin of Los Angeles County reached a similar agreement in 1961 and transfers since have been extensive. In 1975, ground water users executed 38 transfers, accounting for 29.8 cubic hectometres (24,177 acre-feet) of water out of a total adjudicated right of 79.5 cubic hectometres (64,468.25 acre-feet) within the basin.

Although ground water transfers have been proven practical, they are not without pitfalls. This is particularly true in interbasin exchanges, although not without problems if confined within the basin. The obstacles to interbasin exchanges are illustrated by the proposed Anderson Farms transfer. In a June 8, 1977, letter the Berrenda Mesa Water District (BMWD) in western Kern County sought DWR consideration of a water transfer from Anderson Farms Company in Yolo County to BMWD using SWP storage and conveyance facilities. Anderson Farms Company owns or leases approximately 4 600 hectares (11,335 acres) in eastern Yolo County and claimed riparian and pre-1914 appropriative rights to the Toe Drain, a surface source west of the Sacramento River Deep Water Ship Channel. BMWD is a 21 400 hectare (53,000 acre) member district of the Kern County Water Agency and relies totally on imported water supplies from the SWP.

Under the proposed transfer, Anderson Farms would continuously pump ground water, which it would either discharge into the Sacramento River or use for irrigation on its land, and would reduce its surface withdrawals from the Toe Drain in corresponding degree. The SWP would then either reduce its releases from Oroville Reservoir or increase pumping from the Delta into its conveyance system to the amount Anderson Farms had pumped from ground water. This SWP storage would then be credited to BMWD.

On September 2, 1977, the SWRCB disapproved the proposed transfer finding it to violate the emergency regulations regarding export from the Delta, to be potentially contrary to the public interest, and to constitute an unreasonable



41. Water for Marin County. Shown here is the emergency pipeline on the Richmond-San Rafael Bridge as it approaches San Rafael. (Marin MWD photo.)

method of diversion under Article 10, Section 2 of the California Constitution. The transfer was not effected.

Ground water transfers encountered another obstacle in 1977, symbolized by several county ordinances enacted in attempts to regulate the export of ground water. Three counties adopted such ordinances; Butte, Glenn, and Imperial. Butte and Glenn's almost identical ordinances prohibit ground water mining for use outside of the ground water basin area and require users to obtain a county permit before using or selling ground water outside the ground water basin area. Imperial County's ordinance requires any person who intends to export water outside a designated "area of influence" to obtain a county permit.

Successful transfers occurred within the Kings River Service Area in the San Joaquin Valley. The Kings River Service Area encompasses approximately 28 water agencies within Tulare, Kings, and Fresno counties. In 1927, the water users of the Kings entered into an agreement to allocate the natural flow of the stream. This agreement, modified in 1949 and 1963, established a diversion schedule for all the parties, setting the quantity, time, and manner of diversion for each party. The agreement provides a framework for a water transfers market.

On July 7, 1977, Consolidated Irrigation District (CID) and Alta Irrigation District (AID), both users of Kings River water, executed a transfer resulting in the exchange of 21 cubic hectometres (17,000 acre-feet) of water. CID agreed to loan AID the water in exchange for replacement water at a later date. Member units of the Kings River Water Association executed at least two other transfers during the 1977 water year.

The federal water bank program in California has already been described in this report. The program utilized conveyance and distribution systems affecting 27 counties within the State to effect the transfer of water within the Central Valley.

Cloud Seeding

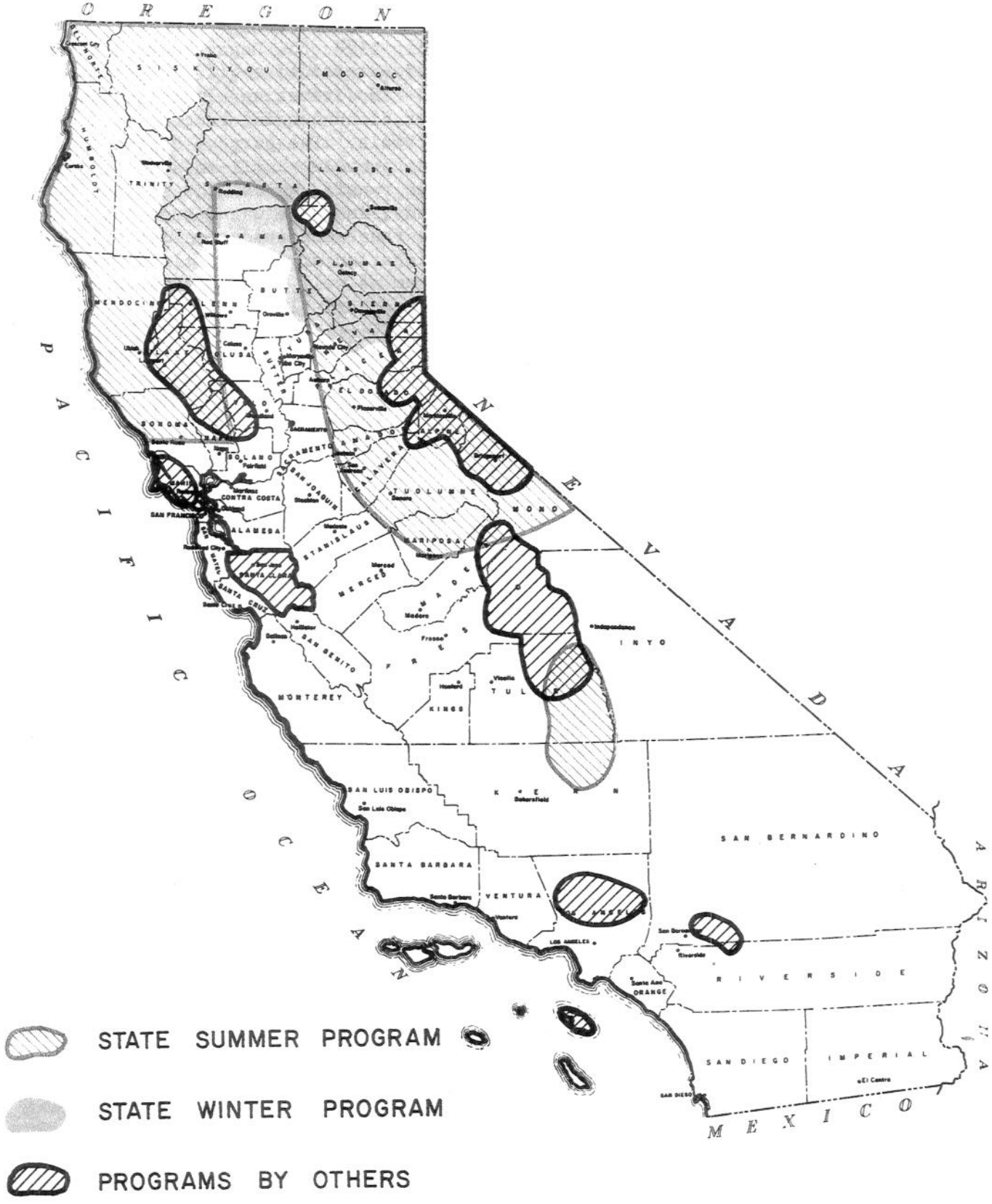
In July 1977, the Department of Water Resources awarded a $127,000 contract to Weather Modification, Inc. to initiate a summer cloud seeding program in Northern California. The purpose of the program was to provide a soil-moisture base for winter runoff, as well as reduce fire hazards, increase water supply and improve range conditions. Figure 25 shows the location of the DWR cloud seeding program as well as others undertaken in 1977 and early 1978.

The summer cloud seeding began on July 20 and ended on September 28, 1977, The Department's consultant concluded that 20 of the 47 seeding operations resulted in enhancing the precipitation. This high measure of success was largely due to the improved seeding procedure used. Airplanes were employed to disperse silver iodide nucleii using pyrotechnic flares into storms and clouds where they would be most effective. Some of the unsuccessful seedings had little hope for success and others may have produced some increase in the precipitation but it was not evident.

On December 19, 1977, a $289,000 contract was awarded to Atmospherics, Inc. to initiate cloud seeding operations over the northern Sierra Nevada and southern Cascade Range as part of the emergency drought relief program. Funded by PL 95-18, the Federal Drought Emergency Program, and administered by the U. S. Bureau of Reclamation, the primary purpose of the Northern California Weather Modification Program (NORCAL-WMP) was to produce water for storage, as an immediate effort to blunt the effects of the drought. Additional benefits would also accrue to vegetative cover, recreational areas, fish and wildlife, aquifer recharge, and improvement of water quality in the Sacramento-San Joaquin Delta.

Figure 25.

WEATHER MODIFICATION PROGRAM AREAS IN CALIFORNIA 1977-1978



In addition, a monitoring and evaluation program of the NORCAL-WMP focused on two principal areas: (1) the effectiveness of the cloud seeding, itself; and (2) immediate identification of detrimental environmental effects as a result of the cloud seeding effort (e.g. avalanche, flash flood, severe weather).

The program employed a total of 44 acetone/propane ground generators which use a stainless steel nozzle to spray the silver iodide/ammonium iodide/ acetone mixture into a flame chamber where it burns in the presence of propane. For the California program, a silver iodide solution strength of 2 percent (by weight) was used with a use rate of approximately 1 litre per hour (output of about 20 grams effective silver iodide per hour). Generators were placed throughout the target area on reasonably high ground where they could take advantage of the general windflow to move the silver iodide upward within the cloud structure to produce an effect in some downwind location.

Three aircraft equipped with silver iodide liquid fuel generators on each wing tip and 40 pyrotechnic seeding units were used to supplement the ground generator program. The aircraft were used not only for delivery of the cloud seeding material, but also for the measurement of air temperatures during seeding missions, estimates of liquid water content, ice crystal concentrations, and the actual cloud top temperatures.

The first seeding operations were conducted on January 11, 1978, targeted in the eastern parts of Lassen and Plumas Counties. Seeding operations continued until suspended on Sunday, January 15, at 1:19 p.m. due to heavy rains in Northern California. A total of 7 flights were flown during the operation.

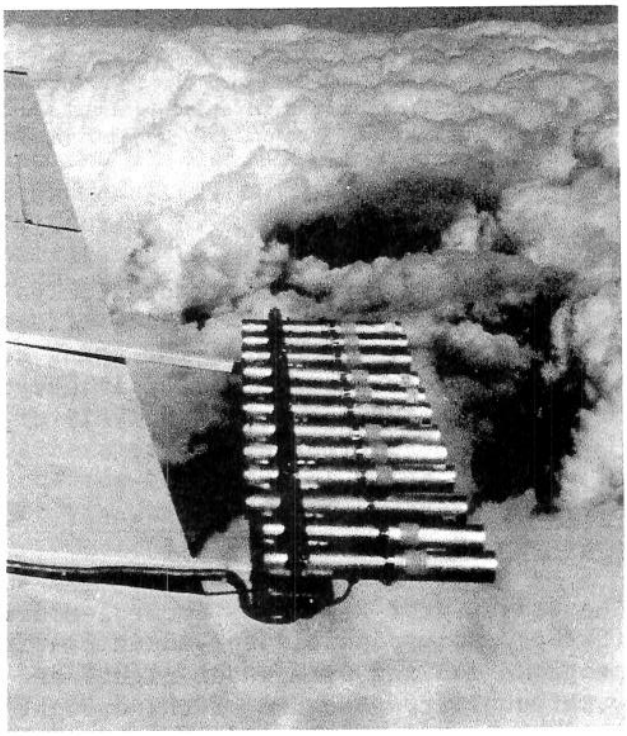
Selective seeding operations were resumed on February 1 and continued until February 6 in the Trinity and Feather River basins where reservoir levels were not yet up to normal and in Modoc County where precipitation was below normal. Seven flights were made during this period.

As a result of the heavy winter precipitation, cloud seeding operations were cancelled effective February 28, 1978.

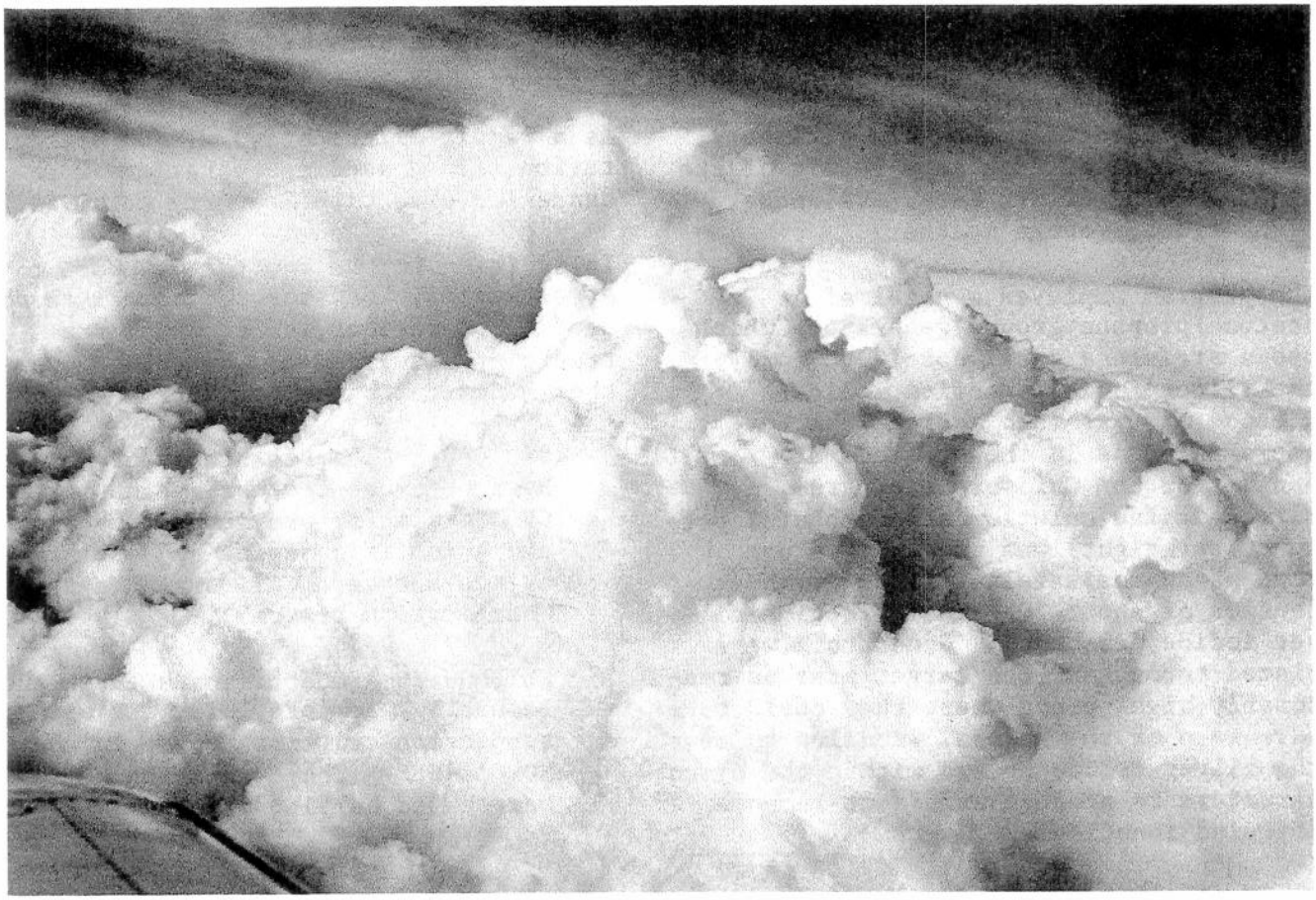
In addition to the contract awarded to Atmospherics, Inc. for the actual cloud seeding operations, three other contracts were awarded as part of the weather modification program.

- $10,000 to the Department of Navy, Naval Weapons Centers, China Lake, California for providing technical and scientific advice and assistance on the Northern California Weather Modification Program.

- $15,000 to Atmospheric Research and Technology for providing DWR with suspension criteria to use in the NORCAL-WMP. The suspension criteria were based on flooding and avalanche



42. Cloud seeding by plane. Pyrotechnic seeding devices are shown while the seeding aircraft is in flight. Silver iodide nuclei are dispensed to produce rainfall more efficiently than if the clouds were left unseeded.



43. Does it work? This photograph illustrates the difference between a non-seeded cloud (seen in the foreground) and a seeded cloud (background). The "fuzzy" appearance of the seeded cloud results from the release of silver iodide nuclei which convert supercooled liquid cloud droplets to ice crystals and enhance the natural rain process. (Atmospherics, Inc. photo.)

problems and also on legal and environmental concerns.

° $20,000 to Escatech Corporation to provide an evaluation of the effectiveness of the NORCAL-WMP using aerial photographs, satellite imagery, radar photographs, and analysis of snow samples (for silver).

Dry Year Program of the State Water Resources Control Board

The State Water Resources Control Board (SWRCB) is responsible for administering programs dealing with water rights and water quality. Because of the drought's impact upon water supplies, concern was expressed that water users would inadvertently interfere with water rights of others unless forewarned of water availability.

To forestall this possibility, the Dry Year Program, designed to protect and enforce priorities of surface water use, was established and administered by the SWRCB. Activities under this program were closely allied with those under the DWR's Sacramento Valley Water Use Survey, discussed elsewhere in this report. In addition, the SWRCB also monitored water rights uses in the San Joaquin Valley.

In actions to ensure equitable use of existing water, the SWRCB sent letters to diverters holding permits and licenses in the Sacramento and San Joaquin Valleys informing them that, due to record low runoffs, water would become unavailable for their use under existing priorities.

On March 29, 1977, about 520 permittees and license holders in the Sacramento Valley were advised that water available for their 1977 uses would probably end in May. Colusa Drain diverters were advised to expect less than half the water available in 1976.

On April 18, 1977, the SWRCB sent letters to 103 permittees and license holders on the San Joaquin River system informing them that under existing priorities water would be unavailable to them at some point during the summer. Cutoff dates for individuals ranged from April to August.

Riparians and permit and license holders in the Delta (2,385 in number) were sent letters on May 18, 1977. Riparians were requested to reduce consumptive use in accordance with expected stream runoffs, and permittees and license holders were informed that no water would be available to them after May 1.

Riparians and pre-1914 appropriators on the San Joaquin River system were informed on May 27, 1977, that water on the Calaveras and Cosumnes Rivers would be unavailable after June 1.

Riparians on other rivers in the San Joaquin Valley were requested to cut back their use to the percentage of available supply as calculated by the State. Pre-1914 appropriators were notified that no natural flows would be available to them commencing in June.

The Board, in cooperation with DWR, also initiated a diversion monitoring program in the Sacramento Valley to ensure that water reached those entitled to receive it. Additional staff was assigned to respond to an unprecedented increase in water rights complaints.

In a related move, the SWRCB held expedited hearings to provide special permits to appropriate water on a temporary basis.

Several hearings were held to consider the question of transferring ground water supplies to augment surface water in short supply elsewhere. The proposed transfers are discussed elsewhere in this report.

The SWRCB also took action to cut off water supplies originating in Northern California to a residential recreational lake in Orange County. In an order dated March 2, 1977, it found the proposed use to be both wasteful and unreasonable in the drought year.

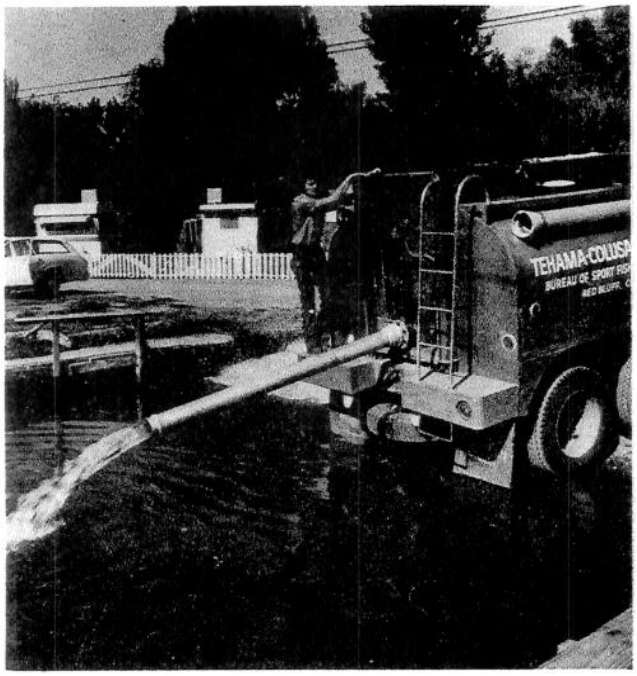
Fish and Wildlife Protection

In the second year of the drought, its effect upon fish and wildlife was more pronounced, but actions taken by the California Department of Fish and Game (DFG) and other concerned agencies maintained the State's fish and wildlife populations while providing maximum recreation possible under adverse conditions.

With lowered outflows, the threat of fish kills in the Sacramento River from copper pollution (stemming from old mine tailings near Spring Creek) and elevated temperatures was higher than normal. The DFG, in cooperation with the U. S. Fish and Wildlife Service, trapped 23,000 adult fish (total weight over 225 tons)[1/] at Red Bluff and hauled them to tributaries where the fish were able to spawn in copper-free water of suitable temperature.

A 1977 fish kill, resulting in the death of over 23,000 fish at the DFG's Camanche hatchery on the Mokelumne River, triggered the abatement of a longstanding pollution problem there. After late September releases from Pardee reservoir upstream washed over toxic sediments from an old mine (exposed by low lake levels) causing the kill, a joint venture involving the East Bay MUD (operators of Pardee and Camanche Reservoirs), the Central Valley Regional Water Quality Control Board, the U. S. Environ-

1/ One ton = 0.90718 tonne.



44. Do barriers hurt fish? Part of the Sutter Slough Barrier program included a study of the impacts to migrating juvenile salmon. Young dye-marked salmon were released at five locations in the Delta and recaptured near Chipps Island. One is shown being examined under black light for dye marking.

mental Protection Agency, and the DFG was formed to correct the situation. In April 1978, work began on the construction of diversion ditches, ponds, and a small dam to control and contain the toxic pollutants. Earlier, East Bay MUD had removed deposits washed into the lake. Costs of the new work are being shared by State and federal agencies and the District.

Emergency water releases by the U. S. Bureau of Reclamation (USBR) and the Department of Water Resources (DWR) eased the potentially disastrous effects of excessive water temperatures on early spawning king salmon in the Sacramento, Feather, and Trinity Rivers. (DWR actions are covered in a later section of this report.) Federal emergency funds were used by DFG to offset power generating losses incurred by the USBR and DWR in releasing the added flows.

Artificial production of migrant fish was also stepped up to produce an additional 2,000,000 brood yearlings for later return to the Sacramento River. This activity helped mitigate the adverse effects of elevated temperatures in the fall months, and possible mortality from copper pollution as well, and promises to add 20,000 to 40,000 spawning salmon to future runs to compensate for losses expected as a result of the drought.

Low to nonexistent flows in San Joaquin Valley streams precluded migration of adult salmon to spawning grounds. The DFG trapped fish in the lower San Joaquin River and moved some of them into the Merced River so they could spawn. Eggs were taken from other fish to be hatched and reared in a fish facility and planted in suitable streams during the spring of 1978.

Even greater artificial activity was necessary in inland fisheries to save the fish and the DFG moved to rescue several threatened populations. When Sheepheaven Creek in Siskiyou County became dry, its redband trout (a threatened species) was rescued and stocked in nearby Trout Creek. The rare Modoc sucker had to be rescued from Washington, Turner, and Hurlbert Creeks in Modoc

County when the streams were nearly dry. Several hundred freshwater shrimp were rescued from Walker Creek in Marin County when the stream became intermittent, then returned to the stream early this year.

Lahontan cutthroat trout were salvaged from Cow, Macklin, and By-Day Creeks, and Little Kern golden trout were salvaged in Tulare County when streams became intermittent during the summer months. The rescued fish were returned to their streams following resumption of continuous flow.

Despite setbacks caused by the drought, mitigation actions reduced their impact. Scheduling was adjusted so catchable trout were planted earlier, where seasonal flows or levels were expected to decline to problem levels. Heavier than normal planting was done where conditions remained suitable.

In the course of the year, the DFG drilled four wells in the Honeylake Wildlife Area in Lassen County and the Gray Lodge Wildlife Area in Butte County to provide additional water for waterfowl. Drought emergency funds were used to drill new wells for Nimbus fish hatchery and to provide a filter system for well water used in temperature control at the Feather River hatchery.

In Modoc and Lassen Counties, the DFG provided supplemental water and assisted the Department of Forestry and the U. S. Forest Service in similar efforts. Pumping helped to maintain ponds for waterfowl breeding and rearing and for migrating waterfowl. A system of water control structures was installed by the DWR to deliver water to managed marshlands in the Sacramento-San Joaquin Delta.

The DFG, in cooperation with the Department of Forestry and the U. S. Forest Service, hauled water for deer in eastern Shasta County and in Lassen County. The DFG also took advantage of the low water levels to plant willows at Berryessa, Oroville, and Millerton Reservoirs, for the future benefit of wildlife.

In other actions, the Department put together a statewide network to provide information on fishing and boat launch reservoirs. This information was coordinated with DWR's Drought Information Center and by cooperating State and federal agencies and public utilities. As fears for fish and wildlife mounted, the DFG developed a dry-year contingency plan which outlined measures that could be taken to alleviate the impact on natural resources.

Additional information on drought-related activities of the DFG is contained in its publication, "1977 Annual Report".

Protection of the Forests

Recognizing the devastating potential of the 1977 fire season, the California Department of Forestry (CDF) developed a plan of augmented fire protection measures. Early in the winter of 1976-77, it launched a massive fire prevention campaign to alert the public to the potential of the upcoming fire season and to seek the public's assistance in reducing the potential damage that could result from wildfires.

Meetings were held with the logging industry, electric utilities, railroads, and other cooperatives to make industrial practices as fire-safe as possible. Numerous radio, television, and newspaper contacts were made with the public. Person-to-person contacts were made with local service clubs and organizations.

As spring approached, the fire prevention effort shifted to physical "on-the-ground inspections" of rural dwellings, rubbish dumps, burning operations, and campgrounds. Fire hazards along high-risk roadsides were removed and high fire-hazard areas in excess of 4 050 hectares (10,000 acres) were designated as "hazardous fire areas".

Eight million dollars were appropriated

for the implementation of a CDF plan to check the increased fire danger. The key points of the mitigative effort included:

- Increased manpower on engine crews.
- Increased number of lookouts and aerial reconnaissance of forests for fire detection.
- Intensified fire prevention effort.
- Renting of water tankers and pumps to increase the availability of water.
- Increased length of time that air tankers and helicopters are available.

The plans paid off when a large number of forest fires initiated by lightning blazed across Northern and Central California in August. There is no question the damage described earlier in this report would have been much higher without the precautionary measures taken.

DWR Actions

As the state agency charged with major responsibility for management of California's water resources, it was inevitable that the Department of Water Resources was called upon to provide the bulk of the planning for, and to carry out, the State government's response to the drought. DWR's ongoing planning programs as well as its design and construction capability made it especially well suited for carrying out that task. In the sections of the report which follow are detailed the actions taken by the Department to alleviate the drought's effects and to provide a planning framework for coping with future dry years.

Drought Information Center

The Drought Information Center was clearly one of the most successful products of the drought response.

The Center, originally known as the Drought Operations Center, was first formed in July 1976. Because of increased public interest, it was expanded on January 3, 1977, as the Drought Information Center. Its functions were two-fold: (1) to collect and disseminate information concerning the effects of the drought, and (2) to match drought-caused needs with resources and mitigative measures.

Organizationally, it was staffed to provide four basic services: (1) answer telephone inquiries from the public and the media, (2) respond to written communications, (3) document the drought and mitigative measures, and (4) maintain contact with other agencies concerned with the drought.

Staff was provided by the Department of Water Resources with some participation by the State Water Resources Control Board.

In its contacts with the public and the news media, the Center was most effective in inducing a conservation ethic. The media was regularly apprised of current water conditions and their effect upon water use. Precipitation, runoff, and water storage figures at locations throughout the State were provided daily. The Center was often quoted and staff members provided innumerable video- and audio-tape reports. A speaker's bureau of DWR spokesmen was instituted to satisfy the demand for personal appearances before interested groups.

In performing its functions, the Center drew upon the knowledge, expertise, and capability of many parts of the Department, as well as other agencies. Written material was available upon request, covering such varied topics as home conservation tips, agricultural water management, reactivating old wells, water-saving equipment, federal aid programs, and many more.

As the drought became more severe and widespread, telephone calls were made to

all communities to learn firsthand their present situation. They were also asked what the projected situation would be if the drought continued. Every two to three months, communities which had some chance of experiencing difficulties were contacted for an updated report on current and projected conditions.

In nearly all instances, the smaller communities queried did not know what to expect if the drought continued because they had never experienced the situation and had no historic drought data concerning (1) streamflow, (2) drop in groundwater level, and (3) reduced flow from springs, etc., during past record dry periods.

Many drought-related problems in the foothill areas involved the drying up of wells; many of these were reported to be old shallow hand-dug wells. Information on ground water conditions was furnished, as well as information on federal assistance programs.

In the "phone room", a toll-free line was installed, which could be dialed from any part of the State. In the late spring and summer, sometimes more than 100 callers a day discussed drought problems with the Center's staff. Many callers in the summer wanted to know which water recreation facilities were still functioning despite the drought.

Representative of the kinds of queries received by the "phone-room" were:

- "What are you doing about the drought?"
- "Isn't the drought being exaggerated?"
- "Why don't we have Statewide rationing?"
- "What sense is there in rationing our community?"
- "Why don't we try cloud seeding?"
- "How about importing snow from the East in boxcars?"
- "Why don't we desalt Pacific Ocean water?"
- "Will there be boating at Lake _____?"
- "How is the fishing?"

A number of callers said they had water-saving devices they wanted the State to sponsor. Those callers were referred to DWR's Resources Evaluation Office, which studied and evaluated scores of ideas and gadgets.

During the 15 months of operation, the Center received more than 4,400 letters, telegrams, and postcards, most addressed to the Governor, and many to legislators and departments of the government other than DWR. The office individually answered all but a relatively few of these communications. (Some writers failed to give their return addresses, or they were illegible.) Most were answered in writing; where appropriate, some writers received responses by telephone. Many letters asked for information. Many offered suggestions. And many demanded action, some unthinkable and some unprintable.

The writers suggested dozens of ways to save or obtain water, or transport it from elsewhere into the State. Some of the suggestions were to pipe it in from the East or North; to ship it in railroad cars, trucks, planes, and ships; to tow icebergs to our shores. Hundreds of correspondents urged a step up in desalinization programs. Hundreds more advocated or opposed mandatory rationing. Many advised the State to do things already being done, such as use the State's ground water. And a large number of writers protested alleged water waste in various parts of the State and in some instances by their next door neighbors.

Other writers promised to end the

drought for a price, usually to be paid in advance. A few writers stated that it rained wherever they went for their vacations and offered to vacation in California if the State would pay their bills.

Most of the letters were sincere and showed genuine concern for California's plight. Some contained innovative suggestions.

An example was the suggestion, received by the hundreds, that the State import snow in railroad cars. (In the winter and spring of 1976-77, while California was suffering a record drought, the eastern coast of the United States was gripped in the iciest winter yet experienced there.) A surplus of snow was available for the asking, if only transportation could be arranged. An analysis showed that in order to make up the deficit in water supply within the State, it would require 182 million carloads of snow, using all tank cars and gondolas in the United States for 500 trips each at a total cost of $437 billion dollars. Obviously, the suggestion, although innovative, was economically infeasible to an advanced degree.

Nearly every week the Center published a drought bulletin describing the current weather picture and general water supply conditions, and related the more pertinent actions being taken within the State in relation to the drought. These bulletins contained graphics to indicate the water storage at major reservoirs, the amount of precipitation, forest fire statistics, and estimated losses by California agriculture due to the drought. A total of 38 bulletins were published, the first in January 1977, and the last on January 10, 1978. Two examples are contained in Appendix F.

During the vacation season, the Center published recreation reports describing conditions at major lakes and reservoirs. (Very few were unaffected by the drought.) It also published bulletins for boating enthusiasts showing river conditions and projected river flows for major California streams. Examples are provided in Appendix G.

Three comprehensive reports were published by the Center to supplement two special reports prepared earlier (in 1976) by the Department to document the dry year then in its beginning. The five reports are:

"Special Report on Dry Year Impacts in California" (February 1, 1976)

"The California Drought - 1976" (May 1976)

"The California Drought, 1977, An Update" (February 15, 1977)

"The Continuing California Drought" (August 1977)

"The 1976-1977 California Drought - A Review" (May 1978)

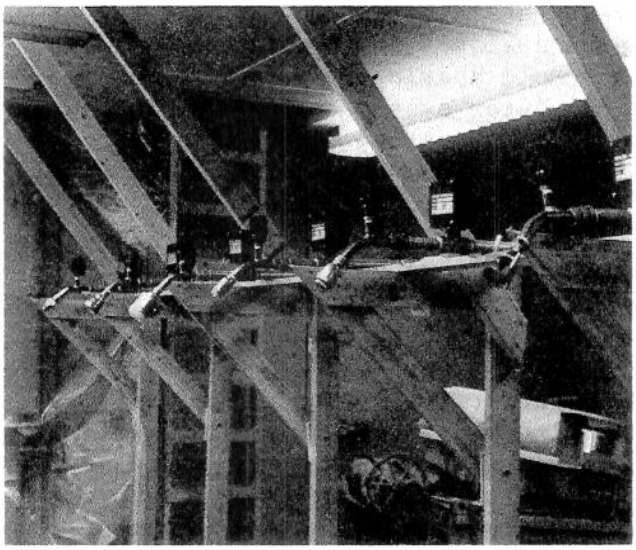
The five publications reported on hydrology of the dry years; their effect upon specific water projects, agriculture, energy, recreation, fish and wildlife, forests and wildlands, and the economy; the efforts taken in mitigation; the outlook for specific areas of concern; and contingency planning.

The liaison aspect of the Center's work came into play when inquiries transcended the responsibilities of the Department. Staff contacted the appropriate agencies to obtain answers to such questions and relayed the answers to the callers or writers.

The Drought Information Center served as a focal point to direct drought-related questions and saved the State administration, legislators, and State agencies much diffused time and effort by keeping the public informed about the drought and efforts to alleviate its impact.

Pilot Conservation Program

Under authorization provided by AB 380



45. Which showerhead saves most? Numerous showerheads are shown being tested at DWR's laboratory facilities in Bryte, California. DWR tested hundreds of water conservation devices including toilet dams, flow restrictors, showerheads, and toilet bottles. (Note: The water was recycled.)

(Chapter 28, Statutes of 1977), DWR in 1977 distributed hundreds of thousands of water-saving kits to selected communities in a pilot program with the objective of learning which methods of distribution were preferable, how acceptable the water-saving devices were to consumers, and the effectiveness of various types of water-saving devices in saving water and energy. This information will be used in the determination of whether a Statewide program should be developed.

Devices were distributed separately and in kits. Kits consisted of a toilet device (either a pair of toilet dams, a pair of one-quart plastic bottles, a plastic displacement bag, or a device which lowers the float ball); a shower device (a low-flow showerhead or an internal shower-flow reducer); dye tablets to detect leaks in toilets; and installation instructions and a water-saving pamphlet. Other devices distributed, in addition to the above, were a water-saving toilet valve replacement device; a change of habit device allowing the user to determine the length of the flush, or a device which lowers the float ball; and an external shower-flow reducer.

The Department used four methods to distribute the water-saving kits and devices: mass (hung on door knob), door-to-door (personal contact at home), depot (roving and stationary), and home delivery (with and without free installation). The most cost-effective methods of distribution in the largest of the programs, in San Diego, was found to be the mass and door-to-door methods.

Based on the results of the San Diego pilot study, if the program was applied statewide, it would result in a water saving of about 110 million cubic metres (89,000 acre-feet) and an energy saving of 1.25 million equivalent barrels of oil at a current cost of $18,750,000.

A final report on the survey, titled "A Water Conservation Pilot Program" (DWR Bulletin 191), is scheduled for release in the summer of 1978. Meanwhile, preliminary results and a description of the programs in each of the study areas follows:

San Diego. The study area is metropolitan, located on the South Coast, and contains about 370,000 households with a population of over one million. Although the area was experiencing some water shortages, there was no water rationing in 1977. The San Diego program was State-managed, involving three methods of distribution: depot (neighborhood pick up stations), door-to-door (delivered in person), and mass distribution (placed on front door knobs). Five types of kits were available, all free of charge, containing various combinations of five types of toilet devices, internal shower-flow reducers, and leak-detecting dye tablets for the toilet. Low-flow showerheads and external shower-flow reducers were also available. About 180,000 kits were distributed (to approximately 39 percent of the households) between July 25 and September 3, 1977. Annual water savings attributable to the toilet devices amounted to nearly 1 600 000 cubic metres (1,300 acre-feet), and 2 100 000 cubic metres (1,700 acre-feet) from reduced

shower flows. Based on a value of $.08 per cubic metre ($100 per acre-foot) for imported water supply, the combined annual water savings of 3 700 000 cubic metres (3,000 acre-feet) is valued at $300,000. Total annual energy savings, primarily from a reduction in water heating requirements for shower use, amounted to about 57,000 equivalent barrels of oil, valued at $855,000.

Santa Cruz County. The study area is located along California's coast, south of the San Francisco bay area, and is urban, with a population of almost 159,000. Almost half of the County was rationed. The Santa Cruz program was county-managed; distribution of single devices and free kits containing water-saving toilet devices, showerheads or internal shower-flow reducers, and leak-detecting dye tablets for the toilet, was through depots (roving and stationary), and a delivery/installation service available free to anyone upon request. The program provided free 66,784 toilet devices and 57,518 shower devices. Annual water savings from the Santa Cruz program are estimated at 1 200 000 cubic metres (960 acre-feet). Annual energy savings amounts to 15,693 equivalent barrels of oil at a cost savings of $235,400.

Sanger. Sanger is a long-established rural, agricultural community of about 3,000 households with a population of about 11,000. Located 20 miles southeast of Fresno, the town has an adequate water supply and is fully metered. There was no water rationing in 1977. The Sanger program was managed locally, with State assistance, and with heavy community involvement. Distribution of one of two types of toilet dams (in pairs) or a set of two bottles, low-flow showerheads, and leak-detecting dye tablets for toilets was arranged through prepaid order postcards sent to all households. Volunteers delivered the free kits to all who requested them. Distributed were 1,479 toilet devices and 1,054 showerheads. It was determined that the Sanger project will save about 38 000 cubic metres (31 acre-feet) of water annually. Energy savings based on household heating of shower water and local water system energy requirements would be about 544 equivalent barrels of oil a year at a cost of $8,160.

El Dorado Irrigation District. Located east of Sacramento in El Dorado County, the District services about 16,200 households, using the increasing block rate method of water pricing. The District employed strict rationing in 1977. In the El Dorado program, one type of kit, containing toilet dams (in pairs) and shower-flow reducers, was sold through the depot method. The total number of kits sold was 5,689, at $1.50 each. The annual water savings owing to the toilet dams and shower inserts amount to 175 000 cubic metres, (142 acre-feet). At $.20 per cubic metre ($250 per acre-foot) the water savings are estimated at $31,000. Annual energy savings due to lowered shower heating requirements amount to $28,000. Annual energy savings attributable to reduced distribution system requirements are 68.4 equivalent barrels of oil, for a $1,026 savings.

