

OCTOBER 2023

# Water Year 2023:

## Weather Whiplash, From Drought To Deluge

California Department of Water Resources  
California Natural Resources Agency  
State of California

## Weather Whiplash

The theme of Water Year 2023 (October 1, 2022, to September 30, 2023) was weather whiplash. Illustrating the dramatic extremes of California's climate, the Governor's emergency proclamations for both drought and flood were in place simultaneously in the latter part of the water year. (The scope of the statewide drought emergency proclamation and executive orders were scaled back in February and March, but the emergency proclamation was not terminated, to allow for response to lingering impacts and timely completion of ongoing response actions.) California's three driest years of record (the drought of Water Years 2020 - 2022) were followed by a wet and very snowy Water Year 2023. The water year wrapped up with 141 percent of statewide average precipitation and 237 percent of April 1st Sierra-Cascades snowpack (based on snow sensor network data). (These averages are computed for the 30-year National Oceanic and Atmospheric Administration climate normal

**Cover:** A flooded 6th Avenue south of Corcoran in the normally dry Tulare Lakebed.

of 1991 - 2020.) The Colorado River Basin, an important supply for Southern California, also benefited from a wet winter that replenished some of the dramatically depleted storage in Lake Mead and Lake Powell, the two largest reservoirs in the United States.

This year's snowpack was one of the largest on record, ranking with the snowpacks of 1952, 1969, and 1983. Because snowpack measurement technology has changed over time (first beginning with manual snow course measurement and then expanding to include automated snow sensors), with significant expansion of the number of



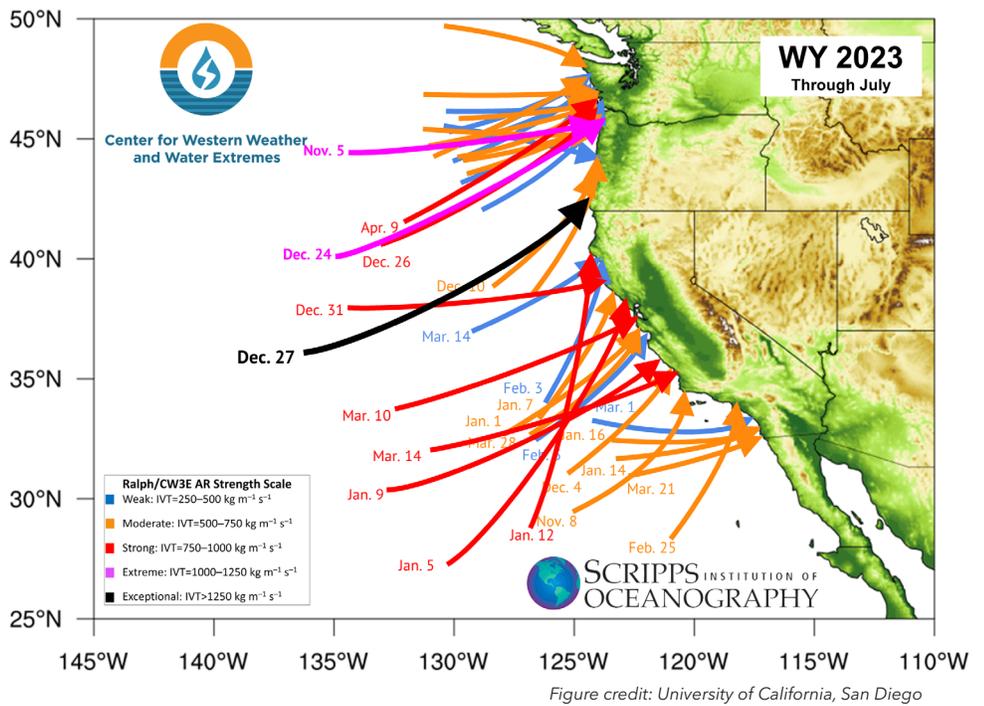
*The one-word summary of Water Year 2023 conditions could be snow. Here, a roadside along Highway 50 in El Dorado County in early March.*



*The Sacramento River at the Colusa Weir in January with the Sutter Buttes in the background. The Sacramento River is California's largest river and has weirs designed to allow high flows to spill from the river into basins and bypasses that help provide flood protection for areas along the river, including the City of Sacramento.*

measurement points since the early 1950s, precise comparisons to these prior years are not feasible. In notable contrast to California's recent decades the winter and spring were relatively cool, which fortuitously contributed to the moderately paced melt-out of the massive snowpack in the central and southern Sierra Nevada. The water year began with continuation of the dry conditions that had characterized the three prior drought years, but a pattern shift occurred in late December with the arrival of an exceptionally strong atmospheric river storm. The remainder of the wet season was characterized by an abundance of atmospheric river storms in stark contrast to their relative paucity in the prior dry years. California received about half of its average annual precipitation between December 26th and January 19th. Multiple state emergency proclamations were issued in March in response to the winter storms, resulting in most of the state's counties being covered by an emergency proclamation by the end of the month. The wet season's storm tracks favored the central and southern Sierra, resulting

### Land-falling Atmospheric Rivers



in 237 percent and 300 percent, respectively, of average snowpacks there. Some of the most significant flood damages also occurred in the middle part of the state, including extensive inundation in the community of Pajaro.

