THE CALIFORNIA TWO YEAR DROUGHT 1/ 647-78

By

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Introduction

Historically speaking droughts are not uncommon, nor are severe droughts unique in California's history. Tree ring studies indicate that there have been exceptionally dry years during several periods in California's past ranging back over a thousand years. In more recent history there were droughts in 1856-57, 1863-64, 1924, 1929-34, and 1959-1961. Two dry years back to back such as 1976 and 1977, however, are rare. The water year 1977 was the driest year in California since records were started over 100 years ago, and 1976 was the fourth driest year of record. These two straight years of little precipitation lef California with record low storage in its surface reservoirs and with ground water basins dangerously overdrawn.

Annual runoff in the State averages about 71 million acre-feet (87 600 cubic hecto metres). This amount has been sufficient to help the State's population to grow from about six million people in the 1929-34 drought period, to a population today of over 21 million a level exceedingly vulnerable to drought. If the State could count on this amount of run-off each year, and could retain all of the water for use, it would have an abundant supply However, several factors prevent this: climatic conditions vary greatly from year to year; much of the water does not originate where it is needed; and rivers which carry about one-fourth of the average runoff are protected by the State Wild and Scenic Rivers Act, pre-venting man-made storage on these rivers.

Extent of Drought

Precipitation. In California, precipitation averages 200 million acre-feet (250,000 cubic hectometres) annually. In the 1976 water year precipitation was 65 percent of average. In 1977, water year precipitation was 45 percent of average. The two years of limited rain and snow reduced runoff to 47 percent and 22 percent, respectively, for 1976 and 1977. Sixteen major rivers in the State set new record lows for runoff in 1977. Pre-cipitation over the State was below average for 25 consecutive months from November 1975 to November 1977, inclusive, with three minor exceptions - August and September 1976, and May 1977.

Reservoir Storage. On October 1, 1975, storage in 152 major reservoirs was 23 million ac-ft (28 400 hm^3), 110 percent of average and 67 percent of capacity. Thus, the drought period began with a slight reserve in surface storage. One year later, storage had declined to 13.7 million ac-ft (16 900 hm^3), 64 percent of average and 40 percent of capa-city. Surface stored water had cushioned the first year! By October 1, 1977 storage was down to 7.9 million ac-ft (9 700 hm^3), 38 percent of average and 23 percent of capacity. Most reservoirs by this time had reached all-time lows, and the State became more depend-ent on ground water supplies.

Snowpack. The lack of precipitation was also evident, in terms of the State's seasonal accumulation of snowpack. On April 1, 1976, the statewide snow water content was 40 percent of average. The following year it was 25 percent of average. In 1977, 16 of 19 major streams had record low April-July snowmelt runoff.

Ground Water. Because of the availability, in 1976, of surface stored water in most areas, ground water levels were not so significantly affected as in 1977. Normally, ground water supplies meet about 40 percent of the State's water needs. In 1977, ground water was called upon to meet approximately 53 percent of the needs, and that year saw a precipitous decline in the water table as ground water mining accelerated. In the San Joaquin Valley, ground water accounted for over three-fourths of the total water used in 1977; compared to about one-half in 1975.

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Effect of Drought on Federal/State Projects

Delta. Operation of State and Federal projects, by the Department of Water Resources (DWR) and the U.S. Bureau of Reclamation (USBR), to maintain a fresh water barrier in the Delta was complicated by the low storage in upstream reservoirs during 1977. The Delta is a triangular shaped area of about 737,500 acres (901 hectares) located at the confluence of the Sacramento and San Joaquin Rivers. These rivers feed from two corners of the triangle into Suisun Bay and subsequently out to the Pacific Ocean. The Delta is interlaced with over 700 miles (1 130 kilometres) of meandering waterways which form about 50 separate islands or tracts.

Prior to the drought, the State Water Project (SWP) was operated to maintain certain Delta water quality objectives established by the State Water Resources Control Board (SWRCB); and the federal Central Valley Project (CVP) was operated to meet water quality standards required by its customers. In 1977, however, water was not available in sufficient quantities to maintain water quality in the Delta. To buffer the impact of the drought on water users the SWRCB relaxed water quality standards so that less water would be released from State and Federal reservoirs to counter salt water intrusion from the San Francisco Bay.

Deliveries. Water deliveries to SWP customers in 1976 were just under 2 million ac-ft (2 410 hm^3). In 1977, deliveries amounted to just over 900,000 ac-ft (1 130 hm^3), less than half the amount delivered the year before. Municipal users were required to take a 10 percent deficiency, and agricultural users to take a 60 percent cut in contract entitlement.