El Segundo. El Segundo, in the coastal metropolitan Los Angeles area, has 16,280 residents in 6,016 households. In 1977, the City mandated a 10 percent reduction in water usage. Distribution of the water-saving devices, conducted by the City, was through a mobile depot. The devices, sold at cost in kits or individually, consisted of two types of toilet dams, plastic displacement bags and pairs of one quart bottles, float adjusters, adjustable flush valves, flush valve controls, external shower-flow reducers, internal shower-flow reducers, brass and plastic low-flow showerheads, faucet flow restrictors, and leak-detecting dye tablets for toilets. A total of 2,054 kits and devices were sold; however, only 1,096 of these were for use in El Segundo.

The remaining device sales were to non-residents employed within the city. Annual water and energy savings attribu-

table to reduced toilet flow amount to 9 000 cubic metres (7.4 acre-feet); and to reduced shower flows, about 1 000 cubic metres (0.8 acre-foot). Annual energy savings amount to 30 equivalent barrels of oil at a cost of $450.

Oak Park. This community of 753 houses in Ventura County on the westerly boundary of Los Angeles County did not have rationing. Local agencies, aided by DWR personnel, went door-to-door and installed toilet dams (in pairs) and internal shower-flow restrictors in 667 homes. Annual water savings are estimated at 54 500 cubic metres (45 acre-feet). Annual energy savings are 825 equivalent barrels of oil at a cost of $12,375.

In connection with the pilot conservation program outlined above, DWR invited manufacturers and suppliers of water-saving devices to submit samples of their wares for testing. Approximately 50 firms responded by providing 131 different varieties of items for inspection and tests. Items submitted included 31 types of toilet devices, 63 flow restrictors or valves, 17 different low-flow showerheads, and 20 leak-detecting dye samples. DWR tested all samples in a testing program conducted at its testing laboratory set up for this purpose. Results were evaluated and formed the basis for selecting state-furnished devices distributed to communities involved in the pilot conservation study.

Marin Study of the Effects of Water Shortage

The Department has undertaken research to determine the effects of the 1976-77 drought and water shortage on the communities of Marin County. Mail questionnaires were sent and personal interview surveys were conducted in March 1977 principally in the Marin Municipal Water District. The survey canvassed a sample of 10,000 residents, composed of single-home dwellers, apartment dwellers, businesses, nurseries, livestock and dairy farmers, city administrations, and state and local agencies. Preliminary findings relating to residential water use were presented at the fall Conference of the American Waterworks Association on October 29, 1977. Preliminary findings reporting the drought's effects on dairy farmers and ranchers were released earlier, on March 22, 1977. The information collected and subsequent statistical analyses are directed at assessing the changes in indoor and outdoor water use brought about by the water shortage; the identification and measurement of costs and losses associated with water shortages for major users; and the public's response to water conservation and rationing restrictions, including an appraisal of water conservation measures undertaken and their effect in reducing water consumption. The findings and conclusions are contained in DWR Bulletin 206, "The Impact of Severe Drought in Marin County, California", to be released this summer. Findings in the report, expected to serve a useful purpose in assisting water district managers in coping with drought and water shortage conditions, include:

1. In 1976 and 1977, more single dwelling respondents changed outdoor watering practices than did apartment or duplex respondents, who instead chose to suspend watering altogether. The most common changes in outdoor use were reductions in the frequency and duration of landscape watering.

2. All of the groups reported they planned to use water for outdoor uses. Two-thirds reported that they would use sources other than Marin MWD water for outside uses. Rainwater and trucked water were the other sources most often used.

3. The majority of respondents installed water-saving devices. Toilet dams and bottles were the most popular devices and low-flow showerheads followed as the second most frequently installed device.

4. Water-saving measures practiced in

the bathroom (less frequent showers and baths, less frequent toilet flushing, and using gray water to flush toilets) were reported to be the most effective.

5. Nearly three-fourths of the respondents considered Marin MWD's rationing program to be "not inconvenient" or "moderately inconvenient". Only 20 percent found the program to be "extremely inconvenient".

6. About one-half of the respondents in the apartment, duplex, and townhouse groups found the rationing rate of $.43 per cubic metre ($1.22 per 100 cubic feet) to be a strong incentive to conserve water. About one-third of single-family dwelling units expressed similar sentiments.

7. Most respondents said they would use (and be willing to pay for) reclaimed water for their lawns and gardens in 1977 and in the future.

8. The average per capita outdoor use by single-family dwelling residents for the summer months was reduced 68 percent from 1975 to 1976 and more than 90 percent from 1975 to 1977.

9. Excluding climatological factors, family size was ranked as the most important factor affecting household consumption in 1975, 1976, and 1977. The second most important factor in 1975 and 1976 was swimming pool ownership, but in 1977 it was the number of children per household.

10. More single dwelling respondents lost landscaping because of the drought than other respondents. Trees and shrubs were reported as the greatest loss in terms of cost to the respondent.

11. The most widely incurred cost was for "water-saving plumbing changes (and devices)" and "leak detection repair".

12. About one-third of the single dwelling and apartment respondents plan to replace their landscaping with drought-tolerant and/or native vegetation.

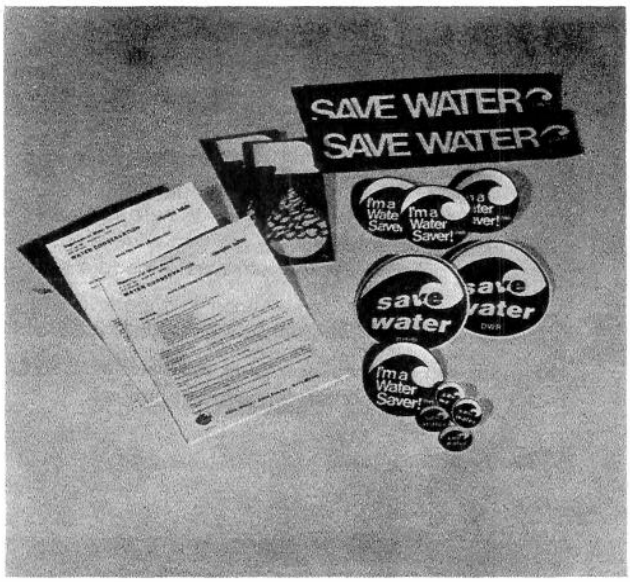
Public Education and Technical Aid

Because of its leadership role in managing the State's water resources, DWR was called upon to provide information and advice on measures to stretch the available supplies. In addition to its Drought Information Center and its participation in the Interagency Agricultural Information Task Force (both described elsewhere in this report), DWR took the lead in providing educational material to the public, the media, the schools, and to agencies involved in water management.

During the worst of the drought (from mid-1977 until the January 1978 rains brought relief), a series of eight "spot-announcements", prepared by DWR, were released to the media for use as public service broadcasts. The announcements, part of a long-range program begun in 1976, were designed to encourage water conservation. Their themes are reproduced here in the accompanying illustrations. All eight were released to television in the English language, seven in Spanish. Seven radio spots were in English, six in Spanish. Ninety-three television stations in California, Nevada, and Oregon (border stations only in neighboring states) received them, while 305 radio stations (all in California) were recipients. Seven TV stations and 13 radio stations broadcast in the Spanish language.

As part of its program to make the public more aware of the need to conserve, DWR designed and distributed eye-catching symbols, including bumper stickers, buttons, and decals espousing the cause of saving water. In addition, the very popular brochure, "Save Every Last Drop", was developed to show various ways to save water around the home.

A landscape water conservation program



46. Rousing the conscience. Shown here are examples of the thousands of buttons, bumper strips, decals and pamphlets that were made available to the public during the drought.

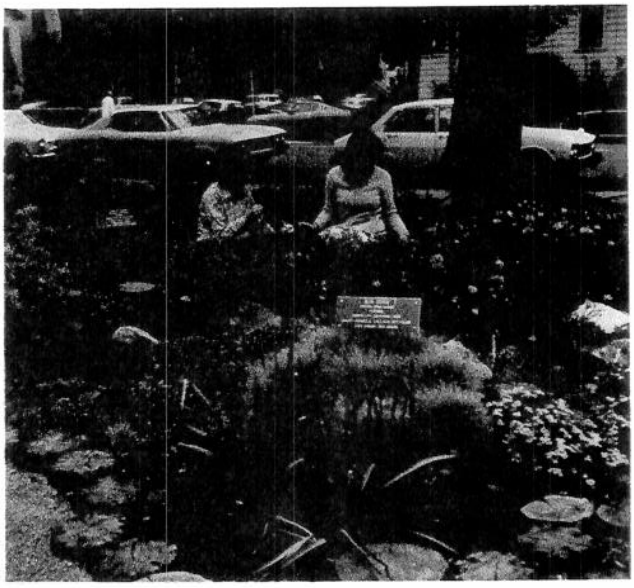
involving private, government, and university experts was developed to prepare information on efficient water use practices for landscape management and design. Ten information bulletins were prepared and mass distributed for use by State and local government agencies, the public, and landscape and planning professionals. The bulletins covered such items as efficient irrigation practices and systems, drought-tolerant plants, the use of gray water, and landscape design and urban planning methods resulting in long-term water savings. The conservation experts helped organize, and participated in, numerous conferences and conventions conerned with landscape and conservation. Educational displays were developed and transported around the State for use by local governments and organizations. Permanent displays promoting the conservation ethic were installed in DWR visitor's centers and in branch offices throughout the State.

A part of the conservation education effort has been the DWR program to assist the development of local demonstration drought-tolerant landscapes. Ten local landscape demonstrations reached the planting stage in 1977 and more are in the planning stages. A prototype demonstration garden showing drought-tolerant plants and water conserving irrigation and horticultural practices was planted with the help of the Office of Appropriate Technology. The demonstration is open to the public and can be seen at 17th and N Streets in the Capitol area of Sacramento.

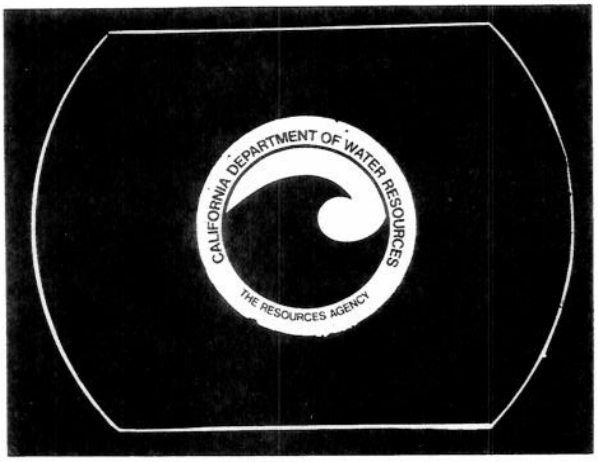
As the visible effects of drought became more pronounced in 1977, the California Water Commission (CWC) and DWR stepped up their educational program to effect water conservation in all parts of the State.

In the fall of 1977, DWR began a statewide water conservation education program in cooperation with the State Department of Education and local water suppliers and schools. The initial target group was children in the fourth, fifth, and sixth grades, and more than 100,000 students were reached with the program by the middle of the 1977-78 school year.

The program was expanded to include



47. Drought demonstration garden. Located in downtown Sacramento, this demonstration garden, showing drought-tolerant plantings and water-efficient irrigation and horticultural practices, is part of the ongoing conservation education effort by DWR.



'77 TV AND RADIO CAMPAIGN

48. The Department of Water Resources released eight 30-second television public service announcements (PSA's) during 1977, urging people to conserve water. This was part of a long-range media program begun in 1976. The program is designed to help change attitudes and personal habits, so that water conservation will become a permanent part of people's lives.

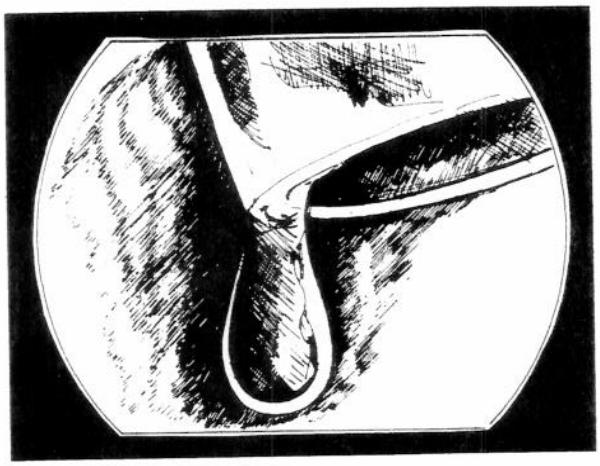
Radio announcements, based upon this material, were also distributed to stations throughout the state.

The radio and TV announcements were released in both English and Spanish-language versions.

Samplings of the 1977 PSA's are shown below.

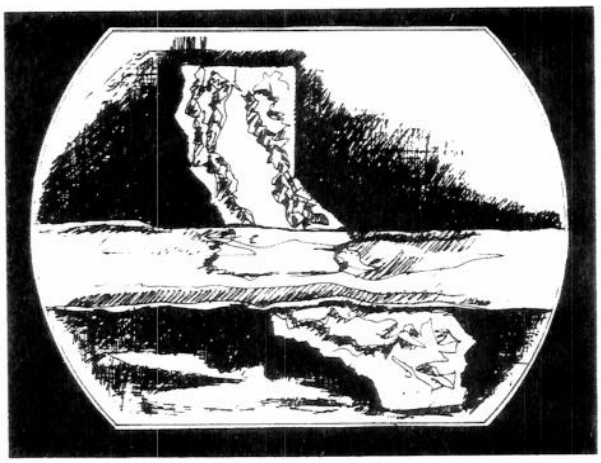
LAST DROP

As water constantly drips from a faucet, the narrator explains: " . . . small leaks add up to big losses . . . "



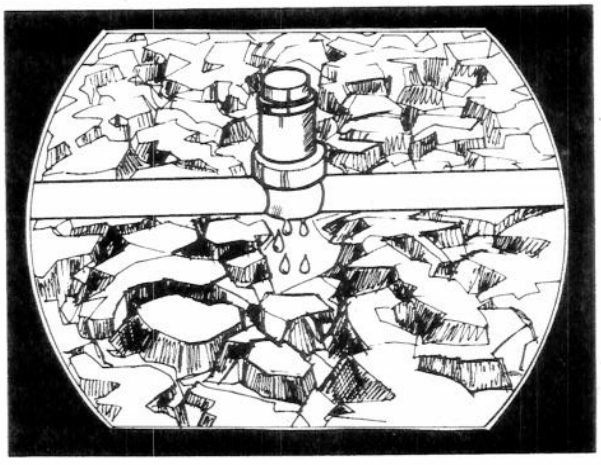
DRY STATE

With a map of the state as a background, water drains from the screen: ". . . there's only so much water in California. There's enough to use, but not enough to waste . . . "



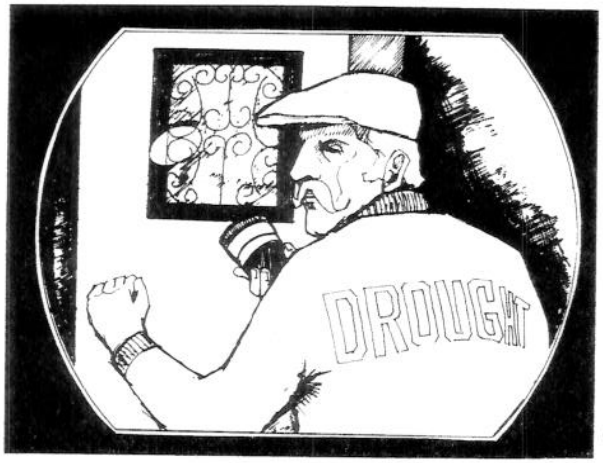
CHILDREN

Candid statements from children apply to everyone: ". . . I waste water . . . when I take a shower . . . by not turning the water off . . . by throwing it out . . . "



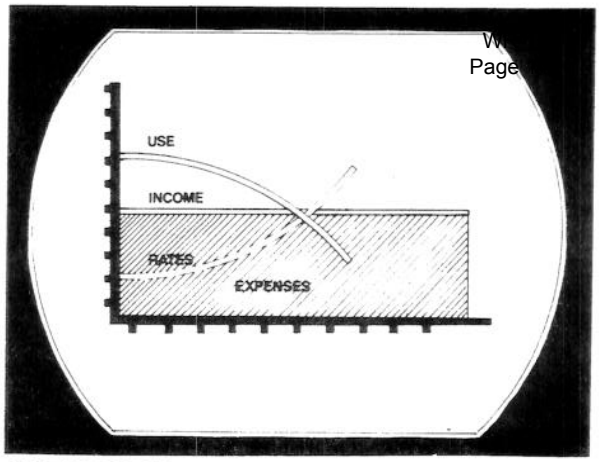
FARM IRRIGATION

Scenes of water-saving irrigation practices in agriculture are shown: ". . . water-conscious farmers can save water by . . . using plastic sheeting (for lining) . . . collecting irrigation runoff for re-use . . . with drip irrigation . . . "



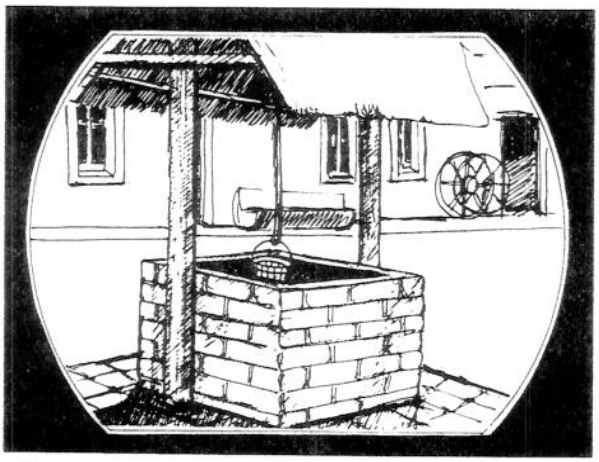
WATER BURGLAR

Drought is portrayed as a burglar stealing water, assisted by: ". . . dripping faucets, . . . leaking fixtures . . . wasteful habits . . . wasteful people . . ."



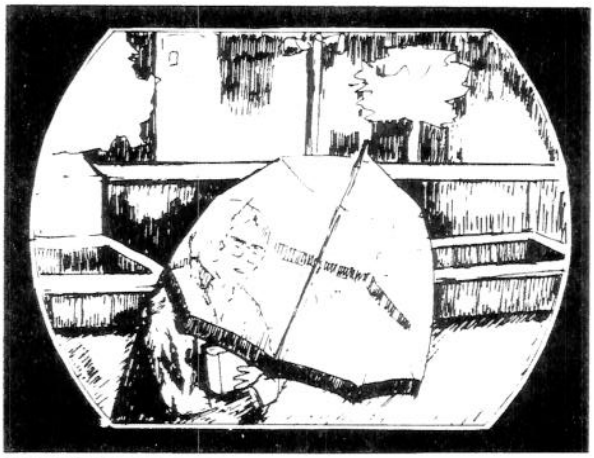
WATER RATES

During the drought people used less water and water utilities raised their unit rates to meet overhead and operating costs: ". . . as water use goes down . . . water rates go up . . . so income will still cover expenses . . ."



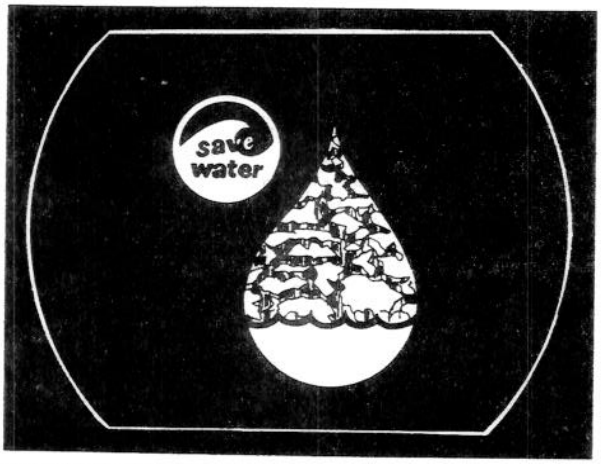
DRY WELL

A dry well and low water levels in rivers and reservoirs reflected the severity of the drought: ". . . not only the wells are running dry . . . but the lakes, rivers, and reservoirs are all at dangerously low levels . . ."



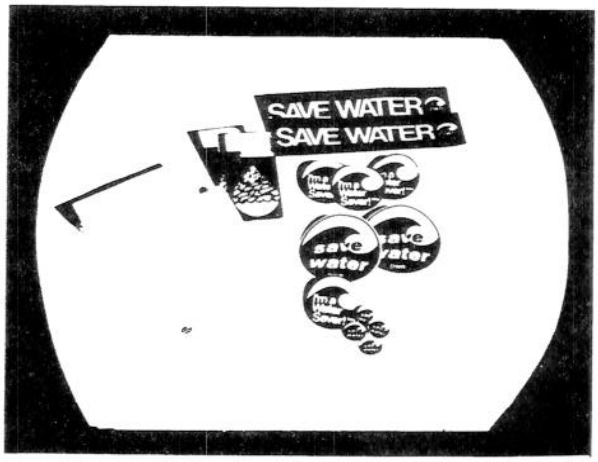
IT'S RAINING AGAIN

Scenes of winter rains and flashbacks of drought-stricken reservoirs remind people to save water year-around: ". . . our reservoirs and groundwater basins were the lowest they had ever been . . . save water -- even when it's raining . . ."



PROGRAM THEME

Each PSA ends with the program theme: ". . . The California Department of Water Resources urges everyone to save water. Save every last drop. It saves energy, too."



WATER SAVING PROMOTIONAL MATERIALS

Other public-oriented water conservation materials that have been developed by DWR include buttons, pamphlets, window decals and bumper stickers.

materials for kindergarten through third grade in February 1978, and plans were made to present a complete kindergarten through eighth grade package for the 1978-79 school year. The package will include a Spanish language version of the 4-6 grade curriculum materials.

While the program's primary purpose is to develop general awareness about water and the need to conserve, it is also designed to have an immediate impact on the families of children exposed to the materials.

As a part of DWR's drought information service, communities which stood a very good chance of being affected significantly by the drought were encouraged to request that contingency plans be formulated by their respective counties. And, in the event the county was unable to formulate such plans, the community was encouraged to request the county to request, in turn, that DWR provide technical advice in formulating such plans, at no charge to the county or community.

In Northern California, technical aid was thus given to the communities of Hornbrook in Siskiyou County and Stonyford, Sites, and Lodoga in Colusa County.

Drought Emergency Loans

In connection with the low-interest (2-1/2 percent) Davis-Grunsky drought emergency loan program made possible by AB 3793 (Keene, 1976), loans were approved for nine small public agencies in 1977 to provide emergency facilities needed to maintain water supplies to relieve drought situations. They are Lime Saddle CSD, granted a $45,000 loan for a new well; Stinson Beach Co. WD, a $45,000 loan to furnish and install water meters; Mariposa PUD, a $40,300 loan to drill a new well; El Dorado ID, a $100,000 loan for transfer facilities; Templeton CSD, a $50,000 loan for a new well; Orick CSD, a $44,250 loan for a new well; Bolinas CPUD, a $100,000 loan for a new well; City of Williams, a $75,000 loan for new wells; and Denair CSD, a $100,000 loan for a new well. Ten emergency loan applications were denied or withdrawn during the year and two more were denied in 1978.

Although not a part of the drought response, DWR's original Davis-Grunsky program served to lessen the adverse impact of the drought. Designed to provide low-cost funding of much-needed water development facilities in small communities, since 1959 the program has provided 54 construction loans amounting to nearly $47 million for 48 local agencies. The State has helped finance urgently needed projects that public agencies could not otherwise finance. The facilities relieved the extreme hardship involving jeopardy to public health, safety, or welfare of the existing population to be served, and provided an adequate water supply which benefited these agencies during the drought crisis.

"Safe Drinking Water" Bond Act Loans

The "Safe Drinking Water" Bond Act was not a part of the drought response, having been initiated prior to the drought's major effects. However, its benefits have extended to drought impacted communities.

The Bond Act, passed by the electorate in June 1976, provides for loans to upgrade existing water systems. During 1977, loans were approved by DWR for the following:

La Habra Heights Mutual* (Los Angeles)	$1,545,000
Quincy Water Company (Plumas)	515,000
Pine Mountain Mutual (Mendocino)	25,000
Patterson City Water Company (Stanislaus)	111,770

* Loan assumed by the La Habra Heights County Water District.

Crestline-Lake Arrowhead WA (San Bernardino)	1,250,000
Borrego Springs Water Company (San Diego)	200,000
Winton Water Company (Merced)	587,100
Rio Plaza Water Company (Ventura)	360,500
Santa Nella County Water District (Merced)	118,000
Camanche North Shore, Inc. (Amador)	143,350

On January 1, 1978, 130 "Safe Drinking Water" loans were pending.

In 1977, 35 applicants were notified of their financial ineligibility for loans under this bond act.

SWP Operations Rule Curve

The unprecedented low storage in the State Water Project's reservoirs in the fall of 1977, resulting from two years of record low runoff coupled with increasing demands upon the system, required a determination of 1978 deliveries possible under a wide range of water supply conditions. In addition to hydrologic conditions, factors considered included contractual and other legal limitations, power requirements, Delta and upstream users needs, total carry-over storage into 1979, and application of possible deficiencies.

As part of the decision process, specific problem areas were examined, including the Delta water quality criteria expected to be in effect, the USBR contribution to meeting Delta water quality requirements, the effect of local projects, Sacramento River diversions or other depletions, consumptive use in the Delta, and conveyance losses.

The development of the decision tool involved 14 basic coordinated operation studies of the SWP and CVP, more than 60 studies of California Aqueduct operation, and numerous partial studies. Drafts of interim conclusions were reviewed by the public and by SWP contracting agencies.

In a report dated December 1977, titled "Operational Criteria for the State Water Project, December 1, 1977-December 31, 1978", DWR presented the final results of its investigations. The conclusions took the form of a chart expressing various levels of deliveries, depending upon the 1977-78 unimpaired flows of four rivers -- the Sacramento, Feather, Yuba, and American. The chart, known as the "Rule Curve", is reproduced here as Figure 26.

Figure 26 shows that delivery of full entitlement amounts to SWP contractors could be made when combined runoff of the four basins reached 12 330 cubic hectometres (10,000,000 acre-feet), and delivery of surplus water would require combined basin runoffs exceeding 20 350 cubic hectometres (16,500,000 acre-feet). Median runoff figures for the four basins total 18 870 cubic hectometres (15,300,000 acre-feet).

Although this initial effort is to provide a basis for operation in 1978, a longer range study using many of the same techniques developed in 1977 is planned to develop detailed operational criteria for all years. Economic risk will be an additional factor in the long-range effort.

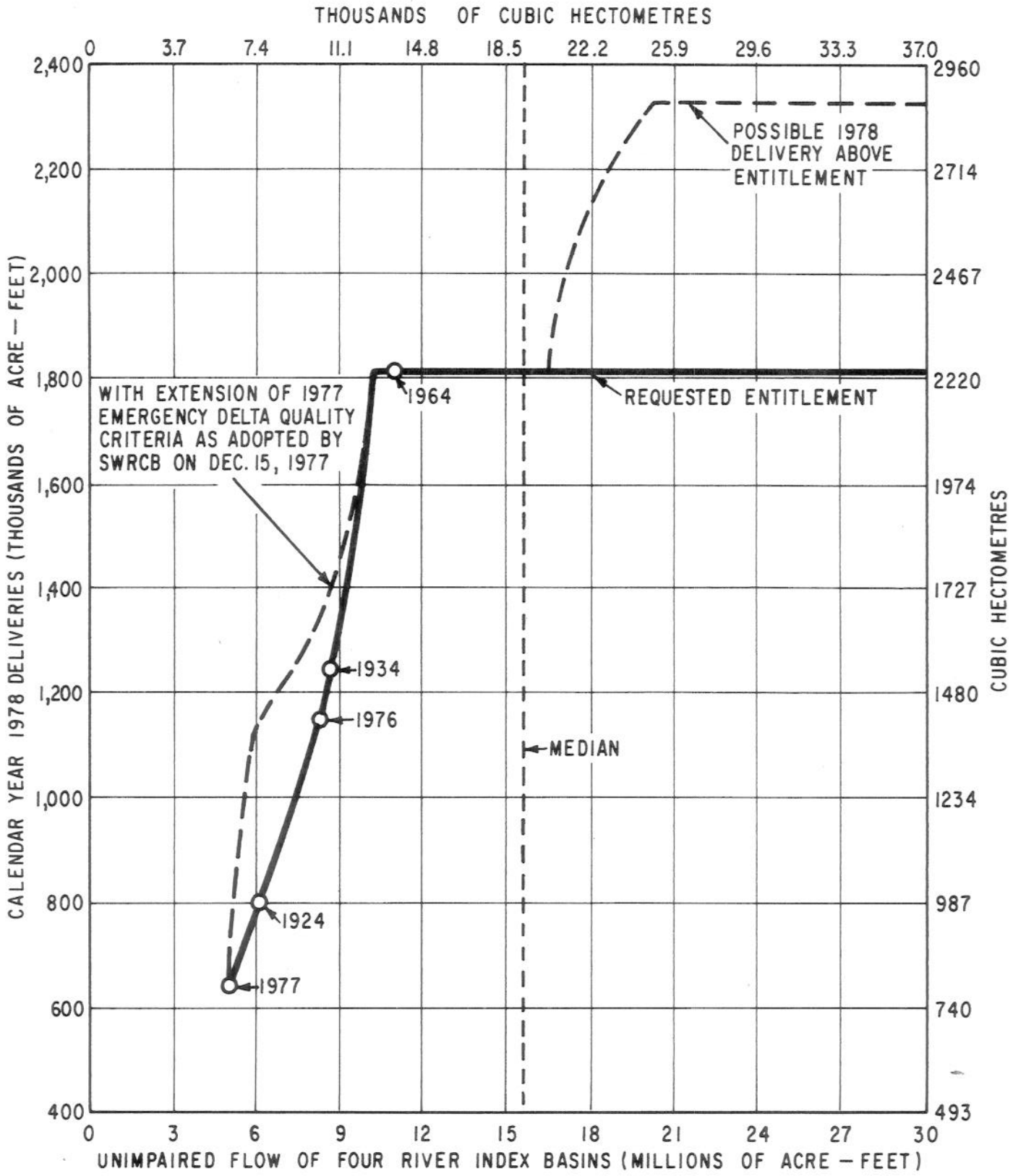
Sacramento Valley Water Use Study

The substantially below-normal precipitation experienced during 1976, in combination with unusually warm climatic conditions, resulted in an increase in water demands in much of the State. This imposed an unusual and unseasonable burden on operation of the State Water Project and Central Valley Project to meet their objectives in the spring and summer of 1976.

The 1976-77 water year, the driest in the State's history, compounded the problem, requiring the two projects to cut deliveries significantly and to request substantial relief from quality objec-

Figure 26.

STATE WATER PROJECT OPERATIONS RULE CURVE FOR 1978



tives in the Delta. Had 1978 continued the dry regime of the two previous years, further reductions in project deliveries would have been necessary.

In 1924, the previous driest year of record, the Sacramento-San Joaquin Water Supervision program was instituted by the State to provide the data base necessary for an allocation of the available supply. Over the years, this program provided the public information on water supply and use, and was of great assistance to various interests in evaluating water covered by earliest rights and the surpluses available for appropriation.

As water became more available with the construction of the CVP and SWP, the need for the program decreased. The dry year of 1976, however, increased demands on the projects and the question was again raised over where the limited supply should be allocated.

To better understand the dry-year hydrology and to provide information to better manage available water supplies in dry years, DWR and other agencies undertook the "Sacramento Valley Water Use Survey". Initiated in July 1976, the study developed and analyzed Sacramento Valley data on precipitation, runoff, streamflow, diversions, accretions (stream inflows from surface and ground water), land and water use, water rights, Delta salinity, and other related information.

The results of the first year's study are contained in a report titled, "The Sacramento Valley Water Use Survey", dated June 1977. Among its conclusions are these:

1. 1976 was the driest year in the Sacramento Valley since the SWP and CVP began operating.

2. The 1976 seasonal distribution of Sacramento River diversions differed significantly from that of recent years, showing a pattern of earlier diversions and of larger magnitude. Figure 27, comparing the 1976 diversions during the months of March-October with those of the five years immediately preceding, illustrates this difference. In addition to the data shown on the Figure, it is known that extensive diversions were made in January and February 1976, but these could not be quantified.

3. In 1976, for the first time in 30 years of record, the Sacramento River apparently had a net loss of water to adjacent ground water aquifers. This reversal during the months of June and July may be partly due to declining water tables and increased use of wells and may signal a trend of diminishing subsurface inflows for the future.

4. Except for isolated cases, Sacramento Valley irrigated agriculture did not suffer from a water shortage in 1976.

5. Sufficient storage releases were made from the SWP and CVP to satisfy salinity control in 1976.

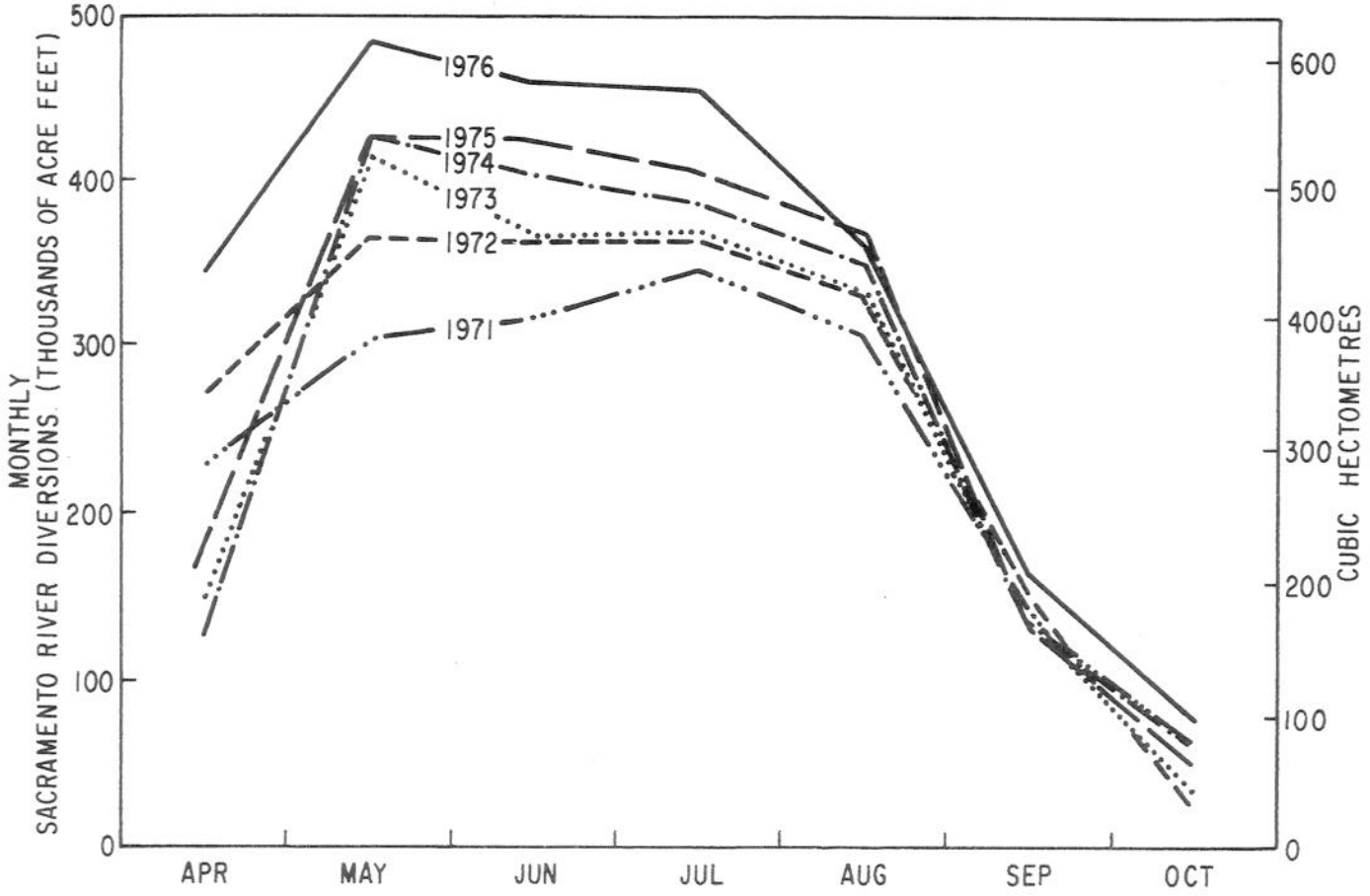
6. Amounts of water taken under unauthorized diversions (those without water rights) were small, probably less than one-half percent of the total 1976 diversions.

As 1977 continued the dry conditions begun in 1976, additional studies were conducted to determine its effect on water use. The results of the second year's study will be contained in a report titled, "The Sacramento Valley Water Use Survey", scheduled to be released this summer. A summary of some of the preliminary findings and conclusions follows:

1. 1977 was the second consecutive dry year of this series, and the driest year of record for the Sacramento Valley.

2. Diversions from main river channels during 1977 were about 75 percent of those measured in 1976. Major fac-

Figure 27.
SACRAMENTO RIVER IRRIGATION DIVERSIONS
(Above Sacramento)
1971 - 1976



tors in this reduction were the cuts imposed upon their contractors by the SWP and CVP.

3. Unmeasured accretions from April through October remained at about the same level as in 1976.

4. Land use was affected by the curtailment in water supply in the upper valley. In the Delta, land use did not change substantially as water availability was only slightly lower than in 1976. SWP and CVP exports from the Delta were materially reduced, but several bay area users were provided emergency supplies.

5. Salinity was allowed to move into the Delta as a result of modified standards allowed by the SWRCB's emergency regulations.

6. Water diverted without proper rights was less than 1 percent of the total. The SWRCB's program to protect and enforce priorities contributed to conserving supplies. Shortages of water to satisfy riparian rights existed from July 1 to September 30, averaging about 65 percent.

For additional information, please refer to the two reports noted.

Delta Barriers and Other Physical Works

A number of physical works were constructed by the Department to minimize the deleterious effect of the drought

upon water quality in the Sacramento-San Joaquin Delta. These included a number of rock barriers (funded by the U. S. Bureau of Reclamation) and new diversion facilities whose functions were described earlier in this report. Their locations are shown on Figure 13.

The physical works were successful in lowering chlorides that would otherwise have rendered some Delta waters unsuitable for domestic and agricultural uses. The improved water quality reduced the amount of flushing water needed for Delta outflow, thereby allowing for conserving additional water in upstream reservoirs.