In the late summer, Southern California experienced uncommon tropical storm activity that set new precipitation records and caused

widespread local flooding. In Water Year 2022, Tropical Storm Kay had become the tropical storm coming closest to Southern California from the Pacific Ocean in the last 50 years, bringing record September precipitation and flash flooding for many areas of Southern California. In Water Year 2023, Tropical Storm Hilary, which made landfall over Baja California, became the first tropical storm to cause issuance of a National



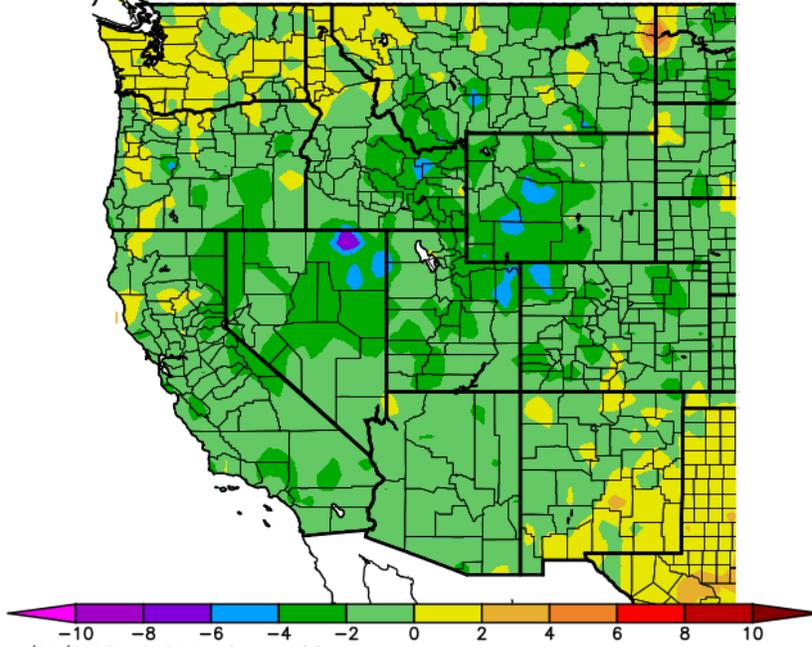
Flooding in the unincorporated community of Pajaro in Monterey County after a March levee break on the Pajaro River.



Although the Tulare Lakebed is primarily farmland, structures have been flooded as well, as indicated in these photographs taken in March and May. Significant flooding of the lakebed began with the March atmospheric river storms and because of the lake's large volume and underlying clayey soils parts of it will remain submerged for many months.

**Average Temperature Departure from Average**

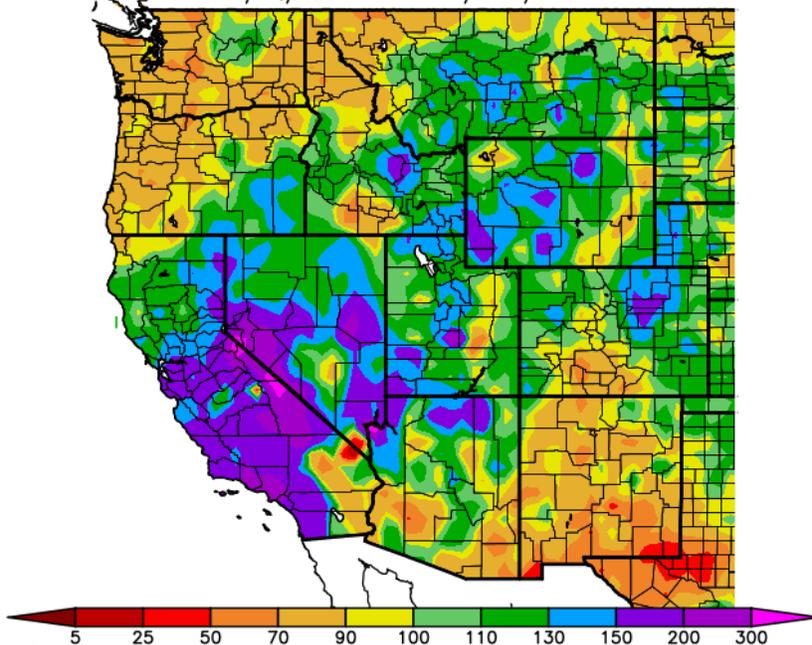
Ave. Temperature dep from Ave (deg F)  
10/1/2022 – 9/27/2023



Generated 9/28/2023 at WRCC using provisional data.  
NOAA Regional Climate Centers

**Percent of Average Precipitation**

Percent of Average Precipitation (%)  
10/1/2022 – 9/27/2023



Generated 9/28/2023 at WRCC using provisional data.  
NOAA Regional Climate Centers

Hurricane Center tropical storm watch for California and one of very few events to maintain tropical storm status over California. The storm caused extensive damage in areas such as Coachella Valley and Death Valley, especially to roads and highways. Warmer than average Pacific Ocean conditions in the latter part of summer were cited as a contributing factor to both the 2022 and 2023 events.

