Drought Vulnerability & Preparedness

Jeanine Jones, Department of Water Resources

How long a drought should we plan for?

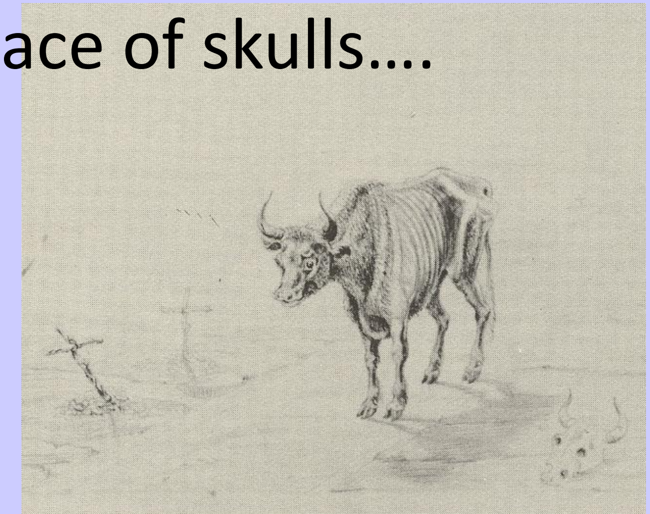
How much risk are you willing to take? And how vulnerable is your system?

Points to Keep in Mind About Drought

- Droughts/dry years are a normal part of the hydrologic cycle
- Drought conditions develop slowly; drought by itself is not an emergency – drought impacts drive action
- Drought impacts are site-specific and sector-specific
- Impacts increase with drought duration
- Drought vulnerability can change over time
- The greatest economic impacts of drought in California have been associated with wildfire and forestry damages, not with urban & agricultural water uses

The Great Drought of 1863-64

1862-63 did not exceed four inches, and that of 1863-64 was even less….The cattle were dying of starvation….The loss of cattle was fearful. The plains were strewn with their carcasses. In marshy places and around the cienegas, where there was a vestige of green, the ground was covered with their skeletons, and the traveler for years afterward we often startled by coming suddenly on a veritable Golgotha – a place of skulls….



UWMP Statutory Requirements

- Urban Water Management Plans (UWMPs), agencies serving > 3,000 AF annually, or 3,000 customers, prepare & update every 5 years
- Water shortage contingency analysis of:
  - Staged response actions to be taken by water supplier for shortages up to 50% reduction in supply
  - Specific water supply conditions associated with each stage
- Actions to prepare for/respond to a catastrophic interruption of water supplies
- Historically, 3-year drought planning requirement

Executive Order B-37-16

STRENGTHEN LOCAL DROUGHT RESILIENCE

8. The Department shall strengthen requirements for urban Water Shortage Contingency Plans, which urban water agencies are required to maintain. These updated requirements shall include adequate actions to respond to droughts lasting at least five years, as well as more frequent and severe periods of drought. While remaining customized according to local conditions, the updated requirements shall also create common statewide standards so that these plans can be quickly utilized during this and any future droughts.

California's 20th & 21st Century Statewide Droughts

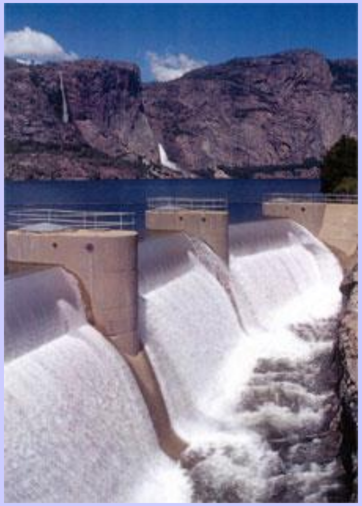
- 1918-20
- 1922-24
- 1929-34
- 1947-50
- 1959-61
- 1976-77
- 1987-92
- 2007-09
- 2012-2016

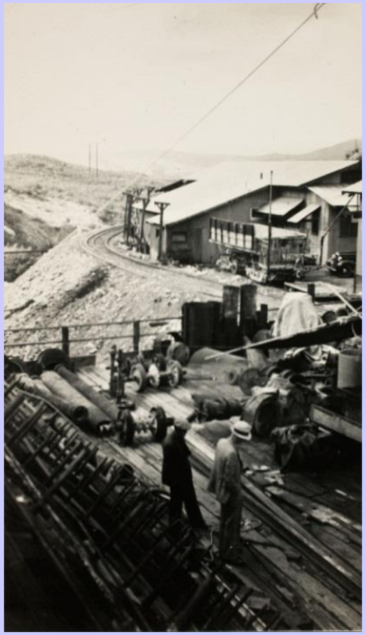
Driest 4 Consecutive Water Years Based on Statewide Precipitation