Water Exchanges and Wheeling Agreements

The Department of Water Resources spearheaded several water exchanges in California in 1977. In some exchanges, regions with sufficient water temporarily gave up their water entitlements so that they could be used in drought-stricken regions where water was in short supply. (For example, four Southern California water agencies relinquished all or part of their SWP entitlement water to agricultural users in the San Joaquin Valley and to San Francisco Bay urban users.) Most of the exchanges were less dramatic, being intraregional in nature. Also, in at least two cases, farmers were permitted to transfer their water entitlements from certain of their properties to other, nonadjacent properties they owned.

To make these exchanges, the Department negotiated agreements, provided electric power to transport water from substitute sources, provided storage and transportation facilities, installed pumps and dams, and regulated water flows.

Detailed descriptions of a number of the exchanges are contained in the August 1977 Drought Report.

The Metropolitan Water District of Southern California relinquished 493 cubic hectometres (400,000 acre-feet) of State Water Project (SWP) water in the biggest exchange, which also involved DWR, the East Bay Municipal Utility District, the U. S. Bureau of Reclamation, the State Water Resources Control Board, Contra Costa County Water District, and Marin Municipal Water District. The water made up shortages in Northern and Central California.

The San Bernardino Valley Municipal Water District, Coachella Valley County Water District, and the Desert Agency also gave up all or part of their SWP entitlements, totaling 43.5 cubic hectometres (35,279 acre-feet).

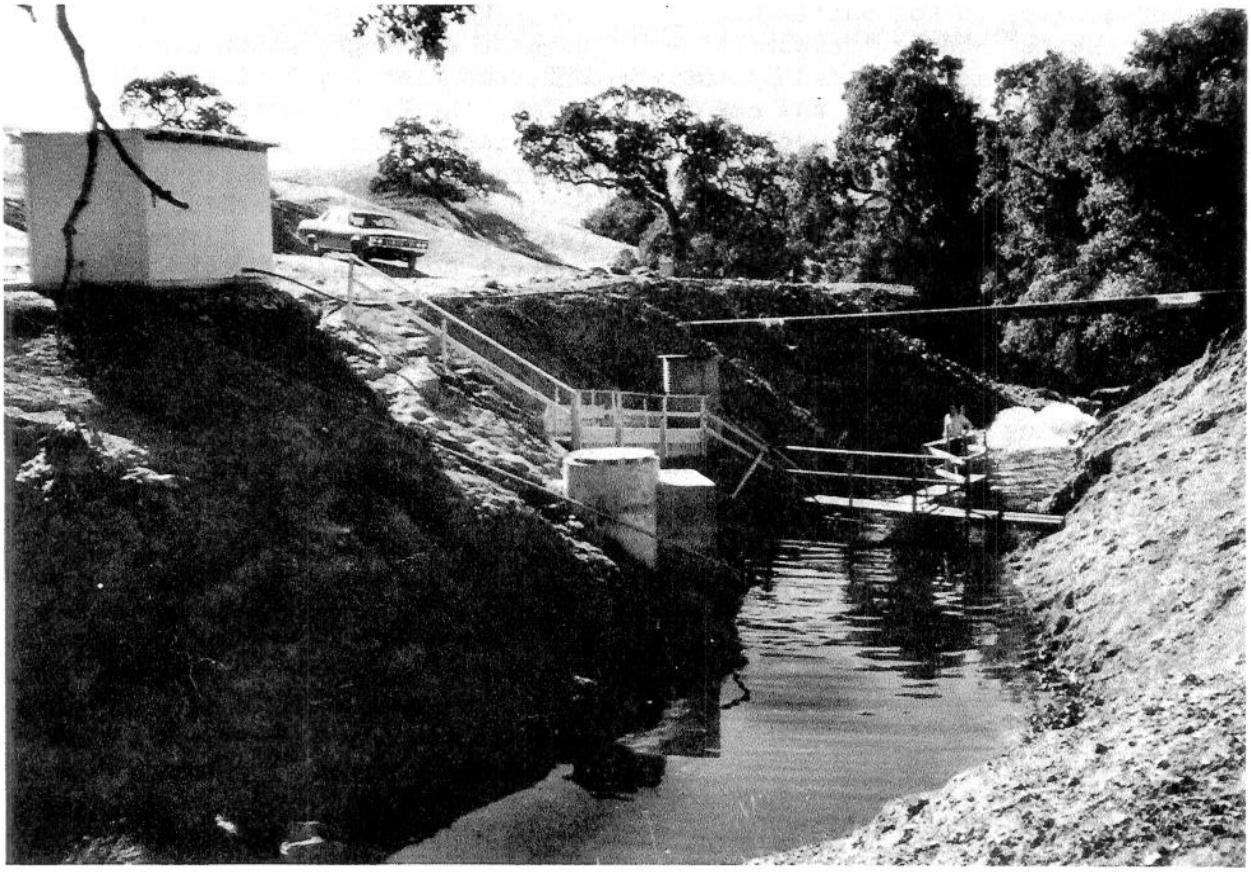
One result of the four Southern California exchanges was that San Joaquin Valley SWP agricultural contractors received enough SWP water in 1977 to equal about 89 percent of their total entitlement, instead of the 40 percent they would have obtained without the exchanges.

Marin Municipal Water District -- in an agreement with DWR, the San Francisco PUC, the City of Hayward, and EBMUD -- was the principal urban beneficiary of the MWD exchange. The first water under the arrangement arrived in San Rafael on June 7, 1977.

SWP facilities were used in an exchange in which the Westlands Water District received water from the Kaweah River, the State Water Project, and the Central Valley Project.

SWP facilities were also used to carry water purchased from rice growers in the Sacramento Valley to farmers in the federal Friant-Kern Service area, under the "Water Bank" provisions of Public Law 95-18.

Devil's Den Water District, a SWP contractor, transferred delivery of 6.1 cubic hectometres (4,550 acre-feet) of its 1977 SWP entitlement to the Westlands Water District (served by the CVP) for use on lands owned by one company with ownerships in both districts.



49. Exchange water on its way to Marin. The water pictured being released from DWR's South Bay Aqueduct will find its way to San Francisco's San Antonio reservoir near Livermore for later transfer through the City of Hayward and EBMUD systems to Marin.

The Tulare Lake Basin Water Storage District similarly transferred 1.2 cubic hectometres (1,008 acre-feet) of Tulare Lake's SWP entitlement for use on lands in Westlands for a company with land ownerships in both districts.

A complicated exchange to achieve better quality water was made in the Contra Costa Canal service area, involving agreements by DWR with EBMUD, USBR, and the Contra Costa County Water District.

DWR also entered into an agreement with Reclamation District No. 341 and the North Delta Water Agency to provide water of usable quality for agricultural purposes to the western end of Sherman Island, which had been threatened with increased salinity intrusion.

The Department constructed and operated rock barriers located on the Old and San Joaquin Rivers to counter tidal action. (These were described earlier in this report.) Signatories to the agreement for this development were DWR and the South Delta Water Agency, whose 60 000 hectares (148,000 acres) of irrigated land were benefitted. Federal reimbursement of costs was provided later by a drought emergency grant from the USBR.

DWR also entered into an agreement with the Department of Fish and Game and certain owners and operators of duck clubs in the Suisun Marsh to provide for bringing higher quality water from Montezuma Slough through the Department of Fish and Game-managed Grizzly Island Wildlife Management Area to the Wheeler-Simon Islands.

Fish Protection at SWP Facilities

In 1977, conditions at Lake Oroville forewarned the likely loss of temperature control for cool water releases required for the downstream fishery in the late summer and fall.

Studies made to determine if some action might be taken to provide cool water to the Feather River Fish Hatchery indicated that sufficient amounts of cold water could be released from the bottom of the lake to mix with the warmer power generation water.

The only facilities at Oroville at a low enough elevation to withdraw this cold water are the Palermo Canal outlet works and the river outlet valve system. Use of either facility to release cold water to the river entails a significant loss of hydroelectric power generation since that water does not pass through the generators at the Hyatt Powerplant.

Palermo Canal discharges water at a temperature of 7°C (45°F) throughout the summer. Because the design discharge capacity is only 57 litres per second (2 cfs) greater than its delivery demand, far less than the quantity of cold water needed at the fish hatchery, it was decided that two waste water evaporation ponds could be converted to cold water holding ponds to protect some spring run salmon.

The ponds were drained and cleaned and a temporary pipe laid to deliver cold water from the Palermo Canal. These modifications were completed and the cold water fish-holding facility was placed in service on August 25, 1977. A continuous flow of 28 litres per second (1 cfs) was passed through the cold water ponds during this operation. Department of Fish and Game (DFG) personnel placed about 200 adult spring run salmon in the ponds and provided continuous surveillance of the operation.

On September 16, water temperatures at the Feather River Fish Hatchery dropped below 14°C (57°F), whereupon the fish were removed and transported to the hatchery, and the operation of this cold water facility was discontinued.

Additional cold water was made available to the hatchery through the river outlet valve system. These valves were designed to allow releases only during the period of initial reservoir filling prior to reaching the storage which would allow release by generation. They are not considered a normal operational feature.

Discharge from these valves bypasses the Hyatt Powerplant generators and flows through the tailrace directly into the Thermalito Diversion Pool. At elevation 61 metres (200 feet), there is a withdrawal portal near the right abutment of the Diversion Dam to supply the Feather River Fish Hatchery and another near the left abutment for releases to flow down the Feather River past the City of Oroville. The hatchery is the primary location where cold water is needed.

It was decided that, in cooperation with DFG, DWR would make releases through the outlet valves to satisfy the temperature requirements of the hatchery. One valve was opened to a discharge rate of 28 cubic metres per second (1,000 cfs) on September 12. The temperature of the water released was 8°C (47°F). Releases were made only as needed to maintain water temperatures below 14°C (57°F) at the fish hatchery when combined with generation releases (warm water) from Lake Oroville. This operation was continued until November 5, 1977, when the river outlet valve was closed for the last time.

The volume of water released from Lake Oroville through the valve amounted to 58.6 cubic hectometres (47,518 acre-feet). During the same period, Hyatt powerplant generation water amounted to 82.7 cubic hectometres (67,047 acre-feet). About 43 percent of the total reservoir release was, therefore, cold, nonpower generating water. The water released through the valve would have

generated about 17.7 million kilowatt-hours of electrical energy worth about $45,900.

DFG also requested that additional water be released down the section of the Feather River from the Thermalito Diversion Dam downstream to the Thermalito Afterbay River Outlet structure. This increase was requested because of the low flow and temperature problems in that section of the river. DWR agreed to the increase and, on October 4, the release was raised to 23 cubic metres per second (800 cfs), decreasing to 17 cubic metres per second (600 cfs) on November 10, and returning to the contractural flow rate of 11 cubic metres per second (400 cfs) on November 15.

The increased flow in this section of the river also entailed a cost to DWR since that water would normally have been routed through Thermalito Powerplant into Thermalito Afterbay. The total volume of additional water released down the low flow section amounted to 38.5 cubic hectometres (31,248 acre-feet). Power generation lost was 2.4 million kilowatthours, representing about $6,250 worth of electrical energy.

DFG has arranged to pay the costs of the entire cold water operation, including special construction or modification, monitoring, and energy loss at both Hyatt and Thermalito Powerplants, and has applied for a federal drought-related grant to help cover the costs of the operation.

Special Ground Water Studies

As part of the Department's ground water measurement program, the regular network of wells (normally measured spring and fall) was measured more frequently. In Northern California, monthly measurements were made in Kelseyville Valley (Lake County) and the number of wells measured was increased. Scotts Valley and Upper Lake basins were measured monthly. Honeylake Basin has been measured approximately every other month since the spring of 1977. The U. S. Geological Survey, in a cooperative program, provided additional measurements in the north coastal area.

A survey was made of every town and public water purveyor in Northern California to determine the effect of the drought, especially on ground water supplies.

Special assistance was provided to the Orland Water Users Association in their planning efforts to obtain a ground water supply. All geologic data were made available to the consultants to help in planning the project.

Efforts were made to keep the public informed on ground water level fluctuations. Water level measurements were sent to newspapers. In Tehama County, a continuing series of reports was furnished to the Red Bluff Daily News on changing conditions. Ground water conditions were furnished on numerous occasions to answer public inquiries. Persons who requested Small Business Administration loans to drill or deepen a well were required to obtain a statement from the Department on ground water conditions. Approximately 50 of these statements were prepared.

In the San Joaquin Valley, ground water levels are usually measured in the spring to determine the static high, and in the fall to determine the static low. In June 1977, with the cooperation of many public and private water agencies, measurements were made on approximately 2,000 selected wells, at which time several hundred quality samples were taken. Another round of water level measurements was made in August in selected wells throughout the San Joaquin Valley.

Information on depths to water and water level changes was made available to many agencies and individuals who required financial assistance to drill or deepen agricultural and/or domestic wells.

A map showing lines of equal depth to water, fall 1977, was drawn for the entire San Joaquin Valley and was distributed. In addition to the annual spring elevation maps, a two-year change map is being prepared which will show the change from the spring of 1976 to the spring of 1978.

During 1977 there were many shallow well failures and thousands of drillers' reports were received and processed for new wells drilled.

Dry Year Precipitation, Streamflow, and Quality Documentation

In the northern reaches of the State, the Department relies on 111 public and private cooperators who take daily precipitation measurements and report those readings monthly. Data from this precipitation network are augmented by daily measurements taken by National Weather Service cooperators throughout this same region. Also, DWR has 25 precipitation storage gages located in very remote areas; these gages are read only once a year. Long-term precipitation records exist at a few key locations; these records are extremely valuable for comparing current precipitation amounts with antecedent maximum and minimum amounts. These data provide basic hydrologic information used to project urban, agricultural, industrial, and recreational water supplies.

The three Northern and Central California district offices of the Department conducted special streamflow surveys in the late spring, summer, and fall of 1977 to help document the effects of the drought.

Studies made at 800 locations on rivers and tributaries in Northern California in August and September obtained information on streamflow amounts, water temperature, and turbidity. Photographs were also obtained.

The areas of survey and the number of streams in each area surveyed were: Northeastern California (50), Sacramento Valley (160), Smith River Basin (30), Klamath and Scott Rivers (200), Trinity River (100), Coastal streams -- Klamath River to Eel River (30), Eel River and Van Duzen River (110), Coastal streams -- Eel River to Point Arena (80), and Clear Lake tributaries (40).

Lake Tahoe was sampled in August 1977. When the lake surface dropped below the rim in September, it was the lowest level at which the lake had been since February 1962. Flow from the lake's outlet gates into the Truckee River ceased at that time. Water quality recording stations were established on the Truckee at Tahoe City and near the town of Truckee during 1977. A streamflow recording station near Truckee was reestablished in a cooperative venture of the U. S. Geological Survey (USGS) and DWR. The water quality and streamflow recording stations were used to monitor the Truckee River's condition during 1977, before and after flows ceased.

In the central part of the State, all streams had below normal flows, and many

50. A dry mouth. Shown is the mouth of Bull Creek as it entered the Eel River near Weott on August 24, 1977. Normal August flow is 0.06 to 0.08 m3/s (2 to 3 cfs).

were dry. No flow occurred in either the Yolo or the Sacramento Bypass.

To more accurately determine accretions to the Sacramento River above the Delta, DWR established a program of monitoring drainage returns to the Feather River, American River, and the Sacramento River above Sacramento. Data from this program are included in the Sacramento Valley Water Use Survey, described elsewhere in this report.

Because of lowered flows in the Sacramento River, tidal action caused reverse flows (which normally do not occur above Walnut Grove) to occur as far upstream as the mouth of the American River near Sacramento. This was verified by tidal cycle measurements and a cooperative SWRCB, USGS, and DWR study. DWR conducted numerous tidal cycle measurements to determine quantities and direction of flows throughout the Delta channels. In addition, on August 23 and 24, 1977, DWR cooperated with the U.S. Corps of Engineers, USGS, and many Delta county agencies to simultaneously measure velocities and qualities in the Bay-Delta system, primarily to verify validity of the Corps of Engineers' Bay-Delta model under low-flow conditions.

In the San Joaquin Valley, special studies were made of the Stanislaus and Tuolumne Rivers, where a number of stations were set up to measure and sample the water. In addition, all diversions and inflow stations of the two rivers were measured.

At this writing, data for the above surveys are still being compiled, but in Northern California there is no doubt that streamflows at most locations reached the lowest point on record, and many perennial streams ceased flowing. Quality was also adversely affected. The following table compares the flows observed in 1977 to those ordinarily expected for a number of north coastal streams.

River	Location	1977 Low Flow (in cfs)	Normal Summer Low Flow (in cfs)
Smith River	Near Crescent City	200	300
Scott River	Near Fort Jones	16	60
Trinity River	At Lewiston (unimpaired flow)	70	160
Van Duzen River	Near Bridgeville	5	20
Eel River	At Scotia	24	130
Mattole River	Near Petrolia	17	70
Navarro River	Near Navarro	0.5	10

These are USGS stations and most of the major streamflow stations were measured by the USGS as part of its cooperative program with the State of California. However, a vast majority of the drought information data collected by DWR was on streams that have no existing stream-gaging stations. Therefore, a comparison of 1977 flows and average summer low flows at most of the 800 locations will have to wait until some later date when streamflows return to normal.

DWR's San Joaquin Valley study showed that some reaches of the Stanislaus and Tuolumne Rivers showed flow gains while others showed losses. The determining factor was the amount of ground water pumping activity on adjacent lands.

In addition to the special streamflow quality documentation outlined above, the DWR continued its regular program of collecting physical, chemical, and biological data from the rivers, streams,

and ground waters of Northern California during the past two years, but with increased frequency of sampling and analysis for more select and specific water constituents.

Increased limnology studies were made on 17 of the main reservoirs and lakes in the northern part of the State, with the major effort being made in 1977. Shasta Reservoir, which was drastically affected by the drought, was surveyed three times in the summer of 1977. Limnologic studies of Folsom Lake were conducted in November 1977, at which time the lake level was the lowest ever surveyed.

Not all of the analytical data have been received from the laboratory, but the limited data available indicate the low flows have resulted in higher concentrations of minerals but not high enough to have noticeable damaging effects. One notable exception is Spring Creek Reservoir, which controls toxic mine drainage before it enters the Sacramento River above Redding. Control of these toxic waters requires their being diluted by high flows in the river. Lack of high flows at a time when the Spring Creek Reservoir fills and overflows to the river would allow these toxic waters to enter the river undiluted and cause fish kills and other water quality problems. Luckily, the heavy rains of January 1978 provided sufficient flows to dilute Spring Creek Reservoir releases without damage to fish or water quality in the river.

Not so lucky were fish at the Department of Fish and Game's hatchery at Lake Camanche, where late in September 1977 fish began dying when releases from Pardee Reservoir upstream washed over toxic sediments resulting from mining operations dating back to the Civil War.

Dry Year Photo Documentation

As part of its program to document the effects of the drought, DWR assembled a comprehensive photographic record of reservoir conditions in 1976 and 1977. This complements the streamflow photographs taken in connection with the streamflow and quality documentation discussed above. In addition, the Department of Forestry provided photographs of disease-ridden trees and fire problems encountered as a result of the drought; the Department of Fish and Game assisted in recording special problems in connection with low streamflow; and the Department of Parks and Recreation provided photographs of recreational problems. DWR also obtained construction and operating photos of Delta mitigative measures, including barriers, and its work in connection with water exchanges.

The entire collection has been indexed and is housed in DWR files.

DWR efforts in reservoir storage documentation merit special note. An aerial photographic survey of a number of major reservoirs was conducted on three separate occasions, in October 1976, April 1977, and again near October 1, 1977. Photographs included black and white prints and color slides. The latter two sessions were in cooperation with the University of California at Davis, which conducted the flights and furnished copies of negatives, photos, and slides.

As part of the drought investigation, the DWR's Northern District ascertained storage levels of all reservoirs in the District over 6.2 cubic hectometres (5,000 acre-feet). A statistical analysis of major reservoirs based on historic runoff was made. Levels of smaller reservoirs were monitored by District staff at various times in the past two years.

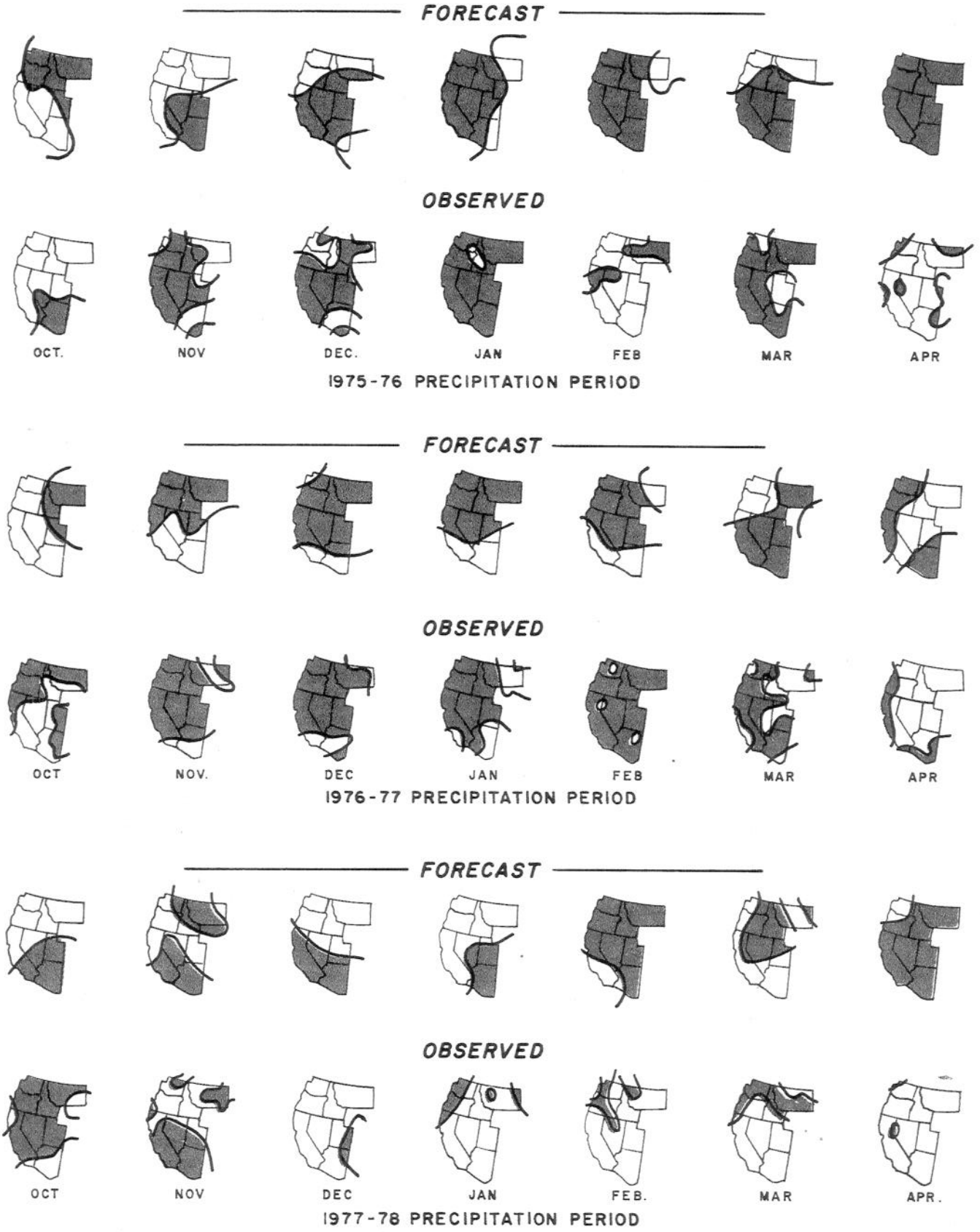
Long-Range Weather Forecasting

The Department has long been involved in water supply forecasting through the California Cooperative Snow Survey Program.[1/] Current forecasting procedures

1/ This program, which originated in 1929, now involves over 50 state, national, and private agencies collecting snow data from over 300 snow courses.

Figure 28.

COMPARISON OF FORECAST AND OBSERVED PRECIPITATION
(Based on 30-Day Forecasts By National Weather Service)



are primarily statistical in nature, involving early season collection of snowpack data and their translation into spring runoff estimates.

There has been one serious problem in these forecasting techniques, and that is the lack of a proven system of long-range weather forecasting. The precipitation levels are never known until relatively late in each season, after the fact.

To improve efforts in this field, DWR has undertaken an attempt to inventory the "state-of-the-art" by determining the current level of skill in this area. Some of the organizations currently involved in long-range forecasting include the National Weather Service (NWS); the Dr. Irving Krick Organization of Palm Springs, California; and the Scripps Institute of Oceanography at La Jolla, California.

The NWS routinely prepares twice-monthly 30-day outlooks on precipitation and temperature for the northern hemisphere. These outlooks give precipitation predictions in two categories -- above median and below median. Temperature predictions are given in three equal probability classes -- below normal, near normal, and above normal.

The procedure used by the NWS in these predictions is beyond the scope of this report, but is based upon predictions of airflow patterns in the atmosphere. The 30-day outlooks have been issued since 1947 but experience shows that success has been modest, with temperature forecasts enjoying more success than precipitation forecasts. Figure 28 is a comparison of observed levels of precipitation in the western United States with those predicted by the NWS's 30-day outlooks for the rainy seasons of the last two years (1976-78).

Although it would be desirable to develop additional skill in forecasting the weather a month hence, what is needed for operation and management of a complex water supply project is a long-term projection, at least a year in advance, with a high degree of reliability.

As an example of the current level of expertise in long-range weather forecasting, Figures 29 and 30 show Scripps' and Krick's meteorologic projections for the 1976-77 season, compared to the average and observed precipitation for the Feather River basin. Although both organizations predicted below average precipitation, the figures show that both forecasts were above the amounts actually observed. It is obvious that more work needs to be done.

In this connection, DWR contracted with the Dr. Irving Krick organization to prepare a forecast for the 1977-78 season. Its projections for precipitation in all Sierra Nevada watersheds were made available June 29, 1977. Because of the unproven skill of long-range forecasting, and the serious adverse effects possible as a result of error, no reliance was placed on the projections by SWP managers. The general results are included here solely to provide an insight into the adequacy of the skills involved.

The projections provided by Dr. Krick covered the months of October 1977 through June 1978 for six stations in the Sierra Nevada; two each in the northern, central, and southern portions of the mountain range. For the nine-month portion of the season indicated, average projections ranged from a high of 76 percent of average for the Pit River drainage, to 66 percent of average for the Calaveras River area. For the critical month of January, projections ranged from a high of 85-95 percent down to 45-55 percent of average precipitation.

The precipitation experience so far in 1977-78 has differed significantly from these projections in all the Sierra Nevada watersheds. Instead of the 70 percent (more or less) indicated by the Krick projections, precipitation at

Figure 29.

SCRIPPS LONG-RANGE METEOROLOGIC PROJECTIONS

Feather River Basin 1976-77

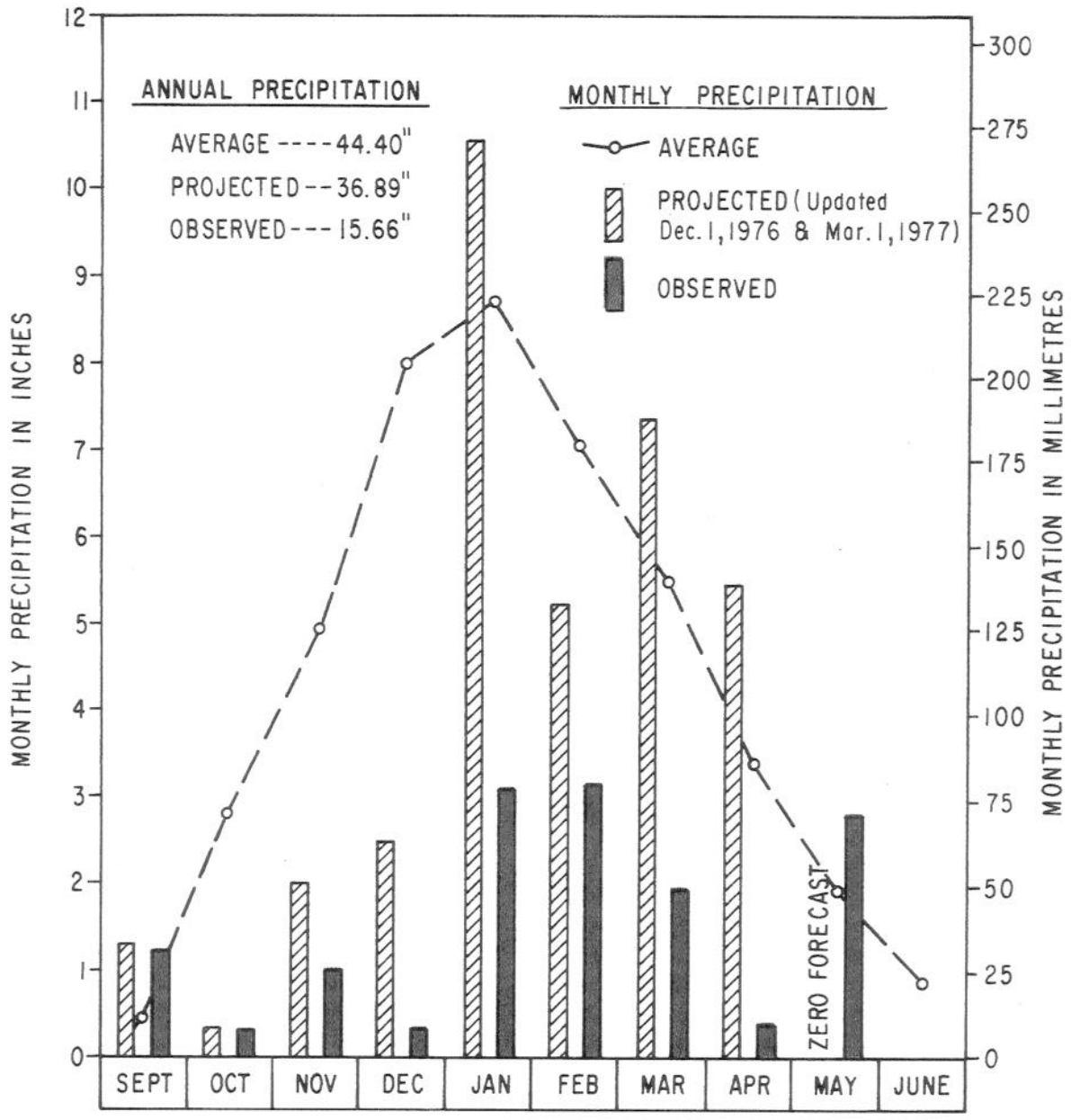
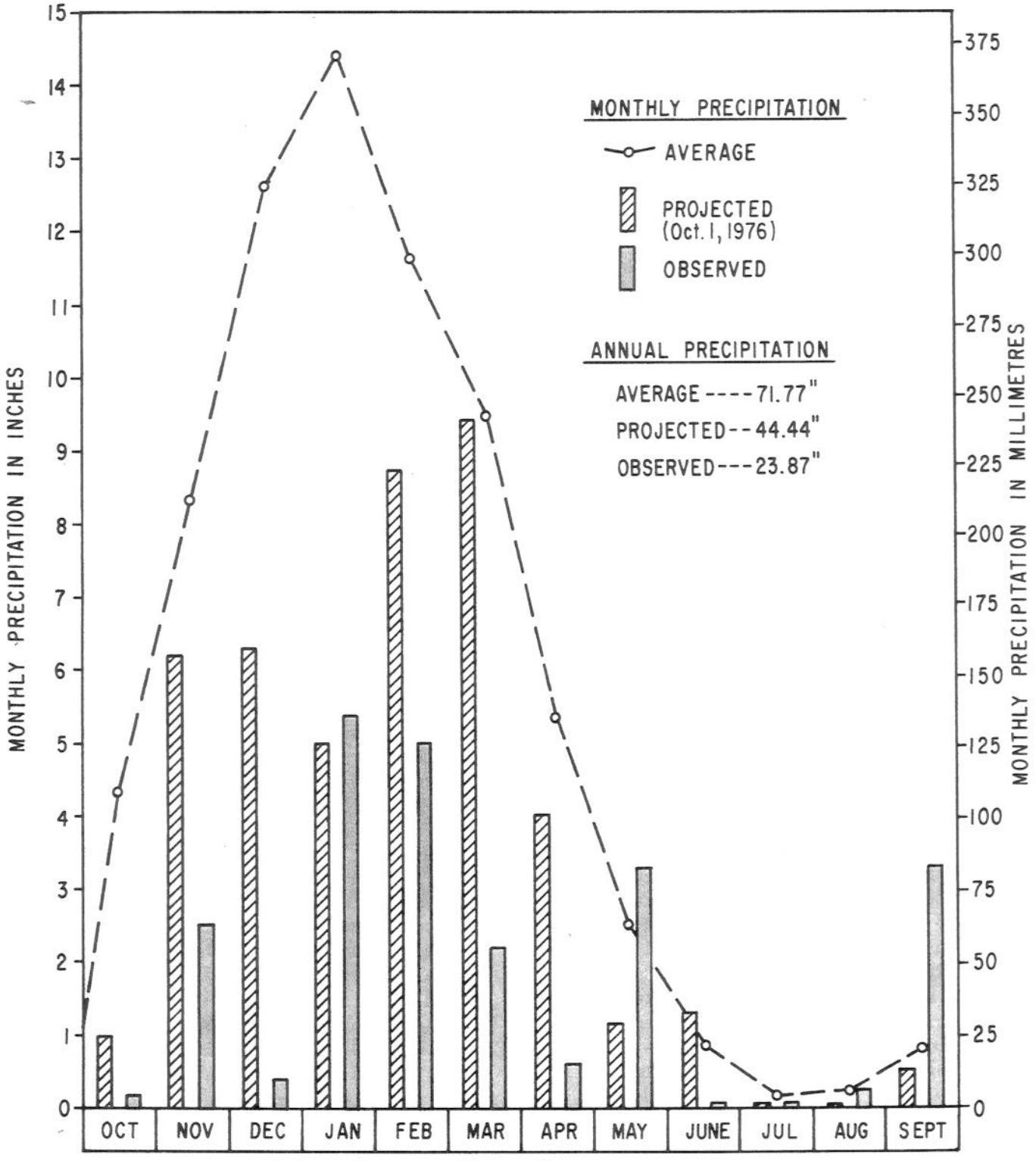


Figure 30.

KRICK LONG-RANGE METEOROLOGIC PROJECTIONS

Brush Creek, Feather River Basin 1976-77



Sierra Nevada stations has actually fallen at about double that rate, with some southern Sierra Nevada stations recording near 200 percent of average.

The Department has also been testing and evaluating experimental forecasts prepared by the Scripps Institute of Oceanography. The Scripps forecast procedure, still in the developmental stage, is part of a continuing research project dealing largely with air-sea interactions sponsored by the National Science Foundation. Procedures used to provide experimental forecasts in the 1976-77 and 1977-78 water years are still undergoing refinement as additional information is developed and evaluations are made of forecast results. At the present time, the methodology appears to hold some promise but results are still inconclusive; additional work needs to be done.

Ironically, one of the best forecasting records for the winter and spring of 1977-78 was turned in by a man who professes not to forecast at all. Dr. Orman Granger, a hydrology and meteorology researcher in the Geography Department at the University of California at Berkeley, calls his procedure "foreshadowing". It involved a statistical comparison of precipitation on the western coast of mid-Mexico with that falling in California. His studies indicated that California precipitation seemed to lag the Mexican figures by seven years. Applying the Mexican experience of seven years ago resulted in a projected much-above-normal California rainfall for 1977-78. Admittedly, such a procedure appears to have its perils, but if this or similar methods can be proven reliable, operating and management decisions can be made so as to minimize the chances for a catastrophe resulting from drought. We cannot afford to overlook possibilities for enhancing our skill at forecasting.

Contingency Planning Efforts

The threat of a third dry year, and the possibility that 1978 could be as dry as 1977, led DWR, in cooperation with the Governor's Drought Emergency Task Force, to develop a drought contingency strategy to ensure meeting critical needs, alleviate general drought conditions as much as possible, and identify actions to make the best use of very limited resources.

For the development of drought strategies, a "worst case" situation was considered, and it was assumed that the 1977 runoff pattern would repeat itself in 1978. (This implied somewhat higher precipitation than in 1977 to offset lower soil moisture and decreased spring and surface mantle drainage expected in 1978.)

Under the preceding assumption, the planning efforts concentrated on mandatory conservation and supply plans of major agencies, the identification of major problems, State, local and federal actions required to solve problems, and the amount of runoff that would be required to solve these problems. Also, nondrought related events that could aggravate the already severe drought conditions, such as a failure of a Delta levee or an outage of the Colorado River Aqueduct, were also investigated.

It was assumed that drought problems could be handled at the local level if the community could expect its 1978 water supply to provide a minimum of 284 litres (75 gallons) per capita per day and meet 75 percent of the 1976 level of governmental, commercial, and industrial water use. (A water use of 284 litres [75 gallons] per capita per day is about one-half the normal value and would not place undue constraints on living under severe drought conditions.) A special problem was considered to exist if less than 284 litres (75 gallons) per capita per day could be expected, and the problem was considered critical if less than 132 litres (35 gallons) per capita per day would be available. The 132 litre (35 gallon) per capita per day was considered to be the minimum average water use to maintain health and welfare.

If a local area did not have reasonable expectations of providing 75 percent of 1976 use for industrial requirements, then this was also considered to be a special problem as economic well-being and jobs could be affected.

Alternative water supply sources considered available to meet the needs of most cities and communities included water conservation/rationing, waste water reuse, recycling water in industry, water hauling, ground water, and water exchanges.

Contingency plans were formulated to provide water for the maintenance of perennial trees and vines and livestock, but not for other agricultural purposes. It was believed that, as a minimum, public agency plans should be made for maintenance water for perennial crops and livestock, especially in areas that lack adequate underlying ground water.

Generally, farmers and local agencies were advised as to actions they could take to stretch out available surface and ground water supplies. These actions included:

- Planting only those crop varieties with short growing seasons.
- Preparing land to prevent winter rainfall runoff.
- Maximizing the beneficial use of existing supplies -- drip and sprinkler irrigation, lining ditches, matching crops and irrigations with soil conditions to reduce percolation, reducing acres planted, and intensifying weed control programs.
- Foregoing the application of water to leach salts from the soil.
- Using gray water or reclaimed waste water on selected crops.

