

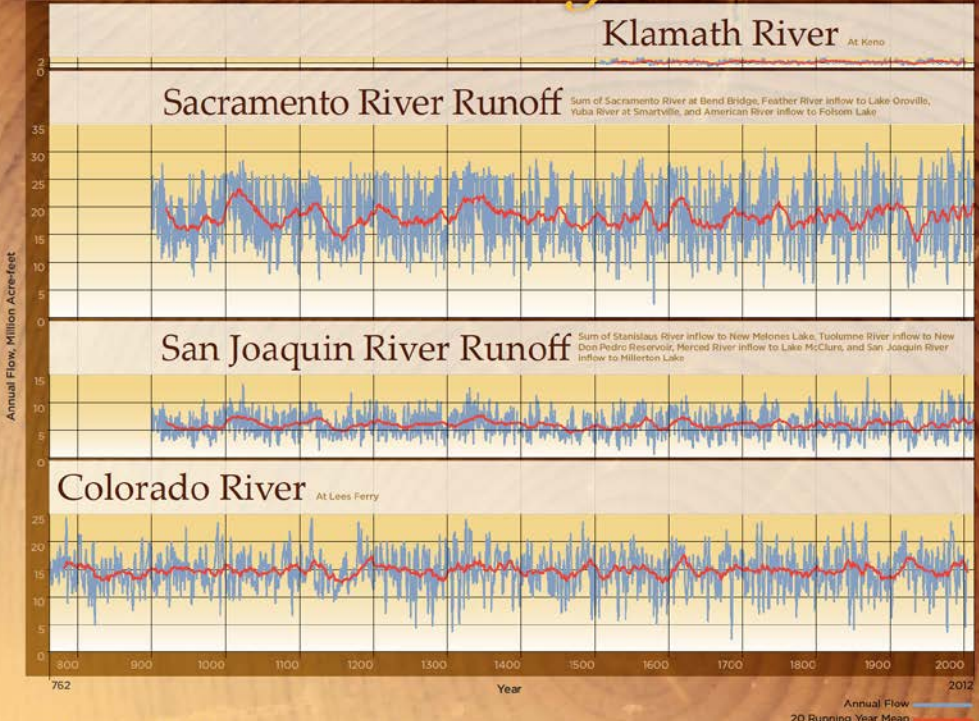


Hydrologic Conditions Overview and Drought Status

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Reconstructed Streamflows & Drought Periods



USING TREE-RINGS TO RECONSTRUCT STREAMFLOW

A tree-ring reconstruction is a set of tree-ring width data that have been calibrated with an instrumental or gaged record of a hydrologic or climatic variable such as annual streamflow or precipitation. The reconstruction, based on a statistical model that describes the relationship between tree growth and the gage record, extends that record back hundreds of years into the past.

Tree growth in dry climates is limited by water availability. Trees that provide the best information about hydroclimatic variability are those particularly sensitive to variations in moisture. These include species such as liver oak, ponderosa pine, Douglas fir, and western juniper, usually growing at lower elevations in sparse stands on dry and rocky sites where soil moisture storage is minimal.

Tree-ring reconstructions of hydroclimatic variables are developed from tree-ring chronologies. A tree-ring chronology is a time series of annual values derived from the ring width measurements of 15 or more trees of the same species at a single site. To create a tree-ring chronology, cores from the sampled trees at each site are cross-dated (i.e., patterns of narrow and wide rings are matched from tree to tree) to account for missing or false rings, so that every annual ring is absolutely dated to the correct year. Then all rings are measured to the nearest thousandth of a millimeter using a computer-assisted measuring device. After growth-related trends unrelated to climate are statistically removed, the ring width values from all sampled trees for each year are averaged to create a time series of annual ring width indices. The complete series of ring width indices from a site is called a tree-ring chronology.

Once a gaged record of interest is selected for reconstruction, a set of tree-ring chronologies from the region near the gage is calibrated with the gage record to form a reconstruction model. A statistical technique called multiple linear regression is commonly used. The reconstruction is evaluated by comparing the observed gage values with the reconstructed values by assessing the amount of variance in the gage record that is explained by the reconstruction.

DROUGHTS PRIOR TO THE HISTORICAL RECORD

The period of reliably measured streamflows for rivers throughout the West seldom reaches beyond 100 years, which represents only a fraction of climatologically modern time. As these streamflow reconstructions show, there have been droughts prior to the historical period that were more severe - particularly in duration - than those in the measured record. The reconstructed record captures a broader range of hydrologic variability than does the historical record, making reconstructions useful for drought preparedness planning. Of particular interest from a scientific perspective is the Medieval Climate Anomaly, a time during which sustained severe drought gripped much of the western United States, as exemplified illustrated in the Sacramento, San Joaquin, and Colorado River reconstructions.

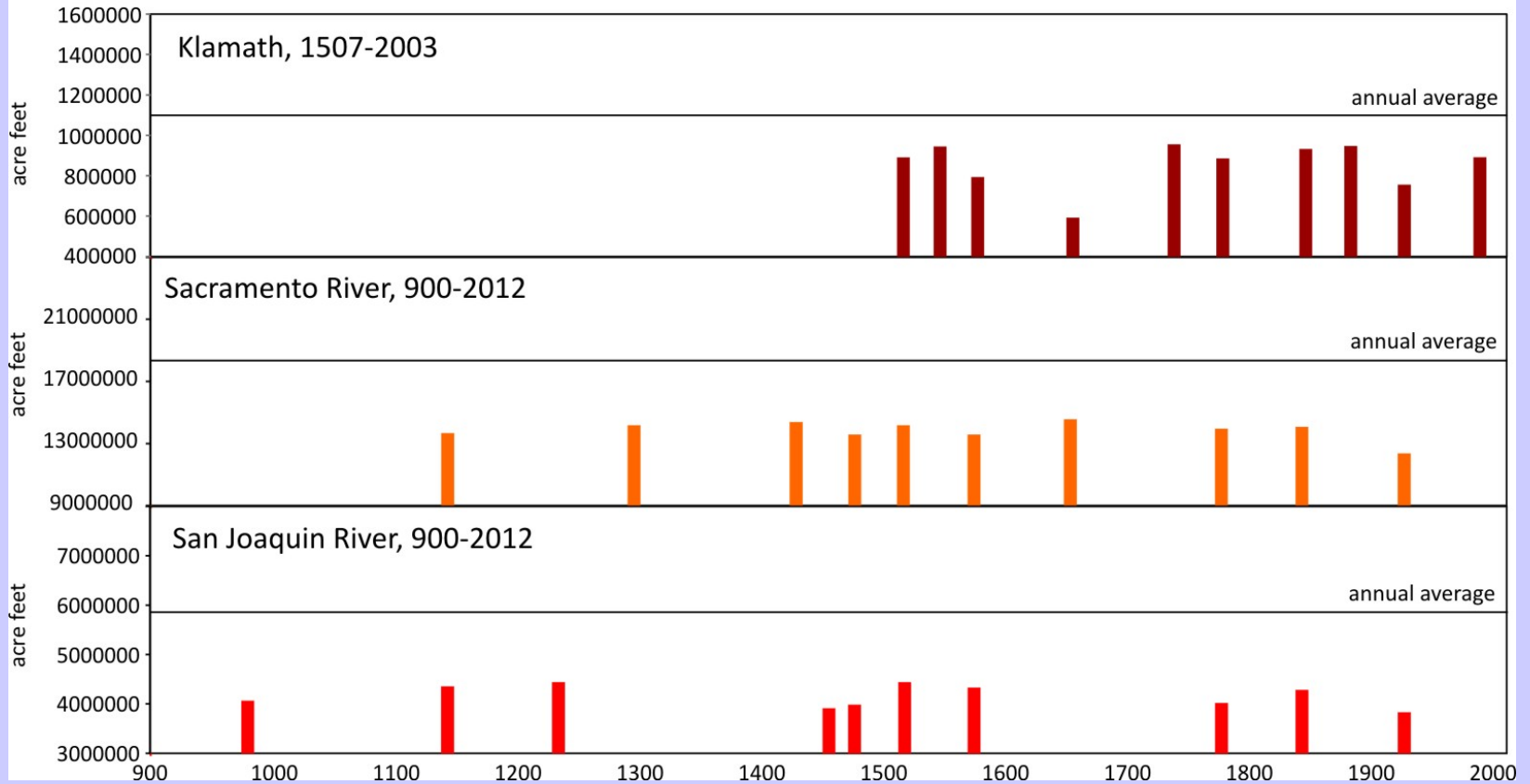


Data source: Work performed by the University of Arizona under contract to the California Department of Water Resources. COWR Agreements 402003362 (David Meko, 2006) and 402004805 (David Meko, Cornie Woodhouse, Ramo Teichert, 2014).

