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Drought in California

California Department of Water Resources
Natural Resources Agency
State of California

Defining Drought

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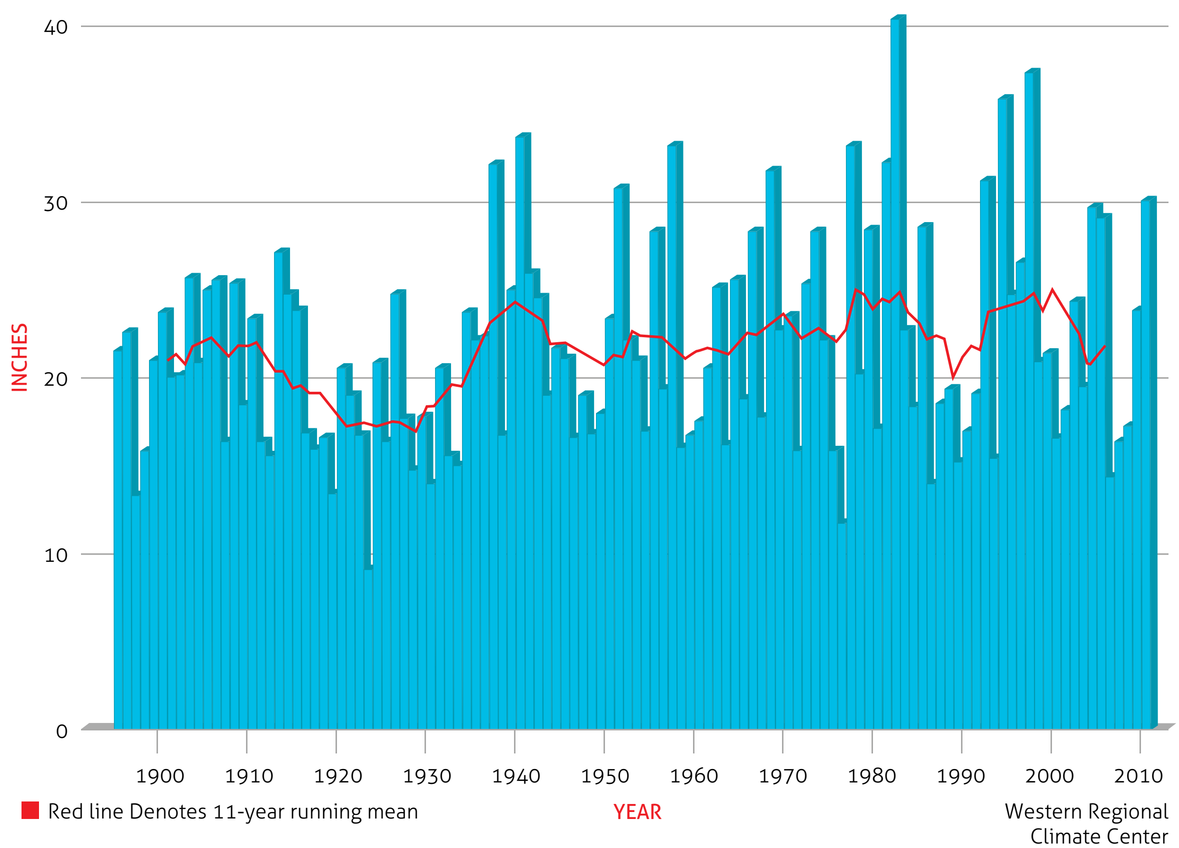
There are many ways that drought can be defined. Some ways can be quantified, such as meteorological drought (period of below normal precipitation) or hydrologic drought (period of below average runoff), others are more qualitative in nature (shortage of water for a particular purpose). There is no universal definition of when a drought begins or ends. Drought is a gradual phenomenon.