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

1920s-30s – A Time of Water Project Planning AND Most Severe Drought Conditions in Historical Record





1929-34

- State population 5.7 million
- WY 1931 is 2nd driest in historical record (statewide runoff)
- Major planning going on for future water infrastructure
- Drought impacts relative to Great Depression & agricultural programs
- The Lake Tahoe Dam war

1987-92

- Longest drought in near-modern times
- State population of 30 million in 1990
- Single driest year – 1991 – was 5th driest on record
- Delta conditions: D-1485, no ESA biological opinions until 1992
- CVP & SWP cutbacks in 1991 & 1992

2007-09 Drought

- Not as severe as big historical droughts in terms of hydrology
- Surplus water no longer available from Colorado River
- Delta: D-1641, new Biological Opinion in 2008
- CVPIA provisions in effect
- First-ever statewide proclamation of drought emergency
- Agricultural impacts in San Joaquin Valley: combined effects of drought + recession
- Small water system problems

What Else Has Changed?

- Extensive interconnections now among largest water projects & urban purveyors
- Much greater experience with water transfers
- New groundwater management legislation
- Beginning in mid-1990s, substantial state grant funding for local projects
- Wildfire risk increasing, especially in Southern California
- Increased acreage of permanent plantings
- Land subsidence in historically unaffected areas
- Small water system/private well owner problems becoming more widespread

Expected Impacts of Multi-Year Drought – Lessons Learned

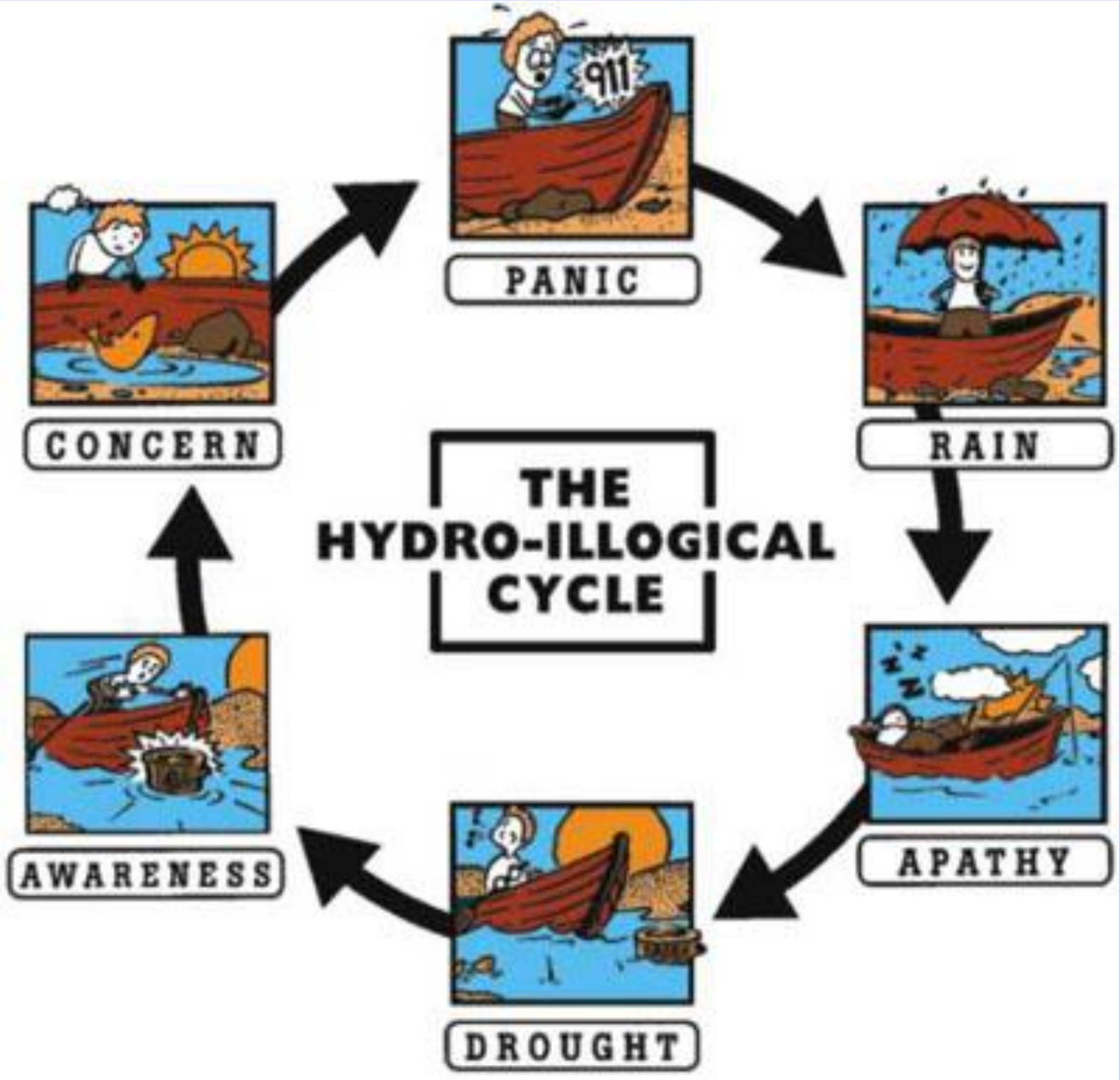
- **Unmanaged systems**
  - Risk of catastrophic wildfire (health & safety, economic)
  - Non-irrigated agriculture (livestock grazing)
  - Fish & wildlife (e.g., salmonids)
- **Managed systems**
  - Small water systems (health & safety)
  - Irrigated agriculture
  - Green industry (urban water supplies)
  - Fish & wildlife (e.g., wildlife refuges, salmonids)
  - Other environmental (e.g., land subsidence)