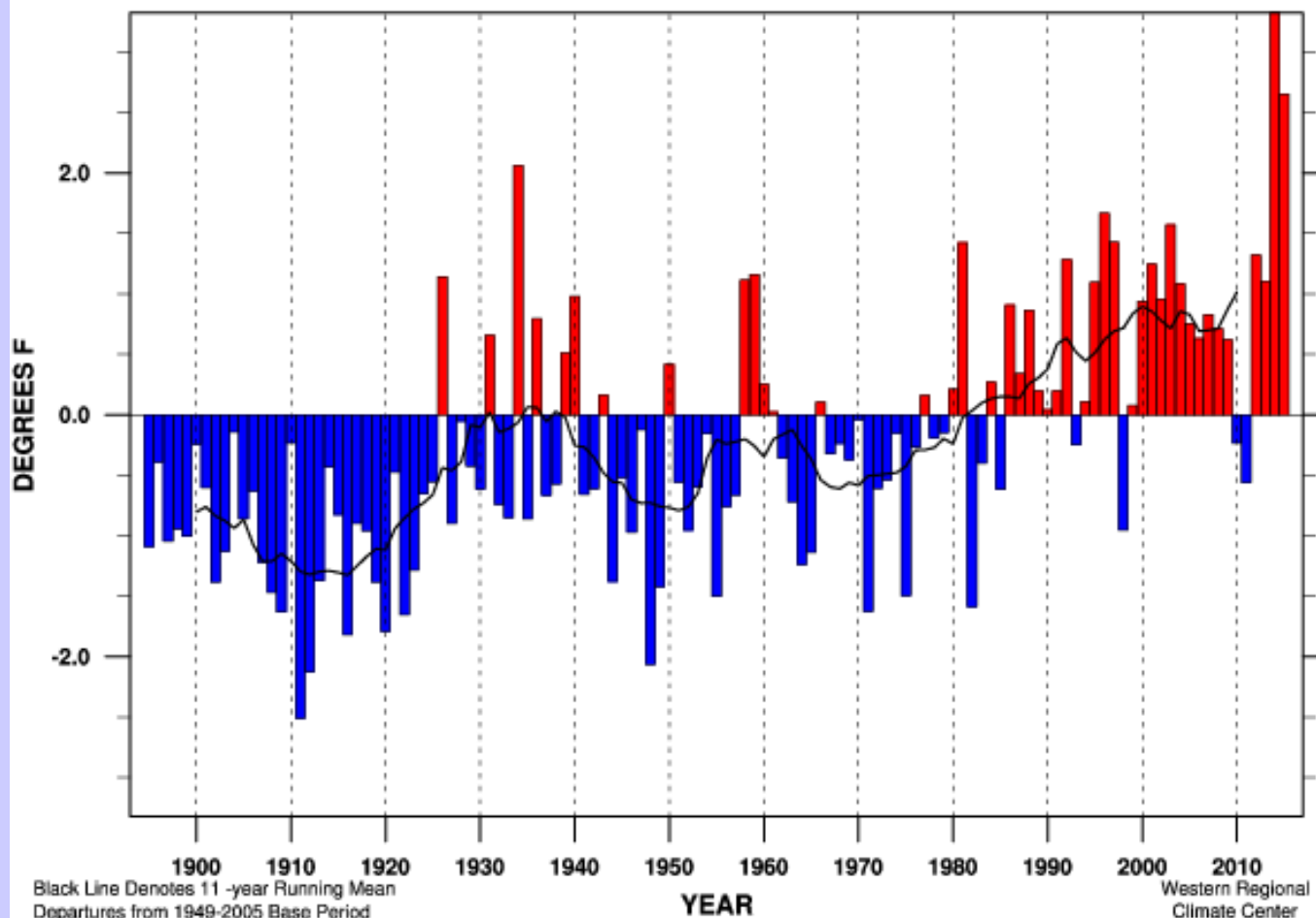


Historical Drought in Perspective

Lowest ten 10-year averages (non-overlapping)



California Statewide Mean Temperature Departure Jan-Dec



Linear Trend 1895-present + 1.71 ± 0.42 °F/100yr

Linear Trend 1949-present + 3.00 ± 1.02 °F/100yr

Linear Trend 1975-present + 4.39 ± 2.20 °F/100yr

Warmest Year 59.4 °F (+ 3.3 °F) in 2014

Coldest Year 53.6 °F (- 2.5 °F) in 1911

Jan-Dec 2015 58.7 °F (+ 2.7 °F)

MEAN 56.1 °F

STDEV 0.87 °F

RANK 120 of 121

Where We've Been in Past Water Years

- 2007 – dry
- 2008 – dry
- 2009 – dry
- 2010 – normal
- 2011 – wet
- 2012 – dry
- 2013 – dry
- 2014 – dry
- 2015 – dry
- 2016 – dry to normal, location-specific



Driest 4 Consecutive Water Years Based on Statewide Precipitation

Year	4-Year Total, inches
2012-2015	62.2
1917-1920	63.1
1923-1926	63.3
1928-1931	64.5
1931-1934	65.1
1921-1924	65.7
1922-1925	65.9
1918-1921	66.8
1929-1932	67.3
1987-1990	67.3
1930-1933	68.0