Impacts of drought are typically felt first by those most dependent on annual rainfall, such as ranchers engaged in dryland grazing or rural residents relying on wells in low-yield rock formations. Drought impacts increase with the length of a drought, as carry-over supplies in reservoirs are depleted and water levels in

CALIFORNIA STATEWIDE PRECIPITATION OCT–SEPT (WATER YEAR)



ground water basins decline. Hydrologic impacts of drought to water agencies may be exacerbated by other factors such as regulatory requirements to protect environmental resources or to satisfy the rights of senior water right holders.

From a water use perspective, drought is best defined by its impacts to a particular class of water users in a particular location. In this sense, drought is a very local circumstance. Hydrologic conditions constituting a drought for water users in one location may not constitute a drought for water users in a different part of the state or with a different water supply. California's extensive system of water supply infrastructure— reservoirs, managed groundwater basins, and inter-regional conveyance facilities—mitigates the effect of short-term (single year) dry periods. Individual water suppliers may use criteria such as rainfall/runoff, amount of water in storage, decline in groundwater levels, or expected supply from a water wholesaler to define their water supply conditions. Criteria used to identify statewide drought conditions—such as statewide runoff and reservoir storage—do not address these localized circumstances. And although California's water supply infrastructure provides a means to mitigate impacts for some water users, other types of impacts (increased wildfire risk, stress on vegetation and wildlife) remain.

California's extensive system of water supply infrastructure—reservoirs, managed groundwater basins, and inter-regional conveyance facilities—mitigates the effect of short-term (single year) dry periods.

Through water year 2012, Colorado River inflow into Lake Powell has been below average in 10 of the past 13 years, resulting in reduced storage levels in Lakes Mead and Powell. The Colorado has historically been a highly reliable water supply for Southern California despite long-term drought, thanks to its large reservoir storage capacity. Interim guidelines adopted in 2007 for Lower Basin shortages and coordinated operations of Lakes Mead and Powell help reduce the risk of shortages to California.

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Droughts in California

Drought played a role in shaping California's early history, as the so-called Great Drought in 1863–64 contributed to the demise of the cattle rancho system, especially in Southern California.

MULTI-YEAR DROUGHTS OF LARGE-SCALE EXTENT SINCE 1900

1918–1920

1923–1926

1928–1935

1947–1950

1959–1962

1976–1977

1987–1992

2000–2002

2007–2009

(Based on statewide runoff)

Subsequently, a notable period of extended dry conditions was experienced during most of the 1920s and well into the 1930s, with the latter time including the Dustbowl drought that gripped much of the United States. Three twentieth century droughts were of particular importance from a water supply standpoint – the droughts of 1928–35, 1976–77, and 1987–92.

The 1928–35 Dustbowl drought established hydrologic criteria widely used in used in designing storage capacity and yield of large Northern California reservoirs. The 1976–77 drought, when statewide runoff in 1977 hit an all-time, low served as a wake-up call for California water agencies that were unprepared for major cut-backs in their supplies. Forty-seven of the State's 58 counties declared local drought-related emergencies at that time. Probably the most iconic symbol of the 1976–77 drought was construction of an emergency pipeline across the San Rafael Bridge to bring water obtained through a complex system of exchanges to Marin Municipal Water District in southern Marin County. The 1987–92 drought was notable for its six-year duration. Twenty three counties declared local drought emergencies. Santa Barbara experienced the greatest water supply reductions among the larger urban areas. In addition to adoption of measures such as a 14-month ban on all lawn watering, the city installed a temporary emergency desalination plant and an emergency pipeline was constructed to make State Water Project supplies available to southern Santa Barbara County.

Emergency pipeline constructed during 1976–77 drought to bring water to southern Marin County.

It is important to recognize that a period of historically recorded hydrology of little more than a century does not represent the full range of the climate system's natural variability. Paleoclimate information, such as streamflow reconstructions based on tree-ring data, shows that natural variability can be far greater than that observed in the historical record. These reconstructions have identified droughts prior to the historical record that were far more severe than today's water institutions and infrastructure were designed to manage. The Colorado River Basin, an important source of Southern California's water supply, has been particularly well studied; its streamflow reconstructions show multidecadal periods when flows were below the long-term average.