Catastrophic Wildfire Risk

- 1991 Oakland Hills fire (25 lives lost)
- October – November 2003 Southern California wildfires (22 lives lost)
- October 2007 Southern California wildfires (1 million people evacuated/displaced)

Drought Preparedness Basics

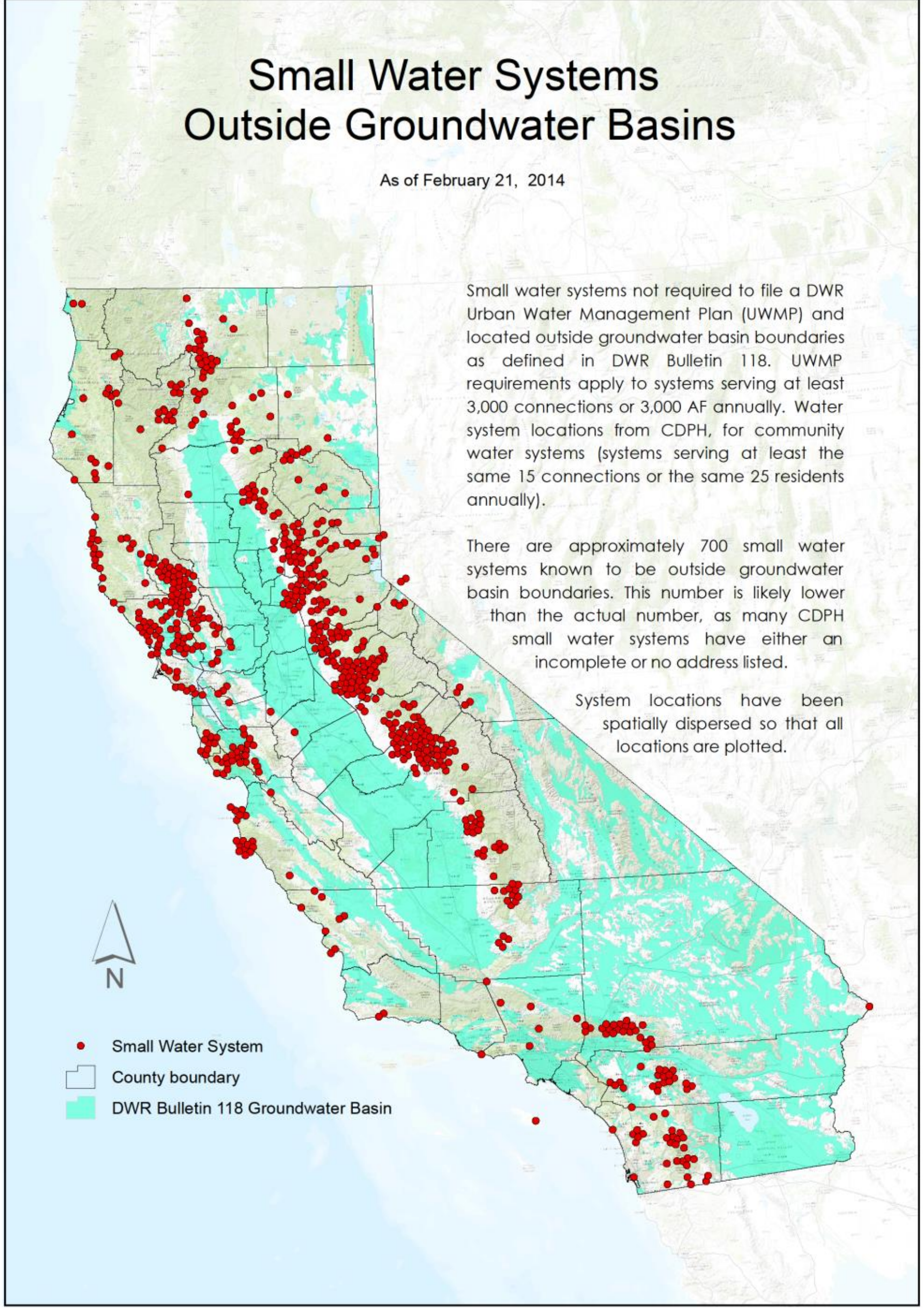
- Vulnerability assessment
- Monitoring
- Planning
  - SDWA emergency plan
  - UWMP, if applicable
  - Long-term planning (CIPs)
- Response