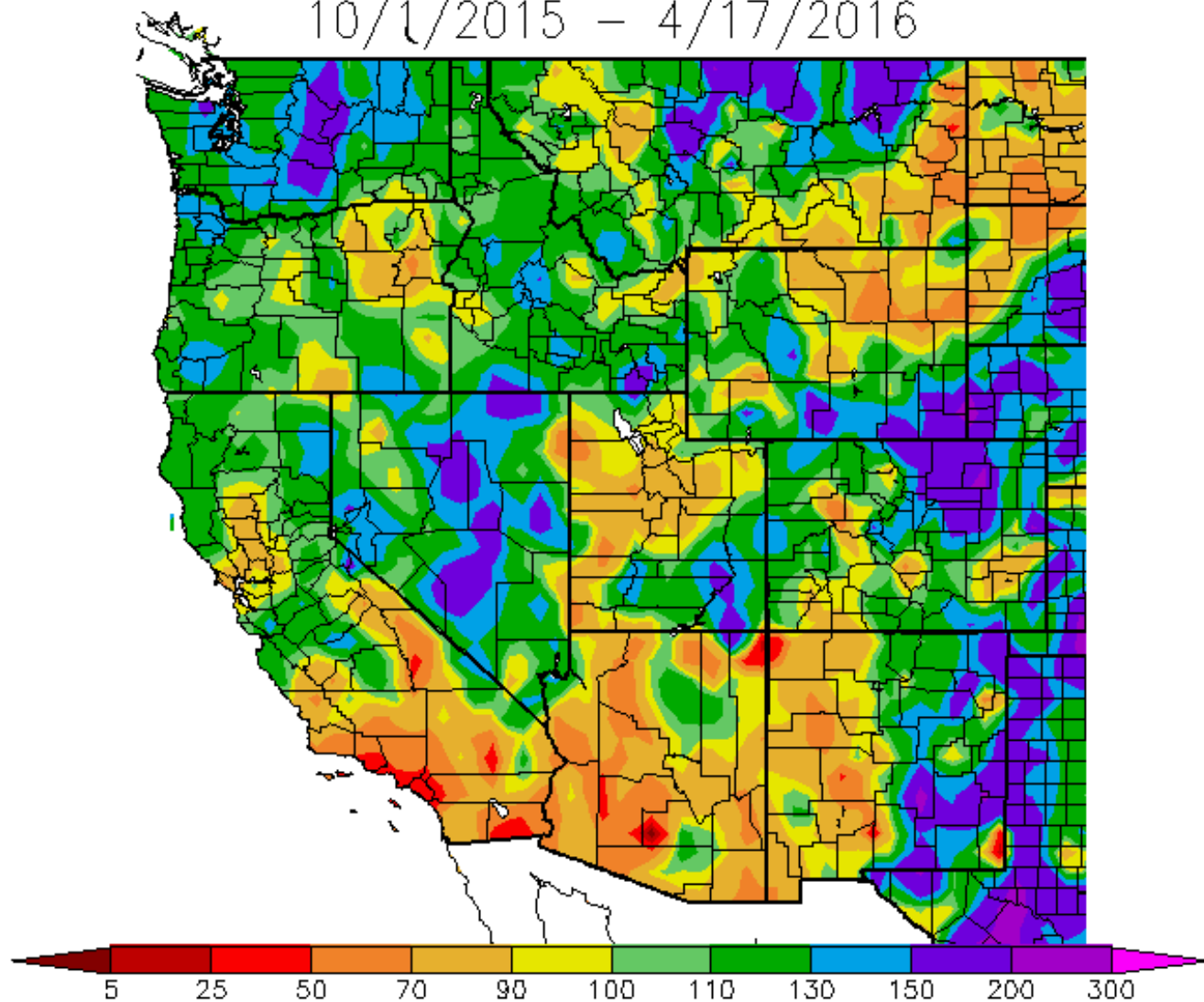
WRCC data

USGS Computed CA WY Runoff

Dozen Driest years -- (rank out of 115)

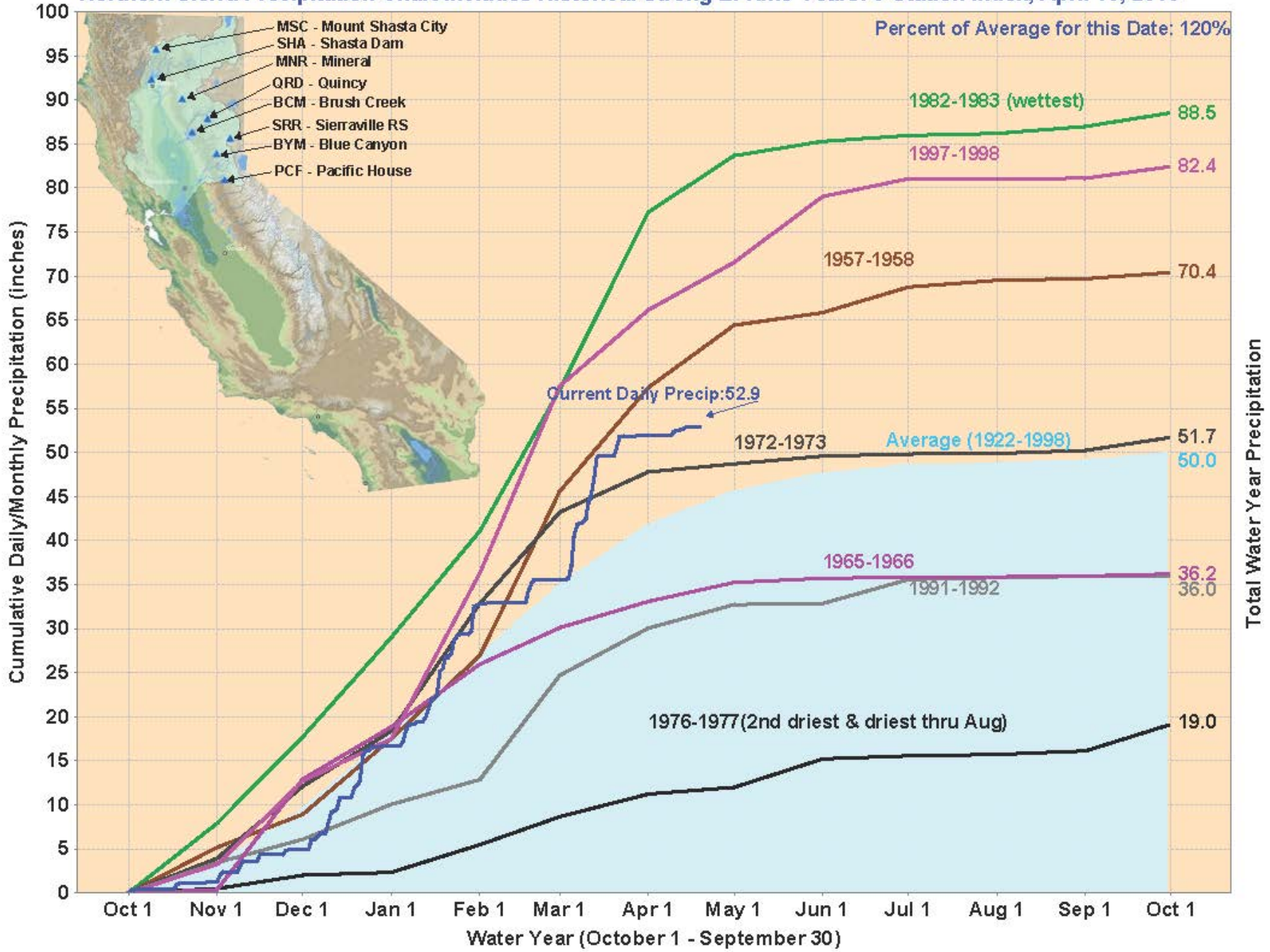
1. 1977	115 th	7. 1990	109 th
2. 1931	114 th	8. 2015	108 th
3. 1924	113 th	9. 2001	107 th
4. 2014	112 th	10. 1934	106 th
5. 1991	111 th	11. 1992	105 th
6. 1994	110 th	12. 1976	104 th