The two things that most stand out for Water Year 2023 are snow and cold air temperatures. Recent water years have been above the long-term average for statewide temperatures, and in some cases well above the long-term average. In contrast, this water year was notably cooler statewide. Winter storms were mostly colder ones producing abundant snowpack, and the unusually cold first half of the calendar year (see National Oceanic and Atmospheric Administration graphic) helped greatly in reducing the risk of feared downstream flooding impacts in the San Joaquin Valley that could have occurred with the massive snowpack.



*Tropical Storm Hilary in August 2023 caused widespread damage to roads in Death Valley National Park and resulted in complete closure of the park. Tentative reopening of portions of the park is set for mid-October. Photo credit: National Park Service*

Water Year 2023 demonstrated California's high climate variability, ending the state's driest consecutive three-year period with one of the snowiest years of record. Even though California has been experiencing a theme of aridity in the 21st century (the statewide droughts of 2007-2009, 2012-2019, and 2020-2022), Water Year 2017 was the state's second wettest in terms of statewide precipitation. Climate change is expected to amplify naturally occurring variability in the long term, potentially result in a shorter wet season for California but one with more extreme atmospheric river storms and hence potentially greater flood damage risk.

### Statewide Average Temperature Ranks

January- June 2023, Period 1895-2023

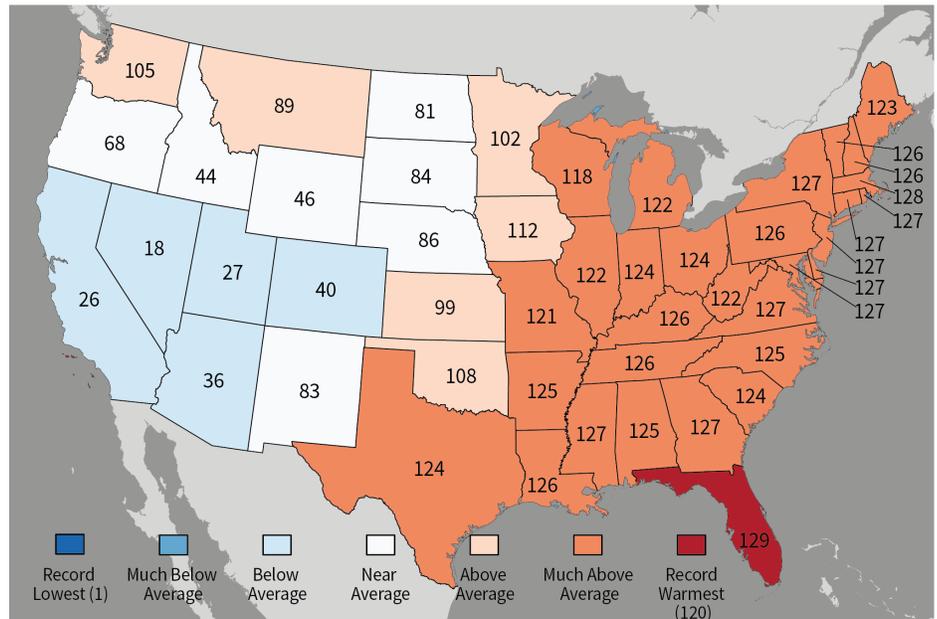
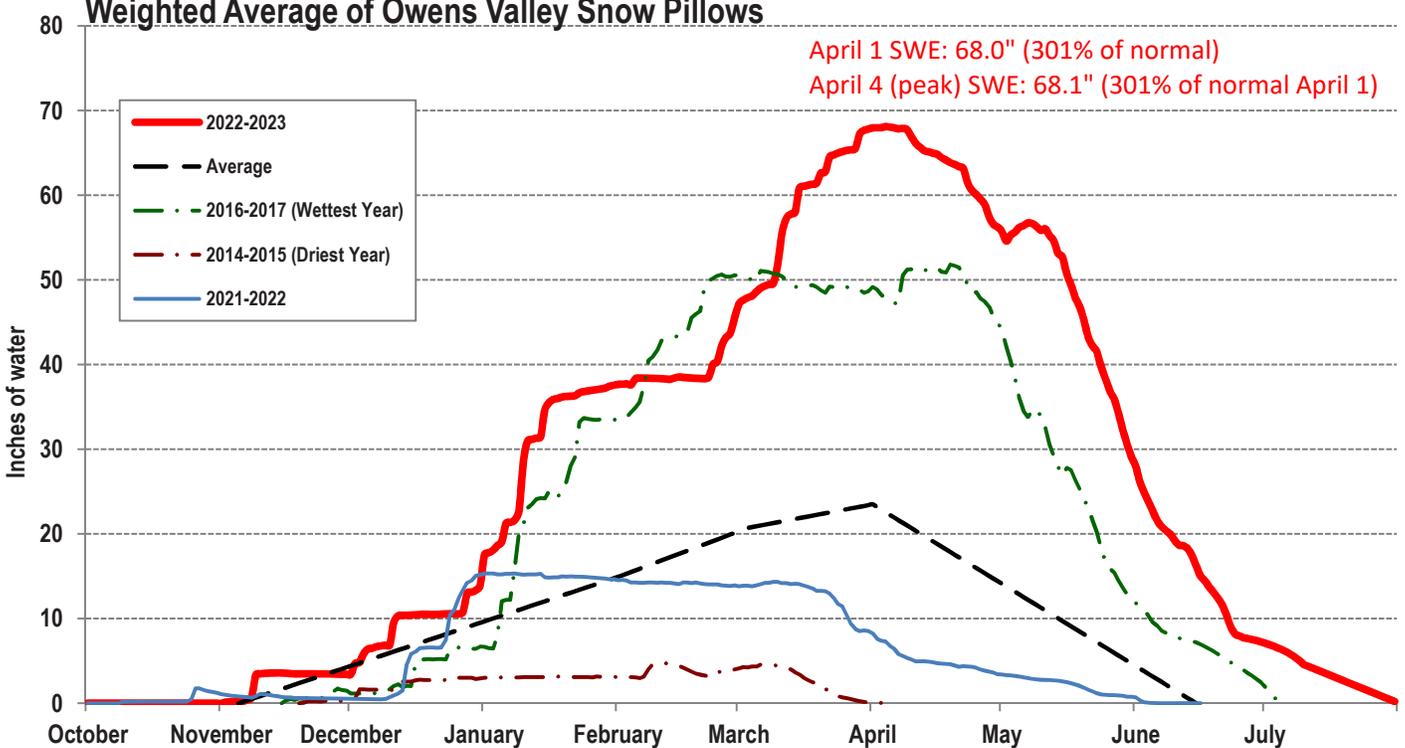