Deliveries from the CVP in 1976 were 6 million ac-ft (7 380 hm^3). Normally, deliveries average about 7 million ac-ft (8 630 hm^3). During 1977, the CVP delivered 3.3 million ac-ft (4 070 hm^3). Users with water rights on the Sacramento River were cut by 25 percent. Agricultural users of CVP water averaged a cut of 75 percent, and municipal and industrial users were cut back 50 percent.

Effect of Drought on Local Level Projects

Extent. The types and extent of responses to the drought at the local level varied widely. The City of San Diego and the Salinas and Imperial Valleys, experienced little or no reduction in water deliveries; although voluntary conservation resulted in water savings. On the other hand, water districts in Marin, Humboldt, and San Mateo Counties and many of the Sierra foothill communities saw their sources of water drastically reduced and had to impose strict conservation measures. Water rates were increased to encourage conservation and to compensate water distributors for reduced consumption. Most of the coastal and foothill cities and communities had few alternatives in responding to the drought, other than to impose some form of voluntary or compulsory rationing or allocation. Over 150 communities were involved in some form of mandatory conservation at the height of the drought in 1977, experiencing from 20 to 75 percent reductions in use.

Conservation Measures. Besides mandatory rationing, other ways used in the State to conserve or develop water included: the purchase or exchange of local water; reactivation of wells; purchase of Metropolitan Water District exchange water (Colorado River water) from the State Water Project; the use of reclaimed water; and the installation of water saving devices in many homes and businesses. Many agencies, spearheaded by the California Department of Water Resources, conducted a rigorous public education program on water conservation.

Larger metropolitan areas of California, such as the San Francisco Bay and the greater Los Angeles areas, survived the drought better than the smaller coastal and foothill communities, due mainly to facilities already existing which brought supplemental water supplies to these areas. Mandatory rationing was still required, though.

Marin County, just north of San Francisco, was one of the areas most severely affected by the drought. Actions taken there were typical of the actions taken by many other communities throughout the State. To prolong its available water supplies, Marin successfully implemented a water allotment program with a target reduction of 57 percent of water use; restricted the use of water for non-essential purposes; used treated wastewater to

irrigate landscaped areas; continued work on the development of two wastewater reclamation facilities; completed two pipelines, one, to receive water from the Russian River, the other to receive water from the SWP; drilled additional wells; distributed free water conservation devices; and planned a new reservoir to increase storage capacity. Some citizens even instituted individual hauling of water.

Impact of Drought on Water Uses and Water Activities

Agriculture. In a normal year, agriculture is estimated to use approximately 85 percent of the total water demand in California. The State Water Project (SWP) and the Federal Central Valley Project (CVP) reduced surface water allotments to agriculture in 1977 by 60 percent and 75 percent, respectively. This forced agricultural users to turn to ground water sources for their remaining needs. Some 8,000 wells were drilled or redrilled for agricultural use. A large number of existing wells were also deepened. In both years the impact of the drought was felt most severely by dairymen, cattlemen, and dryland farmers. According to the California Crop and Livestock Reporting Service (1), 73 percent of the losses to California agriculture in 1977 were sustained by livestock producers. By the second year the State's irrigated agriculture was also heavily affected. The major impact on irrigated agriculture was felt in the San Joaquin and Sacramento Valleys, where most of the state and federal project water cutbacks occurred. Losses to farm income resulted from crop land left idle because of the lack of irrigation water, crop yield reductions due to less-than-optimal water application, and shifts in cropping patterns from high-water intensive crops. Losses to the cattle industry resulted from lower rates of weight gain, reduced productivity of breeding herds, depressed prices as large numbers of animals were marketed due to lack of adequate pastures, and the added cost of hauling hay and water to the livestock which remained.

Energy. Normal annual hydroelectric generation in California is about 33 billion kilowatt hours (Kwh), 20 percent of the State's total electrical energy supply. In 1976, hydroelectric production was about 16 billion Kwh. The deficit was made up by importing power from the Pacific Northwest, and by burning high-cost oil. In 1977, hydroelectric generation was a little under 13 billion Kwh, representing about seven percent of California's total energy production for the year. Most of the deficit was made up through fossil fuel steam generation, requiring 33 million barrels of oil at a cost of $500 million, and resulting in increased air pollution. Only about 4 billion Kwh was imported from the Pacific Northwest during 1977, because that area was suffering similar effects of the drought. Also, the decrease in surface water available, and resulting increase in ground water pumping, created an increased demand for energy (about 1 billion Kwh at a cost of $25 million). However, reduced deliveries of water through the State and Federal Projects saved power. Both the SWP and the CVP cut the net use of energy approximately in half the amount of energy needed to pump water when in full operation.