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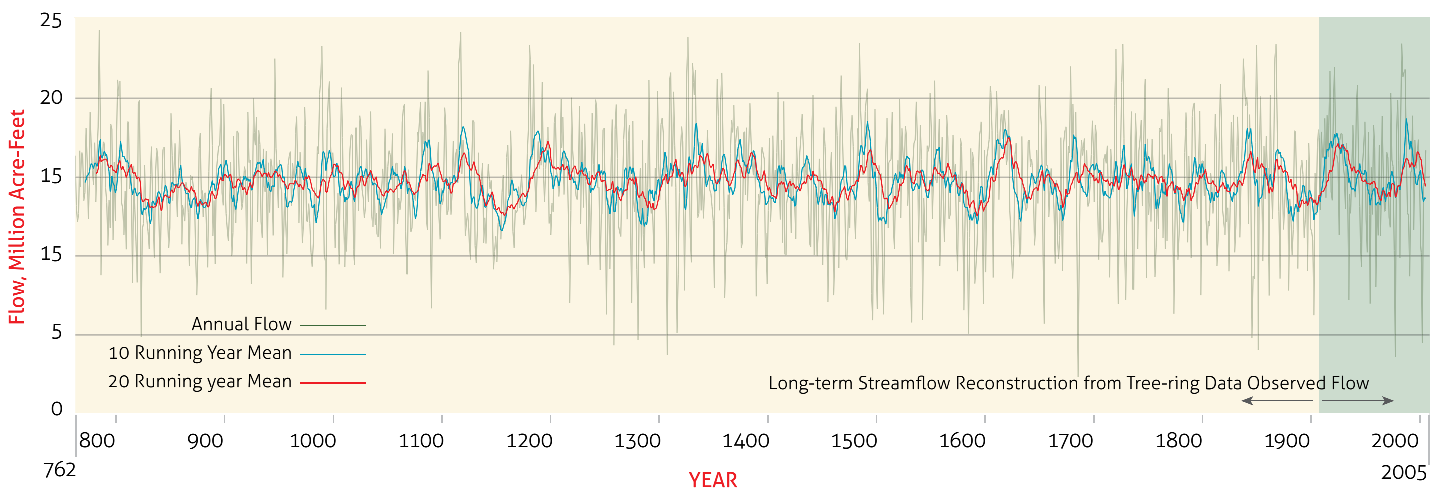
Some 5,000–6,000 years ago these trees were growing on lands now submerged by Lake Tahoe, illustrating centuries-long periods drier than present conditions. National Geographic submersible shown inspecting tree stumps still rooted in place on the lakebed. Photo courtesy of National Geographic.

RECONSTRUCTED COLORADO RIVER STREAMFLOW AT LEE FERRY



Drought Causation and Prediction

Most of California's moisture originates in the Pacific Ocean. During the wet season, the atmospheric high pressure belt that sits off western North America shifts southward, allowing Pacific storms to bring moisture to California.

On average, 75 percent of the state's average annual precipitation occurs between November and March, with half of it occurring between December and February. A few major storms more or less shift the balance between a wet year and a dry one. A persistent high pressure zone over California during the peak winter water production months predisposes the water year to be dry.

Mount Shasta in 2008 at the end of the water year. The impacts of climate change, such as the shift in timing of spring runoff in the Sierra Nevada, are becoming increasingly discernible in analysis of hydroclimate data. Efforts to predict drought must evaluate the natural climate variability seen in historical and paleoclimate records, together with changed conditions such as increased warming.