Figure credit: NOAA

### Snow Pillow Data Plot

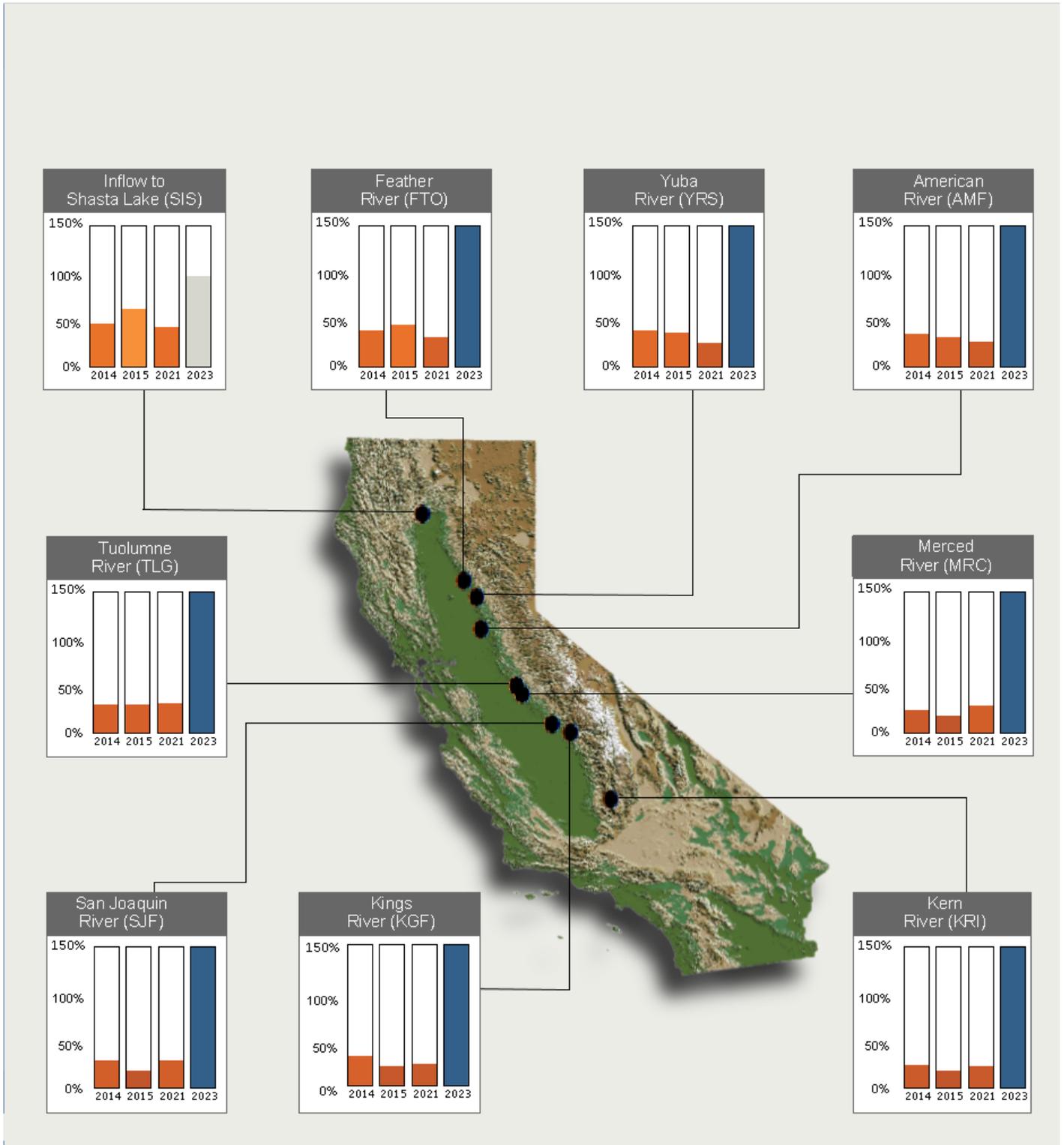
#### Weighted Average of Owens Valley Snow Pillows



The eastern Sierra also received abundant snow, including in the source watershed for the Los Angeles Aqueduct. Note the difference in snowpack between Water Year 2023 and the other years shown.