Percent of Average Precipitation (%)
10/1/2015 - 4/17/2016

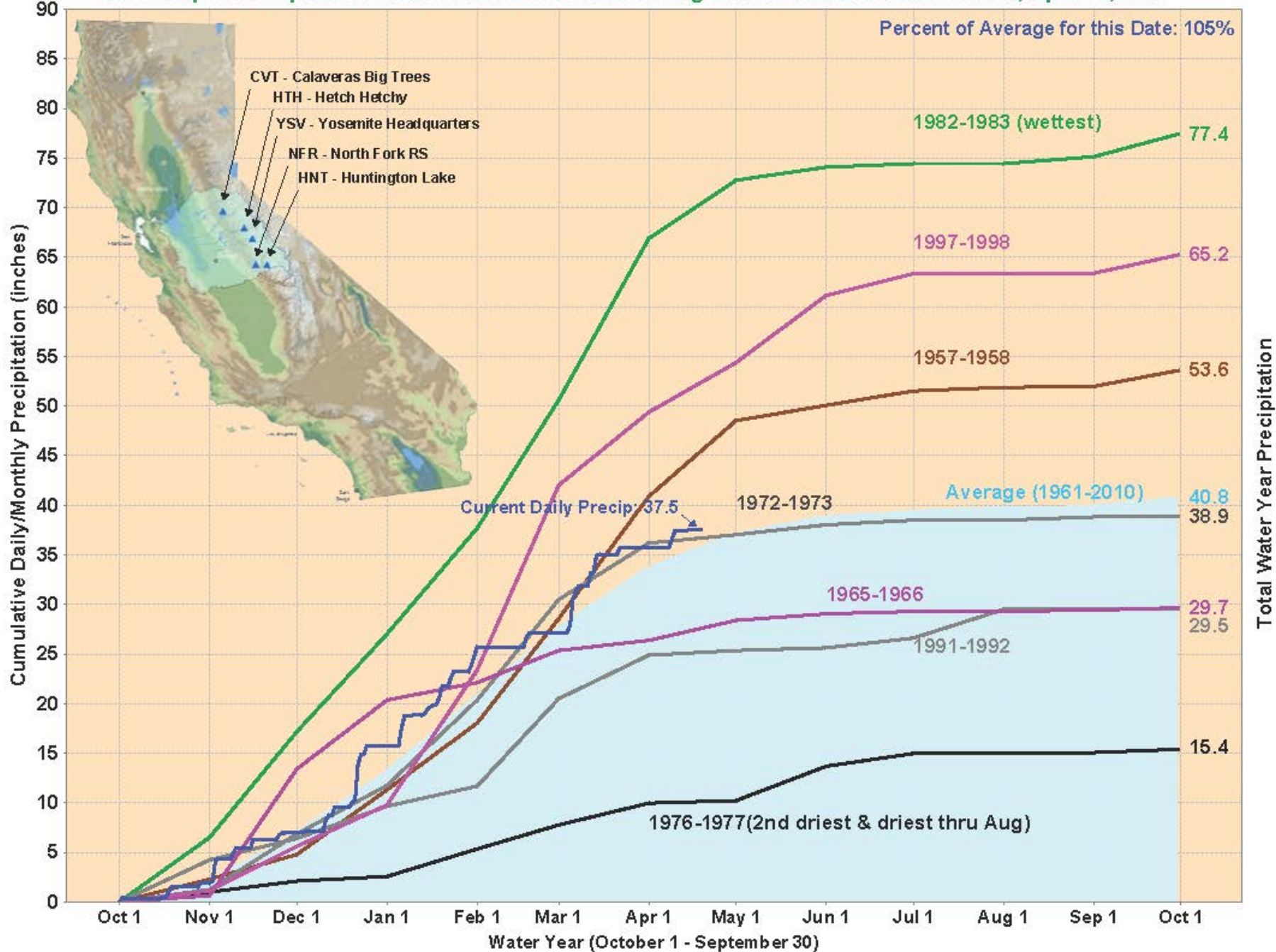


Generated 4/18/2016 at WRCC using provisional data.
NOAA Regional Climate Centers

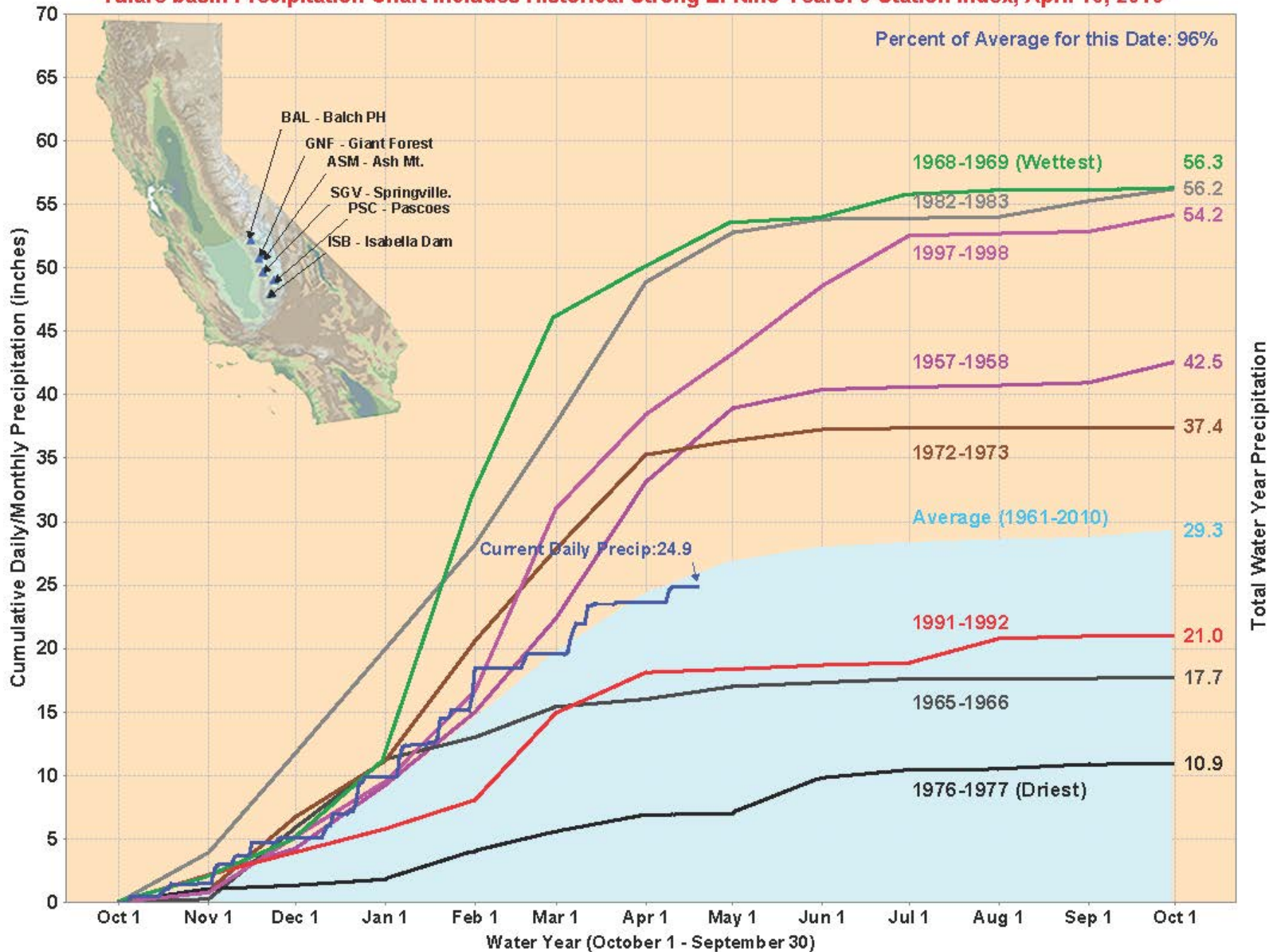
Northern Sierra Precipitation Chart Includes Historical Strong El Niño Years: 8-Station Index, April 19, 2016