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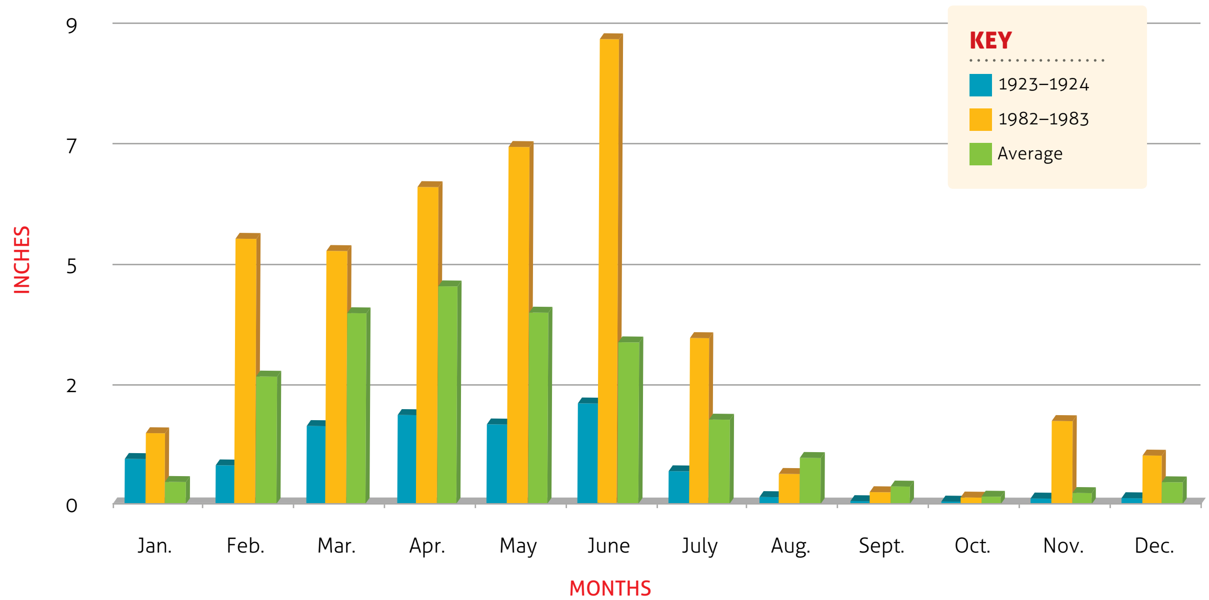
The ability to reliably predict drought conditions at seasonal or annual timescales is very limited. The status of El Niño-Southern Oscillation (ENSO) conditions is presently the only factor that offers a hint of predictive capability for precipitation in California. ENSO is a periodic shifting of ocean-atmosphere conditions in the tropical Pacific that ranges from El Niño (warm phase) to neutral to La Niña (cold phase). La Niña conditions tend to favor a drier outlook for Southern California, but do not typically show significant correlation with water year type for Northern and Central California. The predictive capabilities provided by ENSO events are related to the strength of an event; stronger events yield better predictive signals. In any individual year, interactions with other climate patterns or forcings may affect the outcome that would otherwise be expected from ENSO conditions alone. How other factors such as the Madden-Julian Oscillation, Pacific Decadal Oscillation, North Atlantic Oscillation, or Arctic Oscillation modulate the expression of ENSO conditions remains a subject for research.