Recreation. Losses to the recreation industry are not yet fully known, but rough estimates put direct losses to recreation at $16 million, with another $40 million from indirect losses. Lake recreation was seriously affected in the central and northern areas of the State due to record low reservoir levels. Most resorts did not operate and many came close to bankruptcy, applying for Small Business Administration loans to survive. River boating was very poor throughout the State due to the drought. Less than a dozen of the popular boating stretches had adequate flows for any type of boating. Snow recreation and the ski resort industry were drastically affected by the drought. Most national forest recreation areas in Northern and Central California were open for summer use, but campgrounds generally were without water and no open campfires were permitted outside of designated campground areas. When water was no longer available campgrounds were closed.

Fish and Wildlife. Low flows of the drought adversely affected fish spawning by preventing upstream migrations, and by elevating water temperatures. Emergency water releases from the SWP and CVP eased the effects of higher water temperatures on early spawning king salmon in the Sacramento, Feather, and Trinity Rivers. Fishing in mid-and low-elevations of the Sierra and Coast Range and in the valley floor was seriously affected by low flows. Catchable trout were planted earlier and in greater amounts than normal before streams dried up. On the beneficial side, low water levels in some of the mid-and high-elevation lakes and reservoirs permitted the use of chemicals to remove rough fish which were depressing trout population. Wildlife was relatively unharmed by the drought, although normal forage and water supplies were reduced. The reuse of irrigation water led to concentrations of pesticides in canals and ditches which subjected waterfowl and animals to disease.

Forests. The State's forests suffered from the severe moisture stress caused by the lack of precipitation and were left in a virtually explosive condition. The U.S. Forest Service estimated between 5.3 and 7.7 million trees with a volume of 2.4 to 3.8 billion board feet died during the two-year drought, mainly due to insects, disease, and fire. The "Marble Cone", "Scarface", and "Forks of Salmon" fires were prime examples of what can happen in dry years. Other effects, such as mud slides, continue long after the major fire has been contained. Cause of tree death was mostly a combination of an insect and a disease working together under drought conditions.

Drought Assistance

Governor's Task Force. Organization for the direction and coordination of all state efforts to alleviate drought-caused problems was created by the Governor on March 4, 1977 in the form of a Drought Emergency Task Force. The Task Force included representation from nine state agencies, four federal agencies, the University of California, Farm Bureau Federation, Association of California Water Agencies, and the Pacific Gas and Electric Company. The Task Force attacked the drought problem through educational, legislative, and direct assistance approaches.

Education and feedback, between the public and the many agencies, was important. A Governor's Drought Conference was held in Los Angeles. Regional conferences were conducted in five other cities, and presentations were made by Task Force members at community water resource management workshops.

Legislation. Legislation action was evident at the federal, state, and community levels, mostly in the form of financial aid. The Community Drought Act of 1977 (P.L. 95-31) authorized $225 million for the Economic Development Agency to use for loans or grants. The Emergency Drought Act of 1977 (P.L. 95-18) authorized the U.S. Bureau of Reclamation to make loans, grants, and water purchases to alleviate drought impacts in California. By the end of 1977, the California Legislature had introduced over 50 proposals for drought-related legislation, one-third of which eventually became law.

Drought Information Center. A Drought Information Center was started by DWR in Sacramento in July 1976, and became one of the most successful products of the drought response. The Center served as a focal point for drought-related questions, and was most effective in conveying to the public and the news media the need for water and energy conservation. Most smaller communities did not know what to expect if the drought continued. They had never experienced the situation and had no historic drought data on streamflow, drop in ground water levels, reduced flow from springs, etc., during past dry periods. Information was furnished by the Center on water conditions and on federal and state assistance programs.

Hydrologic Activities

Conservation. Water conservation was unquestionably the single most significant contribution to "getting through the drought". Voluntary conservation programs were instituted in virtually every community, and by April 1977 nearly all Northern and Central California communities were under some form of mandatory conservation.

The conservation restrictions were effective. Final figures for 1977 indicate that California urbanites saved an average of 20 percent. Industrial conservation of water involved such programs as recycling and reclaiming water; increasing storage facilities; and using new sources such as desalted seawater, seawater, and new wells.

Cloud Seeding. Cloud seeding activities were initiated by DWR in the summer of 1977 in Northern California to reduce fire hazards, improve range conditions, and provide a soil-moisture base for winter runoff. As part of the emergency drought relief program, a winter weather modification program was started in January 1978 to produce water for storage, with additional benefits to vegetative cover, recreational areas, fish and wildlife, aquifer recharge, and water quality improvement in the Sacramento-San Joaquin Delta. This program was discontinued on February 6, 1978, after it became apparent the water year was producing much higher than normal precipitation.