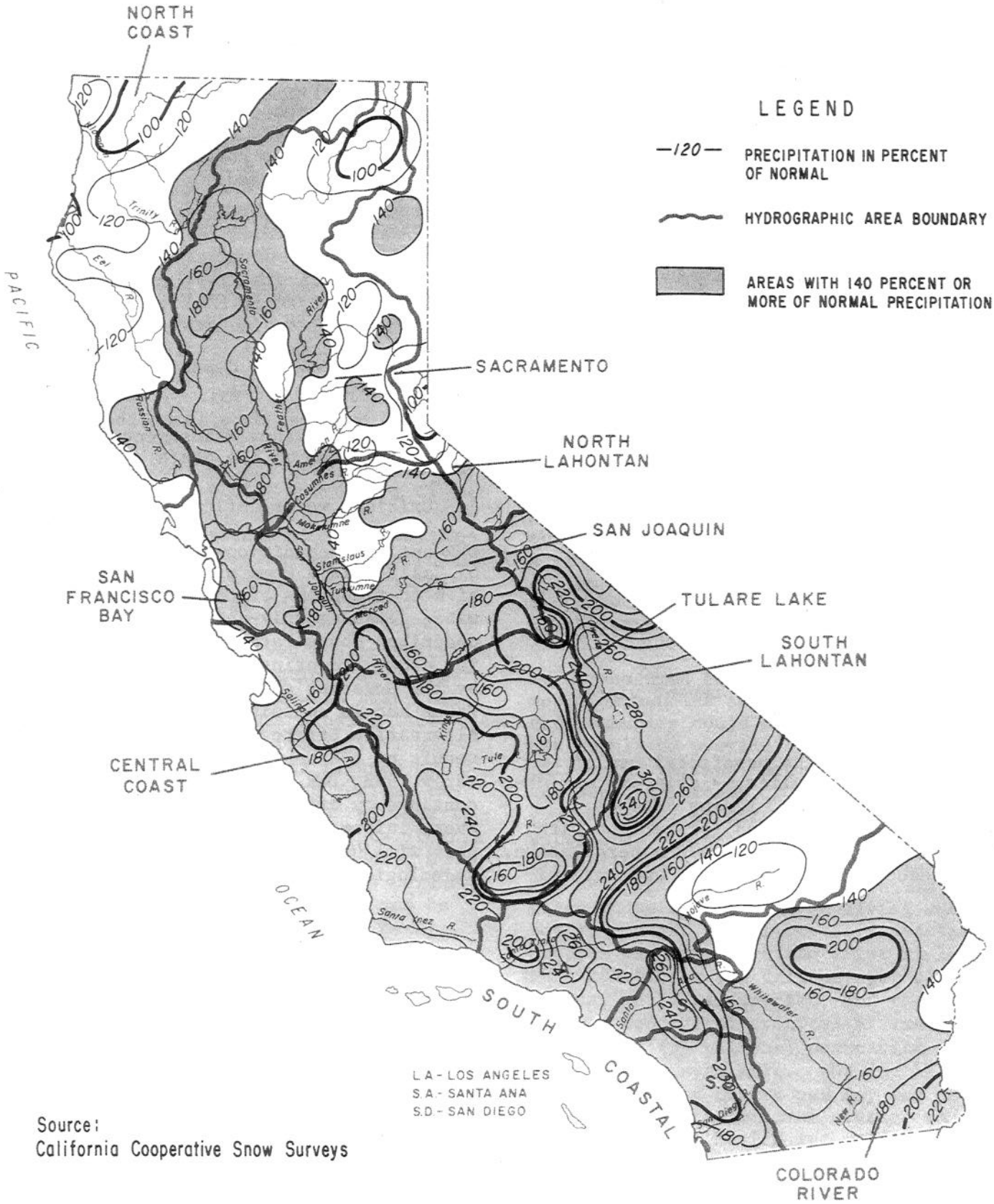
Based on the assumptions and policy guidelines described above, the following elements of the potential 1978 water shortage were analyzed:

- Potential supplies from major reservoirs.
- General operation of water importation projects.
- Water supply and demand by hydrologic areas of the State.
- Water deficiency assessment by hydrologic areas of the State.
- Critical water deficient areas.

DWR analyzed conditions facing a number of California's communities in the event of a continuation of the drought. The water demand-supply-deficiency analysis described above later became the basis for drought contingency plans prepared by the Governor's Drought Emergency Task Force and is contained in its "Drought Alternative Strategies for 1978". As a result of the heavy precipitation in early 1978, DWR suspended its drought contingency efforts on January 8. However, information gathered for the report will be available for similar future hydrologic conditions.

Figure 31.

SEASONAL PRECIPITATION OCTOBER 1, 1977 - APRIL 30, 1978



Source:
California Cooperative Snow Surveys

1978 OUTLOOK

DWR's August 1977 report, in commenting on the possibility that 1978 could be a third consecutive dry year, observed that a drought strategy needed to be developed to make the best use of resources expected to be very limited under those conditions. The Governor's Drought Emergency Task Force, in its "Drought Alternative Strategies", provided the plan.

The actual conditions experienced during the 1977-78 precipitation season have differed radically from those "worst-case" conditions assumed under the plan. From October 1, 1977, through April 30, 1978, precipitation over the Sacramento Valley averaged 145 percent of normal. Five consecutive wet months through the winter and spring have totaled up seasonal accumulations well above last year's record low amounts. For the same period in the San Joaquin Valley, precipitation averaged 170 percent of normal. In Southern California, heavy rains in February and March, plus precipitation since, brought seasonal totals to 220 percent of average. Statewide, precipitation amounts for 1977-78 appear to be headed for 155 percent of the average (see Figure 31). This compares to the 45 percent registered in 1976-1977.

The dramatic change in precipitation pattern is shown graphically on Figure 32, which compares typical storm tracks of the current season with those of the two years just past. In 1976-77, typically, storms were deflected far to the north (into Alaska and Canada) by a very strong high-pressure ridge west of California, Oregon, and Washington. In 1977-78, the storms have generally swept across the southerly latitudes with an increased impact on Southern California. This is reflected in proportionately greater amounts of precipitation falling in the southern Sierra Nevada and in Southern California, as indicated on Figure 31.

Also shown on Figure 32 is the track of the storm hitting Los Angeles February 8-10 which, together with several other high intensity storms this season, provided much of the near-record seasonal precipitation for that area in 1977-78.

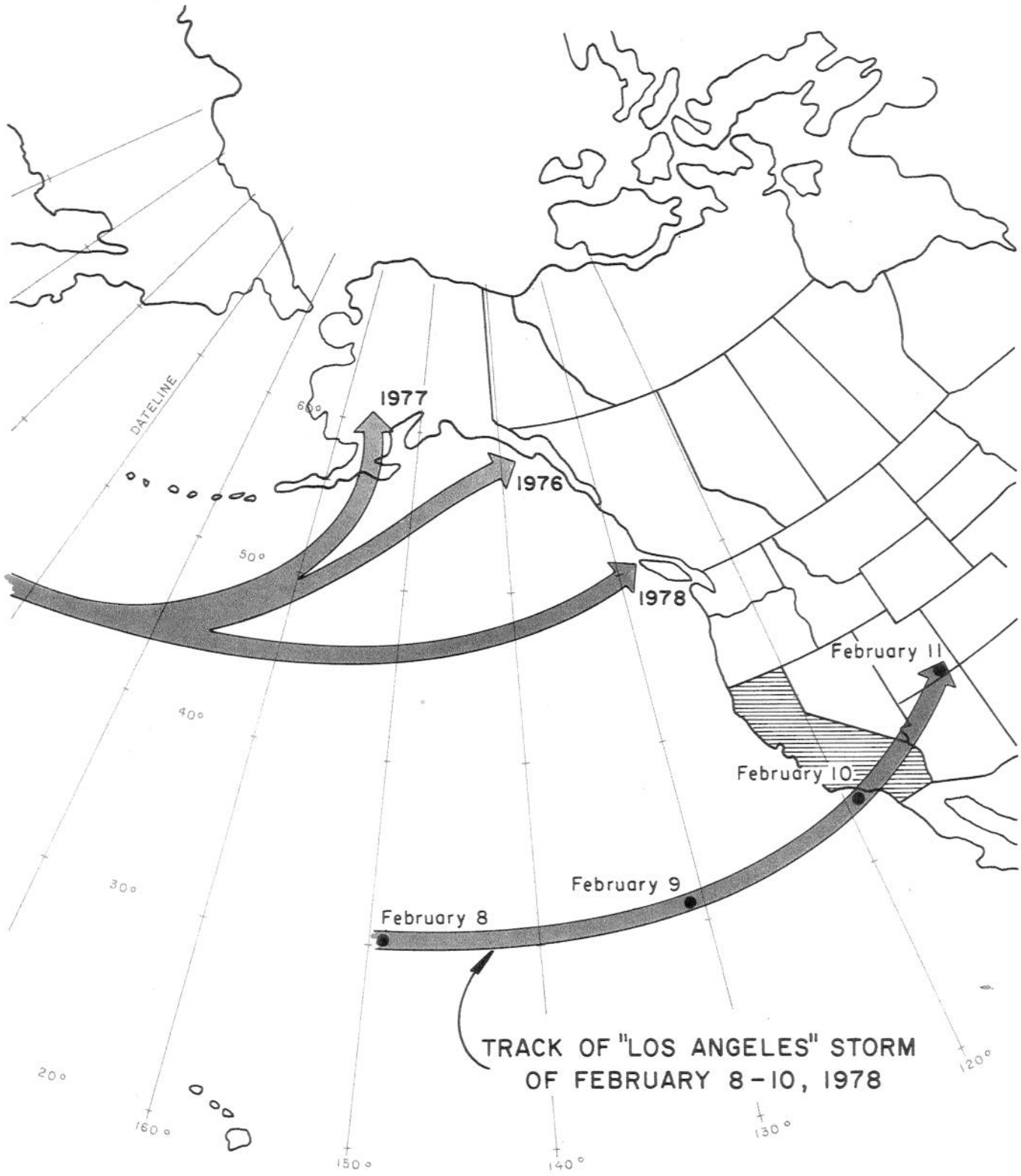
Projected runoff values throughout the State are similarly high. Norden, the snow measurement station at Donner Summit in the Sierra Nevada, again serves as the barometer of things to come as its 1978 seasonal pack, shown in Figure 33, reflects a much above-average accumulation. The May 1, 1978, forecasts of the April-July unimpaired snowmelt runoff range from a low of 141 percent of average on the upper Sacramento River to a high of 295 percent of average on the Kern River. Figure 34 shows the forecasts of water year runoff for 1977-78 in major basins supplying most of California's usable water. The statewide annual runoff is expected to reach 170 percent of the average, compared to the 22 percent estimated for 1976-77.

In addition to the benefits directly bestowed on California, the above average precipitation has ended a two-year drought that has plagued much of the western United States. Figure 35 shows the forecasts of streamflows in the 11 western states. Much of the West, except for parts of Oregon, Washington, and New Mexico, is expected to have average or above average runoff this season. The flow in the Colorado River, a major source of water for much of Southern California, will be about 141 percent of average.

The above-average runoffs will be reflected in improved storage during 1978 for California's many reservoirs. It is now expected that nearly all water supply agencies will start the season of greatest use (beginning about June) with full or nearly full surface reservoirs. Forecasted runoffs to four major reservoirs representative of conditions in Northern and Central California, shown on Figure 36, indicate the greatly improved conditions when compared to 1976

Figure 32.

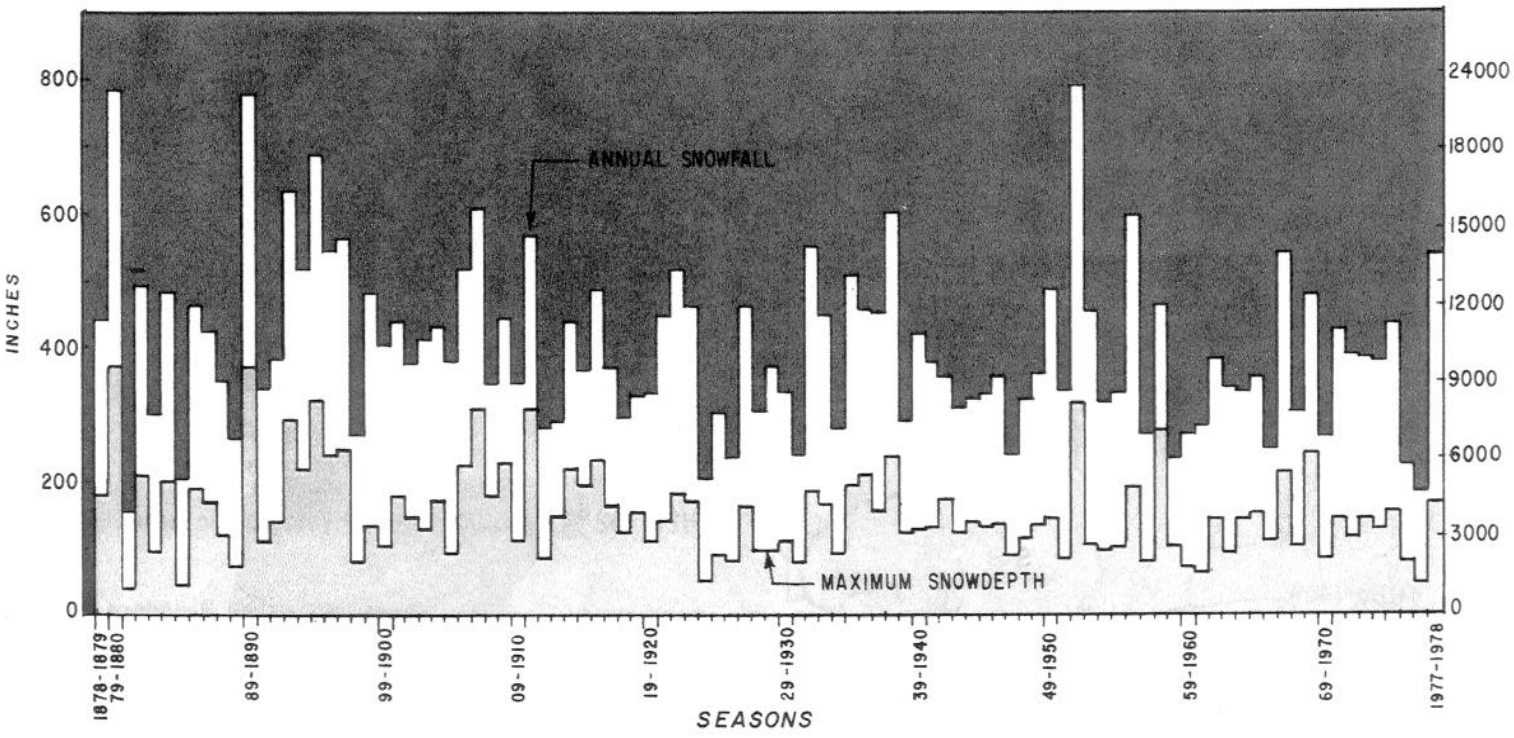
TYPICAL TRACKS OF STORM CENTERS AFFECTING WEST COAST
1976, 1977, 1978 Seasons



INCHES

Figure 33.

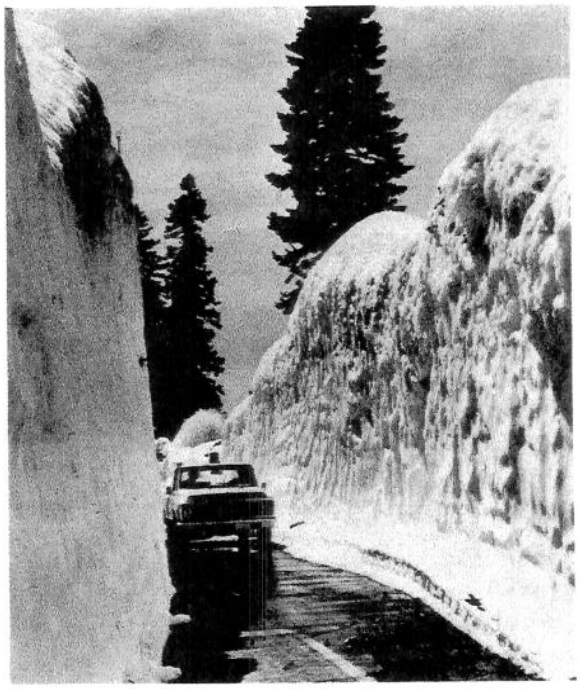
ANNUAL SNOWFALL AND MAXIMUM SNOWDEPTH AT DONNER SUMMIT 1878-1978



and 1977.

Ground water basins, although benefitting substantially from the replenishing rains, in many cases, will require several years to recoup their losses during the two years of drought. This is particularly true in areas of intensive use, such as the lower San Joaquin Valley. The Salinas Valley basin will reflect the improvement brought about by near-normal releases from Nacimiento and San Antonio Reservoirs. Mountain communities dependent on seasonal precipitation to refill their wells should have no problems in 1978. Similar results should be expected by others dependent on springs and stream diversions.

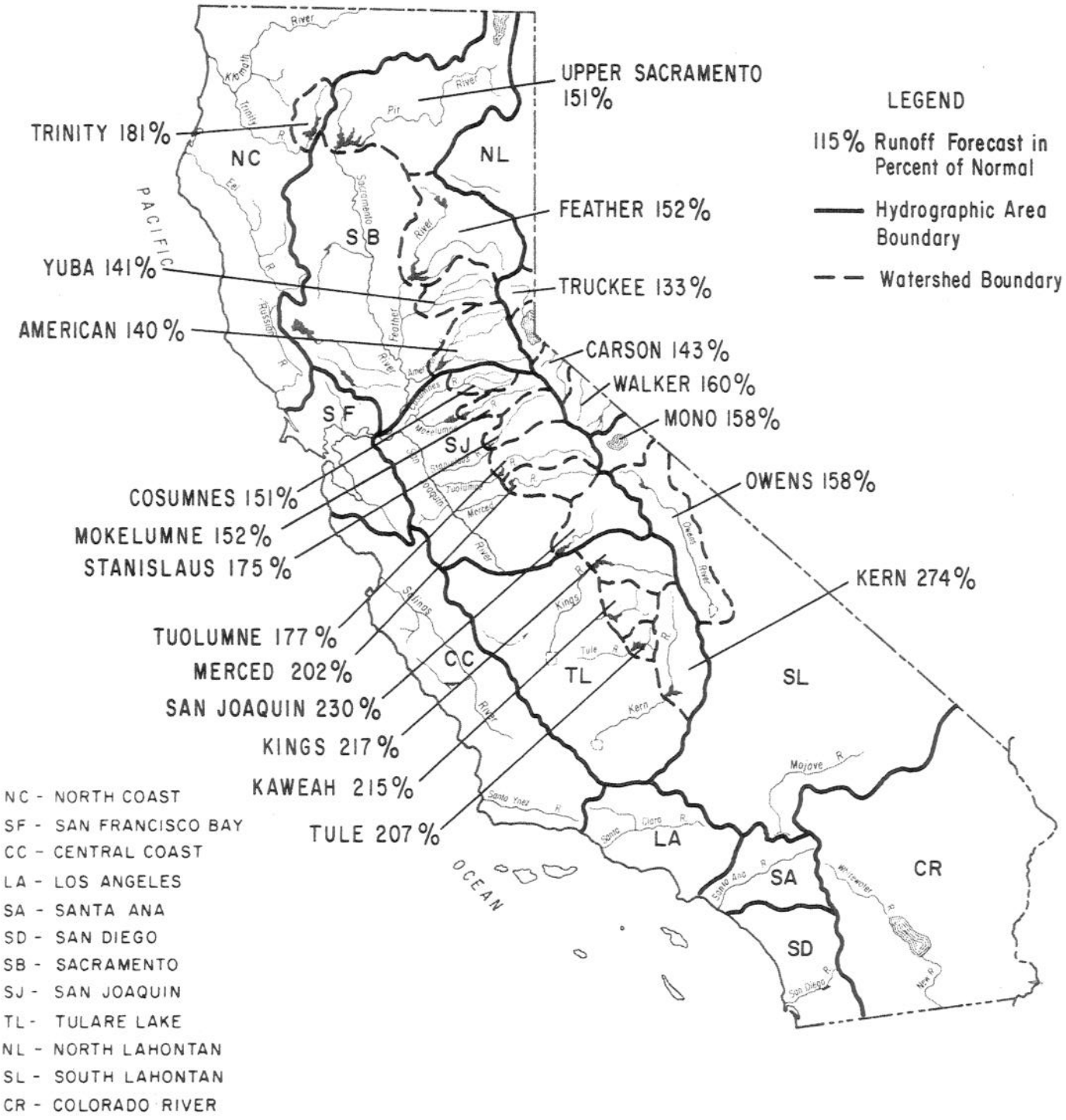
The 1977-78 rainy season has seen a dramatic turnabout in the conditions of several ground water basins. Ground water basins in Southern California, much of whose recharge water is ordinarily supplied by imported water (cut off or greatly diminished in 1977), have rebounded to a remarkable degree and will



51. The snow returns in 1978. A Park Service truck is dwarfed by 4.6-metre (15-foot) snowdrifts as it travels on the General's Highway in Sequoia National Park. This photo was taken on April 11, 1978. (National Park Service photo.)

Figure 34.

FORECASTS OF WATER YEAR UNIMPAIRED RUNOFF *
as of May 1,1978



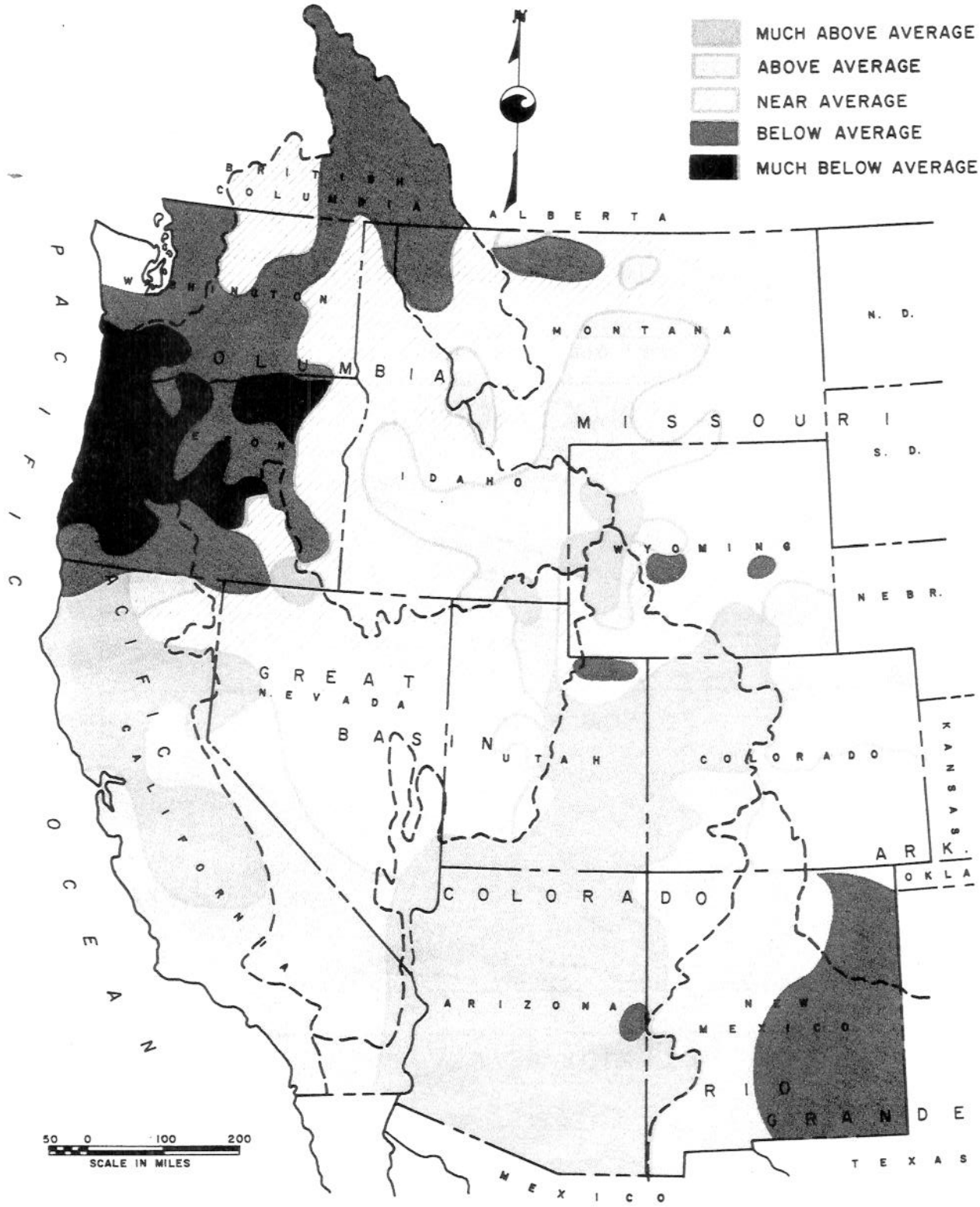
NC - NORTH COAST
SF - SAN FRANCISCO BAY
CC - CENTRAL COAST
LA - LOS ANGELES
SA - SANTA ANA
SD - SAN DIEGO
SB - SACRAMENTO
SJ - SAN JOAQUIN
TL - TULARE LAKE
NL - NORTH LAHONTAN
SL - SOUTH LAHONTAN
CR - COLORADO RIVER

* Forecasts of Runoff Assume Normal Precipitation to Follow.

Figure 35.

PROSPECTIVE STREAMFLOW IN WESTERN STATES *

1978 Snowmelt Season

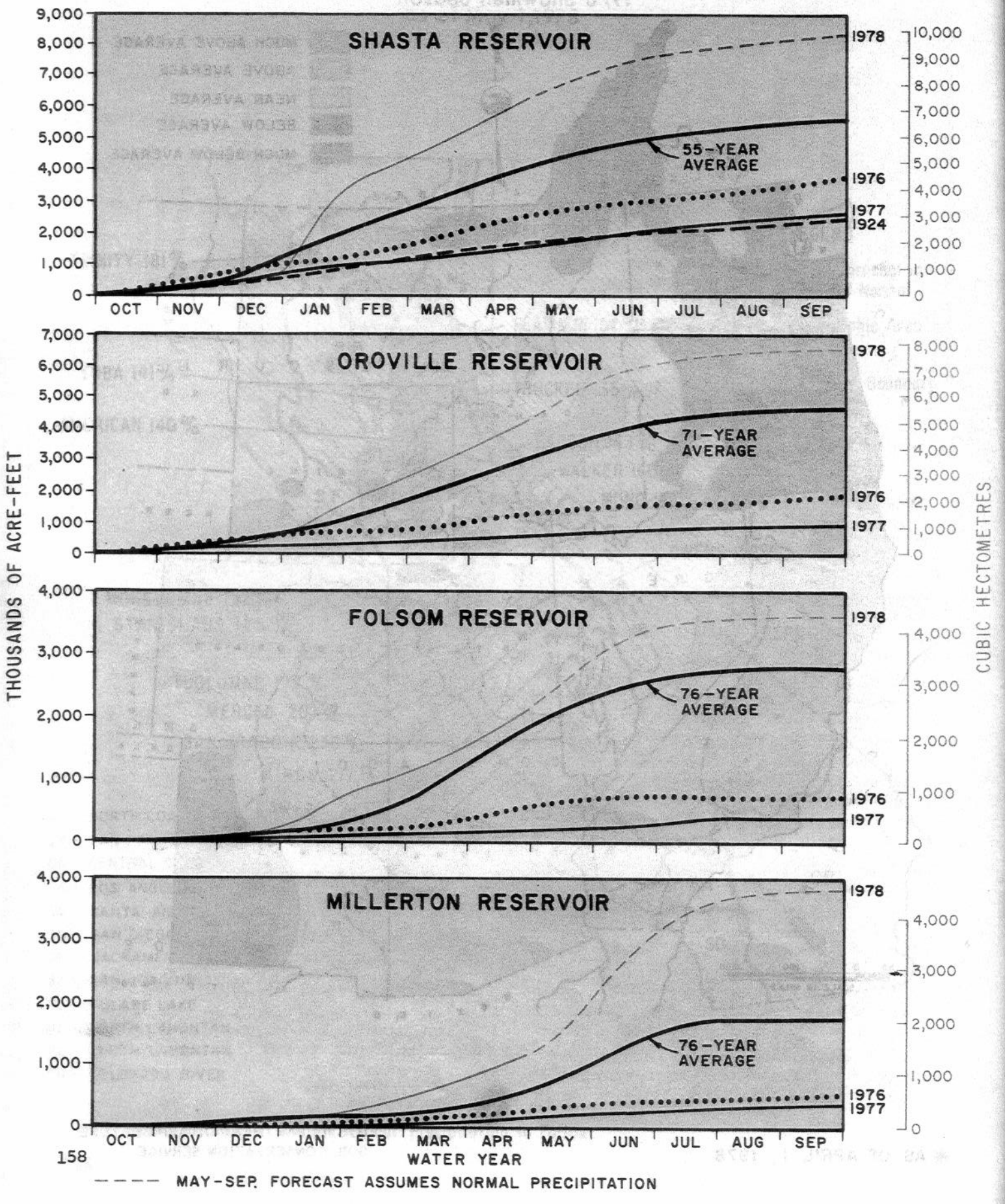


* AS OF APRIL 1, 1978

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

Figure 36.

ANNUAL NATURAL RUNOFF TO MAJOR RESERVOIRS DURING SELECTED YEARS



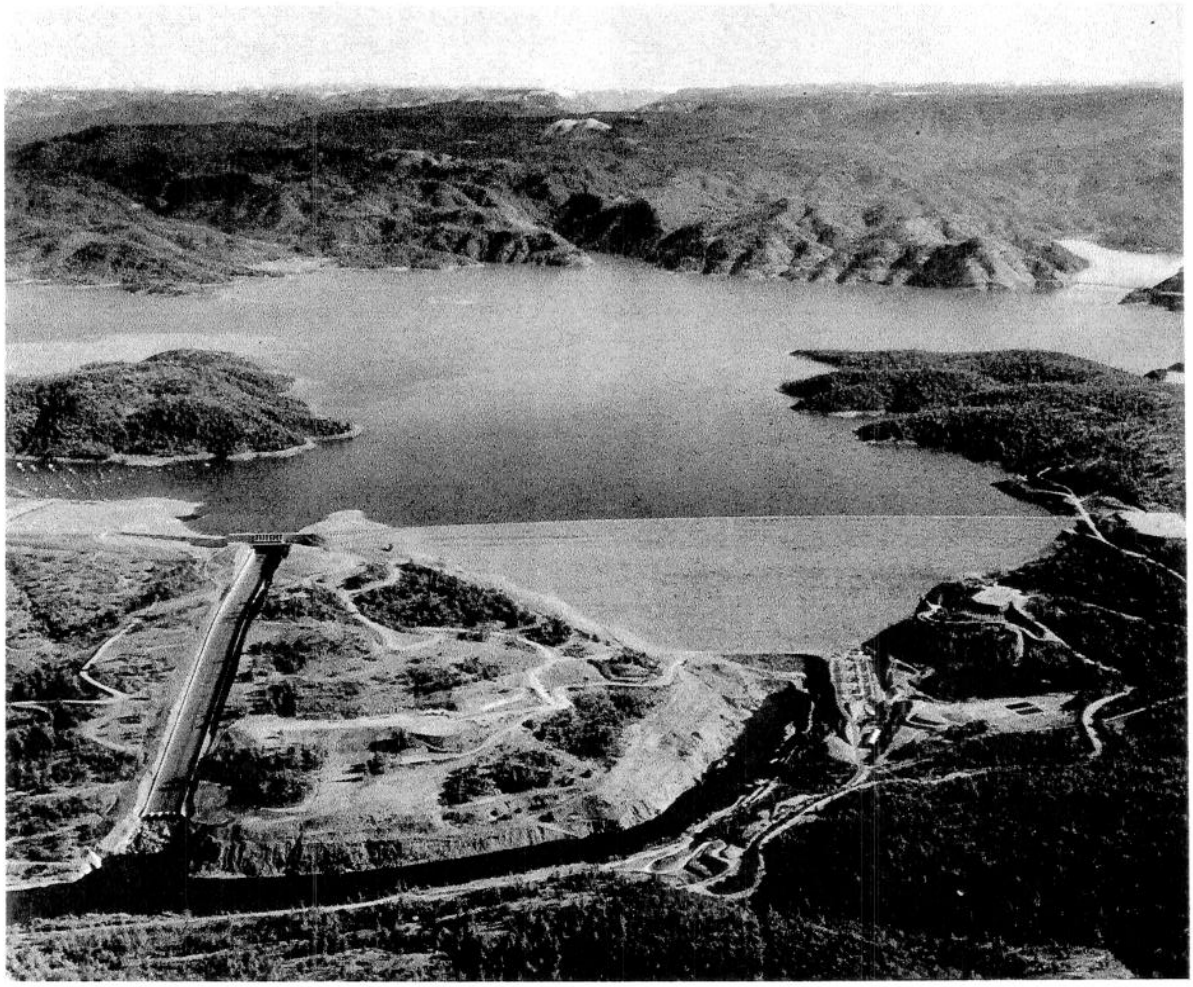
probably see a near complete recovery in 1978 as recharge water is again available. For example, the Los Angeles Department of Water and Power (LADWP) indicates that the Owens Valley basin on the east side of the Sierra Nevada may return to normal levels as a result of heavy precipitation on the valley floor and the recharge effect of the spring snowmelt. The LADWP's San Fernando Valley basin is also expected to return to normal levels. And in Orange County, the underground basin has recovered to a level above that recorded at the start of the drought. Similar gains have been recorded by many other basins, notably those near Clear Lake in Lake County and in Yolo, Sonoma, Mendocino, and Solano Counties. The extent of the recovery is indicated by early 1978 results shown in Table 5, but was still continuing after the measurements were taken.

The surplus of surface water in the southland extended its beneficial effect to ground water, as many agencies stopped pumping ground water to utilize the now abundant and cheaper surface supply.

The following discusses more specifically the 1978 outlook for some of the major water supply systems in the State.

State Water Project

With current seasonal amounts of precipitation ranging from 165 percent of normal at Shasta Dam in the north to over 200 percent of normal at Los Angeles in the south, combined with the above nor-



52. On the road to recovery. Lake Oroville as it appeared in April 1978 after heavy rains had brought a dramatic increase in storage.

53. The manmade river. The California Aqueduct, shown here meandering through the San Joaquin Valley, saw substantial reductions in the amount of water transported in 1977, but will deliver all water needed in 1978.

mal accumulation of snow in the Sierra Nevada, 1978 promises to be a bountiful year for the operation of the State Water Project. The project will be able to deliver all 1978 entitlement water requested, all 1977 entitlements carried over for delivery in 1978, and also other "deferred" water. Along with these deliveries, it appears that all project reservoirs will be filled or nearly filled this year resulting in above-normal carry-over storage next fall. This places the project in a good position for normal water delivery in 1979 even if it is a dry year.

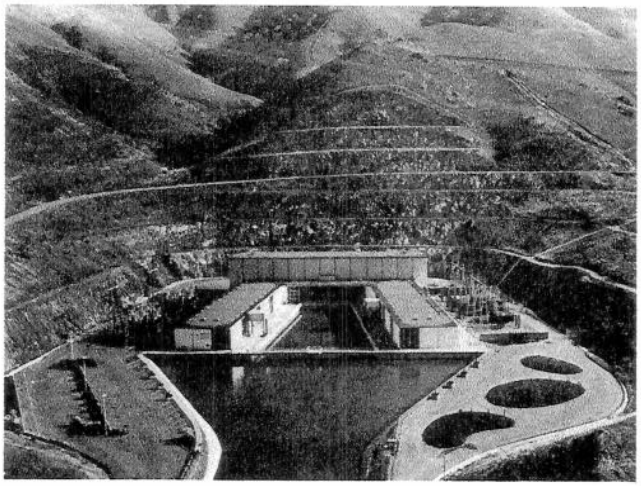
Entitlement deliveries in 1978 are projected to total nearly 1 730 cubic hectometres (1,400,000 acre-feet). Heavy precipitation has reduced the demand in Southern California, which is reflected in projected deliveries reduced from the 2 280 cubic hectometres (1,845,872 acre-feet) set by contract.

In addition to 1978 entitlements, the SWP will deliver 180 cubic hectometres (146,175 acre-feet) reserved by contractors from their 1977 entitlement and 460 cubic hectometres (371,803 acre-feet) of 1977's supply that was unavailable because of the drought. Projected SWP deliveries are shown in Table 6, earlier in this report.

In addition, about 68 cubic hectometres (55,000 acre-feet) conserved from Delta floodflows and 117 cubic hectometres (95,175 acre-feet) held as an emergency reserve in 1977 will be available in 1978.

Central Valley Project

The CVP has shared in the benefits extended by the heavy precipitation amounts falling generally throughout the State. The five major project reservoirs (Shasta, Trinity, Folsom, San Luis, and Millerton) held a combined total of 9 830 cubic hectometres (7,970,000 acre-feet) on May 1, 1978, which is 101 percent of the average for this date. Only Trinity Lake held less than average. Paradoxically, considering the conditions of the past two years, three of the five (Shasta, Folsom, and Millerton)



54. Water for the cities. The A. D. Edmonston Pumping Plant near Bakersfield, where water from the California Aqueduct is lifted over the Tehachapi Mountains for delivery to Southern California, saw little use in 1977 as the available supplies were shifted to Northern and Central California instead. 1978 will see a return to more normal deliveries.

have had to release unused in 1978 large quantities of water to make room for the expected substantially above-average spring snowmelt runoff. (In preparing for the spring runoff on the San Joaquin River, officials at Millerton Lake have released so much water that storage is actually below the May 1 average.)

Projected deliveries for the CVP are expected to be about 10 percent below those of predrought years. As a result, USBR officials are conserving water behind Trinity Dam to bring the storage up to power generation levels. The majority of CVP deliveries in 1978 will be met through releases at Shasta, Folsom, San Luis, and Millerton Reservoirs.

Hetch Hetchy Project

With the return of normal rainfall in the winter of 1977-78, and the anticipated normal or greater than normal runoff to its reservoirs, the San Francisco Water Department, early in 1978, suspended rationing for all Hetch Hetchy customers. The Water Department did, however, urge its wholesale customers in San Mateo, Santa Clara, and Alameda Counties and its City of San Francisco customers to continue to exercise voluntary conservation.

The Water Department has indicated that, presently, it anticipates a reduction in water use of 15 percent because of voluntary water conservation and, therefore, has assumed a water delivery in 1978 of 85 percent of normal.

Mokelumne River Aqueduct

The inflow to the East Bay Municipal Utility District reservoirs in 1978 is also expected to be normal or above normal, bringing Pardee and Camanche Reservoirs to full or near full status. The District, therefore, on February 1, 1978, suspended rationing. However, an active program of voluntary water conservation is being continued and the District anticipates a water use in 1978 of about 20 percent below normal.

Los Angeles Aqueduct

The outlook for the 1978 water supply is good, with no anticipated problems. Precipitation in the Owens-Mono basins through March 14, 1978, has ranged from 205 to 318 percent of normal, which would provide an estimated spring runoff into surface reservoirs of 160 to 170 percent of normal.

Earlier in the year, the aqueduct was operated at 40 percent capacity because of a turbidity problem; however, the plan is to operate the aqueduct at 80 percent capacity later in the year.

The Owens Valley ground water basin was being pumped primarily for local use. The rate of pumping was 1.7 cubic metres per second (60 cubic feet per second) in March 1978.

On January 19, 1978, diversion from Mono Basin for export was suspended and basin runoff is being held in storage or allowed to flow into Mono Lake. Diversion can be resumed at any time if the need arises.

Metropolitan Water District of Southern California

The water supply outlook for 1978 is good. With the restoration of delivery to MWD of its full entitlement amounting to 932 cubic hectometres (755,900 acre-feet) from the State Water Project (SWP), during the remainder of 1978, MWD intends to operate its Colorado River Aqueduct to yield 925 cubic hectometres (750,000 acre-feet). The plan is to use only enough power from the low-cost federal agency energy available to the District from Parker and Hoover Dams to obtain the yield from the Colorado River. (During 1977, MWD had to purchase more expensive power from Southern California Edison Company to pump additional quantities of water from the Colorado River to meet the needs of its member agencies.)