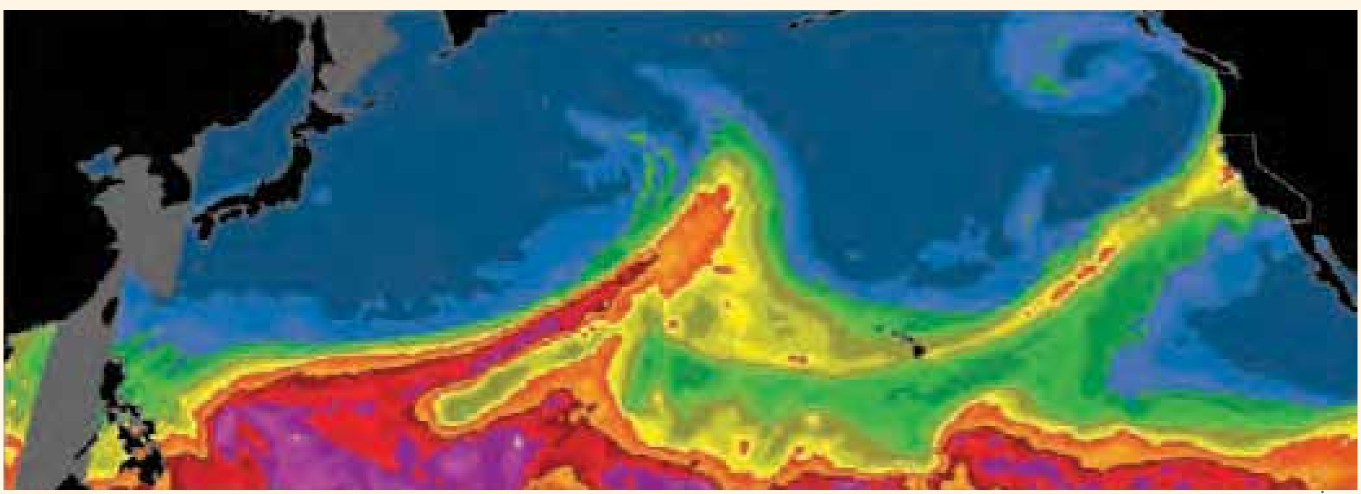
GLOBAL-LEVEL TOP 10 WARMEST YEARS SINCE 1880

Rank	Year	Rank	Year
1	2005	6	2006
2	2010	7	2009
3	1998	8	2007
4	2003	9	2004
5	2002	10	2001

Source: National Climate Data Center

MONTHLY DISTRIBUTION OF STATEWIDE PRECIPITATION, SHOWING WET, AVERAGE, AND DRY YEARS





Satellite image of atmospheric river reaching West Coast. Atmospheric river storms – storms fueled by concentrated streams of water vapor from the Pacific Ocean – are big contributors to annual water supply conditions.

A few major storms more or less shift the balance between a wet year and a dry one.

Image courtesy NOAA Hydrometeorology Testbed.

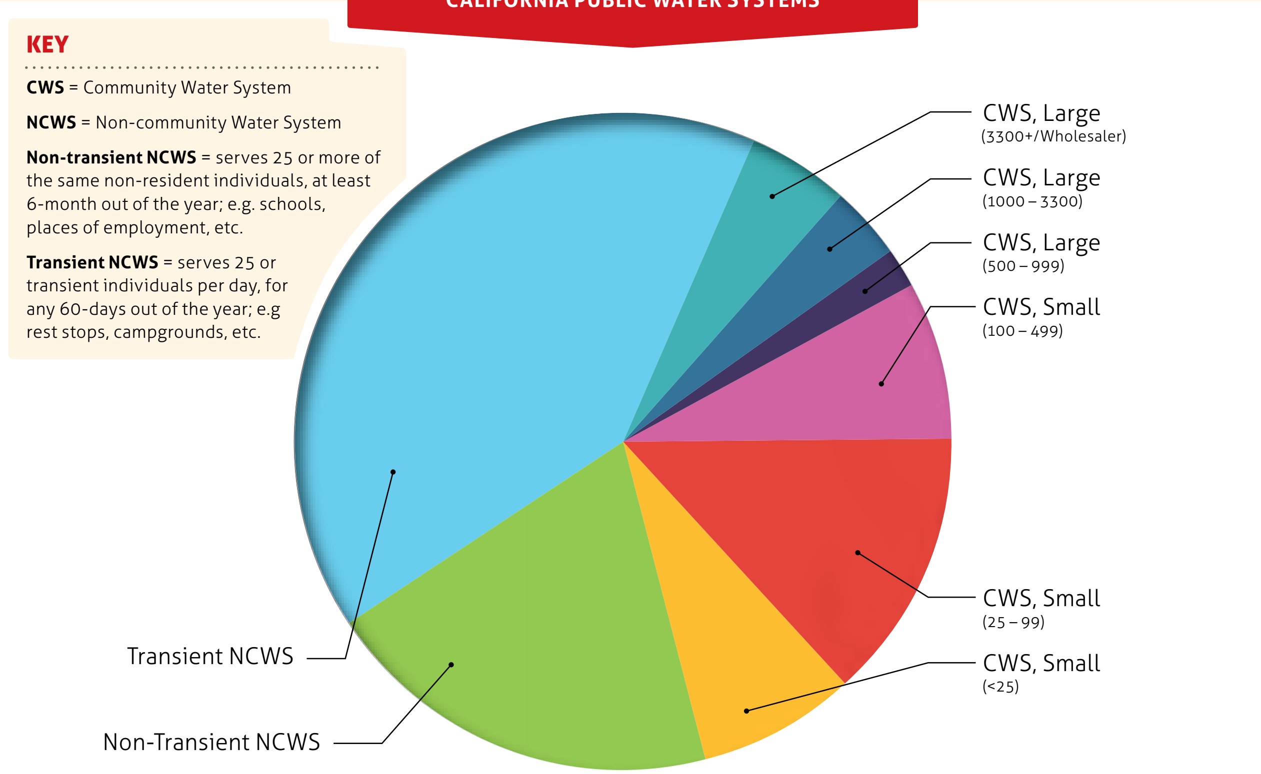
Drought Impacts from a Water Use Perspective