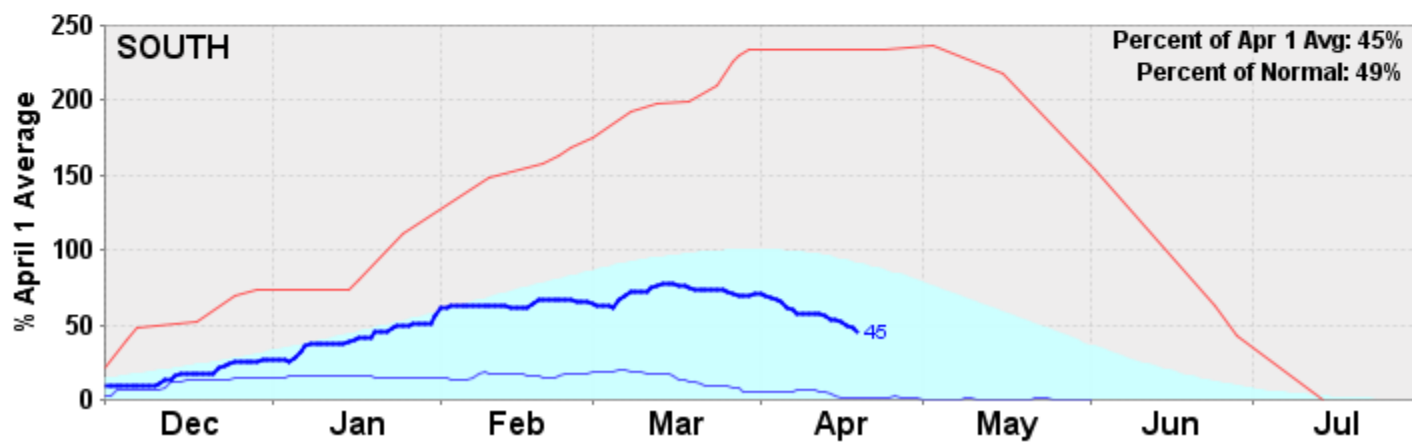
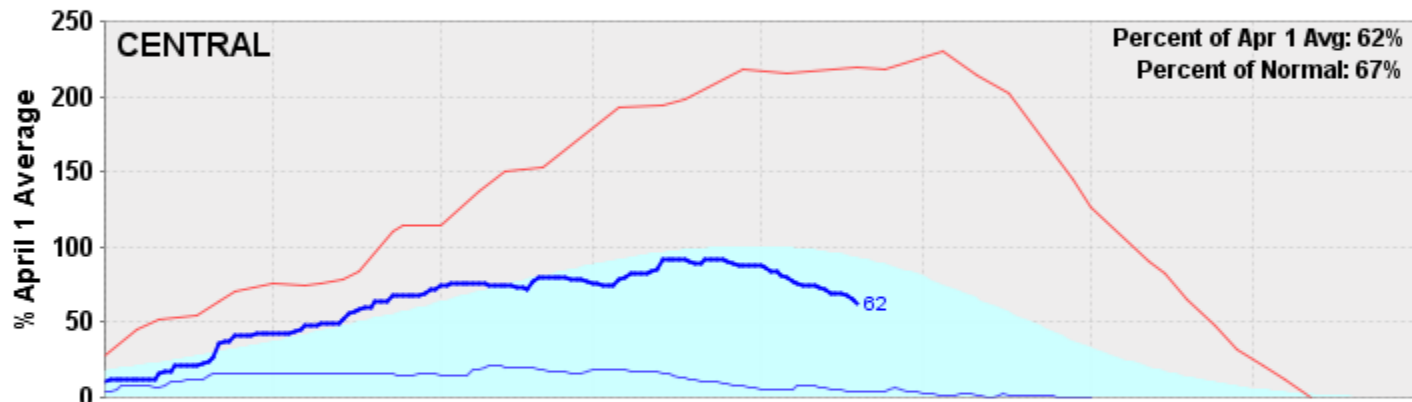
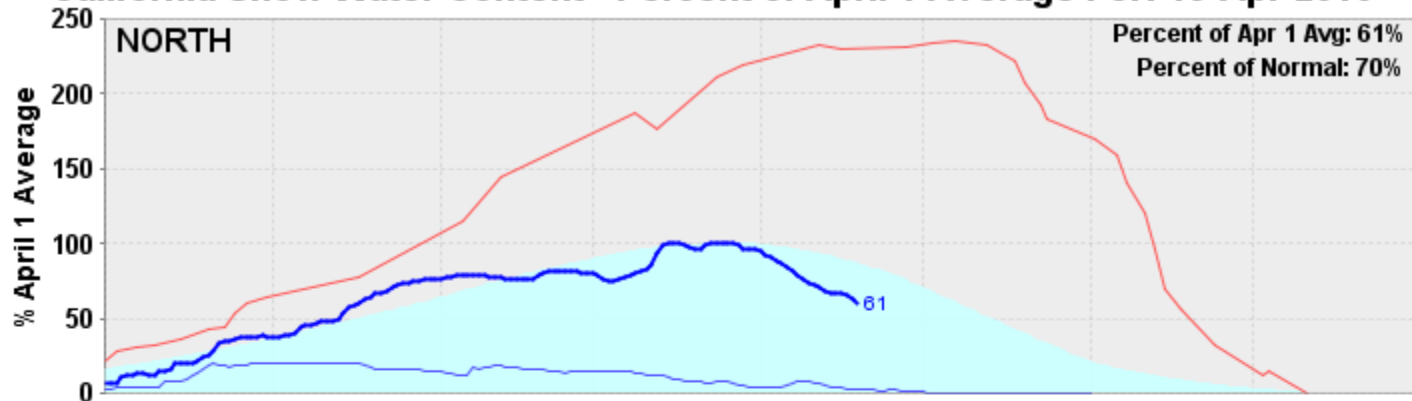
San Joaquin Precipitation Chart Includes Historical Strong El Nino Years: 5-Station Index, April 19, 2016



Tulare basin Precipitation Chart Includes Historical Strong El Nino Years: 6-Station Index, April 19, 2016



California Snow Water Content - Percent of April 1 Average For: 19-Apr-2016



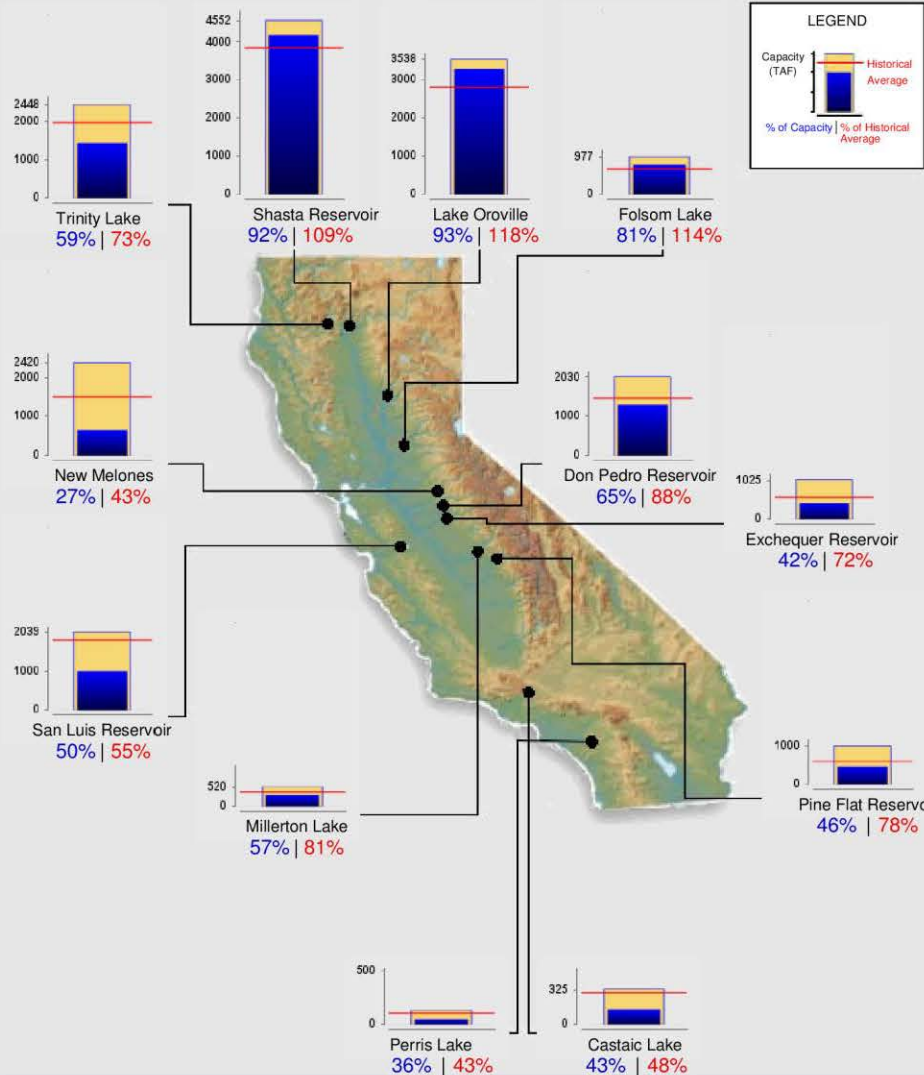
■ Average
 — 1982-1983 (max)
 — 2014-2015 (min)
 — 2015-2016 (current)