The resumption of SWP deliveries will allow MWD to reestablish its blending

program. In addition, 247 to 370 cubic hectometres (200,000 to 300,000 acre-feet) of water will become available for spreading and recharging the ground water basins in Southern California that were overdrafted during the recent drought.

Lake Matthews and Lake Skinner, two terminal reservoirs of MWD, were 85 percent and 92 percent full, respectively, in May 1978, and are being kept near full.

Other Projects

Those irrigation and water districts in the San Joaquin Valley that depend entirely on local supply will be able to meet their full agricultural demands in 1978. There will also be surplus water available to use for ground water recharge to help overcome the effects of excessive ground water withdrawals made during 1976 and 1977 in attempts to meet the demand. According to the water conditions survey of May 1, 1978, the forecast for water year runoff for San Joaquin Valley streams will range from 175 percent of normal on the Stanislaus River to 274 percent of normal on the Kern River.

All municipal water supply systems in the San Joaquin Valley, including those in the foothills, are now operating under normal conditions with full water supply. Mariposa had been operating under enforced rationing because their main source of supply, Mariposa Creek, was dry in 1977. Springville, which gets its supply from the Tule River, had operated under voluntary conservation because the river flow had dropped to almost no flow (about 0.03 cubic metre per second, or 1 cfs) in the fall of 1977.

In the Central Coastal area, full water demand for agriculture and for municipal and industrial uses will be met. For the seven-month period, October through April 1978, runoff on the major streams was 265 percent of normal.

Prospects for Agriculture

The return to higher precipitation figures in 1978 has already benefitted several industries which were among those suffering large economic losses in the 1975-76 and 1976-77 seasons.

The Department of Food and Agriculture reports that the livestock industry, which was estimated to have lost $882 million in the two years, is finally enjoying an upsurge in cattle prices. This is believed to be due in large part, however, to the extreme sell-off of light weight cattle and breeder stock during the drought, a factor which has resulted in the current reduced supply.

Low-priced livestock feed is also more available as the winter and spring rains have stimulated the recovery of grazing and rangelands. It is now expected that these sources will provide an above-average contribution to livestock feed.

Nonirrigated farming received a boost from the seasonal rainfall, and winter grains such as barley, oats, and wheat are expected to come to full maturity with nearly all being brought to harvest. This contrasts with the scenes of 1976 and 1977 when large planted acreages of grain were abandoned with no attempts at harvest.

The outlook for irrigated agriculture is equally bright. Nearly all water irrigation agencies report that they expect surface storage reservoirs to fill by early summer. In the southern San Joaquin Valley, water was released from reservoirs to recharge ground water basins as early as February in anticipation of abundant snowmelt in the spring. This operation continues. With the return to normal upstream releases, Delta agriculture will have the benefit of back-to-normal water quality. Ground water levels are expected to bounce back in many areas of the State. Exceptions will include the areas which traditionally

extract considerably more than is returned as recharge.

Reports from California growers on intentions to plant in 1978 indicate a 2 percent increase in the combined acreage of major field crops. It now appears that growers may plant more barley, rice, and sugar beets, but less wheat and cotton in 1978. Producers will make 1978 planting adjustments in response to full water availability, anticipated prices, and spring weather conditions. Water supplies for livestock producers have greatly improved, and range feed conditions were excellent with the arrival of warmer weather.

The Urban Situation

The rains of December 1977, and January and February 1978, provided relief to many communities whose water supplies were nearly depleted by the drought. Eureka in Humboldt County was the first to go off rationing; its Ruth Reservoir began spilling in mid-December. The Sonoma County Water Agency and the North Marin County Water District, serving a number of communities in the two counties, followed suit in early January 1978, when combined storage in Lakes Pillsbury and Mendocino reached 160 cubic hectometres (130,000 acre-feet). Gilroy lifted its restrictions on January 4. On January 18, Marin Municipal Water District, under strict rationing for two years, ended its rationing program. Contra Costa County Water District also ended its program the same day. San Francisco and Santa Cruz ended their restrictions on January 24, the Monterey Peninsula communities on January 25, and Los Angeles on January 27. East Bay MUD took similar action February 1.

Numerous smaller communities served by PG&E's mountain sources went off rationing during January 1978; they included Jackson in Amador County, Angels Camp in Calaveras County, Willits in Mendocino County, Colfax in Placer County, and Sonora in Tuolumne County. Other communities ending rationing in January included Tahoe City in El Dorado County, Auburn in Placer County, and Quincy in Plumas County.

Mariposa lifted restrictions on February 7 and Nevada Irrigation District acted to end rationing February 8. El Dorado Irrigation District's Sly Park Reservoir filled by April 1, 1978, and, in anticipation, the District acted to end rationing for most uses on February 14, with all restrictions ended on March 14, 1978.

Thus, the urban areas hardest hit by the drought have all ended their programs for mandatory conservation involving rationing or major restrictions on use of water. Many of the communities, in deference to lessons learned in the drought, still maintain conservation efforts, with minor restrictions, such as bans on the hosing off of sidewalks and other paved areas, still in effect.

Energy Forecast

The rainfall and snowpack of 1978 came as good news to energy-consuming Californians. Hydroelectric energy-producing dams saw their reservoirs filling with runoff from low-elevation rains while the higher elevation parts of their drainage basins stored an abundant snowpack. The 1978 year promises to provide California an above-average proportion of cheaper and cleaner energy derived from hydro facilities.

In a normal season, hydroelectric output is 32.6 billion kWh. In 1978, it is estimated that about 38 billion kWh will come from this source. Nonetheless, the extra amounts will not replace in total that energy lost during the two-year drought (estimated at 32.6 billion kWh, a full year's supply). At current rates of replacement it would take five additional years.

Recreation Outlook

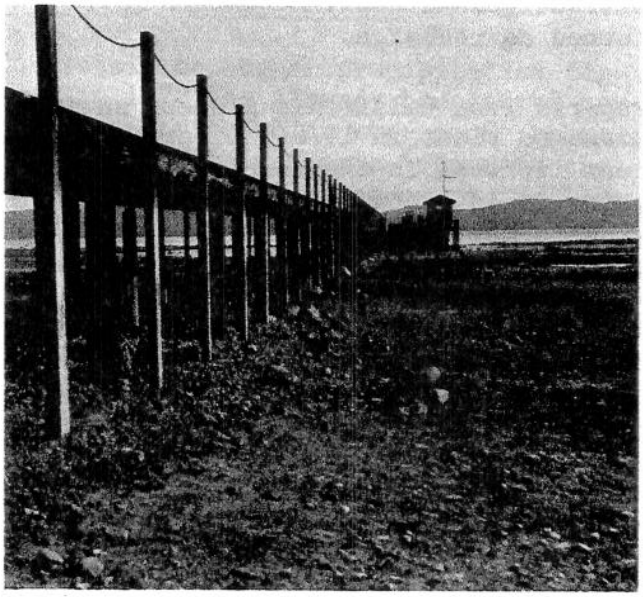
The recreational industry, whose winter sports and water-oriented sectors were

among the hardest hit by the drought, is expected to rebound to normal levels with some areas experiencing record patronage. Already mentioned is the banner year being enjoyed by the ski resort group. The deep snowpacks generally prevalent throughout the State's skiing areas means that winter sports will be available late into the season.

Lake-oriented recreation should see an above-average year, with nearly all surface reservoirs and natural lakes full at the start of the season. The extended runoff promised by the deep snowpack should provide a longer period of near-full conditions.

Stream conditions for the angler, the white-water enthusiast, and those who just plain enjoy running streams appear to be the best in years. Many of the State's hydroelectric projects, whose releases are largely relied upon by this fraternity, have been releasing water nearly continuously since January in anticipation of the snowmelt.

55. Return to normal. Edward Hyatt Powerplant at the base of Oroville Dam, shown here in an interior view, is an example of the hydroelectric generating plants whose power outputs were reduced by drought in 1977 but are expected to produce energy at normal rates in 1978.



56. High and dry. Two years of drought left many boat piers unreachable by boat in 1977. This pier, photographed in November 1977, near Tahoe City, Lake Tahoe, will see use in 1978.

Forest and wildlands, the national parks and forests, and the State and local recreational areas all share in the optimistic outlook for 1978. There should be no closures due to lack of water and the spectre of closures due to extreme fire conditions, which hung so heavily over the prospects of the last two years, has been eased by the beneficial rains.

Forest Conditions

Countering the optimism engendered by the rains of 1978 is the sobering realization that fire fuel accumulations have increased as the result of the addition of drought-killed trees and brush. The potential for disastrous fires in 1978 has actually increased, and needs only a prolonged dry period to propel that potential to major proportions.

Besides the problem of already dead trees, the Department of Forestry reports that insect infestation in the northern part of the State in 1978 is the worst ever experienced by the Department. This infestation covers most of Northern California where drought was experienced, including the

Sierra Nevada, the Siskiyou Mountains, and the Shasta, Clear Lake, Sonoma, and Oroville areas. Pine tree forests are the most affected.

The infestation affects an estimated 10 billion board feet, double the annual production of California's lumber mills. From the start of an infestation, trees can be logged for approximately one year; thereafter the wood deteriorates too badly for harvest.

Both the Department of Forestry and the U. S. Forest Service plan to identify and salvage as much of the timber as possible. The U. S. Forest Service plans include:

1. Evaluation of the current high-mortality areas of pine for the possibility of future catastrophic tree losses and need for direct insect control.

2. Evaluation of recent tree mortality and the computation of loss estimates based on fall 1977 aerial photographs.

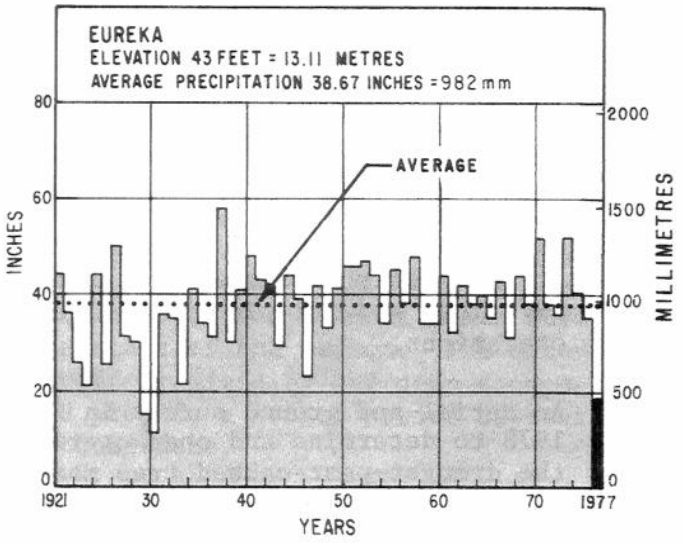
3. Coordination of a spring aerial sketch-mapping survey of tree mortality for early estimates of spring 1978 loss and for planning salvage operations.

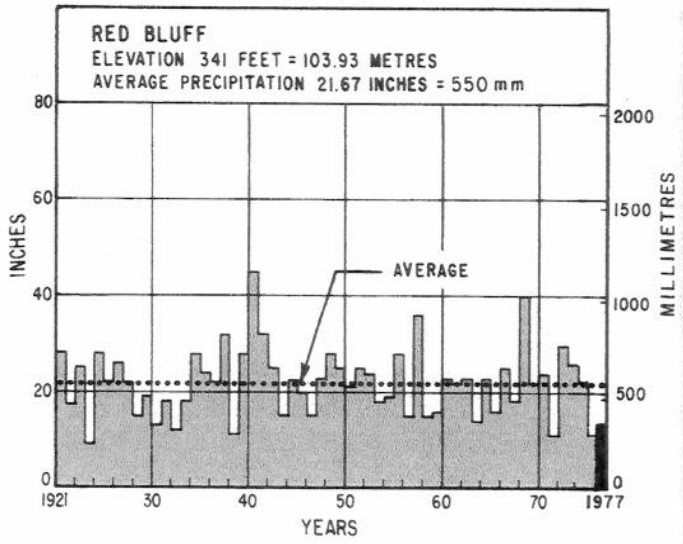
4. An aerial and ground survey in June 1978 to determine and characterize the drought-pest-caused tree mortality which became visible in the fall of 1977.

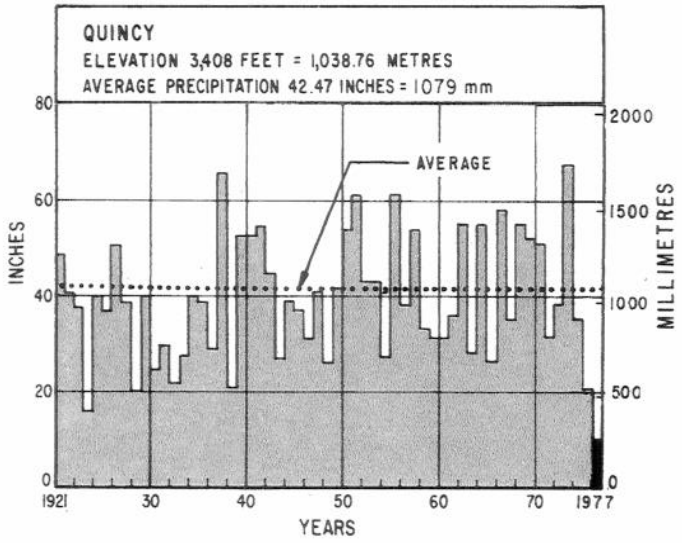
57. Death of a tree. The dead pine tree in the center, photographed in December 1977 near Buckhorn Summit west of Redding, is an example of the drought and pest damage suffered by California's forests after two dry years. Constrast this with the healthy tree to the right.

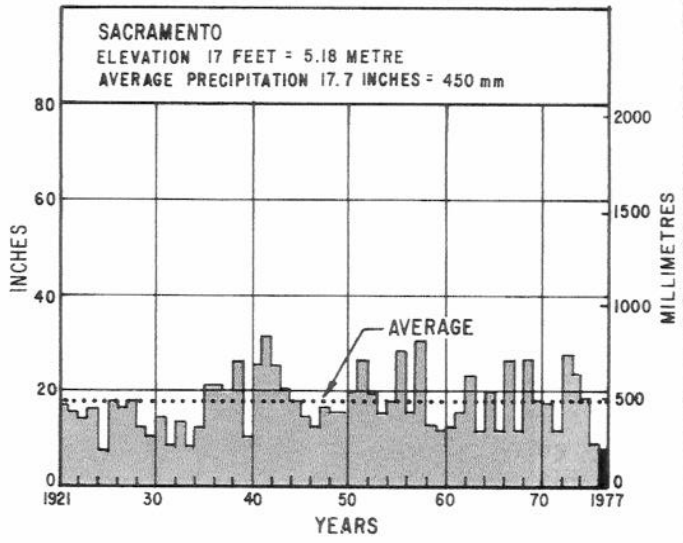
Figure 37.

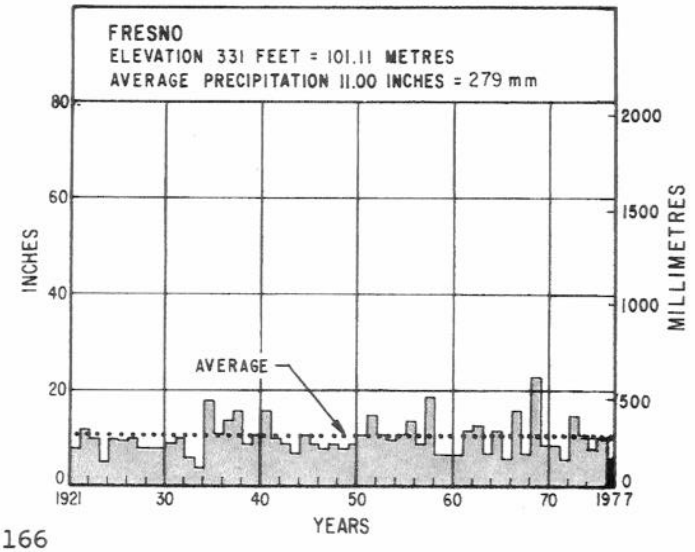
ANNUAL PRECIPITATION AT SELECTED LOCATIONS 1921-1977

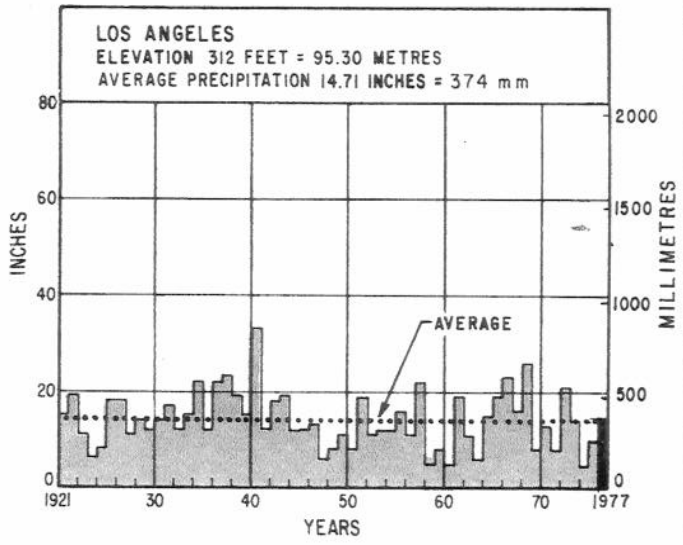












Note: Average based on period up to 1976

THE LESSONS LEARNED

To many Californians the bitter experiences of 1976 and 1977 have been relegated to memory and in many minds exist only as remembrances of past inconveniences. For others, the habits learned during the water-scarce period have become a fixed way of life. It is now apparent that 1978 is transitional; it can be a year of near-normal water use or it can be the beginning of a new way of life, based on the awareness that improvident use of water can have devastating results. Events of the past several years have shown that water scarcity can descend upon the unaware with astonishing swiftness.

History shows us no guarantees that the next several years will not be dry. Reference to Figure 37, recording the variation in annual precipitation at six locations for the period 1921-1977, shows the extreme variation possible in California's weather from year to year. The variability of California weather seems to be its greatest consistency. A case in point is the California drought period of 1928-1934, which for years has served as the model of water supply availability for most modern Northern California water projects. Figure 38 illustrates annual runoff on the American River during this period. During the first three water years of the drought, 1928-29, 1929-30, and 1930-31, annual runoff ranged from 26 to 64 percent of the average value. In 1932, in a temporary respite, runoff amounted to 101 percent of average. However, in 1933 the dry period resumed and for the next two years annual runoff was 49 percent and 44 percent of average, respectively.

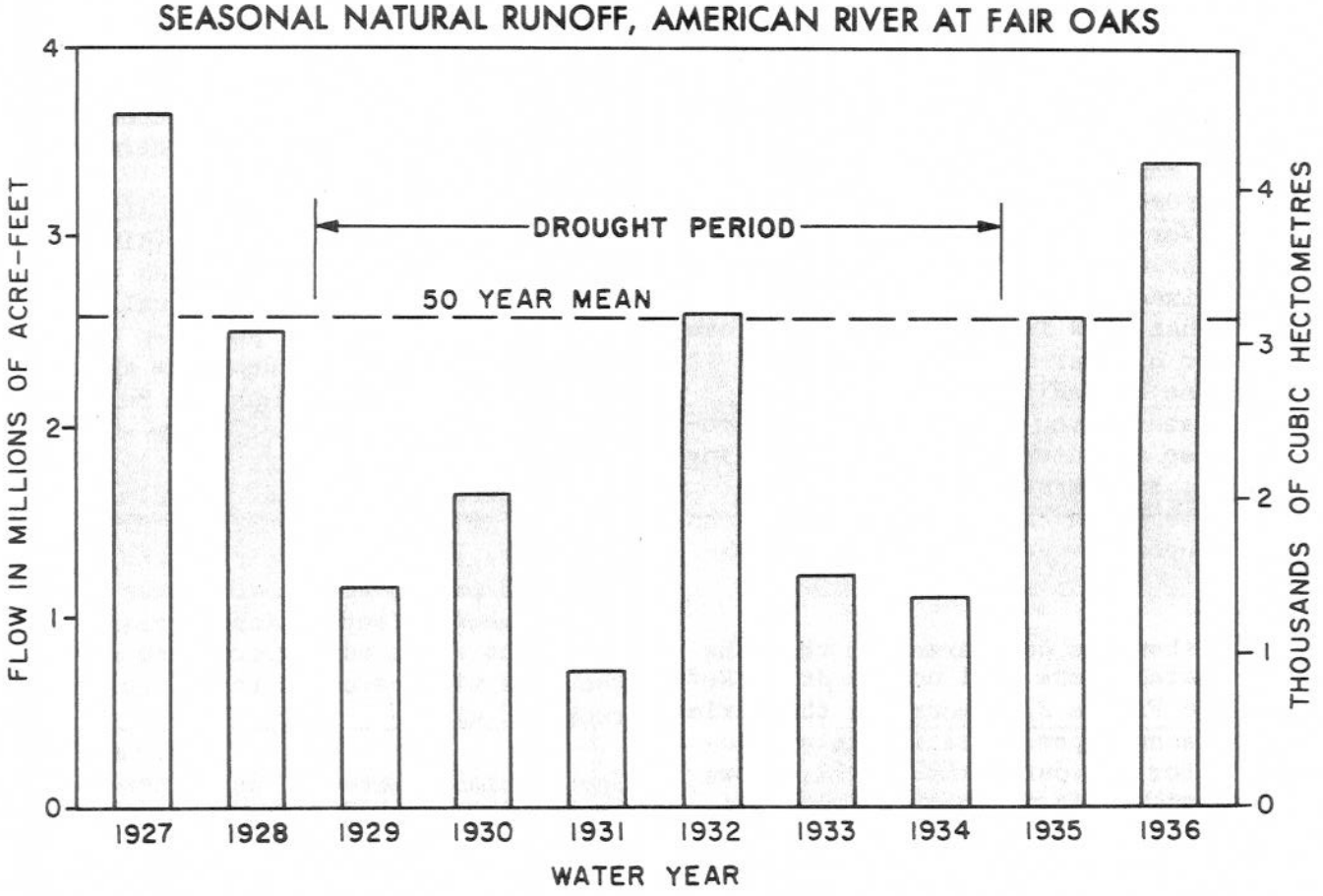
Runoff from other California rivers demonstrates equal variability. Figure 39 is a plot showing variations in annual runoff, in terms of percent of the average, for eight Northern and Central California streams. Even devotees of the cyclical nature of weather will find it difficult to fit a cycle to account for the extreme year-to-year variations shown.

Figure 39 also suggests that California's weather during recent memory (since about 1950) has been more benign than in the past. Annual runoff has generally been above average for that period. Contrast this with the two decades from about 1920 to near 1940 when annual runoffs were more often than not below average. The significance of this to Californians cannot be overestimated. Should the drought of 1975-77 signal the return to the drier regime of the '20s and '30s and 1978 proves to be a temporary peak, the tremendous population increase and attendant water use experienced since the '30s will become a factor to be reckoned with.

Speculation about what the weather will be in 1979 and 1980 is useful only in establishing a framework for planning. As a first step, we must know the extent of our resources. Table 10 is a summary of major surface storage, contained in 143 reservoirs grouped by hydrologic areas, as of May 1, 1978. Also tabulated for comparative purposes are storages for the same reservoirs on the same date for 1975, 1976, and 1977. Total reservoir storage in May 1978 was 31 000 cubic hectometres (25,130,000 acre-feet). This is 202 percent of that recorded in May 1977, 118 percent of that of May 1976, and 97 percent of that recorded in May 1975, before the drought began.

Several generalizations may be drawn from these data. Based on reservoir storage, California may be said to be in much better shape now than at the corresponding dates in 1977 and 1976 and approximately back to predrought conditions. All other factors being equal, it may be inferred, therefore, that Californians could endure a two-year drought of the magnitude of 1975-1977 (but beginning this fall) with no greater strain than was evident in these two years.

Figure 38.



To accomplish this objective with least disruption, some changes will be necessary to bring predrought lifestyles into line with current reality. Some of the changes being recommended by DWR are in a May 8, 1978, letter directed to all California water agencies. In it the Department pledges to continue its efforts in educating the public and in providing information useful in making more beneficial use of the water resource. (A copy is included as Appendix H.)

This report has detailed the disruptions and dislocations of the last two years and the actions taken in their mitigation. If we have learned our lessons well, the social and economic impact of a repeat of the drought can be minimized so as to create even less strain. The actions of 1976 and 1977 can be taken as the foundation of a planning blueprint for "worst-case" conditions in 1979 and 1980.

For example, urban conservation in 1977 achieved an estimated one-year reduction in water usage of 1 233 cubic hectometres (1,000,000 acre-feet). Assuming that 50 percent of this figure reflects permanent annual savings possible without need to resort to extraordinary measures such as rationing or bans on outdoor use, possible annual savings amount to 617 cubic hectometres (500,000 acre-feet). Two years' savings at the same level of effort would double this and equal the two-year savings of the recent drought.

The advantage of spreading out the urban impact over two years is substantial. The urban problems encountered in 1977, including the rationing and ensuing impacts on certain economic sectors, were

Figure 39.

ANNUAL NATURAL RUNOFF ABOVE SELECTED STATIONS (IN PERCENT OF AVERAGE) 1921-1977

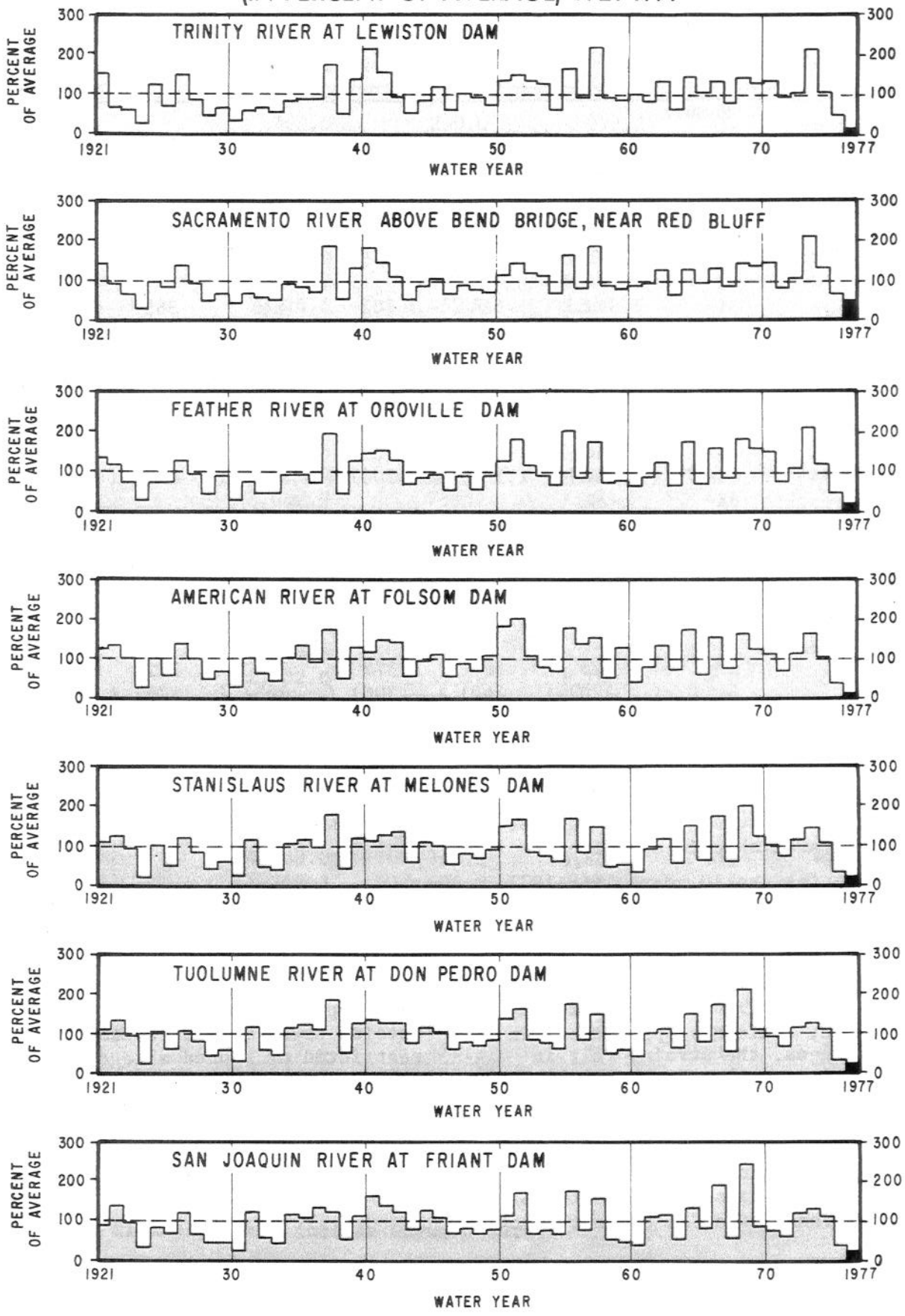


TABLE 10

RESERVOIR STORAGE BY HYDROLOGIC AREA*
May 1, 1978
CUBIC HECTOMETRES
(thousands of acre-feet)

Area	Number of Reservoirs	Total Capacity	10-Year Ave. Storage 1/	Storage May 1 1975	Storage May 1 1976	Storage May 1 1977	Storage May 1 1978	1978 as Percent of Average
North Coastal	6	3 456 (2,803)	2 902 (2,353)	3 017 (2,446)	2 733 (2,216)	1 431 (1,160)	2 208 (1,790)	76
San Francisco Bay	17	846 (686)	614 (498)	702 (569)	476 (386)	385 (312)	698 (566)	114
Central Coastal	6	1 210 (981)	855 (693)	1 148 (931)	854 (692)	501 (406)	1 061 (860)	124
South Coastal	28	2 603 (2,111)	1 439 (1,167)	1 480 (1,200)	1 375 (1,115)	1 106 (897)	2 120 (1,719)	147
Sacramento Valley	47	20 796 (16,866)	15 915 (12,902)	17 294 (14,020)	13 380 (10,847)	7 550 (6,121)	17 350 (14,066)	109
San Joaquin Valley	31	12 100 (9,814)	7 009 (5,682)	7 817 (6,337)	7 035 (5,703)	4 127 (3,346)	7 313 (5,929)	104
Lahontan	8	525 (426)	328 (266)	377 (306)	324 (263)	212 (172)	247 (200)	75
TOTAL	143	41 536 (33,687)	29 062 (23,561)	31 835 (25,809)	26 177 (21,222)	15 313 (12,414)	30 997 (25,130)	107

* The reservoirs used in this tabulation include most, but not all, of the storage capacity available in each area.

1/ Average for the 10 years 1968-1977.

a direct result of starting too late. There was very little urban water conservation in 1976. Water conservation, if practiced in 1976 to the degree outlined above, would have prevented, in most instances, the strains felt in 1977.

DWR's survey of 35 municipal and industrial water agencies (Table 11) shows that water use since the end of the drought (in the first three months of 1978) has remained at 21 percent below predrought levels. A partial explanation for this phenomenon is that the above-average winter and spring rains have kept consumption at low levels. Outside uses, most of which were either restricted or banned altogether during the drought, are expected to increase water consumption levels as summer approaches. Water district officials feel, however, that users have learned how to conserve water and will continue to do it.

TABLE 11

COMPARATIVE WATER USE BY MAJOR M & I[1/] AGENCIES
JANUARY 1 - MARCH 31
1976, 1977, 1978

City	Water Use (1,000,000 Gallons)[2/]			% Difference		
	1976	1977	1978	76-77	76-78	77-78
Eureka	303.0	260.0	292.2	-14	- 4	+12
Redding	282.1	291.7	295.7	+ 3	+ 5	+ 1
Chico	705.8	638.5	563.6	-10	-20	-12
Alturas	44.8	48.9	47.6	+ 9	+ 6	- 3
Subtotal	1,335.7	1,239.1	1,199.1	- 7	-10	- 3
Sacramento	4,387.1	4,053.4	3,980.6	- 8	- 9	- 2
San Francisco	8,674.0	7,464.0	6,459.0	-14	-26	-13
San Jose	7,726.1	6,459.4	5,648.5	-16	-27	-14
East Bay MUD	16,473.4	13,051.1	10,805.2	-21	-34	-17
Alameda Co. WD	1,889.1	1,599.0	1,504.8	-15	-20	- 6
Stockton	1,695.3	1,373.2	1,200.9	-19	-29	-13
Contra Costa Co. WD	7,458.1	7,157.6	2,228.0	- 4	-70	-69
Santa Clara	1,460.7	1,333.9	1,182.9	- 9	-19	-11
San Mateo	924.8	719.7	617.2	-22	-33	-14
Daly City	639.4	547.9	409.2	-14	-36	-25
Hayward	1,067.9	791.7	NA	-26	--	--
Sunnyvale	1,462.6	1,291.7	1,181.7	-12	-19	- 9
Marin MWD	1,828.8	1,008.9	1,073.2	-45	-41	+ 6
North Marin WD	421.7	345.2	291.0	-18	-31	-16
Santa Rosa	878.0	694.0	687.0	-21	-22	- 1
Subtotal	55,919.1*	47,099.0*	37,269.2	-16	-33	-21
Fresno	3,188.0	2,613.7	2,412.8	-18	-24	- 8
Bakersfield	2,502.0	2,303.6	1,780.7	- 8	-29	-23
Modesto	1,645.0	1,389.1	1,347.1	-16	-18	- 3
Merced	600.4	468.6	449.0	-22	-25	- 4
Monterey Bay	1,119.4	785.2	641.2	-30	-43	-18
Sonora-Jamestown	96.0	97.4	65.0	+ 1	-32	-33
Subtotal	9,150.8	7,657.6	6,695.8	-16	-27	-13
Los Angeles	42,367.7	41,127.1	29,930.9	- 3	-29	-27
Long Beach	4,888.0	4,345.3	3,807.4	-11	-22	-12
San Diego	11,342.3	10,606.3	9,480.2	- 6	-16	-11
Anaheim	3,699.3	3,383.5	2,305.8	- 9	-38	-32
Riverside	2,724.0	2,412.0	2,336.8	-11	-14	- 3
Santa Barbara	1,058.3	874.2	743.1	-17	-30	-15
Oxnard	1,250.9	1,213.2	1,178.8	- 3	- 6	- 3
Ventura	1,577.7	1,281.5	1,086.5	-19	-31	-15
San Luis Obispo	443.5	446.0	366.7	+ 1	-17	-18
Santa Maria	547.4	479.3	391.5	-12	-28	-18
Subtotal	69,899.1	66,168.4	51,627.7	- 5	-26	-22
Total Reported	136,304.7	122,164.1	96,791.8	-10	-29	-21

1/ Municipal and Industrial.

2/ 1,000,000 gallons = 3 785.4 cubic metres.

* Subtotal figures do not include Hayward data.

The San Francisco Water Department may have to raise water rates because San Franciscans have continued to save water. Department officials based their revenue forecasts on 85 percent of predrought usage, but two months after mandatory rationing was lifted in that city, water customers were still conserving at 70 to 75 percent of their predrought consumption level.

Elsewhere in the bay area, water consumption had remained below predrought levels up to April 1978. Water consumption in the East Bay MUD area was 66 percent of normal, Contra Costa County WD was at 30 percent of predrought levels, Alameda County WD reported consumption was 20 percent below predrought levels, and the City of Napa showed that residents were using 19 percent less water than they did before the drought.

In the Central Valley, the residents of Lodi were using 30 percent less water after the drought. On the other hand, Sacramentans showed a savings of only 9 percent.

Among the other lessons learned from two years of drought is that water is a limited resource, and water conservation and water recycling are practical and must become a way of life. As the opportunity to develop more dams and surface reservoirs diminishes, present water supplies must be conserved and reused to meet future water demands.

Local water conservation programs based on specific community needs and values must be developed. Uniform, statewide rules were not requested as water needs and supplies vary from one locale to another. Rationing programs result in a loss of revenue to water purveyors and usually require rate increases, causing conflict between the public and the water agencies and affecting the public's acceptance of water conservation programs. It is recommended, however, that each water agency set water use targets below those of predrought levels and provide the leadership necessary to achieve those goals.

Based on the experience of 1977, and now in 1978, it is clear that Californians can carry on nearly all domestic activities, with little more than a minor crimp in lifestyles, with a rather substantial reduction in water consumption. Few people really suffered from water shortage; they changed habits to waste less. The public would be ill-served by encouraging a return to old habits which result in waste. Not only are the limited supplies of water better used for other purposes, they have an economic cost measurable in terms of development and conveyance costs as well as energy, another scarce resource. Those who waste water on hosing down driveways and sidewalks, watering at mid-day, not repairing leaks, and using 6 gallons per flush are driving up the cost of water, raising the price to everyone.

Public agencies have the obligation to lead the efforts in reducing waste and in assuring that the water and energy resources are utilized for beneficial use. As guardians of the public trust, we must accept no longer the premise that past consumption dictates the path of future development.

It is important to encourage Californians to install water-saving fixtures in the bathroom, where 41 percent[1/] of residential water is used. Low-flow showerheads are especially attractive because of the energy and money saved in reducing use of hot water.

Substantial water savings can be accomplished outside the home, where 44 percent[1/] of residential water use occurs, by promoting use of drought-tolerant landscaping. Furthermore, the loss, during drought, of expensive plantings can be reduced.

A potential exists for considerable sav-

1/ Water Conservation in California, DWR Bulletin 198, May 1976.

ings in industry and each should be encouraged to eliminate waste and expand recycling efforts. It makes little sense to provide large amounts of drinking quality water for many industrial applications when lesser quality will do. This is true also of parks, golf courses, and other large-scale landscaping.

The drought has proved that urban areas are able to reduce consumption more readily than agricultural users and should be expected to do so. The existing contract priorities which require agriculture to take the first and largest deficiencies seem to be backwards. The drought showed that the reverse is easier and less disruptive economically.

However, California agriculture has demonstrated its ability to take shortages by changing cropping patterns, using the more efficient drip and sprinkler irrigation techniques, and reusing tail water supplies. Encouragement of these efforts should continue.

The ability to interconnect urban and agricultural water systems is also necessary because it allows the ready exchange of water from areas of surplus to areas of need. During the drought, the lack of a "water grid" complicated drought mitigative actions in the San Francisco Bay area. A completely new pipeline was placed from the East Bay to Marin County by blocking a traffic lane on the Richmond-San Rafael Bridge. Water was transported from the Delta to Contra Costa County, to the East Bay, to Hayward, back to the East Bay and over the bridge to Marin. Had a need been anticipated, a more direct and efficient transfer to Marin could have been made (and can still be done).

Made more apparent during the drought was the fact that water is an elastic commodity. People paid more for water during the drought. Farmers in the San Joaquin Valley, who normally pay $7-$25 per acre-foot[1/], paid from $40-$80 per acre-foot, and urban users who normally pay $40-$150 per acre-foot, paid from $50-$375 per acre-foot. (The latter figure is an estimate of the cost to Marin County for the Southern California exchange water.) While serious economic problems occurred in some areas, greater capabilities existed than had been expected.