Even a single dry year can pose problems for activities that are wholly dependent on unmanaged water supplies, such as dryland farming or livestock grazing.

Some unmanaged recreational uses can also be affected, such as rafting in rivers where flows are not controlled by reservoir releases. Single dry year impacts to the natural environment can often be seen in the form of increased wildfire risk, a risk that increases in multiple dry years. Damages associated with wildfires and loss of timber resources can be one of the largest economic impacts of drought, and California faces increasing risk of damages as urban development encroaches on the urban/wildland interface. California's most devastating urban/wildland fire episodes (Oakland hills in 1991, Southern California in 2003, Southern California in 2007) occurred during a drought or in a year immediately following a multi-year drought, when dry vegetation created conditions favorable for massive fire outbreaks.

Multiple dry years predictably create problems for small water systems in at-risk areas. Urban water suppliers, particularly those serving larger metropolitan areas, normally provide highly reliable supplies for their customers, as they have the resources and the revenue base to prepare for and respond to drought impacts. The majority of serious water

SIZE DISTRIBUTION OF CALIFORNIA PUBLIC WATER SYSTEMS



California Department of Public Health data supply problems during droughts (e.g. inability to maintain fire flows, need for truck haulage of water) are experienced by small water systems. Although small systems serve a low percentage of California's total population, they constitute the majority of the state's public water systems. Small systems tend to be located outside the state's major metropolitan areas, often in lightly populated rural areas where opportunities for interconnections with another system or water transfers are nonexistent. Small systems also have limited financial resources and rate bases that constrain their ability to undertake major capital improvements. Most small system drought problems stem from dependence on an unreliable water source, commonly groundwater in fractured rock systems or in small coastal terrace groundwater basins. Historically, particularly at-risk geographic areas have been foothill areas of the Sierra Nevada, Coast Range, and inland Southern California mountains, and the North and Central Coast regions.

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In the irrigated agriculture sector, the largest at-risk area has been the west side of the San Joaquin Valley, particularly the area supplied by Central Valley Project south-of-Delta exports. Central Valley Project contractors in this area received 100 percent of their supplies in only three years during the 23-year period from 1990 through 2012, and 75 percent or better of their supplies in only eight of those years, due to combined impacts of dry conditions and environmental regulatory requirements. The impacts of reduced supplies were evident in the 2007–09 drought, when growers abandoned permanent plantings such as orchards and vineyards due to water shortages.

Orchard on Westside of San Joaquin Valley abandoned during 2007–09 drought.