Figure credit: Los Angeles Department of Water and Power

Comparison of Water Year 2023 Natural Flow at Selected Locations to that of Some Recent Drought Years.



# Reservoir and Groundwater Storage

California ended Water Year 2023 with well above average statewide reservoir storage, a circumstance last seen in Water Year 2019. The only one of the state's larger reservoirs not fully recovering from depleted storage conditions was Trinity Lake, which was at the northern edge of the tracks favored by most of the season's storms. This year's good carry-over storage will improve water supply reliability even if Water Year 2024 is dry.

It is more difficult to discern the immediate results of this wet year on groundwater storage for two reasons: data latency and the relatively slow rate at which groundwater recharge occurs. Many of the wells contributing water level information to the Department's database are only measured twice a year (spring and fall), and submission of fall measurements

is just beginning. This spring's measurements occurred too soon to capture much of the recharge. Although shallow wells in unconfined aquifers (aquifers without relatively impermeable strata that impede the downward movement of water) may recharge relatively quickly, deeper wells with more complex subsurface conditions can be much slower to respond to wet conditions. Wells in some areas have experienced decades of long-term overdraft and far more than a single wet year

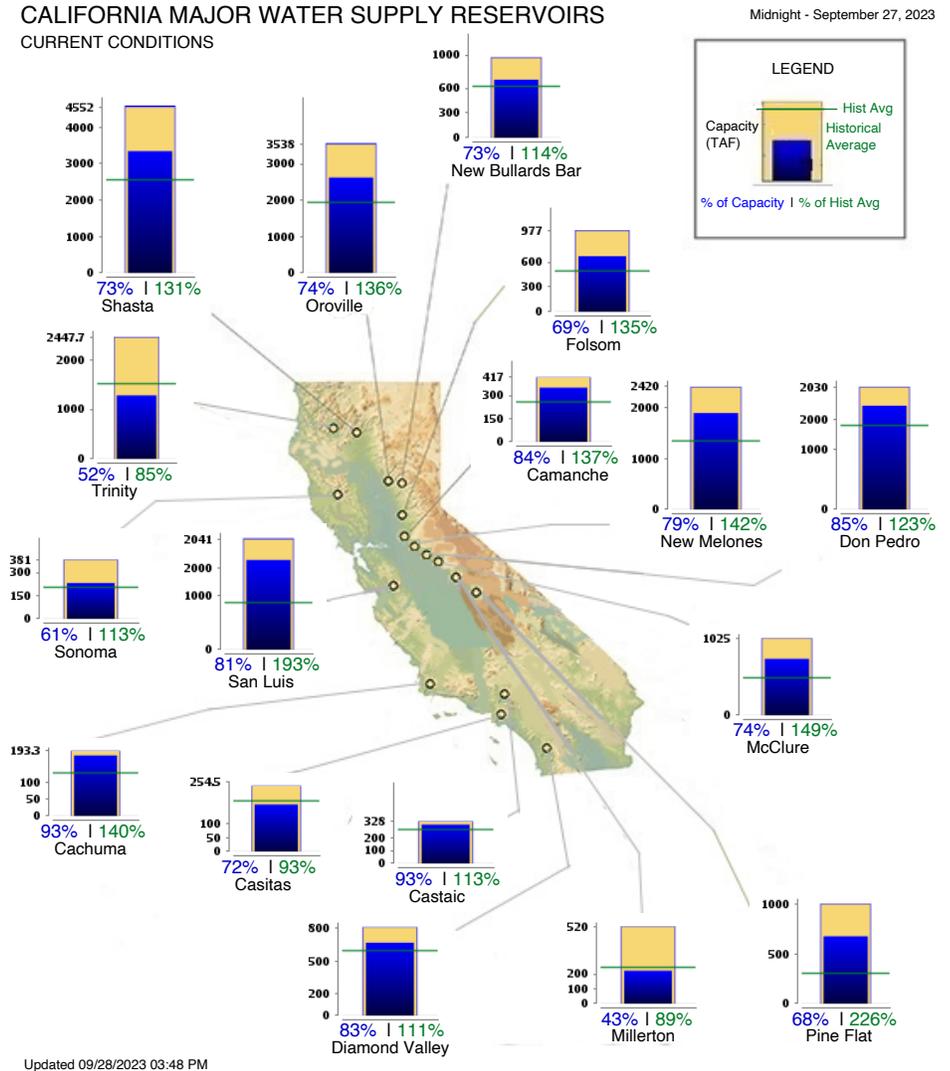
would be required to recover some of that lost groundwater storage. A better perspective on the outcome of this water year will be available next spring after the spring 2024 measurements are submitted. Local agency implementation of groundwater sustainability plans adopted pursuant to the Sustainable Groundwater Management Act (SGMA) is in very early stages and outcomes of that process will not yet be apparent on a statewide map such as the one shown.