The drought provided new insight into the water releases needed from upstream storage to maintain summer and fall water quality in the Sacramento-San Joaquin Delta. Water availability during 1977 was the lowest since the CVP and SWP began operating and, as a consequence, DWR and the USBR were unable to provide normal minimum releases for purposes of maintaining Delta water quality. Thus, the flushing actions were greatly reduced. The Delta conditions were closely monitored and, as a result of knowledge gained, the SWRCB was able to develop new standards applicable in the future for the extremely dry year. These new standards will provide for greater flexibility in dealing with the normal variation from year-to-year and will allow additional water to be conserved in upstream reservoirs for other uses, without degrading the Delta environment.

Also in connection with the Delta, and brought home forcibly, was the need for cooperation among the various users in that region, as well as those upstream. During the drought, the actions of each user, in many cases, adversely affected the other users. As a first step in minimizing problems, a coordinated agreement between the USBR and DWR is absolutely essential to assure that the federal CVP meets the same quality standards for the Delta, Suisun Marsh, and San Francisco Bay as the SWP does to protect existing water rights, anadromous fish, wildlife, and the productiv-

1/ 1,000 acre-feet = 1.2335 cubic hectometres.

ity of the bay. The operating policies of other public and private agencies must also be examined as they relate to the Delta.

Not only the Delta, but all areas of the State can benefit from a spirit of cooperation.

Ground water will play a larger role in combating droughts in the future. Ground water "banks" need to be developed to store excess water during wet years for subsequent use during droughts. Ground water now accounts for about 50 percent of California's water supply, and most of it is simply extracted and used without regard to subsequent years. Greater conjunctive operation of surface and underground supplies is needed so that excess floodflows, such as are occurring in 1978, can be captured and delivered to ground water banks for storage and use during future droughts.

Additional research is needed in the area of long-range weather forecasting. DWR currently has contracts with several meteorologists to determine the accuracy of their techniques and the possibility of using long-range weather forecasting as an additional operational tool. At the present, there are several forecasting techniques being studied, and, to date, none has proven reliable enough to base DWR project operations upon.

In addition, hydrologic techniques should be examined in light of the recent drought. Traditional runoff and ground water patterns do not take place during droughts because of the extreme dryness of the ground. Much of the precipitation during the drought percolated directly into the ground, reducing expected river flows. Water from the rivers flowed to the lowered water tables, reducing still further the expected surface water supply. Agricultural water demand began earlier in the year and increased during the drought because natural rainfall did not "pre-irrigate" the fields, and, after the drought, there will be an increase in agricultural use to flush out salts that have accumulated in the soil because of reduced water supplies the last two years.

There needs to be a reevaluation of operating techniques employed by water project operators. The drought has shown that operational criteria long used by major projects do not work well enough in a major drought. The SWP, for example, must look more closely at its criteria for providing water in any given year when the following year (or years) may bring an extremely dry year such as 1977. Analysis of the relationship between surplus and entitlement deliveries is needed. Feast and famine are not the results of good operational policies. The CVP must also consider whether operational criteria which forced low quality water upon one of its major urban customers should be changed. And in other multipurpose projects, there have been raised new questions regarding the propriety of large releases for power generation at the expense of other uses. All these questions must be addressed and answers found before dry years hit again.

Drought has often been referred to as "a creeping phenomenon", and this characteristic was partly responsible for the delay of the Federal Government in providing assistance. Because the Federal Government was initially slow to mobilize, what might have become "mitigation" measures actually became relief efforts. More effective drought contingency planning and sound management practices can reduce those drought costs incurred as a result of relief.

Short-term federal mitigative efforts were criticized for being slow to respond, initially inflexible, and lacking communication with the public (again initially). There is a need for improving State and federal "trigger mechanisms" for mobilizing short-term mitigative activities.

This is not to say, however, that federal programs did not provide much-

needed assistance. The ability of farm managers to engage in adaptive strategies was due, in large part, to prior long-range programs sponsored by federal agencies aiding in reservoir construction, well drilling, soil conservation activities, plant research, and other agriculture-related activities.

We must also learn not to rely solely upon the traditional solution. In this time of rapidly declining resources, we must make full use of our water supplies. Waste-water reclamation, long held in low regard, is recognized as a method for increasing the usefulness of our limited supplies. We must expand its use in those areas where it can be used without detriment, thus freeing an equivalent amount of unused water for the higher purpose.

We must look again to the overlooked or to the solutions bypassed because they were not economically viable at some past date. The construction of low-yield hydroelectric plants can provide additional much-needed energy and reduce the strain on existing multipurpose installations. Other alternative energy sources can do the same.

And finally, the growth of California and the satisfaction of its residents' true needs dictate that additional water supplies be found so that a recurrence of the natural drought cycle does not find us unprepared. There are any combination of projects using a diversity of water sources which can accomplish this objective. All should be considered.

58. Future supplies. Irrigation of cotton and other crops is just one of the many uses for reclaimed waste water.

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APPENDIXES

federal register

THURSDAY, APRIL 14, 1977

PART III

DEPARTMENT OF THE INTERIOR

Bureau of Reclamation

■

EMERGENCY DROUGHT ACT OF 1977

1976-77 Drought Loan, Grant and Deferment Provisions

Title 43—Public Lands: Interior

CHAPTER I—BUREAU OF RECLAMATION, DEPARTMENT OF THE INTERIOR

PART 423—1976–77 DROUGHT LOANS, GRANTS, AND DEFERMENTS

Rules for Emergency Loans, Grants, and Deferments Under the Emergency Drought Act of 1977

AGENCY: Bureau of Reclamation, Interior.

ACTION: Final rules.

SUMMARY: These rules provide guidelines on the implementation of the Bureau of Reclamation Emergency Drought Act of 1977, approved April 7, 1977, allowing qualified applicants to obtain loans, grants, and deferments to remedy the effects of actual or prospective substantial economic injury resulting from the 1976–77 drought. Areas eligible for assistance may be designated by the President or the Secretary of the Interior. The program includes short-term actions to increase water supplies; makes funds available for loans to repair, replace, or improve affected water supply facilities in such areas; and provides authority to establish a water bank of available water for redistribution.

DATES: These rules are effective on April 14, 1977, and expire on September 30, 1977. Public comments on these rules may be submitted for consideration in future modifications or corrections.

FOR FURTHER INFORMATION CONTACT:

Eugene Hinds, Bureau of Reclamation, Department of the Interior, Washington, D.C. 20240, 202–343–5104.

SUPPLEMENTARY INFORMATION: Legislation to provide temporary authorities to the Secretary of the Interior to facilitate emergency actions to mitigate the impacts of the 1976–77 drought was enacted by the Congress and signed by President Carter on April 7, 1977. The legislation provides the authority to appropriate $100 million to augment, utilize, and conserve water supplies for irrigation farming operations on projects constructed or funded under Reclamation law, Indian irrigation projects constructed by the Secretary, and irrigation projects financed with non-Federal funds. Certain fish and wildlife activities are also covered. The objective is to mitigate losses and damages due to the 1976–77 drought period.

The funds will be used to (a) establish a water bank to assist water users to purchase water from willing sellers, including producers of lower value annual crops, and to redistribute such available water supplies for the maintenance of higher value perennial crops, crops to support foundation dairy and beef cattle herds and other breeding stock; and other uses as appropriate; (b) to augment water supplies in 1977 by permitting water user organizations to undertake construction; develop wells; build pipelines; pump water from dead pool storage, rivers, streams, and drains; and other activities to alleviate the impact of the drought; (c) to conduct studies to identify opportunities to augment, utilize, or conserve water supplies and evaluate potential facilities to mitigate the effect of a recurrence of the current emergency and make recommendations to the President and the Congress. The Secretary's authority under the Emergency Fund Act of June 26, 1948, is broadened to cover actions required because of the 1976–77 drought and to allow projects financed with non-Federal funds to obtain reimbursable loans from the expanded Emergency Fund for drought measures. However, the funds for non-Federal projects are limited to 15 percent of the available funds, and not more than $1 million may be expended for any individual non-Federal contracting entity.

During fiscal year 1977, a State water resource organization may obtain emergency funds up to $1 million in a given State for its drought emergency programs that provide benefits of a widespread and diffuse nature, but the total for this program is limited to 5 percent of the available funds. Expenditures for those State programs are nonreimbursable.

Funds are authorized up to $10 million on a nonreimbursable basis to purchase or to acquire entitlement to water from any available source to mitigate damages to fish and wildlife resources caused by drought.

The Department of the Interior has determined that this document does not contain a major proposal requiring preparation of an Inflation Impact Statement under Executive Order 11821 and Office of Management and Budget (OMB) Circular A–107.

It is hereby determined that publication of this proposed rulemaking is not a major Federal action significantly affecting the quality of the human environment and that no detailed statement pursuant to section 102(2)(c) of the National Environmental Policy Act of 1969 (42 U.S.C. 4332(2)(c)) is required.

Under authority of Pub. L. 95–18, it is proposed to amend Subtitle B, Chapter I, Title 43 of the Code of Federal Regulations by adding a new Part 423, Subpart A, as set forth below.

Subpart A—Emergency Drought Act Policies, Procedures, and Authorizations

Sec.

423.1 General.
423.2 Objectives.
423.3 Applicant eligibility.
423.4 Definitions.
423.5 Creation of the water bank.
423.6 Water bank operation for acquisition and priority for redistribution of available water.
423.7 Purpose of loans pursuant to the Act.
423.8 Application process for water bank loans.
423.9 Loans (terms and conditions).

Deferment of Existing Payments

423.10 Deferment of 1977 payments.
423.11 Eligibility.
423.12 Application process for deferment actions.
423.13 Deferment contracts.

Programs Pursuant to Emergency Fund Act of 1948

423.14 Authority.
423.15 Eligibility.
423.16 Application process for programs pursuant to the Emergency Act of 1948.
423.17 Terms and conditions for reimbursable funds.
423.18 Procedures for State water resources agencies to obtain nonreimbursable funds.
423.19 Fish and wildlife mitigation procedures.
423.20 Studies and reporting requirements.
423.21 Disclaimer.

Authority: Pub. L. 95–18.

Subpart A—Emergency Drought Act Policies, Procedures, and Authorizations

§ 423.1 General.

This Subpart A of Part 423 prescribes the policies, procedures, and authorizations of the Bureau of Reclamation for making loans and grants to contracting entities, water districts and other entities, and deferring payments owed to the United States under existing repayment contracts pursuant to the Emergency Drought Act of 1977.

§ 423.2 Objectives.

The basic objective of emergency loans and deferment actions is to provide financial assistance to eligible contracting entities and agricultural operators to purchase water; drill wells; install pumps in wells, drains, lakes, and streams; build diversion structures for providing additional water; install water conservation measures such as replacing open ditches with pipes; line canals and laterals; install water measuring devices; implement improved system operations and irrigation practices; acquire and transport water; defer installment payments on construction and/or operation and maintenance costs owed to the United States by existing contracting entities for 1977 because of hardship conditions created by the drought; and all other appropriate actions to alleviate the effects of the drought.

§ 423.3 Applicant eligibility.

Applicants eligible for loans and/or deferments are contracting entities which are located in an area that has been determined by the President and/or the Secretary of the Interior to be an emergency drought impact area. (Loans requested by individuals shall be processed under existing authority of the Department of Agriculture.)

(a) On projects constructed or funded under Reclamation law;

(b) On Indian irrigation projects constructed by the Secretary (rules and regulations pertaining to Indian irrigation projects will be issued separately); and

(c) Irrigation projects financed with non-Federal funds.

§ 423.4 Definitions.

(a) Act—Emergency Drought Act of 1977.

(b) Contracting Entity—(1) an organization that distributes water on projects constructed or funded under Reclamation law, (2) Indian irrigation projects constructed by the Secretary, (3) Non-Federal water using entity organized pursuant to State laws and as determined by the Bureau of Reclamation to be acceptable.

(c) Commissioner—The Commissioner of the Bureau of Reclamation.

(d) Drought—The 1976–77 drought.

(e) Reclamation—Bureau of Reclamation.

(f) Secretary—The Secretary of the Interior.

(g) Solicitor—Field or Regional Solicitor of the Department of the Interior.

(h) Water Bank—The program established by the act to finance purchases, sales, and redistribution of water.

§ 423.5 Creation of the water bank.

Pursuant to the act, the Secretary or his designees will consult with the Department of Agriculture, universities, and other parties as appropriate to determine equitable water values. The Secretary may purchase, sell, and redistribute water which will be needed. The Secretary may authorize the Commissioner to establish water banks in each eligible district. The Secretary shall authorize the Commissioner to determine who shall receive the water, loans, and deferments under these rules.

§ 423.6 Water bank operation for acquisition and priority for redistribution of available water.

(a) Funds available to the Secretary under the act may be used for loans to purchase water or entitlement to water and redistribute such water acquired for the water bank. Prices paid for water by the district or the Secretary can be negotiated; however, such sales and purchases are not to allow undue benefit or profit to the seller. Any purchased water is to be sold at a price to cover actual expenditures involved in acquiring and redistributing the water. The negotiated purchase price of the water may be determined by one or a combination of the following:

(1) Enterprise analysis showing net income adjusted for fixed and variable costs already incurred and associated variable costs or expenses foregone.

(2) A reasonable percentage of average gross crop values (3- to 5-year historic averages from annual Reclamation crop reports or other comparable census data).

(3) A reasonable return on investment plus fixed costs.

(4) Any other reasonable evaluation process or technique for an equitable measurement of the price of water which will not allow undue benefit or profit to the seller.

(b) Priority in allocating water for redistribution will be for use in the following order: (1) Preserving orchards and other perennial crops that have the longest remaining productive life, (2) Irrigating alfalfa or other forage or grain crops to support foundation dairy and beef cattle herds and other breeding stock; and (3) Achieving crop maturity suitable for harvest if determined to be in the best interests of the contracting entity and the United States.

§ 423.7 Purpose of loans pursuant to the Act.

Any contracting entities located in a designated drought area may be eligible to obtain loans for the following:

(a) *Purchase and redistribution of water.* (1) For uses in the order designated in § 423.6(b) above. (2) For any other need determined by the Secretary to alleviate conditions of the drought.

(b) *Facilities.* (1) The Secretary is authorized to make loans to water user organizations or contracting entities for such activities as the drilling of wells; installing pumps in wells, drains, lakes, and streams; building diversion structures for providing additional water; installing water measuring devices; implementing improved system operations and irrigation practices; acquiring and transporting water; and other appropriate actions to alleviate the effects of the drought. However, such facilities must be capable of providing the most effective emergency relief with the least capable investment. Any of the above work programs may be accomplished by the contracting entity or by Reclamation.

§ 423.8 Application process for water bank loans.

(a) To the extent that this program is presently covered by the requirements of OMB Circular No. A–95, the procedure for drought assistance is as follows: Copies of the application will be sent to the State and areawide clearinghouses at the same time they are submitted to the funding agency. The applicant will also notify the clearinghouses that, because of the short time restrictions, any comments will have to be made almost immediately and addressed to the funding agency. If comments or objections from clearinghouses are not received prior to completion of application processing, they will not be considered.

(b) The application for a loan to obtain water or facilities pursuant to § 423.7(a) or § 423.7(b) shall be submitted to the appropriate Regional Director of the Bureau of Reclamation (addresses shown below).

Regions	*Mailing Address*
Pacific Northwest, Regional Director, Bureau of Reclamation, Federal Building 550 West Fort Street, Boise, Idaho.	Federal Building and U.S. Court House, 550 West Fort Street, Box 043, Boise, Idaho 83724.
Mid-Pacific, Regional Director, Bureau of Reclamation, Federal Office Building, 2800 Cottage Way, Sacramento, California.	Federal Office Building, 2800 Cottage Way, Sacramento, California 95825.
Lower Colorado, Regional Director, Bureau of Reclamation, Nevada Highway and Park Street, Boulder City, Nevada.	P.O. Box 427, Boulder City, Nevada 89005.
Upper Colorado, Regional Director, Bureau of Reclamation, 125 South State Street, Salt Lake City, Utah.	P.O. Box 11568, Salt Lake City, Utah 84147.
Southwest, Regional Director, Bureau of Reclamation, Herring Plaza, 317 East Third Street, Amarillo, Texas.	Herring Plaza, Box H–4377, Amarillo, Texas 79101.
Upper Missouri, Regional Director, Bureau of Reclamation, Federal Office Building, 316 North 26th Street, Billings, Montana.	P.O. Box 2553, Billings, Montana 59103.
Lower Missouri, Regional Director, Bureau of Reclamation, Building 20, Denver Federal Center, Denver Colorado.	Denver Federal Center, P.O. Box 25247, Denver, Colorado 80225.

The application shall include appropriate information as follows:

(1) Identification of contracting entity with name, address, telephone number, and title of the appropriate official.

(2) Identification of water conservation plan or plans, quantities of water involved, orchard or other perennial crops and/or crops for foundation livestock uses, purchase and sales price criteria, and other relevant data on water uses and expected results.

(3) Identification of plans to construct or install facilities showing the starting date, the expected completion date, and estimated cost.

(4) Relevant financial data, records, or statements which demonstrate or support the ability to repay the loans and the need for financial assistance.

(5) A statement or resolution setting forth the commitment and the expected time required to repay the loan covered by the application.

(6) Evidence that applicable State water laws and/or other water right entitlements have been complied with.

(c) Applications must be postmarked no later than June 1, 1977, to ensure eligibility under the initial allocation of funds. Applications postmarked after June 1, 1977, will be considered within remaining fund availability.

§ 423.9 Loans (terms and conditions).

(a) *Purchase and redistribution of water.* (1) Federal financial assistance for the purchase of water or entitlement to water pursuant to § 423.7(a) will be handled through interest-free loans with repayment by the contracting entity over a period not to exceed 5 years. The contracting entity will arrange for purchase of available water for high priority agricultural uses with Federal assistance in locating sources of water and allocating supplies as identified in § 423.6(b). As an alternative, Reclamation may purchase available water and allocate and sell it to contracting entities.

(b) *Facilities.* (1) Any facilities obtained or constructed must be installed and operational on or before November 30, 1977.

(2) Federal financial assistance for facilities pursuant to § 423.7(b) will be handled through interest-free loans.

The loans will be repaid in annual installments without interest within 5 years unless otherwise determined by the Secretary or his designee. Such payments shall begin not later than the first year following the next year of normal water supply, as determined by the Commissioner.

(3) In the event facilities provided pursuant to § 423.7(b) generate benefits which are useable beyond 1977, the repayment period for such items may be established beyond 5 years beginning not later than the first year following the next year of normal water supply, as determined by the Commissioner; however, such repayment period shall be based on the payment capacity of the water users, or the estimated useful life of the facilities whichever produces a shorter repayment period.

(4) Operating costs associated with pumping water from ground water aquifers, dead pool storage, rivers, streams, and other sources, may be capitalized and included in the loan with the contracting entity if such costs would be in excess of the contracting entity's reasonable ability to pay such operation and maintenance costs as they occur.

(c) *Repayment contracts.* (1) Contracts for repayment of any loan will be developed separately and apart from any existing repayment and/or water service contracts between the United States and a given contracting entity. The contract will cover the terms and conditions for repayment specified above and will be approved by the appropriate Regional Director of Reclamation in behalf of the Secretary following review and certification of the contract's legal sufficiency by the Solicitor.

DEFERMENT OF EXISTING PAYMENTS

§ 423.10 Deferment of 1977 payments.

The Secretary or his designee shall have authority to defer payments for construction installments and/or operation and maintenance costs owed to the United States for 1977 by existing contracting entities upon their showing of hardship conditions related to the drought in an area.

§ 423.11 Eligibility.

Eligibility of the contracting entities within the designated drought areas for projects constructed or funded under Reclamation law will be determined on a case-by-case basis. The entity's ability to pay the 1977 payment or payments will be considered based upon a showing of hardship relating to the drought.

§ 423.12 Application process for deferment actions.

(a) The application must be processed as provided by § 423.8(a).

(b) The application for a deferment action pursuant to this section shall include appropriate information as follows:

(1) Identification of the contracting entity with name, address, telephone number, and title of the appropriate official.

(2) Amount of 1977 payment or payments to be deferred.

(3) Justification for the needed deferment because of drought related conditions.

(4) Relevant financial data, records, or statements which demonstrate or support the need for financial assistance.

(5) A statement or resolution setting forth the need for the deferment and the commitment to repay the deferment covered by the application.

(6) Other relevant and supporting data or justification.

§ 423.13 Deferment contracts.

(a) Construction installments and/or operation and maintenance costs owed to the United States for 1977 by existing contracting entities may be deferred upon a showing of hardship conditions relating to the drought. Such deferment action will be documented and a contract will be written using the following standards:

(1) Beneficiaries who receive the relief generally will repay the deferment. Any deferred payment or payments shall be rescheduled for repayment in annual installments, along with existing payments, as soon as practicable, within the water users' payment capacity. The initial payment for the deferred amount shall begin not later than the first year following the next year of normal water supply, as determined by the Commissioner. Such deferred payments may be added to the end of the repayment period if necessary to stay within payment capacity.

(2) Any interest bearing costs that are deferred will be added to the capital obligation and will bear interest at the authorized rate for project repayment during the time the deferred amount is outstanding.

(3) Provisions will be included for the contracting entity to repay the deferred installment earlier than the negotiated time period.

(4) Such contracts meeting the above criteria will be approved by the appropriate Regional Director of Reclamation in behalf of the Secretary following review and certification of the legal sufficiency of each contract by the Solicitor.

(b) The contract form will be simplified to the extent practicable but will properly reference existing contracts, amendments, or supplements. No new terms and conditions will be added except those required to repay the deferred amount and each contract will be negotiated based on the foregoing criteria.

PROGRAMS PURSUANT TO EMERGENCY FUND ACT OF 1948

§ 423.14 Authority.

The Secretary is authorized for this drought period to expend funds allocated by the act and any other appropriations that deal with the drought through the Emergency Fund Act of 1948. The authority granted by the act shall cease on September 30, 1977.

§ 423.15 Eligibility.

Applicants eligible for loans under this section shall be those designated in § 423.3(a), and as determined by the Commissioner to be able to repay the loan: *Provided, however,* That each nonfederally funded project may not borrow more than $1 million and only 15 per centum of the total funds available may be used for non-federally funded projects.

§ 423.16 Application process for programs pursuant to the Emergency Act of 1948.

The application must be processed as provided by § 423.8.

§ 423.17 Terms and conditions for reimbursable funds.

(a) Emergency Fund requests will be reviewed on a first-come-first-served basis and disbursement will be made based on need as determined by the Secretary or his designee. Each reimbursable proposal must meet engineering and repayment capability.

(b) A contracting entity must be suitable to the United States. By appropriate resolution, the contracting entity must agree to enter into a repayment contract covering the costs of emergency work.

(1) Standard Bureau of Reclamation contract terms and conditions will apply. The 160-acre limitation will not be applicable for those projects not previously constructed with Federal funds.

(2) All costs shall be repaid without interest in accordance with § 423.9(b) above.

§ 423.18 Procedures for State water resources agencies to obtain nonreimbursable funds.

(a) Nonreimbursable funds may be expended through State water resources agencies as designated by the Governor for drought emergency programs that provide benefits of a widespread and diffused nature, provided not more than $1 million may be expended on behalf of any one State.

(b) The application must be processed as provided by § 423.8(a), and must be received by June 1, 1977, in order to be considered in the initial allocation of funds. The need for action must be attributable to the drought and the proposal must be a project consisting of physical structures or facilities or other conservation measures to alleviate the effects of the drought.

(c) The application for the nonreimbursable funds pursuant to this section shall include appropriate information as follows:

(1) Identification of the State Water Resource Agency or designee of the Governor with name, address, telephone number, title of the appropriate official.

(2) Identification of the plan or plans for the program, estimated costs, and schedule showing the estimated starting and completion dates for construction or installation of facilities.

(3) Compliance with all applicable State water laws and/or other water right entitlements is required.

(4) Proposed work program and supporting statements must demonstrate that the completed project will provide widespread and diffuse benefits in accordance with the act.

§ 423.19 Fish and wildlife mitigation procedures.

(a) Nonreimbursable funds up to $10 million may be expended by the Secretary to purchase or otherwise acquire available water or entitlement to water to mitigate damage to fish and wildlife resources caused by the drought.

(b) The application must be processed as provided by § 423.8(a), and must be received by June 1, 1977, in order to be considered in the initial allocation of funds. The need for action must be attributable to the drought. Regional Directors of Reclamation shall submit any such applications they receive to the Commissioner with recommendations for consideration and approval.

(c) The application for the nonreimbursable funds pursuant to this section shall include appropriate information as follows:

(1) Identification of the appropriate State or Federal agency representing the fish and wildlife resources, including name, address, telephone number, and title of the contact official.

(2) Identification of the water acquisition plan, level and extent of coordination with State and local officials, the holders of the water rights and their willingness to sell, quantities of water involved, justification of the reasonableness of the purchase price, compliance with applicable State water laws, and other relevant information.

§ 423.20 Studies and reporting requirements.

(a) Reclamation is authorized to perform studies to identify opportunities to augment, utilize, or conserve water supplies available to Federal Reclamation projects constructed by the Secretary. Reclamation will undertake studies of means to mitigate the effects of a recurrence of the current emergency and to make recommendations to the President and to the Congress evaluating potential undertakings including but not limited to drilling wells, installing pumping plants, lining canals, replacing open ditches with pipelines, making alterations to outlet works of existing impoundments, and other actions as appropriate. Study proposals may be submitted to the appropriate Regional Director by local interests at their own expense. Such studies and evaluations will be coordinated for input from other Federal and State agencies as appropriate.

(b) A detailed report on expenditures and accomplishments under the act will be prepared and submitted to the President and the Congress on or before March 1, 1978.

§ 423.21 Disclaimer.

Actions taken or water used pursuant to the legislation do not modify, alter, or otherwise affect existing Federal, Indian, State, local entity, and/or other authorities and rights to use water, nor is there any intent to modify interstate compacts.

Dated: April 12, 1977.

CECIL D. ANDRUS,
Secretary of the Interior.

[FR Doc.77-11075 Filed 4-13-77;8:45 am]

APPENDIX B

FEDERAL DROUGHT-RELATED LAWS - 1977

PUBLIC LAW	DATE SIGNED	TITLE OR PURPOSE	AGENCY	FUNDS (AUTHORIZED) OR APPROPRIATED
P.L. 95-18	4/7/77	Emergency Drought Act of 1977 "Water Bank Bill"	USBR	($100 million)
P.L. 95-26	5/4/77	Supplemental Appropriations		
		For P.L. 95-18	USBR	$100 million
		Emergency Fund of 1948	USBR	30 million
		Agricultural Conservation Program (DFCP)	ASCS	100 million
		Community Facilities Program	FmHA	225 million
P.L. 95-29	5/13/77	Appropriations-Economic Stimulus (to implement P.L. 95-31)	EDA	$175 million
P.L. 95-31	5/23/77	Community Emergency Drought Relief Act of 1977	EDA	($225 million)
P.L. 95-51	6/20/77	Disaster Relief Act of 1974, Amendments To authorize emergency well-drilling and water transportation.	Corps of Engineers	-
P.L. 95-89	8/4/77	Small Business Act Amendments Interest rate changes	SBA FmHA	
P.L. 95-107	8/17/77	To amend P.L. 95-18 (Extending deadlines, etc.)	USBR	-
P.L. 95-113	9/29/77	Food and Agriculture Act of 1977 (Section 1105). Emergency Feed Program	Dept. of Agriculture (ASCS)	-
P.L. 95-156	11/8/77	To exempt disaster payment for the 1977 crops of wheat and certain other crops from the $20,000 limit on such payments.	ASCS	

APPENDIX B (Continued)

FEDERAL DROUGHT-RELATED PROGRAMS

Department of Agriculture
- Farmers Home Administration (FmHA)
  - Emergency Loans
  - Emergency Livestock Loans
  - Farm Operating Loans
  - Farm Ownership Loans
  - Soil and Water Loans
  - Irrigation and Drainage Loans
- Agriculture Stabilization and Conservation Service (ASCS)
  - Emergency Conservation Measures Program
  - Emergency Livestock Feed Program
  - Agricultural Conservation Program
  - Disaster Payments Program
  - Hay Transportation Program
  - Cattle Transportation Assistance Program
  - Emergency Feed Program
- Federal Crop Insurance Corporation
- Forest Service
  - Rural Community Fire Protection Program
  - Drought-Related Stewardship
  - Cooperative Forest Insect and Disease Management
  - Cooperative Forest Fire Control
- Soil Conservation Service
  - Great Plains Conservation
  - Resource Conservation and Development

Department of the Interior
- Bureau of Reclamation
  - Emergency Fund
  - Drought Emergency Program
- Bureau of Land Management
  - Grazing Privilege
  - Agency Drought and Stewardship Programs
- Fish and Wildlife Service

Department of Commerce
- Special Economic Development and Adjustment Assistance Program
- Public Works Impact Projects

Small Business Administration
- Emergency Drought Disaster Loans
- Physical Disaster Loans
- Economic Injury Disaster Loans
- Product Disaster Loans

Federal Disaster Assistance Administration (FDAA)
- Hay Transportation Assistance
- Cattle Transportation Assistance
- Emergency Livestock Feed Assistance*
- Individual and Family Grants Program

Source: Directory of Federal Drought Assistance: 1977, U. S. Department of Agriculture.

* Administered by the Agricultural Stabilization and Conservation Service as of October 1, 1977.

APPENDIX C

California Communities Receiving Assistance
Under Community Emergency
Drought Relief Act of 1977

Community Assisted	Amount of Aid Grant	Loan	Description of Project
Lompoc	$ 31,000	$ 124,000	Domestic water well and pipeline construction.
Olivehain MWD		610,000	Cover and expand reservoir.
Tract #180 Mutual Water Company		275,000	Drill new well, install pump, replace water mains.
Lake Madrone WD	95,500	95,500	Repair water line, install well and water storage facility.
Compo Band of Mission Indians	62,000		Rehabilitate 11 wells, purchase tanker, three 1,000 gallon trailers.
Contra Costa CWD	119,000	476,000	Test drill and develop new wells, water conservation materials and rationing devices.
Paramount CWD	131,800	527,200	Construct well, install 250 water meters.
LaJolla Band of Mission Indians	165,750		Drill and equip well, install storage tank, pipeline and chlorination station.
Comrosa CWD		460,000	Rehabilitate 2 wells, construct reservoir, and water conservation program.
Pauma Band of Mission Indians	31,000		Well pump control, pump house, and water lines.
Owens Valley Paiute Tribe	124,000		Purchase 5-ton 4-wheel-drive truck to transport water.
Northern Valley Indian Health, Inc.	27,000		Purchase two 4-wheel-drive 3/4 ton pickups for distribution of water.

APPENDIX C (Continued)

Community Assisted	Amount of Aid Grant	Loan	Description of Project
Placer County Water Agency		$ 310,000	Construct transmission-distribution pipeline.
United Indian Health Service	$ 200,000		Purchase trucks, tanks, pipe, water pumps and construct well and administration expenses.
Morongo	22,600		One well.
Norco	408,000	1,632,000	Two wells, construct reservoir and connecting pipeline.
Dry Creek Tribe	3,900		Drill and develop community well and extend water main.
Soboba Band of Mission Indians	121,060		New well, replace water lines, install new storage tank.
Orleans Karok	208,500		Trucks, water purchase, bladder and storage reservoirs, and administration costs.
Laguna Beach CWD		650,000	Purchase 3/4 ton pickup, tank, pump and administration expenses.
Boron CSD	59,600	238,400	Pipelines, standby generator valves, and other items.
Littlerock Creek ID	112,400	449,600	Replace 29,200 l.f. of pipeline, and 5,300 l.f. of 8" pipe; reactivate a tail water reservoir and construct storage tank.
Hoopa Valley Tribal Council	537,000		Water system development.
San Lorenzo Valley CWD	60,000	240,000	Rehabilitate existing well, construct 250,000 gallon reservoir; install pump station and pipeline.

APPENDIX C (Continued)

Community Assisted	Amount of Aid Grant	Loan	Description of Project
Jurupa CSD	$ 492,000	$1,968,000	Install well, refurbish well, install 3 tanks and booster station with connecting pipeline.
Tuolumne Band of Mi-Wok Indians of the Tuolumne Rancheria	156,900		Purchase water and vehicles for its distribution, water irrigation system improvements.
Chino	94,000	376,000	Develop and construct water well and water transmission line for domestic and fire needs, water conservation program.
Cerritos	80,000	320,000	One 18" x 1,000' gravel pack well, drilling and equipping.
Hayward Water System	70,000		Repair and rehabilitate 4 wells, rehabilitate a prestressed reservoir, and install mains and intertie for distribution system lodging.
Los Angeles Dept. of Water and Power	1,000,000		Purchase 67,000 acre-feet of water.
Ontario	282,000	1,128,000	Redevelop 6 wells, refurbish 7 wells, and construct 2 booster stations.
Buena Park	46,600	186,400	Drill new well and refurbish five existing wells.
Upland	174,000	647,000	Install pipeline, refurbish well, and conservation program.
Sanger Public Works	16,600	66,400	Construct new wells and install 300 water meters.
Turlock	81,000	134,000	Drill and equip two new wells, lower five well bowls, and two mainline sections.

APPENDIX C (Continued)

Community Assisted	Amount of Aid Grant	Loan	Description of Project
Blue Lake Springs Mutual Water Co.	$ 167,500	$ 137,912	Drill wells, install tanks and treatment facility.
South Coast CWD		757,000	Replace water distribution lines; water reclamation system; construct 5-million-gallon reservoir, and purchase mobile storage tank trucks.
Woodland	106,800	427,200	Drill well, equip with pumps, lower pumps and extend mains.
Oroville-Wyandotte ID	80,000	320,000	Repair 5000' of pipe in Bangor Canal, replace 18" and 36" redwood siphon, repair Bald Hills Syphon and replace other deteriorated leaky pipe.
San Jose	41,600		Reconstruct park water system.
Manzanita Band of Mission Indians	20,000		Purchase 2,500-gallon water tanker truck.
County of Sonoma	16,200		Purchase water hauling equipment.
Antioch	25,800		Drill and equip wells to augment City's reduced allocation of water.
Big Valley Village Corporation	3,000		Remove intake facilities, extend pipeline, improve existing works.
San Rafael	46,800		Develop independent water sources for use in park system, right-of-way and public buildings and grounds. Water conservation.
Ventura County	150,000		Construct new water well, repair water storage reservoirs, rehabilitate water wells, and a water conservation program.

APPENDIX C (Continued)

Community Assisted	Amount of Aid Grant	Loan	Description of Project
Paradise ID	$ 562,600	$ 104,400	Paradise dam enlargement and Magalia outlet works enlargement.
LaJolla Band of Mission Indians	20,000		Purchase water tanker truck.
Fresno	56,000		Construct water system interties and a conservation program.
Delano	36,800		Construct water well and water conservation program.
San Bruno	52,400	209,600	Replace leaking pipes, repair existing well, and two new pumping stations.
Hanford	96,000	384,000	Two new wells, lower 12 well pumps, and replace leaking pipes.
Benicia	471,500	471,500	Replace and repair pipelines, and water recycling systems.
Ceres	185,000	165,000	New wells and standby emergency electrical generator.
Soboba Tribal Council	7,500		Purchase water and pipeline.
San Francisco	376,450		Pipeline, repair leaking pipes, purchase water and recycling.
Madera	21,000	84,000	Drill and equip one deep well and lower bowls of five existing wells.
Indian Wells Valley CWD	325,600	1,302,400	Elevated storage reservoir, new well, two auxiliary diesel engines, conservation program.
Seal Beach	72,000	288,000	Deep well and associated equipment.

APPENDIX C (Continued)

Community Assisted	Amount of Aid Grant	Loan	Description of Project
Nevada ID	$ 401,000		Install water meters and water filters, cloud seeding program and pipeline repairs.
Orangevale Mutual Water Company	46,000	$ 184,000	New wells, storage tanks and pumps.
Paradise ID	19,400		Purchase water.
Lodi	55,000		New well and pumps.
North Marin County	46,000	46,000	Pipeline and new well.
Redding	950,000	950,000	Water mains, rehabilitate wells.
Stockton	1,934,000	1,834,000	Transmission line, wells, pumps and conservation kits.
Rohnert Park	56,000		One deep well and a waste water retention reservoir.
Placer County Water Agency	1,200,000		Pipeline and water storage tanks.
Oakdale ID	500,000	500,000	New well, pumps and pipeline.
East Bay MUD	1,493,295	5,973,178	Pumping stations, carbon feed facilities, and electricity and chemicals.
Marin MWD	1,387,000	5,550,000	Pipeline, purchase water, wells and pumps.
Placer County Water Agency	85,000	85,000	Electricity for emergency pumping.
El Dorado ID	2,406,000	2,306,000	Three interties, two reservoir filters, repair leaking reservoirs.
North Marin CWD	87,942	351,770	New wells and off-stream storage.
Vacaville	124,200	496,800	Rework existing well-water storage, emergency standby electrical generator, water mains and water meters.

APPENDIX C (Continued)

Community Assisted	Amount of Aid Grant	Loan	Description of Project
Davis	$ 42,400		Two wells and rehabilitate and lower two pumps.
San Juan Suburban WD	128,000	$ 512,000	Replace leaky pipes and install four units for distribution system looping.
Pittsburg	107,000	92,000	Five new wells and casing, pumping and distribution to existing system.
Monte Vista CWD	225,600	745,844	Three new wells and pipeline.
City and County of San Francisco	15,600		Reactivate old well.
Kern County		5,000,000	Purchase water.
Tracy	1,042,600	4,170,400	Water treatment plant and transmission line.
Fountain Valley	130,000	520,000	Three new wells.
Fairfield	301,800	544,200	Leak survey and replace water mains.
Solano ID	200,600	613,100	Five wells, seven temporary dams, pipeline, storage tank.
Sonoma County Water Agency	138,000	552,000	Develop emergency ground water supplies, a water rationing and conservation program.
Roseville	113,400	453,600	Two new wells and a booster pump.
Vallejo	1,061,200	4,244,800	Add water main, line water main, reservoir rehabilitation and conservation measures.
Santa Rosa	407,000		Rehabilitate six wells, drill two wells, public information program and water purchase surcharge.

APPENDIX C (Continued)

Community Assisted	Amount of Aid Grant	Loan	Description of Project
Kings County	$ 41,200		Purchase two tanker trucks with fire pumping capability, 10,000 ft. of 3" hose and 2,000 water-saving kits.
Pico CWD	168,000	$ 238,000	Replace water main.
Stockton East WD	591,500	591,500	Drill wells and supplement existing facilities.
Pauma Indian Reservation	20,000		Purchase water truck.
American Canyon	272,000		2 MGD filtration plant and 2 MG reservoir with connecting mains and distribution lines.
Oakland	87,400	349,600	Drill wells, install pump stations, construct ponds.
Vista ID	20,800	83,200	Two 12", 600' deep wells.
Colusa Indian Tribe	17,000		Purchase truck, water bladder and water.
Central Valley	163,700		Purchase 12 pickup trucks and water and containers.
Lake Elizabeth		1,094,000	Construct a surface water treatment facility and replace water lines.
Millbrae	50,000	200,000	Construct new storage facility and water conservation program.
Pacific Reefs	5,200	20,800	Develop springs, holding tank, installation of pump.
Santa Rosa Band of Mission Indians	17,900		Purchase water truck and trough.
Mendocino County Indian Health Service	136,313		Seven storage tanks, three water transport vehicles and three water bladders.