Reservoir Conditions

Ending At Midnight - April 18, 2016

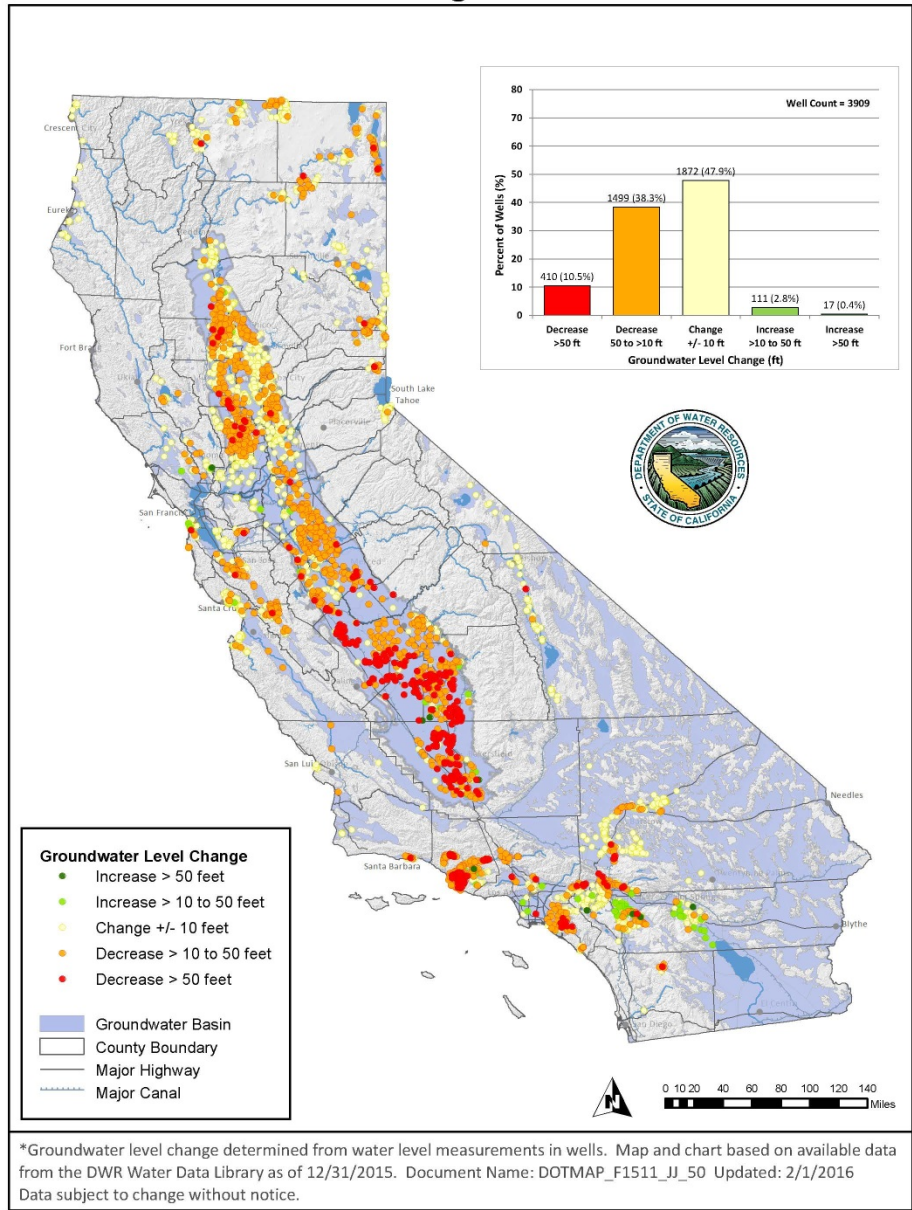
CURRENT RESERVOIR CONDITIONS



Comparison of Historical Water Project Allocations in Dry Years

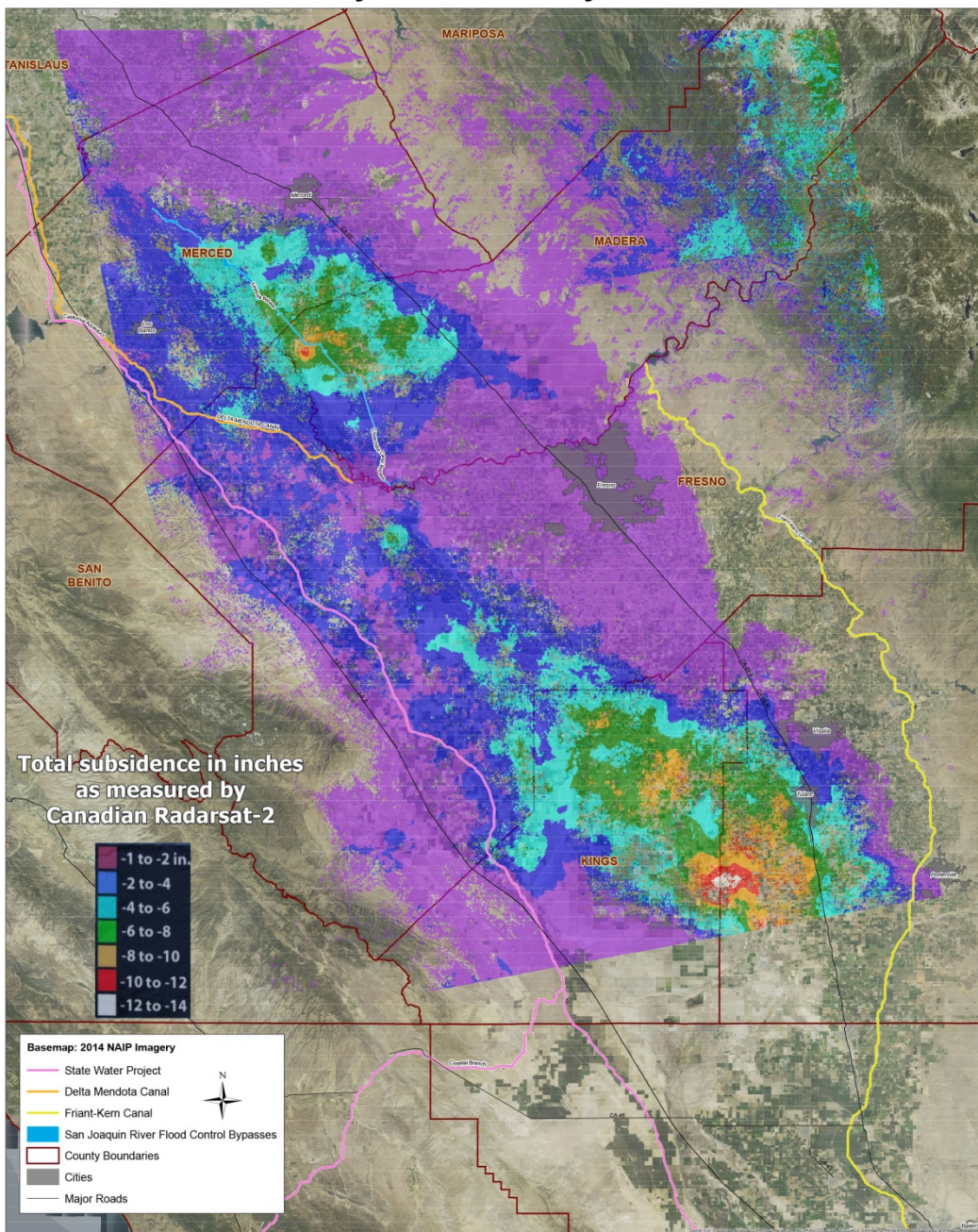
	1991	2009	2014	2015
SWP	30%/0	40%	5%	20%
CVP N of Delta Ag	25%	40%	0	0
CVP S of Delta Ag	25%	10%	0	0
Friant	100%	100%	0	0
CVP Sac water rts	75%	100%	75%	75%
CVP SJ water rts	75%	100%	65%	75%

Groundwater Level Change* - Fall 2011 to Fall 2015



*Groundwater level change determined from water level measurements in wells. Map and chart based on available data from the DWR Water Data Library as of 12/31/2015. Document Name: DOTMAP_F1511_JJ_50 Updated: 2/1/2016 Data subject to change without notice.