University of Nebraska

Vulnerability Factors

- Fractured rock groundwater
- Fewer connections
- Single source (e.g., groundwater)
- Limited storage capacity
- No interconnections
- Rural location
- Wildfire risk area



1:1,542,907

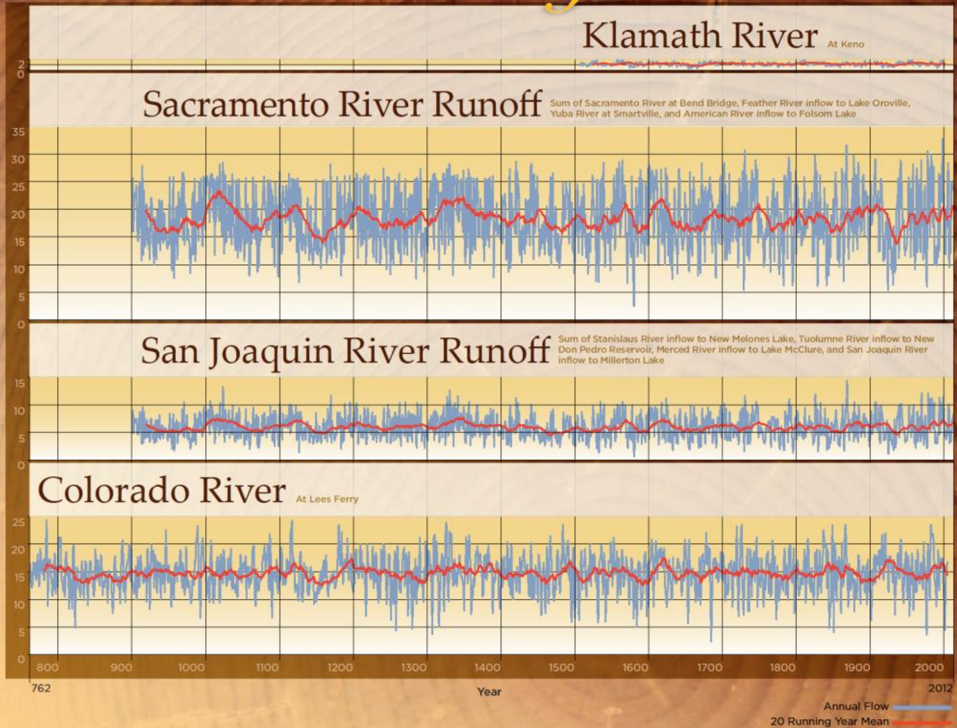
Coordinate System: NAD 1983 UTM Zone 10N
Projection: Transverse Mercator

Produced by Division of Statewide Integrated Water Management, Data Management, Publication and Exchange Section
Document Path: K:\Statewide Data Management\Drought\CDPH\SmallWaterSystems201400507.mxd

Southern California Imported Supplies

- SWP, Colorado River, Eastern Sierra
- Shortage risk has increased over time for all of these sources

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 blue 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 10 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.