APPENDIX C (Continued)

Community Assisted	Amount of Aid Grant	Loan	Description of Project
Kern County Water Agency		$ 859,855	Water purchase.
Monterey Park	$ 32,000		Purchase water, drill three wells, defray cost of electrical systems, and conservation.
Big Valley	68,000		Intake facility, PVC line, storage tank and electrical system.
Yosemite	100,000		Drill well, construct storage tank, meter system and electrical equipment.
TOTALS	$24,448,810	$54,726,159	

APPENDIX D

California Agencies Receiving USBR Drought Loans and Grants in 1977

	Agency	Loan/Grant Amount	Purpose
	1. Loans Under Authority of Emergency Fund Act of 1948.		
1.	Santa Ynez River WCD	$ 340,000	2 wells.
2.	Alpaugh ID	102,000	1 well.
3.	Santa Clara Valley WD	1,250,000	Effluent treatment, pumps, pipelines.
4.	Chowchilla WD	4,500,000	Wells and other equipment.
5.	West Stanislaus ID	200,000	4 wells.
6.	James ID	205,000	Wells and associated materials.
7.	Feather WD	125,000	2 wells.
8.	Madera ID	1,193,273	Pipelines.
9.	Placer Co. WA	201,020	Canal repair, pipelines, pump, control gates, and pumping.
10.	Westside ID	569,000	Pipelines.
11.	Natomas Central Mutual Water Co.	200,000	Pumps, pump station modification, dredging, piles.
12.	Pacheco WD	65,000	Well reactivation.
	Subtotal	$ 8,950,293	
	2. Loans Under P.L. 95-18, Small Reclamation Projects.		
1.	Georgetown Divide PUD	$ 184,750	Diversion structure, pipe, and cleaning reservoir.
2.	Jackson Valley ID	300,000	Pipelines.
	Subtotal	$ 484,750	

APPENDIX D (Continued)

3. Loans Under P.L. 95-18, Non-federal Reclamation Projects.

1.	Marquin CWD	$ 440,000	20 wells.
2.	Willow Creek Mutual Water Co.	65,000	2 wells and drainage recovery facilities.
3.	Jacob Rancho Water Co.	500,000	5 wells.
4.	El Nido ID	1,000,000	Wells.
	Subtotal	$ 2,005,000	

4. State Water Resource Grants Under P.L. 95-18.

1.	California Department of Water Resources	$ 3,604,103	Rock barriers in Delta, weather modification, Governor's Drought Emergency Task Force.
	Subtotal	$ 3,604,103	

5. Fish and Wildlife Grants Under P.L. 95-18.

1.	Willow Creek Mutual Water Co.	$ 10,500	Water purchase.
2.	California Department of Fish and Game	418,000	Well, pipelines, purchase and and diversion of water.
3.	U. S. Fish and Wildlife Service	480,000	Wells, pipelines, water chillers.
4.	Cole Duck Club	92,500	1 well.
	Subtotal	$ 1,001,000	

6. Loans for Purchase of Water Under P.L. 95-18.

1.	Berrenda Mesa WD	$ 1,000,000	Purchase of 46,600 acre-feet.
2.	Buttonwillow Improvement District	255,000	Purchase of 9,122 acre-feet.
3.	Pond-Poso Improvement District	189,000	Purchase of 6,762 acre-feet.
4.	Wheeler Ridge-Maricopa WSD	1,000,000	Purchase of 45,013 acre-feet.
	Subtotal	$ 2,444,000	
	TOTAL	$18,489,146	

DROUGHT

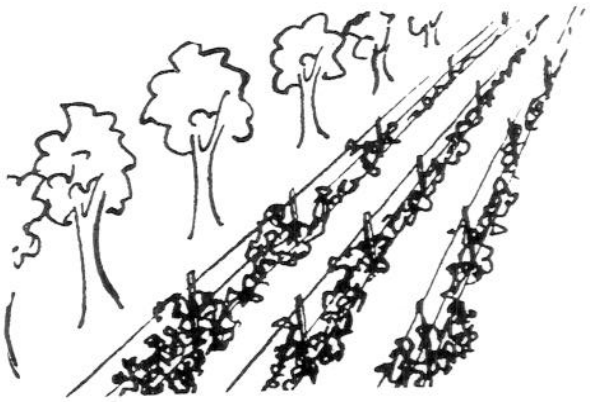
TIPS

CROP WATER USE

CENTRAL COAST INTERIOR VALLEYS

FIELD CROPS TREES AND VINES

Pasture, Alfalfa Deciduous Orchard Grapes



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NORMAL CROP WATER USE [1]
CENTRAL COAST INTERIOR VALLEYS [2]
EVAPOTRANSPIRATION (CONSUMPTIVE USE) TABLE

Crop and Growing Period [3]	ESTIMATED MONTHLY EVAPOTRANSPIRATION (inches) [4]												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	TOTAL
Pasture – annual [5]	1.6	2.1	3.4	4.4	5.7	6.2	6.8	6.0	4.8	3.7	2.3	1.4	48.4
Alfalfa – annual	1.7	2.2	3.3	4.3	5.5	6.1	6.6	5.9	4.7	3.7	2.4	1.6	48.0
Deciduous Orchard [6] with cover crop – annual	1.6	2.1	3.4	4.8	6.5	7.5	8.2	7.2	5.6	4.1	2.3	1.5	54.8
Deciduous Orchard [6] without cover crop													
3/1 – 10/31			2.0	3.2	4.7	5.7	6.5	5.7	4.4	2.9			35.1
3/15 – 11/15			1.0	2.9	4.4	5.4	6.5	5.7	4.6	3.2	1.0		34.7
3/30 – 11/30				2.6	4.0	5.2	6.2	5.7	4.7	3.5	1.9		33.8
Grapes [7]													
3/1 – 10/31			.7	2.6	4.5	5.1	5.0	3.1	1.4	.5			22.9
4/15 – 11/15				.5	2.1	4.3	5.5	3.8	1.9	.7	.2		19.0
5/1 – 11/30					1.2	3.6	5.3	4.5	2.5	1.1	.3		18.5

[1] Estimated evapotranspiration (Consumptive Use) data were obtained from historic measurements, and from calculations based on data in Figure 8, Table 22 and 23, Crop Water Requirements, No. 24 Food and Agricultural Organization of the United Nations.

[2] Interior portions of Contra Costa, Alameda, Santa Clara, San Benito, Monterey, San Luis Obispo, Santa Barbara and Ventura Counties.

[3] Leaf out to leaf drop. Where applicable values shown are for mature trees and vines. For smaller trees and vines consult local Agriculture Extension or S.C.S. Office for appropriate ET reductions.

[4] Other crops which have similar growing seasons, ground cover, and growth characteristics have similar ET requirements.

[5] Pasture - based on well managed pasture with animals removed before significant elimination of shading of ground surface.

[6] For deciduous trees where irrigation is ended before harvest, water use during the later part of the growing season will be less than values shown.

[7] Wine grapes.

NOTES

Evapotranspiration (Consumptive Use) for each crop is a measure of the moisture used by the crop and evaporated from surrounding soil surfaces. It does not include water lost through deep percolation or runoff from the field, which must be added in to calculate the total irrigation requirement.

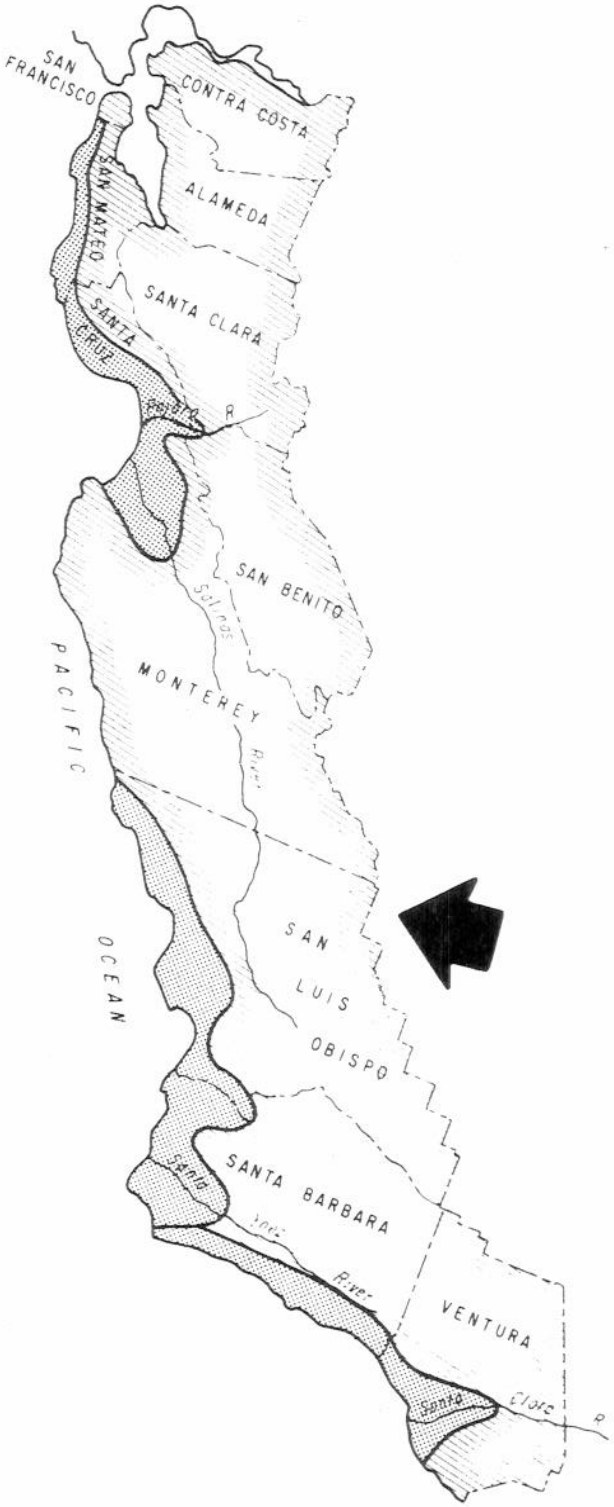
The quantity of each irrigation to be applied and stored within the root zone, depends upon the rooting depth of each crop, the moisture holding capacity of the soil, and the irrigation system efficiency.

The monthly evapotranspiration rates shown in this folder are guides, based on the average crop growth stage and average, long-term climatic conditions in your region. The values may need adjustment depending upon the growth stage of your crop and current climate conditions. The tables shown will permit you to estimate your water losses and make-up requirements.

Call your Farm Advisor, Soil Conservation Service representative or Department of Water Resources for detailed assistance.

FOR FURTHER INFORMATION CONTACT:

Agricultural Research Service
Department of Water Resources
Soil Conservation Service
State Water Resources Control Board
University of California
U. S. Bureau of Reclamation
U. S. Geological Survey


SAN FRANCISCO
CONTRA COSTA
ALAMEDA
SAN MATEO
SANTA CLARA
SANTA CRUZ
Pajaro R.
SAN BENITO
Salinas
MONTEREY
River
PACIFIC
OCEAN
SAN LUIS OBISPO
SANTA BARBARA
Santa Ynez
River
VENTURA
Santa Clara R.

DROUGHT

TIPS

CROP SALINITY

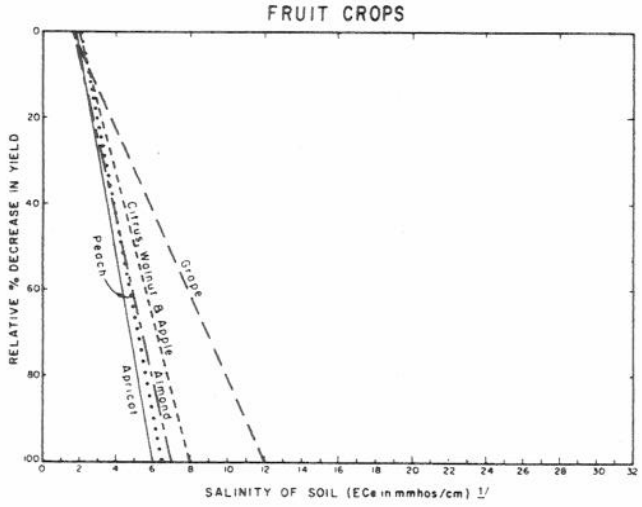
TOLERANCE

DROUGHT TIPS CROP SALINITY TOLERANCE

This brochure is to help determine how best to use whatever amount of water that may be available for irrigation under present drought conditions.

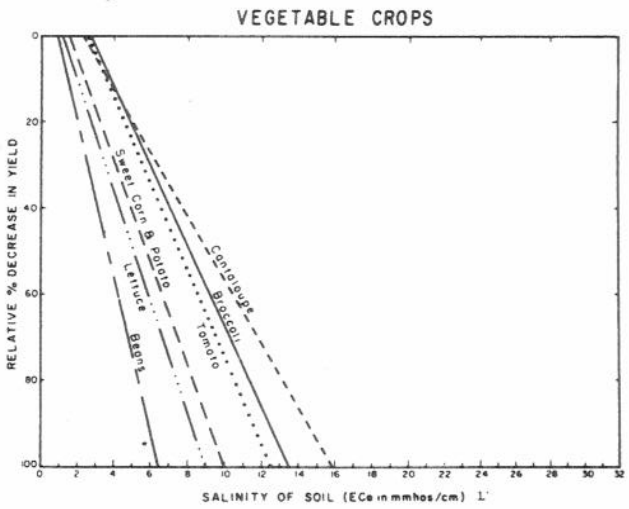
Salts must be taken into account when supplies are limited. Most crops can tolerate some salts; however, when salts concentrate in the root zone of plants they can cause serious effects by reducing crop yields or in some cases they may rise to levels which disrupt movement of fluids through the plant and the plant fails to grow and eventually dies.

During a drought year, when less water is available for irrigation use, and when natural supplies tend to be more salty, it is especially necessary to pay careful attention to the salinity of water in the root zone. Charts indicating the response of major types of crops to varying levels of soil salinity are included in subsequent parts of this brochure. Individual charts for fruit, vegetable, field, and forage crops are included. These charts can be used as guides to the best use of available supplies during the current drought situation. The listing has been arranged in order of increasing tolerance to soil salinity to recognize the possibility of changing cropping practices to minimize the potential effects of drought conditions and soil salinity on crops. Although there is little prospect for changing fruit crops short of removing the trees or vines, there may be various lands where more salt tolerant field and forage crops can be selected for planting taking into account the prospective availability and salinity of water for irrigation.



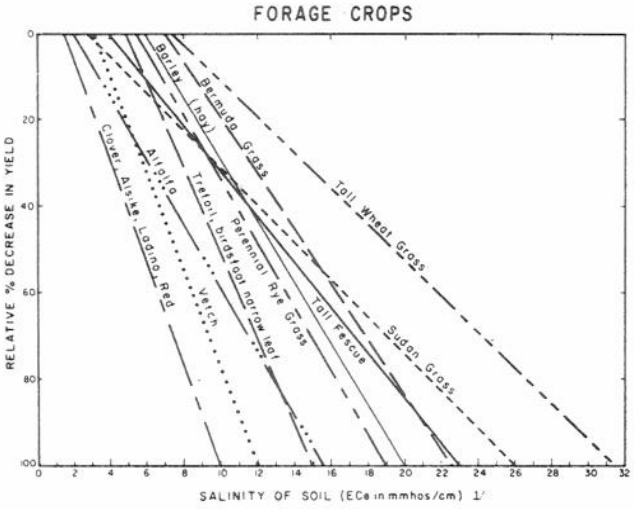
SALINITY OF SOIL (ECe in mmhos/cm) 1/

The above chart shows the relative response of major fruit crops to soil salinity. Apricots are shown to be the most sensitive to soil salinity and grapes as the most able to accommodate higher salinity levels. These values are relative, and it should be recognized that these values are more restrictive than for any other of the crops normally obtaining their water supply through irrigation, as shown in subsequent charts.



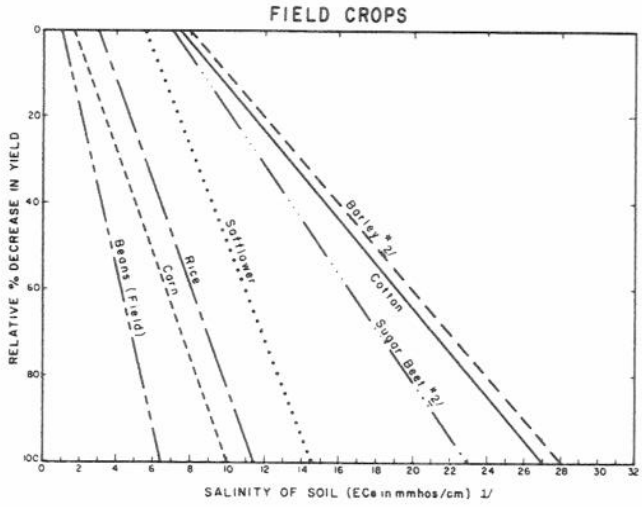
SALINITY OF SOIL (ECe in mmhos/cm) 1/

The chart above illustrates the relative response of vegetable crops of soil salinity. Beans and lettuce are shown to be the most sensitive whereas tomatoes, brocolli, and cantalope are shown to be more salt tolerant.



SALINITY OF SOIL (ECe in mmhos/cm) 1/

The above chart relates soil salinity to the relative response of forage crops. Clover is shown to be the most sensitive to salinity and tall wheat grass the most tolerant to high soil salinity levels.



SALINITY OF SOIL (ECe in mmhos/cm) 1/

The above chart illustrates graphically the relative response of various, major field crops to soil salinity. It is readily apparent that certain crops such as beans and corn are much more sensitive to salinity levels than other crops such as barley, cotton, or sugar beets.

1/ Electrical Conductivity of the soil solution - Larger numbers indicate higher salt content.

2/ Crops less tolerant of salt during germination:

Sugar beets - ECe should not exceed 3mmhos/cm

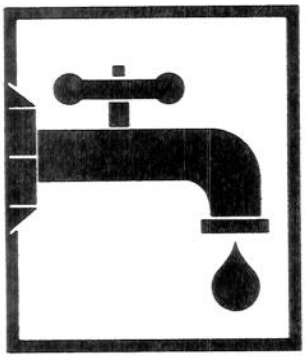
Barley - ECe should not exceed 4mmhos/cm

SUMMARY

Plant scientists have been studying the effects of water salinity and the accumulation of salts in and around the roots of plants and the subsequent response of the plants to varying levels of root-zone salinity for many years. Much of this work is summarized on the foregoing charts. However, it is suggested that you contact your local County Farm Advisor, the U.S. Soil Conservation Service, or the University of California Cooperative Extension Service Specialist for help in making a more detailed evaluation of the crop response information summarized in this brochure.

Distributed by Interagency Agricultural Information Task Force

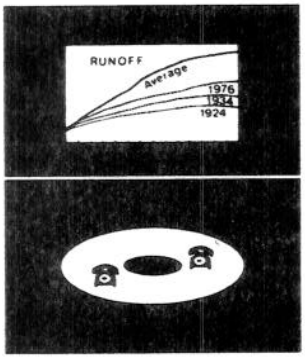
DATE February 14, 1977



DROUGHT INFORMATION BULLETIN

COMPILED BY THE

Department of Water Resources
And Co-Sponsors
Office of Emergency Services
State Water Resources Control Board



DROUGHT INFORMATION CENTER

(916) 445-1835

GENERAL WEATHER PICTURE:

The same description of weather continues, namely, a persistent ridge of high pressure near the West Coast. It appears from the forecast charts that the ridge will continue through this week.

GENERAL WATER SUPPLY CONDITION:

The snow depth at Norden is the lowest of record (6 inches) for this date.

The Metropolitan Water District of Southern California has signed an agreement under which it will make between 300,000 and 400,000 acre-feet of water available to the DWR during 1977 for allocation to areas of need.

The U. S. Bureau of Reclamation has announced tentative cutbacks of 25 percent for users of Sacramento River water and a cutback of up to 75 percent for San Joaquin Valley users.

Orland Water Users Association in Glenn County anticipates having only 4,000 acre-feet available for irrigation during 1977. Normal demand within the district is 125,000 acre-feet.

DROUGHT PROBLEM STATUS:

Public interest in conservation and drought-related information continued to keep the phones busy in the Drought Information Center at Headquarters and in the District Offices. Reported filling of two recreational lakes at Southern California subdivisions generated many inquiries.

The Office of Emergency Services has agreed to loan about 7½ miles of 8-inch pipe and one 1,500 GPM pump with accessories to two water districts in Marin County, and about 6 miles of 8-inch pipe and two 1,500 GPM pumps to the City of Lakeport in Lake County.

Some rural mountain residents near Willits in Mendocino County are trucking water to their homes because their domestic wells are drying up. Similar problems are reported to be occuring in Shasta and Humboldt Counties.

Nevada Irrigation District has adopted mandatory "Water Conservation Measures." This was necessary as the district estimated that they would run out of water in August if the people continued normal water use.

DWR representatives and City of Santa Cruz staff members are discussing a proposed pilot project for the State to supply, and local agencies to install, water conservation kits including toilet "dams" and shower "flow-restrictors". Santa Cruz is one of four proposed pilot project sites.

Sonoma County Board of Supervisors will hold hearings regarding a proposal to drill 5 production wells along the Sonoma County Water Agencies aqueduct to supplement supply to the aqueduct in anticipation of the Russian River going dry. By County ordinance, water contractors must adopt mandatory conservation measures to be effective March 1, 1977. The same ordinance makes water rationing mandatory when the Russian River goes dry. Major contractors include the cities of Santa Rosa, Sonoma, and Petaluma, the North Marin Water District, and the Valley of The Moon Water District.

Mariposa (population 1,000) which depends on surface flow in Stockton Creek, and on wells (producing about 50 gpm), has called for increased water-saving actions by customers. Two new wells producing about 50 gpm each have just been completed and others are under construction.

The "Conservation Idea of the Week" goes to San Francisco International Airport where they suggested that all airlines wash their aircraft in cities where water is plentiful.

DATA SUMMARY

Date Feb. 14, 1977

PRECIPITATION (in inches)

AREA	STATION	AVERAGE		CURRENT SEASON		
		ANNUAL	OCT. 1 TO DATE	OCT. 1 TO DATE	% OF AVE.	LAST 7 DAYS
No. Coast	Cresc. City	71.9	44.8	8.43	19	.51
Sac'to. Basin	Shasta Dam	58.2	37.5	6.22	17	.88
Feather Basin	DeSabla	66.0	43.0	8.88	21	.62
Amer. Basin	Blue Canyon	62.0	39.2	8.75	22	.79
San Joaquin Basin	Yosemite	37.1	22.7	4.33	19	.10

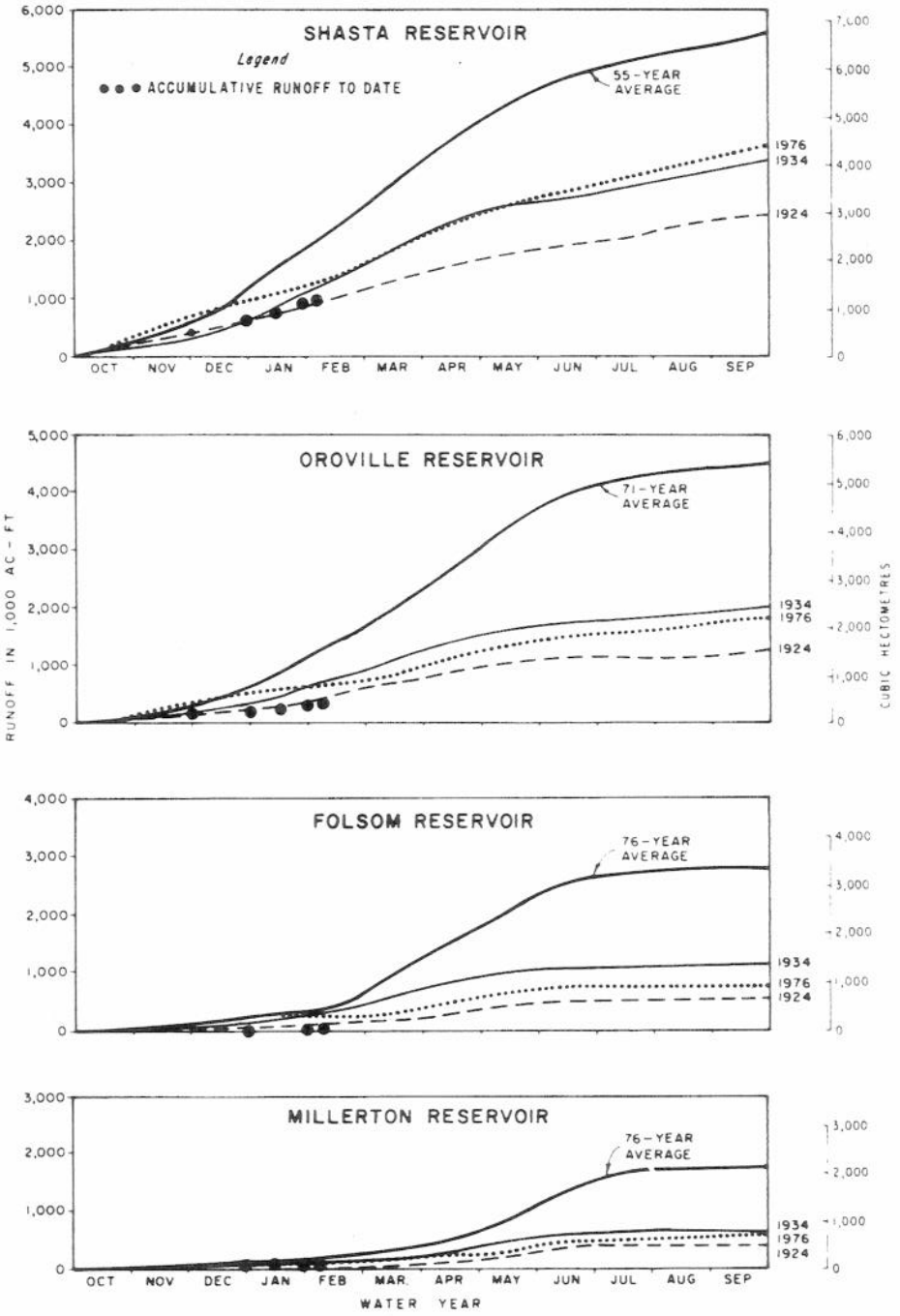
SNOW PACK (in inches)

AREA	STATION	ELEVATION	DEPTH 1 YR. AGO	DEPTH TODAY	LAST 7 DAYS
Feather	Norden	7,000	20"	6"	6"
Amer.	Blue Cyn.	5,280	1"	0	2"
San Joaquin	Yosemite	3,970	0	0	1"
San Joaquin	Grant Grove	6,600	15"	0	0

WATER STORAGE (in acre-feet)

RESERVOIR	10 YR. AVE.	1 YR. AGO	TODAY	DIFFERENCE AVE. TODAY
Shasta	3,406,414	2,937,100	1,492,400	-1,914,014
Oroville	2,472,179	2,692,600	1,588,900	- 883,279
Folsom	599,960	548,700	276,900	- 323,060
Millerton (Friant)	369,674	359,259	242,005	- 127,669
Cent. V. Total	14,853,656	14,238,937	8,210,876	-6,642,780

ACCUMULATIVE NATURAL RUNOFF TO SELECTED RESERVOIRS DURING DRY YEARS



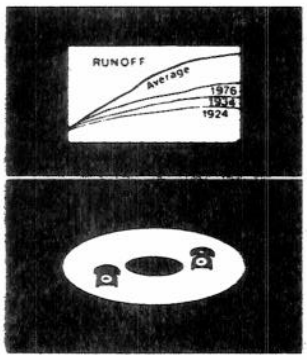
DATE October 3, 1977

DROUGHT INFORMATION BULLETIN

No. 32

COMPILED BY THE

Department of Water Resources
and Co-Sponsors
Office of Emergency Services
State Water Resources Control Board



DROUGHT INFORMATION CENTER
1416 Ninth Street, Room 1617-16
Sacramento, CA 95814
(916) 445-1835

GENERAL DROUGHT REPORT

SEPTEMBER RAINFALL

Although September rains had little overall effect on the drought picture, storage increased at Lake Shasta and the Federal-State River Forecast Center in Sacramento issued its first "River Forecast Bulletin" since March 1975. (River Forecast Bulletins are issued to warn of impending or existing river flood stages.)

The heaviest rainfall in the State was recorded in the Shasta and North Coastal areas where over 152 millimeters (mm) (6 inches) fell. As a result of this rainfall and reduced releases, the water level in Lake Shasta has risen about 2.6 meters (8.5 feet). Storage increased nearly 80.1 cubic hectometers (65,000 acre-feet). The Forecast Bulletin was issued because of heavy rainfall in the Smith River Basin in Del Norte County.

In other areas of the State: about 88.9 mm (3.5 inches) fell at De Sabla (near Oroville); 25.4 mm (1 inch) in the San Francisco and Red Bluff areas; 12.7 mm (0.5 inch) in the Sacramento area; 6.35 mm (0.25 inch) in the Yosemite area; and a "bare trace" in the South San Joaquin Valley and Southern California areas.

The major beneficial effect of the storms was the dampening of tinder-dry forest areas thus reducing fire hazards in Northern California.

THE CONTINUING CALIFORNIA DROUGHT, AUGUST 1977

The State Department of Water Resources has issued an update of drought conditions in the State under the title "The Continuing California Drought, August 1977".

The report provides an up-to-date summary of drought effects; a measure of the effectiveness of State, Federal and local actions in combatting drought effects; and an analysis of water supply conditions which will face California communities and water agencies during the present water year should dry conditions persist.

In assessing critical areas, the 138-page report assumes that local water agencies will be using their own resources to the limits of their capabilities to cope with the drought and that the State will use its emergency powers and intervene only in extreme cases. Such cases would involve hardships and/or inability of local agencies to provide a minimal level of water supply to its customers.

A number of California communities are faced with the prospect of being without water from traditional sources this year unless there is significant precipitation this winter. The water storage reservoirs of these communities may be wholly depleted in 1978 or early 1979 if the drought continues.

Ronald B. Robie, DWR Director, said that "Californians have no assurance that 1977-78 will not be another dry water year. We must plan for the worst on the assumption that the dry conditions of 1975-76 and 1976-77 will continue for another year. If such is the case, drought impacts will be far more severe than the impacts of the past two years."

DROUGHT IMPACTS ON EMPLOYMENT

Between September 6 and 16, 20 persons were laid off their jobs because of the drought. There was no reported reemployment of energy-or-drought related laid-off persons during the two-week period.

According to the latest Drought/Energy Employment report:

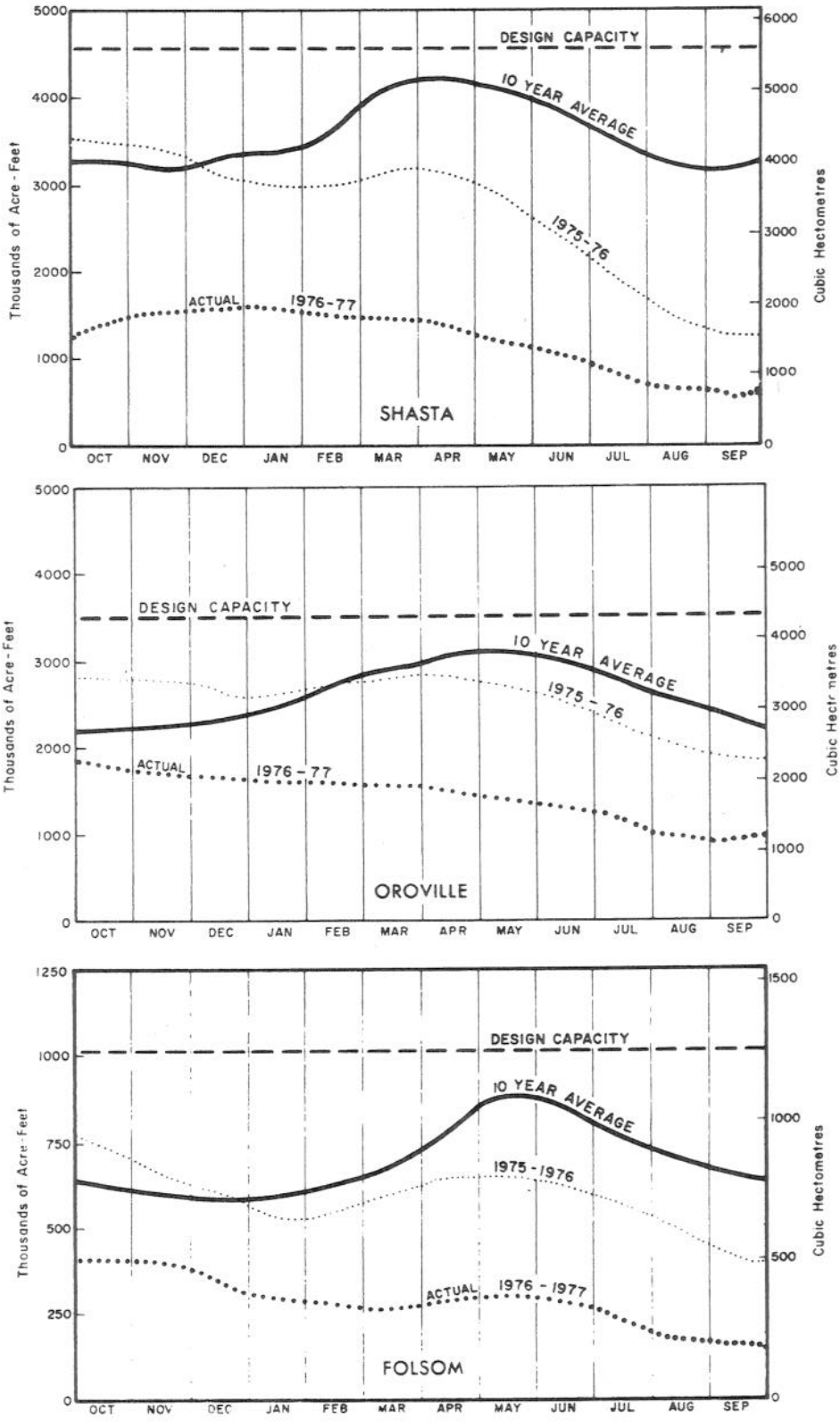
January 1, 1977, to date	Energy Related	Drought Related	Total
Number laid off	7,500	1,484	8,984
Number recalled	6,350	35	6,385
Net number on lay off	1,150	1,449	2,599

The major impacts on employment were felt: in the spring and early summer; in nursery, landscaping, roofing, and some farms; and in the Central Valley and Coastal areas of the State.

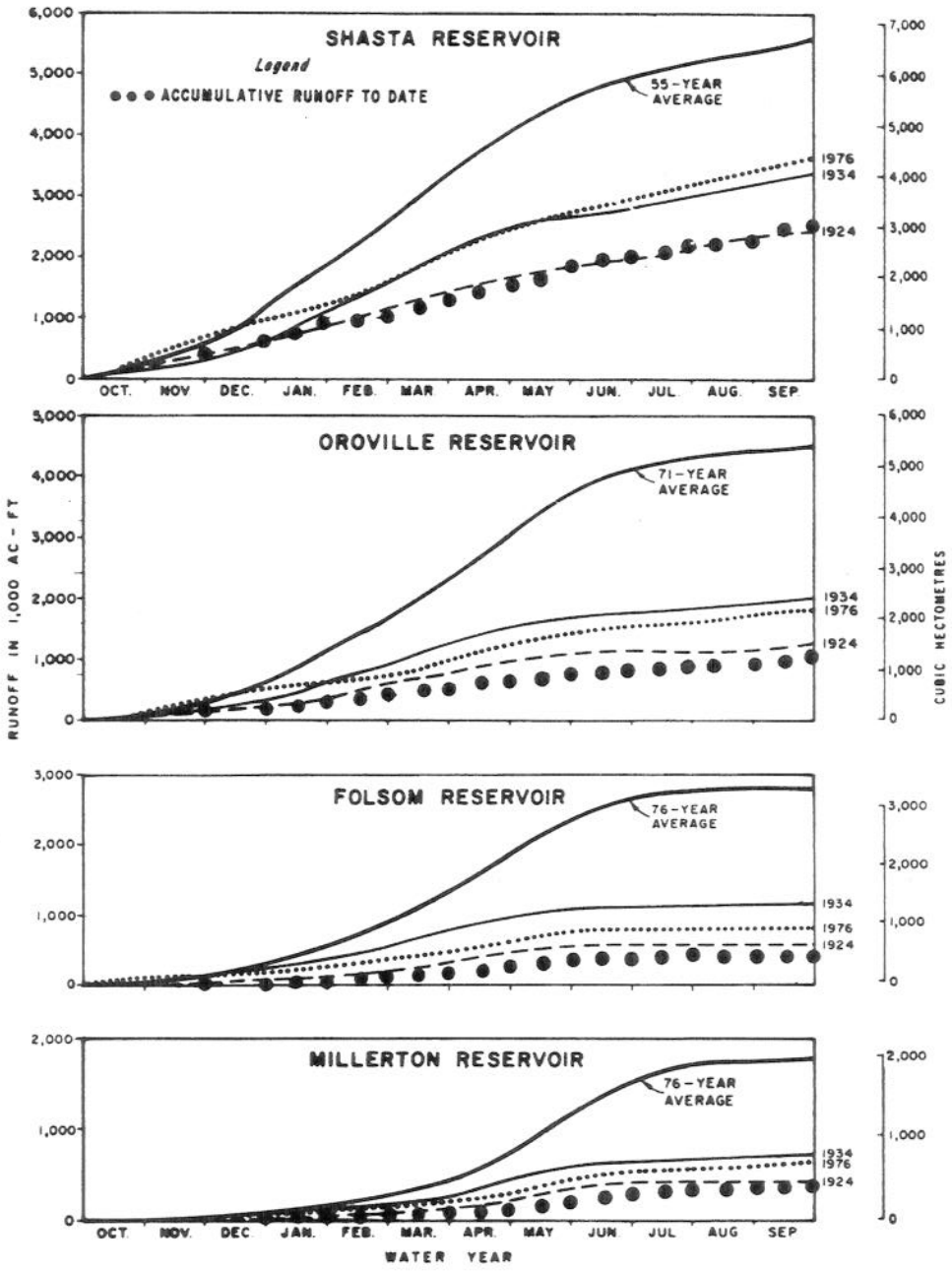
In general the impacts on employment, as reported by the Department of Employment Development, have been described as "eventless" inasmuch as reported problems were far fewer than were anticipated early in the year.

WATER STORAGE (AND PROJECTED STORAGE) IN SELECTED CENTRAL VALLEY RESERVOIRS

The graphs opposite compare the 1975-76 and 1976-77 (to date) drought years to the 10-year average-water-storage in three California Central Valley reservoirs.