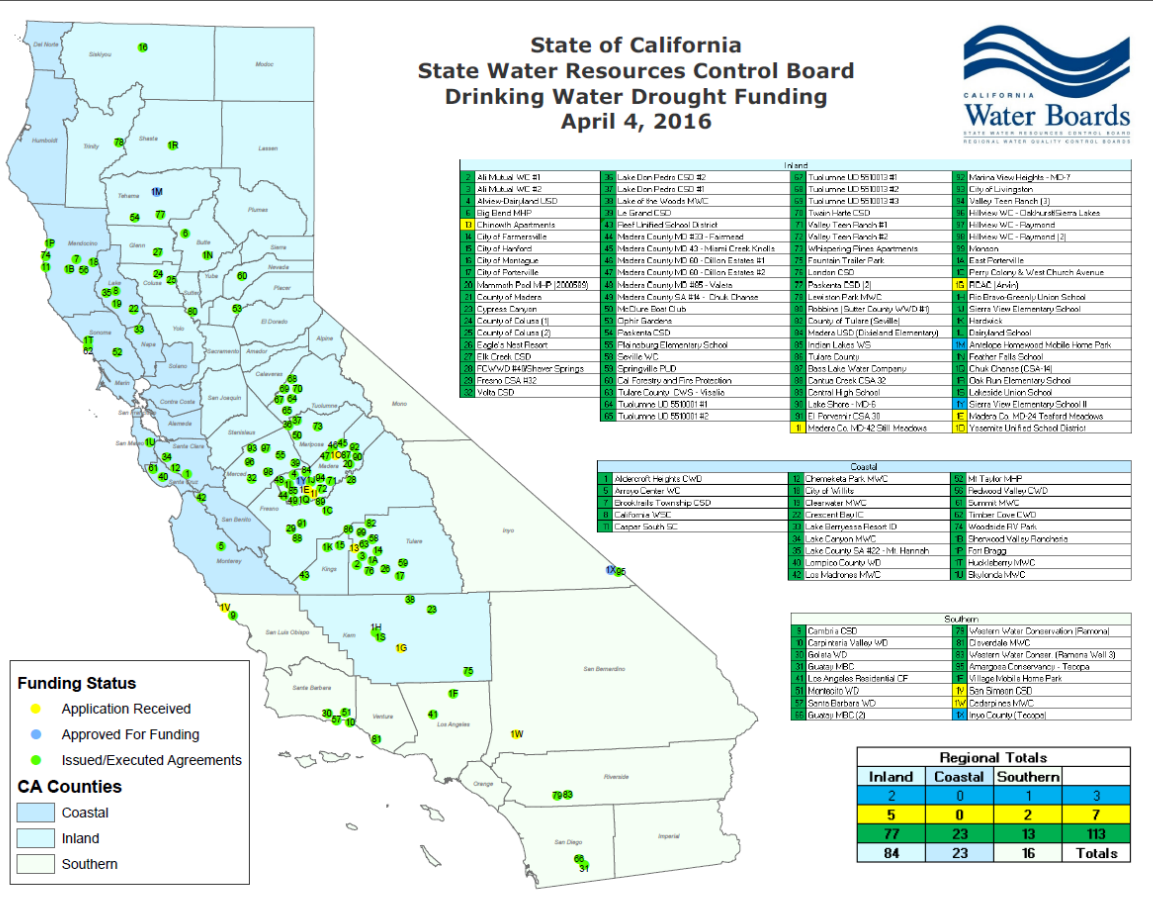
San Joaquin Valley Subsidence May 2014 to January 2015



Drought Impacts

- Reduced surface and groundwater supplies
- Water shortages for small water systems & private well owners
- Declining groundwater levels and land subsidence
- Agricultural land fallowing
- Increased urban water costs
- Tree mortality, wildfire risk
- Fishery impacts





State Drought Response Actions

- May 2013 Executive Order on water transfers
- Dec 2013 formation of Governor's Drought Task Force
- Jan 2014 Governor's emergency proclamation
- March 2014 drought relief legislation
- April 2014 proclamation of continued state of emergency
- Sep 2014 Executive Order for emergency drinking water assistance
- Dec 2014 Executive Order continuing CEQA waiver for specified actions
- March 2015 drought relief legislation
- April 2015 Executive Order
- October 2015 emergency proclamation on tree mortality
- November 2015 Executive Order, continuing conservation/small water systems



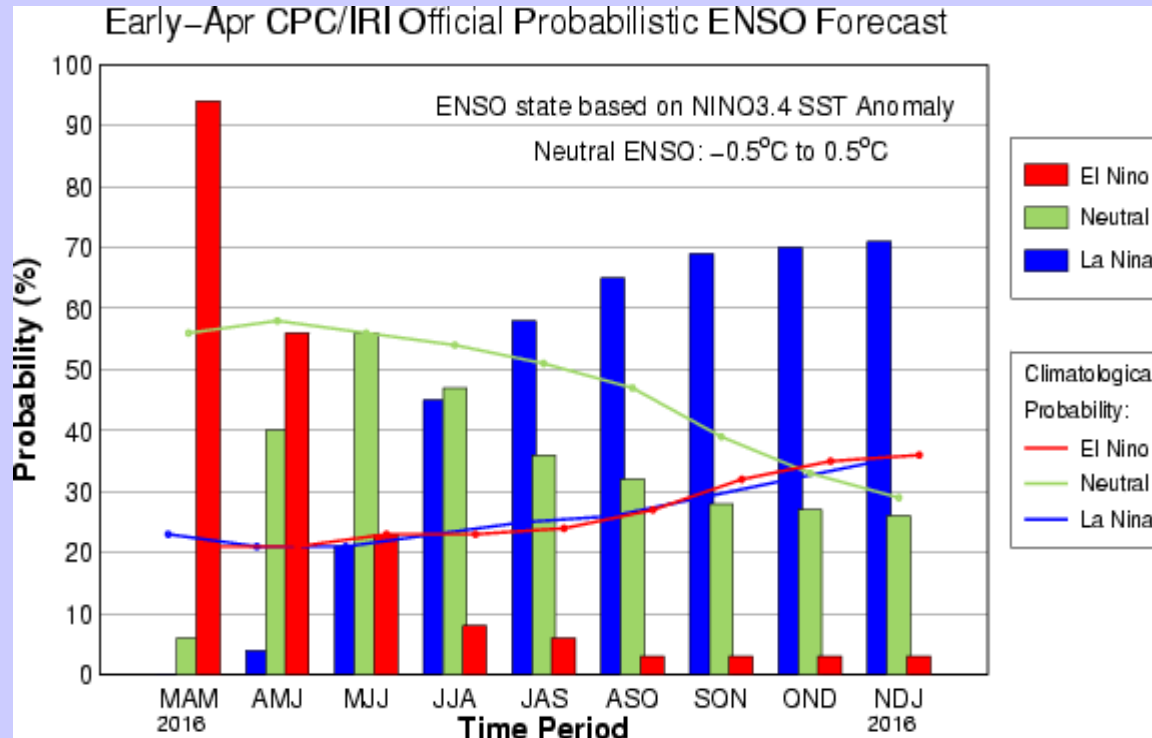
And What If 2017 Is Dry?