## End of Water Year Statewide Reservoir Storage September 2023

Water Year	Statewide Reservoir Storage end of August (MAF)	Percent of Historic Average
2023	29.4	129
2022	14.2	67
2021	12.5	58
2020	20.2	93
2019	26.9	124
2018	21.5	99
2017	25.9	120
2016	17.8	82
2015	11.9	55
1977	7.8	36

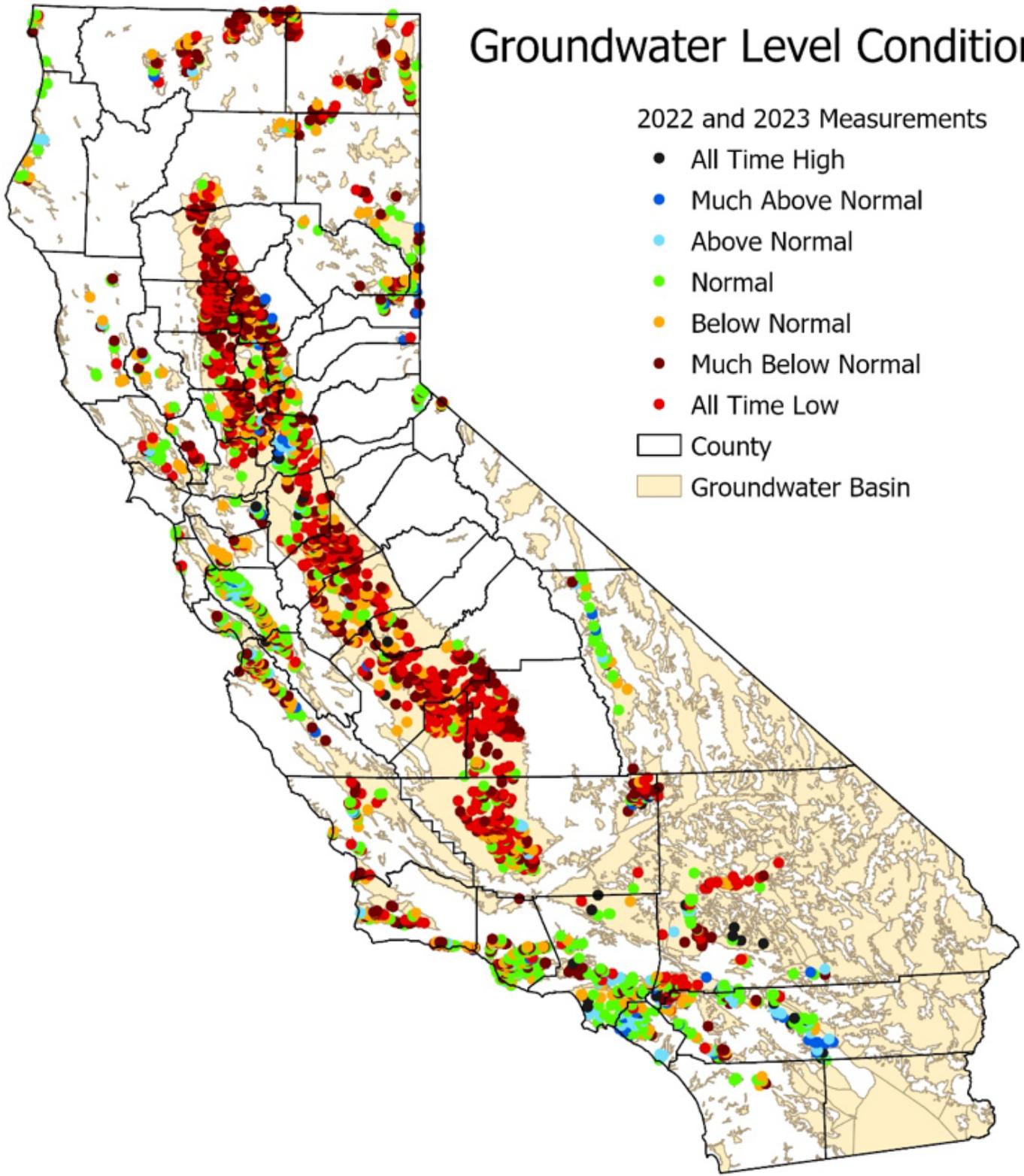
## Current Reservoir Conditions

### CALIFORNIA MAJOR WATER SUPPLY RESERVOIRS CURRENT CONDITIONS

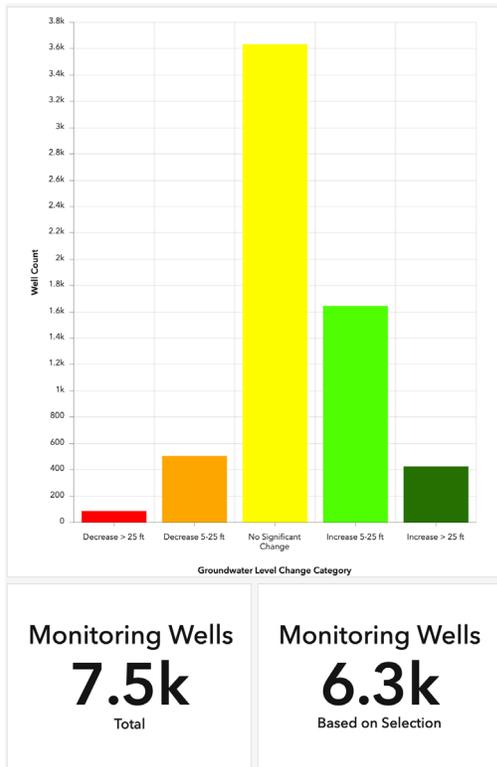


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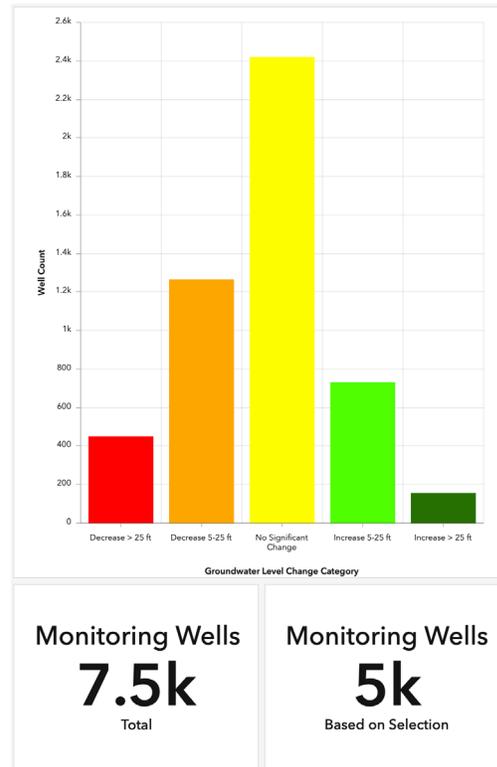
# Groundwater Level Conditions



### Seasonal Groundwater Level Changes (1 years)



### Seasonal Groundwater Level Changes (3 years)



Changes in groundwater level conditions are best interpreted by examining changes over multiple years. Looking at a single-year change (spring 2023 compared to spring 2022) shows that the majority of wells experienced no significant change in water levels, but looking at a three-year change shows more wells with a decline in water levels. This decline is to be expected given the dry hydrology of recent past year.

The wet conditions of Water Year 2023 translate to less need for water users to turn to groundwater in response to surface water shortages, resulting in lower rates of land subsidence than were occurring in recent dry years. In response to the prior drought conditions the Department

accelerated the frequency with which interferometric synthetic radar data are processed and displayed, and readers are encouraged to view this information on the [SGMA data viewer](#).

## Water Supply Conditions

Water Year 2023 provided welcome relief from the shortages of the prior drought years. Not only was California not subject to a shortage in its Colorado River supplies, but the State Water Project and the federal Central Valley Project provided full supplies to their contractors for the first time in years. For the State Water Project, the last year with a 100 percent allocation had been 2006. The year's big water

supply challenge was maximizing opportunistic groundwater recharge to take advantage of the wet conditions, and an executive order directed state agencies to collaborate on expediting permitting of recharge projects and to work with local agencies to facilitate such projects.

Last year the Lower Colorado River Basin experienced its first shortage declaration pursuant to the provisions of the U.S. Bureau of Reclamation's (Reclamation's) Interim Guidelines for Lower Basin Shortages and Coordinated Operations of Lake Mead and Lake Powell adopted in 2007. That shortage declaration was repeated in calendar year 2023. Supplies to Arizona, Nevada, and Mexico were reduced, but California's apportionment was not affected because Lake Mead's