DESIGN CAPACITY
10 YEAR AVERAGE
1975-76
ACTUAL 1976-77
SHASTA
Thousands of Acre-Feet
Cubic Hectometres
OCT NOV DEC JAN FEB MAR APR MAY JUN JUL AUG SEP
DESIGN CAPACITY
10 YEAR AVERAGE
1975-76
ACTUAL 1976-77
OROVILLE
Thousands of Acre-Feet
Cubic Hectometres
DESIGN CAPACITY
10 YEAR AVERAGE
1975-1976
ACTUAL 1976-1977
FOLSOM
Thousands of Acre-Feet
Cubic Hectometres

ACCUMULATIVE NATURAL RUNOFF TO SELECTED RESERVOIRS DURING DRY YEARS



STATE DEPARTMENT OF WATER RESOURCES -- DROUGHT INFORMATION CENTER

The Drought Information Center collects boating, camping and fishing information from local, state and federal organizations. The general public may obtain this information, plus stream flow data of interest to rafters and anglers, by calling (916) 445-1835 or the Center's toll-free telephone (800) 952-5530.

U. S. BUREAU OF RECLAMATION

Although recreation facilities at most USBR reservoirs are operated by other federal, state or local agencies, information about conditions at East Park, Stony Gorge and Berryessa reservoirs, which are operated by USBR, can be obtained by calling (707) 966-2111 for Lake Berryessa, and (916) 934-7066 for East Park and Stony Gorge.

U. S. FOREST SERVICE

Specific site information about the most popular National Forest recreation areas in California can be obtained by calling the U.S.F.S. at the following: San Francisco - (415) 982-1771; Shasta-Trinity - (916) 246-5338; Sierra - (209) 487-5456; Stanislaus - (209) 532-9784; El Dorado - (916) 622-5061.

U. S. ARMY CORPS OF ENGINEERS

The Corps supplies recreation information on California reservoirs under its jurisdiction to the Drought Information Center. The public may contact the Corps directly by calling (916) 440-2326.

NATIONAL PARK SERVICE

Specific site information about most popular National Park recreation areas in California can be obtained by contacting the National Park Services, 450 Golden Gate Ave., P.O. Box 36063, San Francisco, 94102 (415) 556-6030, in Los Angeles (213) 688-2902.

STATE DEPARTMENT OF FISH AND GAME

DFG's five regional offices will maintain current information on fishing opportunities, including boat-launching conditions and up-to-the-minute status of access. The regional offices and their phone numbers are: Redding (916) 246-6273, Sacramento (916) 445-0990, Yountville (707) 944-2443, Fresno (209) 222-3761, and Long Beach (213) 590-5177.

STATE DEPARTMENT OF PARKS AND RECREATION

Information on State Park campsite reservations and visitor facilities (and possible closures) can be obtained by calling (916) 445-8828.

PACIFIC GAS AND ELECTRIC COMPANY

PG&E will furnish information on stream and lake conditions on 15 watersheds from the Pit River on the north to the Kern River on the South in its PG&E Stream Scout Report, which is released to local newspapers on Thursdays. This PG&E information will also be available through the Drought Center.

DROUGHT INFORMATION BULLETIN

No. 27
August 1, 1977

RECREATION REPORT

Published by the
State Department of Water Resources
with the cooperation of the
State Departments of
Fish and Game
Parks and Recreation
Navigation and Ocean Development
the
U. S. Forest Service
U. S. National Park Service
U. S. Bureau of Reclamation
U. S. Army Corps of Engineers
and the
Pacific Gas and Electric Co.

DROUGHT INFORMATION CENTER
1416 Ninth Street, Room 1617-16
Sacramento, CA 95814
(916) 445-1835

ANTICIPATED LAKE RECREATION AT SELECTED LOCATIONS, SUMMER – 1977

RESERVOIR OR LAKE NAME	CONTACT	Boating Ramps Available	Fishing	Camping	Swimming	REMARKS
Almanor (Canyon Dam) (Plumas)	U.S.F.S., Chester (916) 258-2141	•	•	•	•	Ramps to be made available all summer. PG&E and Federal camp grounds open, first come, first serve. Private resorts around lake, call for reservations.
Amador Lake (Jackson Ck) (Amador)	Concessionaire (209) 274-2625	•	•	•		No water skiing. Boat rental available. Day use picnic and recreation area.
Anderson Reservoir (Santa Clara)	Co. of Santa Clara (408) 779-3634 Marina, (408) 779-4895	•	•			Facilities in operation. Day use only. No swimming.
Antelope (Plumas)	U.S.F.S., (916) 284-7126		•	•	•	Lake 1/3 full. Launching of car-top and portable boats OK. No boat ramp. All campsites open. Fishing fair.
Bass Lake (Madera)	U.S.F.S., (209) 683-4665 Bass Lk Resort Off. (209) 642-3212	•	•	•	•	Facilities expected to be available through Labor Day. Plenty of campsites available. Lake 1/2 full with boat ramps usable.
Berryessa (Napa)	U.S.B.R., (707) 966-2111 8-5 daily	•	•	•	•	Boat ramps in operation. Recreation facilities all open and in operation. Private resorts around lake.
Big Bear Lake (San Bernardino)	Chamber of Commerce (714) 866-4601	•	•	•		Fishing excellent. 8 U.S.F.S campgrounds, most on "Ticketron". No swimming at present.
Boca (Nevada)	U.S.F.S., Truckee (916) 587-3558	•	•	•		Ramps in operation. Skiing and fishing OK. Campground open, with water. Campgrounds along Hwy Rte 89 to be open all summer. Call for current status.
Britton, Lake (Shasta)	Calif. State Parks, (916) 335-2777	•	•	•	•	Boat ramps, camping, fishing, swimming all open and operating. Day use picnic area. Small boat rental available.
Bucks Lake (Plumas)	U.S.F.S., Oroville (916) 534-6500	•	•	•	•	All facilities available. Lake low. Road from Oroville side in poor condition. Call for current status. Whitehorse Campground – no water, use fee dropped temporarily.
Cachuma (Santa Barbara)	Santa Barbara Parks (805) 966-1611 Ext. 244	•	•	•		No water contact activities on reservoir. Swimming pool at concession. Horseback riding.
Camanche (San Joaquin)	E.B.M.U.D., (209) 772-1325 Camanche Regional Pks (209)772-1277	•	•	•	•	New boat ramps available. Water skiing good. Lake low. North concession (209) 763-5121, South concession, (209) 763-5178.
Camp Far West (Placer)	Concessionaire (916) 645-8069	•	•	•	•	Boat ramps in good condition. No water skiing. No marina or gas on lake. North side camp grounds closed. 46 units on south side open.
Casitas (Ventura)	Lake Casitas Recreation Area (805) 649-2233	•	•	•		No adverse effect on recreation, due to drought, is anticipated.
Castaic (Los Angeles)	L.A. County Parks Department (805) 257-2845	•	•	•	•	Boat ramp at Dam Overlook in operation. Forest Service camp ground nearby. Boat rental available.
Clear Lake (Lake)	C. of C., Lakeport (707) 263-6131 Sheriff (707) 263-2331	•	•	•	•	State park boat ramp closed. Launching to 24-ft. at resort areas. County parks, day use only. State park open. Resorts have swimming pools and boat rentals.
Collins Lake (Yuba)	Concessionaire, (916) 692-1600	•	•	•	•	Lake 1/2 full. Launching any size boats. Water skiing restricted to southern end of lake. Boat rental and dock moorage available. Camping – RV park normal.
Copco Lake (Siskiyou)	Concessionaire, (916) 459-3654	•	•	•	•	All facilities in operation. Camping area for self-contained vehicles only. Cabins available. Water skiing restricted to one area of lake. Lake near full.
Crowley (Mono)	L.A. Dept. of Pks. & Rec. (213) 485-4853	•	•	•	•	New ramp and road constructed. Special water skiing season (July 1 to September 5). Day use only but private accommodations nearby.
Davis Lake (Plumas)	U.S.F.S., (916) 836-2575		•			Lake low. Boat ramp closed at Lighting Tree. Boats can be launched at Coot Bay and Big Flat at boaters' own risk. Campgrounds are open. No swimming.
Del Valle (Alameda)	E. Bay Regional Pks., (415) 443-4110 E. Bay Rec. & Pks., (415) 531-9300	•	•	•	•	Lake speed limit 10 mph, no water skiing. Swimming, picnicking, fishing, OK. Camping on first come basis, no electricity. Boat ramp, hiking and equestrian trails.
Don Pedro (Tuolumne)	Don Pedro Rec. Agy., (209) 852-2396	•	•	•	•	All facilities available. Swimming and marina at Fleming Meadows.
Eagle Lake (Lassen)	U.S.F.S., (916) 257-2595	•	•	•	•	Natural lake. Lake near full. Forest camp grounds open. First come, first serve. Heavy use.
Edison, Lake T.A. (Fresno)	U.S.F.S., (209) 841-3294 S.C.E.C. at Big Ck. (209) 893-3260	•	•	•		Lake low, launching of car-top boats only. 15 mph speed limit. Hikers ferry service is available.
Englebright (Narrows) (Nevada)	U.S.C.E., Park Mgr., (916) 639-2342 Concessionaire, (916) 639-2272	•	•	•	•	Two launch ramps open, lake full, boat-in camping on first come, first serve basis. Full facilities on water.
Exchequer (McClure) (Mariposa)	McClure Point, (209) 378-2521 Barrett Cove, (209) 378-2711	•	•	•	•	Boat ramps to be extended at Barrett Cove and McClure Point as necessary. Two concessionaires on lake. Make reservations with Park Ranger: (209) 378-2521.
Florence Lake (Fresno)	U.S.F.S., (209) 841-3294 S.C.E.C., (209) 893-3260	•	•	•		Lake low. Launching near resort. Car-top boats only. 15 mph speed limits. Hikers ferry service is available.
Folsom (Sacramento)	Calif. State Parks (916) 988-0205 Marina (916) 933-1300	•	•	•	•	Launching at Brown's Ravine and haul road (Beals Point) for boats up to 26-ft. No gas on lake.
French Meadows (Placer)	U.S.F.S., (916) 367-2224		•	•		Car-top boats only. Camping facilities open. Water low. Gas not available at lake.
Frenchman (Plumas)	U.S.F.S., (916) 253-2223		•	•	•	No boat launching available. Must carry car-top boats a long way to water. Camping, 80 units. Picnicking and swimming OK.
Huntington Lake (Fresno)	U.S.F.S., (209) 841-3311	•	•	•	•	Recreation normal. Lake near full. Expect facilities in operation through Labor Day.
Ice House (El Dorado)	U.S.F.S., Fresh Pond (916) 644-2348, 8-6 daily		•	•	•	No boat ramp facilities. No reservations necessary. Call for current status.
Indian Creek (Alpine)	U.S. Bureau of Land Management (702) 882-1631	•	•	•	•	Boat launching primarily for fishing type boats. Recreation expected to be about same as last year.
Iron Gate (Siskiyou)	Pacific Power & Light Co. (503) 243-4795	•	•	•	•	Normal recreation. Three boat ramps open, eight camp and picnic facilities available.
Isabella (Kern)	U.S.C.E., Park Mgr., (714) 379-2742	•	•	•	•	Launching still OK. Water skiing OK.

Jackson Meadow (Nevada)	U.S.F.S., (916) 265-4531		•	•	•	Lake low. Cartop boats only. No launching. Fishing poor. Pass Creek and Woodcamp campground open with water. Call for any changes.
Keswick (Shasta)	U.S.F.S., (916) 246-5222 Visitor Information, (916) 243-2643	•	•			Normal recreation at this fishing facility and picnic site. Day use only.
Lewiston (Trinity)	U.S.F.S., (916) 246-5222 Assoc. (916) 243-2643	•	•	•		Normal recreation. Boat launching, camping, picnicking available. Speed limit 10 mph
Little Grass Valley (Plumas)	Oroville-Wyandotte I.D. (916) 534-1221		•	•		Ramps closed. Carry-in boats OK. Fishing, camping and picnicking OK through September.
Loon Lake (El Dorado)	U.S.F.S., Fresh Pond (916) 644-2348	•	•	•	•	Boat ramp available for boats up to 16' only. No reservations required, first come, first served. Call for current status.
Lopez (San Luis Obispo)	San Luis Obispo Co. FC&WCD	•	•	•	•	No adverse effect on recreation, due to drought, is anticipated. No reservations accepted over telephone. Must be made in person at main gate no earlier than 3 days in advance.
Lower Hell Hole (Placer)	(916) 626-1550 Recording (916) 622-5061		•	•	•	Car-top and portable boats only. All other recreation normal.
Mammoth Pool (Fresno)	U.S.F.S., (209) 877-2218	•	•	•	•	Unpaved boat ramp available. Cartop and portable boats OK. Lake down 30 ft. All other recreation normal.
McSwain, Lake (Mariposa)	Marina (209) 378-2534 Reservations (209) 378-2521		•	•	•	No water skiing on this lake. Fishing, camping and overnight use available. Call and check for reservations.
Melones (Calaveras)	U.S.C.E., Park Manager (209) 847-0225		•	•	•	Ongoing construction in area. No potable water. Call for any changes.
Mendocino, Lake (Mendocino)	U.S.C.E., (707) 462-7581		•	•	•	Boat ramps now out of water. Car-top or portable boats OK. Camping and picnicking all year.
Millerton (Friant) (Fresno)	Millerton State Recreation Area (209) 822-2332	•	•	•	•	Water level has peaked and is slowly dropping. Boat launch and other recreation facilities should be usable all summer. Reservations for 90 days in advance.
Modesto (Stanislaus)	County Operated (209) 874-9540	•	•	•	•	60 camp sites. Gas and oil available. Food and picnicking.
Nacimiento (San Luis Obispo)	Nacimiento Recreation Area (408) 424-0866	•	•	•	•	Recreation conditions normal.
Natoma, Lake (Sacramento)	Calif. State Parks (916) 988-0205	•	•	•	•	All facilities in operation. No water skiing. Speed limit 20 mph.
New Bullards Bar (Yuba)	U.S.F.S., (916) 288-3242		•	•		Boat ramp approximately 20 ft out of water. Hand-carried boats only. Camp sites accessible by boat closed. Some debris on lake. Call for current status. Campgrounds open.
New Hogan (Calaveras)	U.S.C.E., Park Mgr, (209) 772-1343 Concessionaire (209) 772-1462	•	•	•	•	Launching OK through July. Boat rental and gas available at Marina.
Oroville (Butte)	Park Headquarters, (916) 534-2409	•	•	•		Launching available at several locations, call for current status. No night launching, ramps not lighted.
Perris (Riverside)	State Dept. of Parks & Recreation (714) 657-7321	•	•	•	•	All facilities in operation. Boat rentals available. 250 new camp sites open.
Pillsbury (Lake)	U.S.F.S., Soda Creek (707) 743-1582	•	•	•	•	Resorts have restored launching ramps and can launch boats up to 21-ft. All facilities are in operation.
Pinecrest (Strawberry) (Tuolumne)	U.S.F.S., (209) 965-3434 Concessionaire (209) 965-3333	•	•	•	•	Lake full, 20 mph speed limit. No water skiing or houseboats. Sailing OK. 300 camp sites - 200 through "Ticketron". Picnic, swimming, boat rentals and launch area available.
Pine Flat (Fresno)	U.S.C.E., Park Mgr., (209) 787-2589		•	•	•	Ramps closed. U.S.F.S. Sycamore #1 and #2 campgrounds have no water. Water level falling, but still a lot of lake surface.
Piru (Ventura)	United Water Conservation Dist., (805) 525-4431	•	•	•	•	One boat ramp in service. Fishing normal. Camping normal. Some limitations on water skiing.
Pyramid (Los Angeles)	U.S.F.S., (805) 259-2790	•	•		•	Boat ramps OK. Some picnic facilities available. Day use only, first come, first serve. Use limited to parking facilities. No fee for use. Boat rentals available.
Rancho Seco (Sacramento)	Sacramento Co., Parks Rec. (916) 366-2061	•	•		•	No power boats. Sail boats, canoes and row boats OK. Fishing from piers also. Organized groups call (916) 366-2066.
Red Bluff, Lake (Tehama)	U.S.B.R., (916) 527-7440	•	•	•	•	Boat ramp and picnic facilities available. Private camp ground nearby.
Ruth (Trinity)	U.S.F.S., Mad River Ranger Dist., (707) 574-6233	•	•	•	•	Newly installed boat ramp in operation. Camp grounds and all facilities open.
San Antonio (Monterey)	San Antonio Recreation Area (802) 472-2311	•	•	•	•	Recreation normal.
San Luis Resv. & O'Neil Forebay(Merced)	State Parks and Recreation (209) 826-1196	•	•	•	•	Overnight facilities at O'Neil Forebay only. Swimming best at O'Neil Forebay beach area. Water skiing best at O'Neil.
Santa Margarita (San Luis Obispo)	San Luis Obispo Co. FC&WCD	•	•	•	•	Recreation normal.
Shasta (Shasta)	U.S.F.S., (916) 246-5222 Visitor Info. (916) 243-2643	•	•	•	•	Portable ramp moved from Jones Valley to Silverthorn. Cartop boats can be carried to lake. Camping facilities open. Call for current status.
Shaver Lake (Fresno)	U.S.F.S., (209) 841-3311	•	•	•	•	Boat launching possible at your own risk. Lake is about 25% full. Gradual drawdown now underway. Plenty of camping space available.
Silverwood (San Bernardino)	State Dept. of Parks & Recreation, (714) 389-2281	•	•	•	•	Boating available. Picnicking, camping and swimming OK. Boat rentals available. Reservations available through "Ticketron".
Siskiyou, Lake (Siskiyou)	Lake Siskiyou Campgrounds (916) 926-2618	•	•	•	•	Normal operations. Lake full since April. No water skiing. Speed limit 10 mph. Sail boats OK. Call for reservations.
Spaulding (Nevada)	U.S.F.S., (916) 273-1371	•	•	•	•	24 camp sites available; seven day limit, first come, first serve. $2.00 per night. Ramp now open for trailerable boats.
Stampede (Sierra)	U.S.F.S., Truckee, (916) 587-3558		•	•		Cartop boats can be launched from shore line. Camping facilities open. Call for current status.
Success (Tulare)	U.S.C.E., Park Mgr., (209) 784-0215	•	•	•	•	Launching through mid-August (on west side of lake only).
Tahoe (Placer)	Call Marina or Resort Areas in Yellow Pages	•	•	•	•	Boat launching available at most resorts. Channel deepening now underway in most areas.
Terminus (Tulare)	U.S.C.E., Park Mgr., (209) 597-2301	•	•	•	•	Launching year round. All recreation facilities operating.

ANTICIPATED LAKE RECREATION AT SELECTED LOCATIONS, SUMMER – 1977

RESERVOIR OR LAKE NAME	CONTACT	Boating Ramps Available	Fishing	Camping	Swimming	REMARKS
Thermalito Forebay (Butte)	Calif. State Parks, (916) 534-2393	•	•		•	No power boats, sail boats only. Day use facilities only.
Thermalito Afterbay (Butte)	Calif. State Parks, (916) 534-2335	•	•			Power boats OK. Day use facilities only.
Trinity Lk. (Clair Engle) (Trinity)	U.S.F.S., (916) 246-5222 Visitors Info., (916) 243-2643	•	•	•	•	Launching at County Road 24. Portable ramps at Cedar Stock, Estrellita, Fairview, and Recreation Plus. Lakeshore camping OK. Recording (916) 246-5338.
Tulloch (Tuolumne)	Concessionaire, (209) 881-3335	•	•	•	•	Trailer park, boat rental, gas available. Call to check current status of facilities.
Turlock Res. (Stanislaus)	Calif. State Parks, (209) 874-2008	•	•	•	•	Boat launching from sand bar when water low. Camp site reservations through "Ticketron".
Whiskeytown (Shasta)	N.P.S. (916) 241-6584 Visitors Info., (916) 243-2643	•	•	•	•	Normal recreation this summer until after Labor Day. Camping, picnicking, beach and boat launching facilities available.
Wishon (Fresno)	U.S.F.S., Dinkey Ck, (209) 841-3404 PG&E, (Fresno) (209) 264-3806	•	•	•		Lake near full but starting to drop slowly. Boat speed limit 15 mph. Resort and campgrounds open. Unpaved boat ramp usable.

Recreation areas presently considered to have limited or no recreation facilities include:

BEARDSLEY, COURTRIGHT, DONNELLS, EAST PARK, INDIAN VALLEY, PARDEE. PROSSER, ROLLINS, SHASTINA, SLY PARK, STONY GORGE, UNION VALLEY, BLACK BUTTE.

VACATIONERS SHOULD --

(1) Be aware of great fire danger. (2) Have valid fire permits where necessary. (3) Phone ahead first - make reservations if possible.

RIVER FLOW DATA

for

BOATERS

August 15, 1977

Published by the
STATE DEPARTMENT OF WATER RESOURCES
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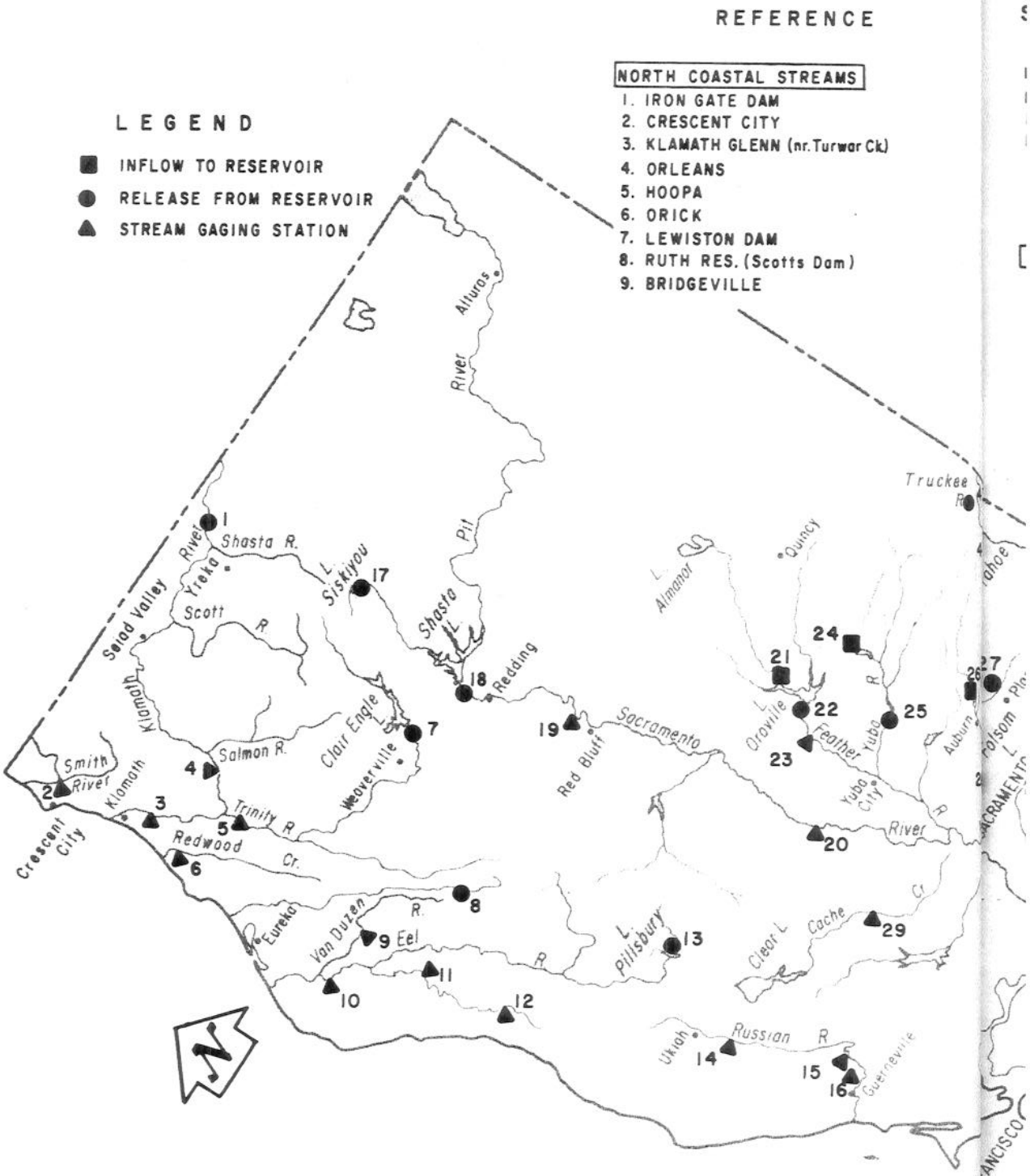
STATE DEPARTMENT OF NAVIGATION
AND OCEAN DEVELOPMENT



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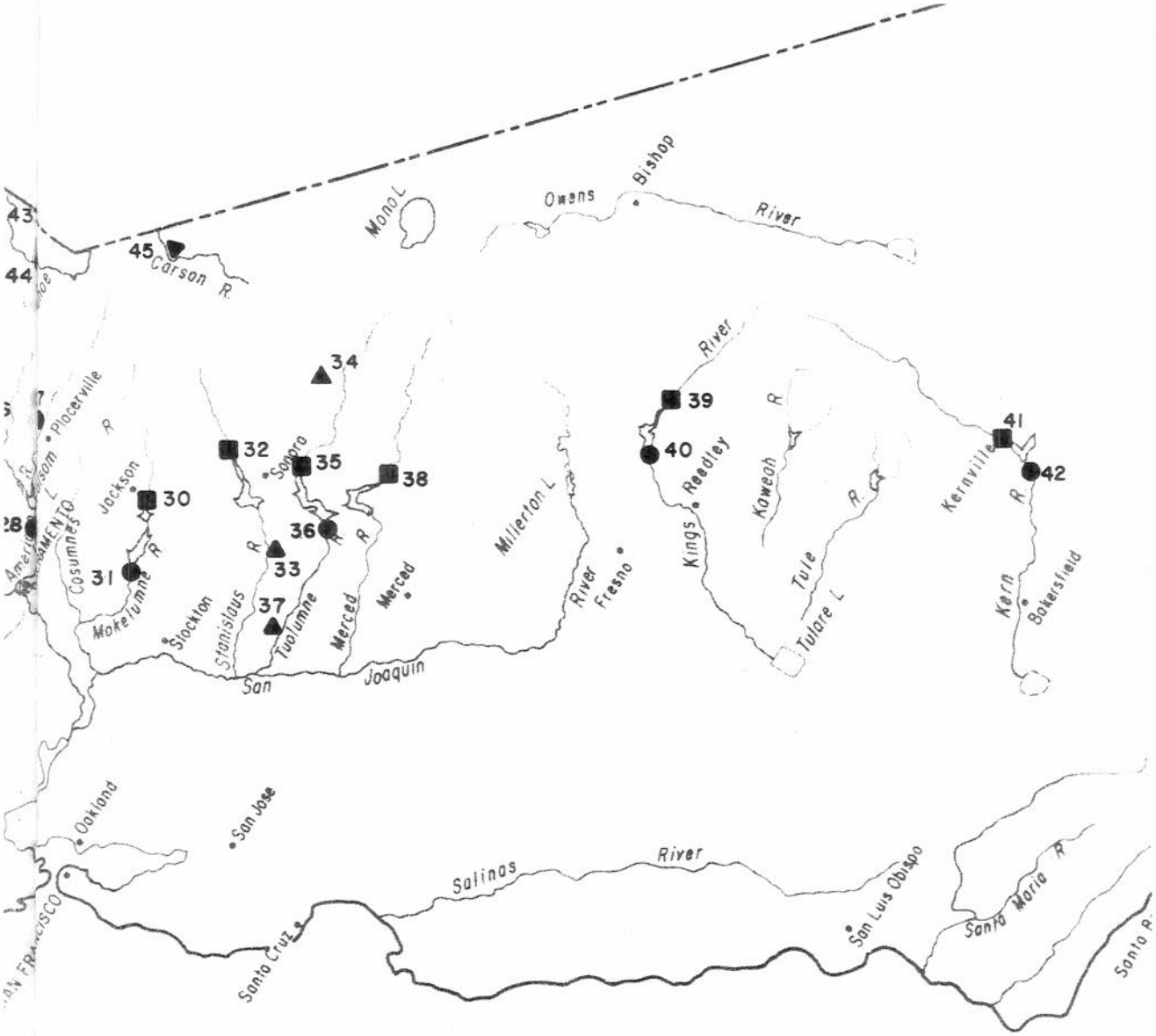

STREAMFLOW DATA

RIVER FLOW AND BOATING CONDITIONS REPORT

In response to requests from boating enthusiasts, current river conditions and projected river flows have been listed for major California streams. (For locations, see map on inside page.) Current reservoir inflows and releases, and current river flows are available on a telephone recording, (916) 322-3327, prepared daily (Monday - Friday) by DWR. Flows may vary widely during any given day due to release changes, rainfall, or stream runoff. Novice boaters are advised to travel only in the company of advanced paddlers, and never attempt any river which may be beyond their skills.

SAFETY INSTRUCTION

The basic skills in canoeing, kayaking and rafting can be obtained from Red Cross training programs. Some chapters of the YMCA, Sierra Club, Boy Scouts, and various recreation departments are also expanding their boating safety programs to include instruction for manually propelled vessels.

For information on white water classes available in your area, call DNOD (916) 445-2427.

STREAM	COUNTY	REACH	River Miles	Gage 1/ Ref. No.	Whitewater	Flatwater	Desirable Flow (cfs) 2/ Min.	Desirable Flow (cfs) 2/ Max.	Approx. August Flows (cfs)	REMARKS
American R.; No. Fk.	Placer	Colfax to Ponderosa Way	9	26	X		200			Too low for boating.
So. Fk.	El Dorado	Chili Bar to Folsom Lk.	19	27	X		500		<10	Intermittent flows on short notice.
Lower Main	Sacramento	Nimbus Dam to Sacramento R.	23	28		X	850		800*	Marginally satisfactory boating flows. 3/
Cache Ck. 1.	Yolo	Bear Ck. to Rumsey	8	29	X		350		<10	Much too low for boating.
2.	Yolo	Rumsey to Guinda	7	29		X	350		<10	Much too low for boating.
Carson R., E. Fk.	Alpine	Markleeville to nr. Gardnerville	18	45	X		400	3000	<10	Much too low for boating.
Eel R., Main 1.	Mendocino	Scott Dam to Van Arsdale D.	9	13	X		300		50 *	Much too low for boating.
2.	Mendocino, Trinity, Humboldt	Dos Rios to South Fork	78	11	X		1000		30	Much too low for boating.
3.	Humboldt	South Fork to Rio Dell	22	10		X	2200		80	Much too low for boating.
Middle Fk.	Mendocino	Eel River R.S. to Dos Rios	30	–	X		750		20	Too low for all boating.
South Fk.	Mendocino, Humboldt	Leggett to Main Eel mouth	64	12	X	X	500		50	Too low for all boating.
Feather R., Main	Butte, Sutter, Yuba	Thermalito to Sacramento R.	44	22, 23		X	1000		1500*	Satisfactory for small craft.
Kern R.; 1.	Kern	vicinity Kernville	–	41	X		275		110	Too low for boating.
2.	Kern	Miracle Hot Sp. to Democrat Sp.	14	42	X		450		250*	Minimal. 3/
Kings R., 1.	Fresno	above Pine Flat Dam	10	39	X		500		100	Too low for boating.
2.	Fresno	Alta Weir to Reedley	27	40		X	800		1600*	Satisfactory for small craft. 3/
Trinity R.; Main 1.	Trinity	Lewiston to Junction City	30	7	X		550		150	Marginal.
2.	Trinity	Junction City to Cedar Flat	31	–	X		1000		160	Marginal.
3.	Trinity	Hawkins Bar to South Fk.	8	–	X		1350		180	Marginal.
4.	Humboldt	South Fk. to Weitchpec	31	5	X		1600		200	Marginal.
South Fk.	Trinity	Underwood Ck. to Trinity R.	20	–	X		550		100	Too low for all boating.
Truckee R.	Placer, Nevada	Tahoe City to Boca	25	43, 44	X	X	250		75	Marginal. Flows may cease in September.
Tuolumne R. 1.	Tuolumne	Lumsden Br. to Wards Ferry	18	34, 35	X		600	4000	*	Too low for boating.
2.	Stanislaus	Logrange to Waterford	20	36		X	200	1000	*	Too low for boating.
3.	Stanislaus	Waterford to San Joaquin R.	28	37		X	100		*	Minimal for canoeing.
Van Duzen	Humboldt	Bridgeville to Carlotta	22	9	X		500		<10	Too low for boating.
Yuba R., No. Fk.	Nevada	Goodyear Bar to Rt. 49	9	24	X		300		40	Too low for boating.
Main	Yuba	Rt. 20 to Marysville	16	25		X	200		300*	Marginally suitable for paddle craft.

1/ Stations for which daily data are available. Other streams do not have daily data available for this report.

2/ The reported "desirable flow" for white water streams are considered satisfactory for the average Kayaker; Canoes would require about 50 - 80% of these flows; Rafts would require about 150 - 200% of these flows; on Flat water streams, all craft require similar flows.

3/ Release may be further reduced in early September; moderate impact on boating conditions.

* Subject to variation due to upstream reservoir operations.

The use of the following guide books has been most helpful: "West Coast River Touring" by Dick Schwind, 1974; "Sierra White Water" by Charlie Martin, 1974; and "Canoeing Waters of California" by Ann Dwyer, 1973.

RIVER FLOWS AFFECT SAFETY.

STATE OF CALIFORNIA—RESOURCES AGENCY
EDMUND G. BROWN JR., Governor

DEPARTMENT OF WATER RESOURCES
THE RECLAMATION BOARD
1416 – 9th Street, Room 335-18
Sacramento, CA 95814
(916) 445-9454

(916) 445-9248

May 8, 1978

All California Water Agencies:

We are experiencing what can be classed as a wet year. Based on April 1 snow survey data, water conditions show a very good outlook for the remainder of this water year. The water content of the snow pack averages about 150 percent of normal in most of the Sierra. The snow melt runoff for the April through July period is expected to produce about 200 percent of normal flows for the San Joaquin Valley tributaries.

Despite this welcome situation, strong water conservation efforts must be continued. The history of California shows vividly that drought will return. And we learned during the past two years that during times of plenty we often have used more water than necessary. This wastes both resources and money.

There are some encouraging signs that Californians have retained some of the lessons of the drought. For example, it appears that present urban water use is about 20 percent less than during a comparable pre-drought period.

Another indication comes from a statewide poll taken for the Department by the Field Corporation that showed about 60 percent of the population feels water conservation is "extremely important" or "very important" despite the return of wet weather. The sampling of 1,000 persons also showed that about 78 percent were inclined to save water to save energy. (A copy of the findings by geographic area is attached for your information.)

These healthy public attitudes form a good foundation for long term conservation and one of the arguments that strikes home for individuals is that conservation in residences saves both water and energy. The use of flow restrictors in showers can save a considerable amount of energy. There is a statewide potential saving of up to 10 million barrels of oil equivalent as a result of using less hot water in showers. Energy is also needed for pumping water, for treatment of water and for waste water treatment.

The Department recommends that each water agency set water use targets at per capita or per acre levels below those of pre-drought conditions and closely monitor water use during the coming months.

The Department will continue to provide water information services, monitor water use throughout the State, and work with local agencies on conservation programs.

The Department's cooperative program with the Department of Education for conservation education in grades kindergarten through six is now available.

save water

for use by water agencies and schools in all areas of the State. A more comprehensive program is now being prepared for the fall. Please contact Don Engdahl at (916) 322-6820 to find out how you can participate in the school program.

The Department will also continue to make other water conservation materials -- films, decals, bumper stickers, pamphlets, and so on -- available.

On January 1 of this year, a State law (Section 17921, Health and Safety Code) went into effect which prohibits use in new construction of tank-type toilets that use more than three and one-half gallons per flush.

In addition, it is important now to encourage Californians to install low water-using bathroom devices and to modify their water-using habits elsewhere. As previously mentioned, low-flow showers are especially attractive because of the energy and money consumers can save by reducing the use of hot water.

Substantial savings in water can also be accomplished through education about water use outside the home. Promotion of drought-tolerant landscaping is very important because not only does it reduce summer water demand, it can greatly reduce water use during periods without loss of expensive plantings.

We also believe that considerable amounts of water can be saved by industries, most of which reduced their water demands sharply during the drought. They should be encouraged to continue to look for ways to eliminate waste and increase recycling of water in their processes.

The water conservation staff of the Department is ready to help you continue your urban water conservation efforts; the contact person for these programs is Jim Koyasako at (916) 445-9959.

The drought forced us to conserve. Let's work together to maintain the progress we made and to build a solid water conservation ethic for the future.

Sincerely,

(sgd) Ronald B. Robie

Ronald B. Robie
Director

Attachment

DBBrice:ms

FIELDSCOPE WATER CONSERVATION QUESTION RESULTS (March 1978)
(By Geographic Area)

QUESTION: As you now see the drought situation, how important do you feel it is to continue to conserve water? Some people say that even if water were available in unlimited quantities, conservation should still be practices since saving water saves energy. Others say the amount of energy that can be saved by conserving water is not that important. In regard to energy saving possibilities, which of these categories best describe how inclined you would be to save water?

		----------SOUTH----------			-------NORTH---------		
	TOTAL STATE (pct.)	SOUTHERN CAL. (pct.)	LA/ ORANGE (pct.)	OTHER SOUTH CAL. (pct.)	NORTHERN CAL. (pct.)	BAY AREA (pct.)	OTHER NORTH CAL. (pct.)
Extremely Important	24.6	20.4	19.6	22.3	30.4	31.4	29.2
Very Important	35.7	34.6	34.1	35.8	37.2	34.9	40.1
Somewhat Important	24.9	26.8	26.8	26.9	22.3	22.9	21.5
Not Very Important	7.7	8.5	8.5	8.6	6.6	7.2	5.8
Not at All Important	6.2	8.3	9.7	4.8	3.4	3.6	3.2
Can't Say/No Opinion	.9	1.4	1.3	1.6	.1	--	.2

FIELDSCOPE WATER CONSERVATION QUESTION RESULTS (March 1978)
(by Geographic Area)

QUESTION: Some people say that even if water were available in unlimited quantities, conservation should still be practiced since saving water saves energy. Others say the amount of energy that can be saved by conserving water is not that important. In regard to energy saving possibilities, which of these categories best describes how inclinced you would be to save water?

		---------SOUTH---------			--------NORTH--------		
	TOTAL STATE (pct.)	SOUTHERN CAL. (pct.)	LA/ ORANGE (pct.)	OTHER SOUTH CAL. (pct.)	NORTHERN CAL. (pct.)	BAY AREA (pct.)	OTHER NORTH CAL. (pct.)
Very Much More Inclined	38.0	34.2	33.4	36.0	43.3	42.9	43.8
Somewhat More Inclined	40.6	41.3	40.2	43.9	39.5	37.6	42.0
A Little More Inclined	12.6	13.9	14.7	12.0	10.8	11.0	10.5
Not At All More Inclined	7.4	8.3	9.5	5.4	6.3	8.5	3.4
Can't Say/No Opinion	1.4	2.3	2.2	2.8	.1	--	.2

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