Physical Works. Rock barriers, new diversion facilities, and a new pumping plant were constructed in 1977 to minimize the deleterious effect of the drought upon water quality in the Delta. The physical works successfully reduced the amount of flushing water needed for Delta outflow against seawater intrusion, thereby conserving additional water in upstream reservoirs.

Exchanges. Water exchanges and agreements provided important relief to certain drought stricken areas. The biggest exchange involved the Metropolitan Water District of Southern California relinquishing 400,000 ac-ft (500 hm^3) of State Water Project entitlement to make up some of the shortages in Northern and Central California. Most of the exchanges involved transfer of water entitlements from certain farm properties to other non-adjacent properties owned by the same farmer. A number of exchanges involved bringing better quality water to areas where quality was an important consideration.

New Technology. Additional information has become available during this decade on snow water content obtained from pressure recording snow sensors (5), and on snowcovered area (SCA) obtained from satellite imagery. The satellite imagery very dramatically depicted the lack of snowcover in the Sierra in 1977 (9). More specific use of the snowcover data in operational forecast techniques is being tested in California, and in three other states (Colorado, Arizona, and Oregon) as part of a NASA instituted Applications Systems Verification and Transfer (ASVT) program (8).

Water Supply Forecasts During the Drought

The two dry years posed some special problems for the water supply forecasters. Most volumes of runoff in 1976 and 1977 were near or below the previous minimum values of record and so extrapolation was required below the previous lower limits of the historic data.

Another concern was the very dry soil moisture conditions. It was anticipated that an above normal proportion of the snowpack melt would go to satisfy the soil moisture requirement, decreasing the surface runoff. The forecasts were reduced somewhat for this reason, although the determination of the reduction was highly subjective due to lack of actual soil moisture data.

There was some question also as to the advisability of using the assumption of median precipitation and snowpack accumulation subsequent to the date of the forecast, because of the possibility of some validity in the idea of the persistence of the drought conditions. However, forecasts continued to be made with the assumption of median precipitation and snow accumulation. Emphasis was given to the lower value of the 80 percent probability range as the most likely runoff, should the drought conditions continue.

Basically, forecasts are made for April-July snowmelt runoff. When making these forecasts on February 1 and on March 1, estimates are made for the February and March flows. In 1976 and 1977, estimates of February and March flows were adjusted downward from the normally anticipated values expected from median precipitation during these months primarily because of the very dry soil conditions and the very low fall and winter flows from October through January.

A final difficulty encountered in forecasting the dry years involved the 80 percent probability range, which, based on the forecast, is the range within which the actual runoff should fall eight times out of ten. During the dry years, the computed lower value of the range often came out very low or even zero. But zero was known to be an improbable answer so the low values were adjusted by using a percentage of the previous minimum of record (usually 1924). The percentage was generally in the range of 75 to 90 percent.

Conclusions

The water picture today (April 1978) shows a complete reversal from the previous year (April 1977). Reservoir storage statewide has returned to average. Precipitation for the water year period October 1, 1977 to March 31, 1978 averaged 150 percent statewide. Statewide runoff during the same six-month period was 160 percent of average. April-July forecasts were 195 percent of average for the San Joaquin Valley, 125 percent for the Sacramento Valley, and 145 percent elsewhere in the State. Snow water content in the

southern Sierra basins on April 1, 1978 was the third highest in 50 years of record, surpassed only by the big snow years of 1952 and 1969. Water content in the Kern Basin was second highest of record.

The two year drought created many problems to water managers at all levels of government, and for the citizens of the State. Most problems were overcome, largely due to the personal commitments of the people, and to the willingness to share the water which was available. Even though the water supply is more than adequate now, there are still some lasting effects on the drought. Water conservation, and the attached energy savings, should be continued as a desirable habit. The drought also highlighted the reliance placed upon the overdrafting of ground water supplies to mitigate water shortages; and it pointed out the importance of conjunctive management and use of ground and surface water, as well as the need for effective integration of water supply and quality programs. Some additional surface water conservation and distribution facilities are still needed to fully provide for the future water needs of the State. The two year drought dramatically illustrated a problem area. If adequate water supplies are not developed to meet future needs, then the alternative to get through future droughts is to limit growth and economic development--particularly for irrigated agriculture which uses the largest amount of water.

The drought also emphasized the importance of the reservoir of water stored in the winter's snowpack, and the value of advance information on the amount of snowmelt expected. The objective of the California Cooperative Snow Surveys Program is to continue to improve upon the timeliness, frequency, and accuracy of water supply forecasts, and to include in the development of forecast procedures the ability to use recent data available through advances in technology, such as snowcovered area from satellite imagery, and water content from telemetered snow sensors.

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