*Floodwater from the Kings River being used for groundwater recharge in a dormant orchard at Terranova Ranch in March.*



*DWR initiated an emergency program in the Central Valley to provide funding and rented equipment to local agencies to divert floodwaters for groundwater recharge. Here one of the rented pumps is being used by James Irrigation District (Fresno County) in May.*

projected elevation did not drop to the California shortage trigger level. The Bureau began a supplemental environmental impact statement (SEIS) process in 2023 for potential changes to the existing Interim Guidelines in response to both reservoirs' record low elevations. The Bureau's August 2023 modeling results used to establish the operating criteria for the following calendar year would trigger a 2024 Lower Basin shortage identical to that of 2023, but the outcome of the SEIS process could potentially change 2024 operations. The Bureau's September 1st forecast of unregulated inflow into Lake Powell for Water Year 2023, a key metric for Colorado River conditions, was 142 percent of average. The wetter water year combined with reductions in water use increased Lake Mead and Lake Powell storage to 38 and 34 percent of average, respectively, as of early September. In addition to mandated Lower Basin water use reductions imposed by the shortage declaration water users took additional voluntary actions to reduce water use. The Bureau projects that California's consumptive use for calendar year 2023 will be about 3.8 MAF as compared to its 4.4 MAF interstate allocation.

## Prospects for Water Year 2024

Accurately predicting seasonal precipitation and reliably answering the question if California's coming winter will be wet or dry is not within present National Weather Service capabilities. The National Ocean and Atmospheric Administration's (NOAA's) Climate Prediction Center

(CPC) produces precipitation outlooks for the winter months important to California's water supply, but the historical skill of these outlooks is minimal. The high annual variability in California's annual precipitation means that any year could hold the possibility for either record wet or record dry conditions. Improving the ability to make seasonal precipitation predictions is critically needed to support more efficient water management.