CPC/IRI Probabilistic ENSO Outlook

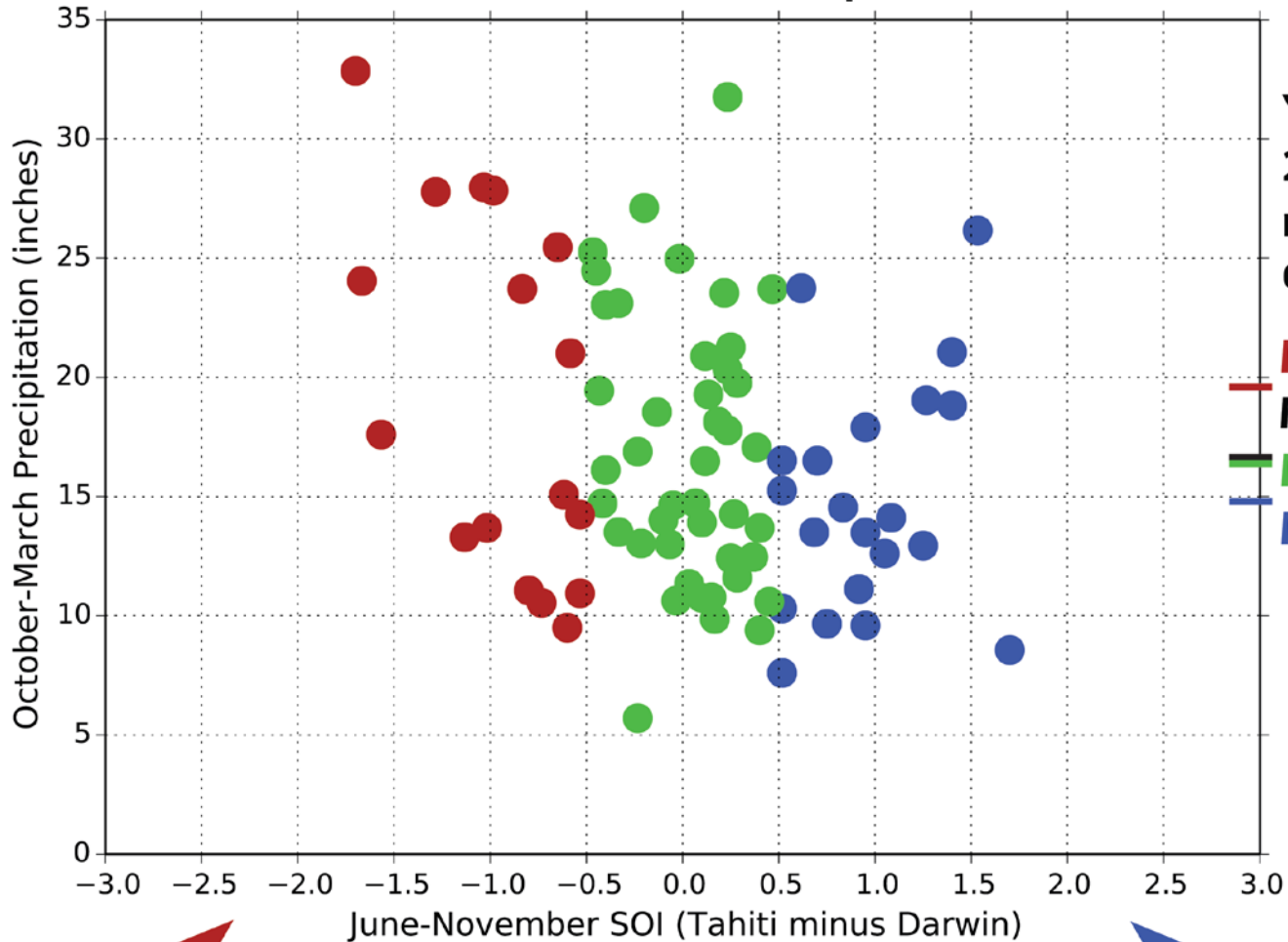
Updated: 14 April 2016

The chance of El Niño gradually decreases during the spring and ENSO-neutral is favored during May-June-July (MJJ) 2016. The chance of La Niña increases to more than 50% in July-August-September (JAS) 2016.



CA Division 5 October-March Precipitation

(versus Southern Oscillation Index for prior June-November)



Years 1933/1934-
2013/2014

$r^2 = 0.09$

Correlation = -0.3

Mean = 19.21 in

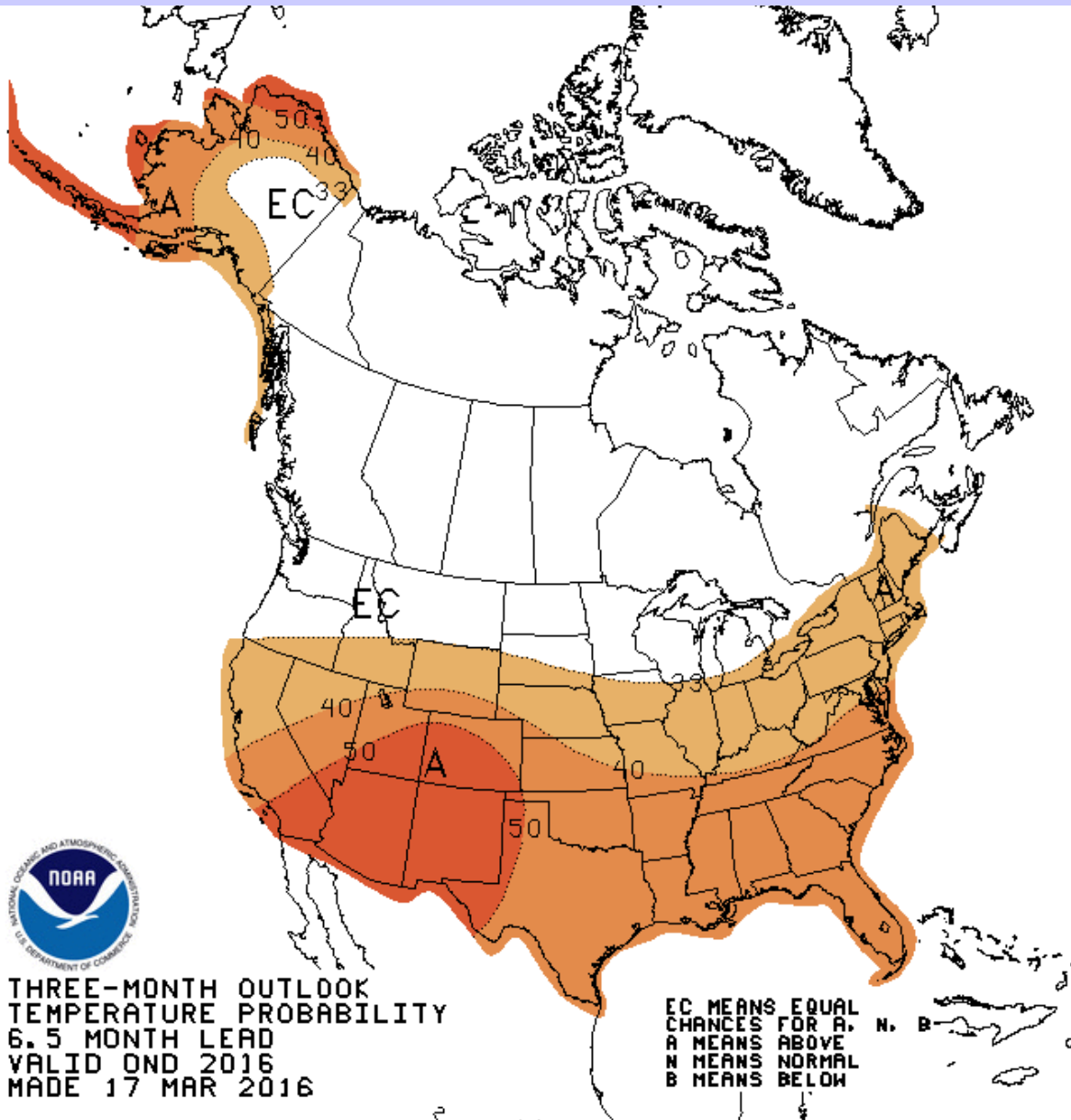
Mean all = 16.83 in

Mean = 16.83 in

Mean = 14.91 in



Western Regional
Climate Center



THREE-MONTH OUTLOOK
 TEMPERATURE PROBABILITY
 6.5 MONTH LEAD
 VALID OND 2016
 MADE 17 MAR 2016

EC MEANS EQUAL
 CHANCES FOR A, N, B
 A MEANS ABOVE
 N MEANS NORMAL
 B MEANS BELOW