Some avocado growers in Southern California stumped orchards as a short-term measure to reduce water use while keeping the trees alive, in hopes of improved future water supplies after the 2007–09 drought.

Droughts and Groundwater

Some users of managed surface water supplies have the ability to increase their use of groundwater when those surface supplies are reduced.

An increase in the number of new wells being drilled or of existing wells being deepened is typical during droughts; private residential wells represent the single largest category of new or deepened wells. As with small water systems, residential well problems are common in fractured rock groundwater production areas.

Increased groundwater use is reflected in declining groundwater levels; in groundwater basins not experiencing overdraft, a pattern of water level drawdown during dry conditions and recovery during wet conditions is typically seen. Groundwater level decline in overdrafted basins is typically exacerbated by drought. Data availability limitations make it difficult to assess drought impacts on groundwater at statewide or large regional scales in a near real-time manner, as can be done for surface water.

GROUNDWATER BASINS

Groundwater basins as defined by DWR are shown in blue. Areas outside these basins are often fractured rock groundwater zones, where groundwater production capability is uncertain.

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California's extensive system of statewide and regional-scale water infrastructure greatly enhances the state's drought resilience by providing the capacity for facilitating water transfers and exchanges. Lessons learned from past droughts and from disasters such as earthquakes and wildfires have fostered system interconnections among the state's major water utilities, helping enable mitigative measure such as transfers.

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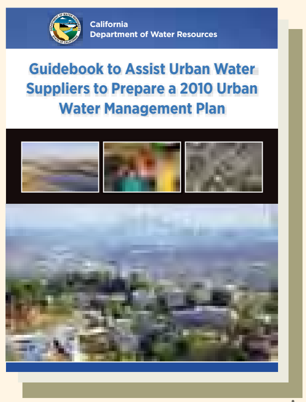
Over more than three decades, California's voters have authorized substantial amounts of state financial assistance to local urban and agricultural water agencies, funding projects — such as water conservation, water recycling, or groundwater storage – that are tools for drought preparedness. In recent years, the 2002 Integrated Regional Water Management Act established state policy of encouraging local agencies to work cooperatively to manage local and imported water supplies to improve their quantity, quality, and reliability. In 2002 and 2006 the voters approved two bond measures which specifically authorized a combined $1.5 billion for water supply-related integrated regional water management planning and projects.



The Urban Water Management Planning Act was adopted in 1983, setting in motion a process of continuing refinements and updates to local plans for ensuring service area water supply reliability.

Drinking water supplies are additionally covered by statutory and administrative provisions. California Water Code Sections 10610 et seq. require that public water systems providing water for municipal purposes to more than 3,000 customers or serving more than 3,000 acre-feet annually prepare an urban water management plan and update it every five years. The plans must include a water shortage contingency analysis that addresses how systems would respond to supply reductions of up to 50 percent, and must estimate supplies available in a single dry year and in multiple dry years. The plans must also address systems' responses to catastrophic supply interruptions. Although smaller water systems are not covered by these requirements, state drinking water regulations require that the systems demonstrate technical, financial, and managerial capacity (including having an emergency response plan) as part of being eligible for financial assistance.

In the agricultural sector, individual water users (i.e., growers) are eligible for a variety of programs authorized by the Farm Bill and administered through the U.S. Department of Agriculture. Programs range from risk management programs (crop insurance) to disaster financial assistance for drought impacts or prevented planting.

Many managed water supplies have associated environmental regulatory requirements that provide dry year protections such as mandated instream flows for fishery purposes. Operations of the State Water Project and federal Central Valley Project in the Sacramento-San Joaquin River Delta, for example, are intensively managed to meet water quantity and quality requirements for fish species of special concern. Major wildlife refuges in the Central Valley have been guaranteed specific quantities of water since the 1990 passage of the Central Valley Project Improvement Act.

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California Department of Water Resources
1416 Ninth Street, Sacramento, CA 95814
www.water.ca.gov/drought