The El Niño - Southern Oscillation (ENSO), a periodic fluctuation in sea surface temperatures and atmospheric pressure in the

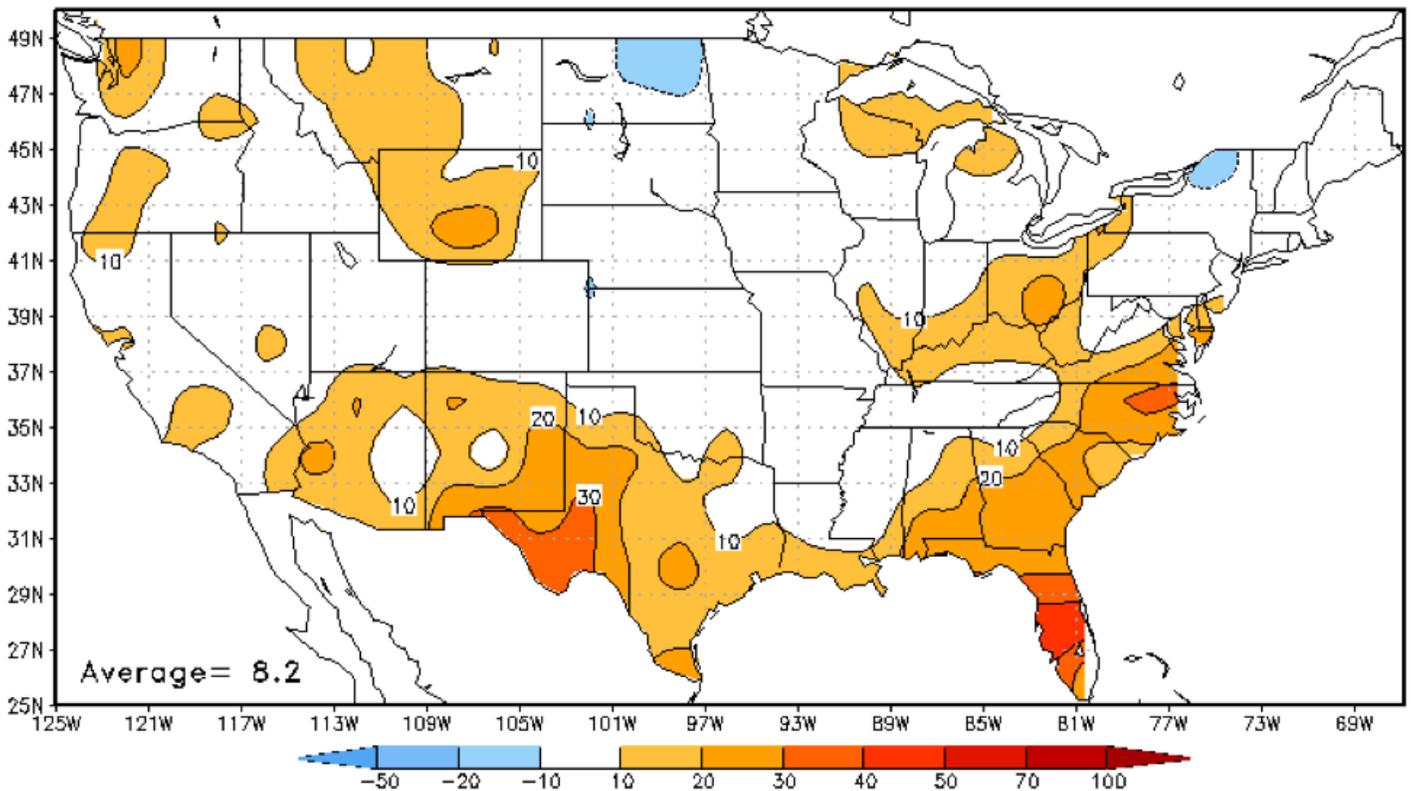
equatorial Pacific Ocean, has been extensively studied since the mid-1990s and many attempts have been made to use ENSO conditions to predict seasonal precipitation. ENSO is one of the primary factors considered by CPC in the development of its seasonal outlooks. However, the observed historical record demonstrates that ENSO conditions alone are a poor predictor of precipitation for areas such as California and the Upper Colorado River Basin because other (yet to be determined) factors modify any signal provided by ENSO. California's observational record shows that La Niña years are often, but not always, associated with dry conditions in Southern California. Apart from this

relationship, ENSO does not provide an indication of potential water supply outcomes. El Niño conditions are present as of September 2023 in the tropical Pacific Ocean, and NOAA predicts their continuation through the coming winter. Some El Niño years, like the exceptionally strong El Niño event of Water Year 1983 were very wet, while others, including the so-called Godzilla El Niño of Water year 2016 were drought years.

**Back cover:** A buried cabin in the Kern River watershed, with just the top of its stove pipe showing.

### NOAA Climate Prediction Center Verification

Heidke Skill Score for Dec/Jan/Feb Precipitation Outlook Issued Mid-Nov from 1995 to 2022



A score of zero means no more skill than predicting average climate conditions, a score of 100 is a perfect forecast.  
Figure credit: NOAA



[water.ca.gov](http://water.ca.gov)