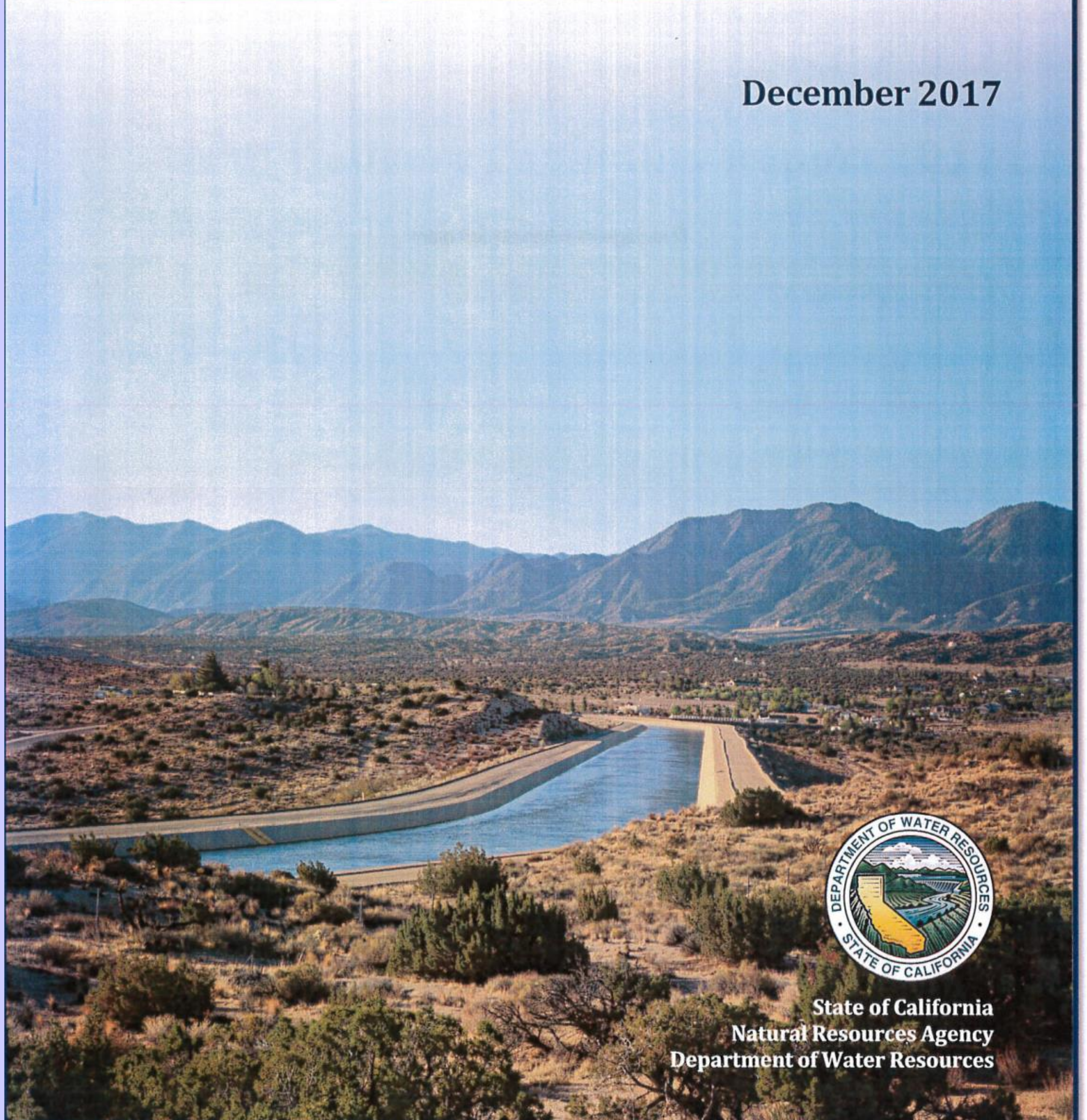
DROUGHTS PRIOR TO THE HISTORICAL RECORD

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.

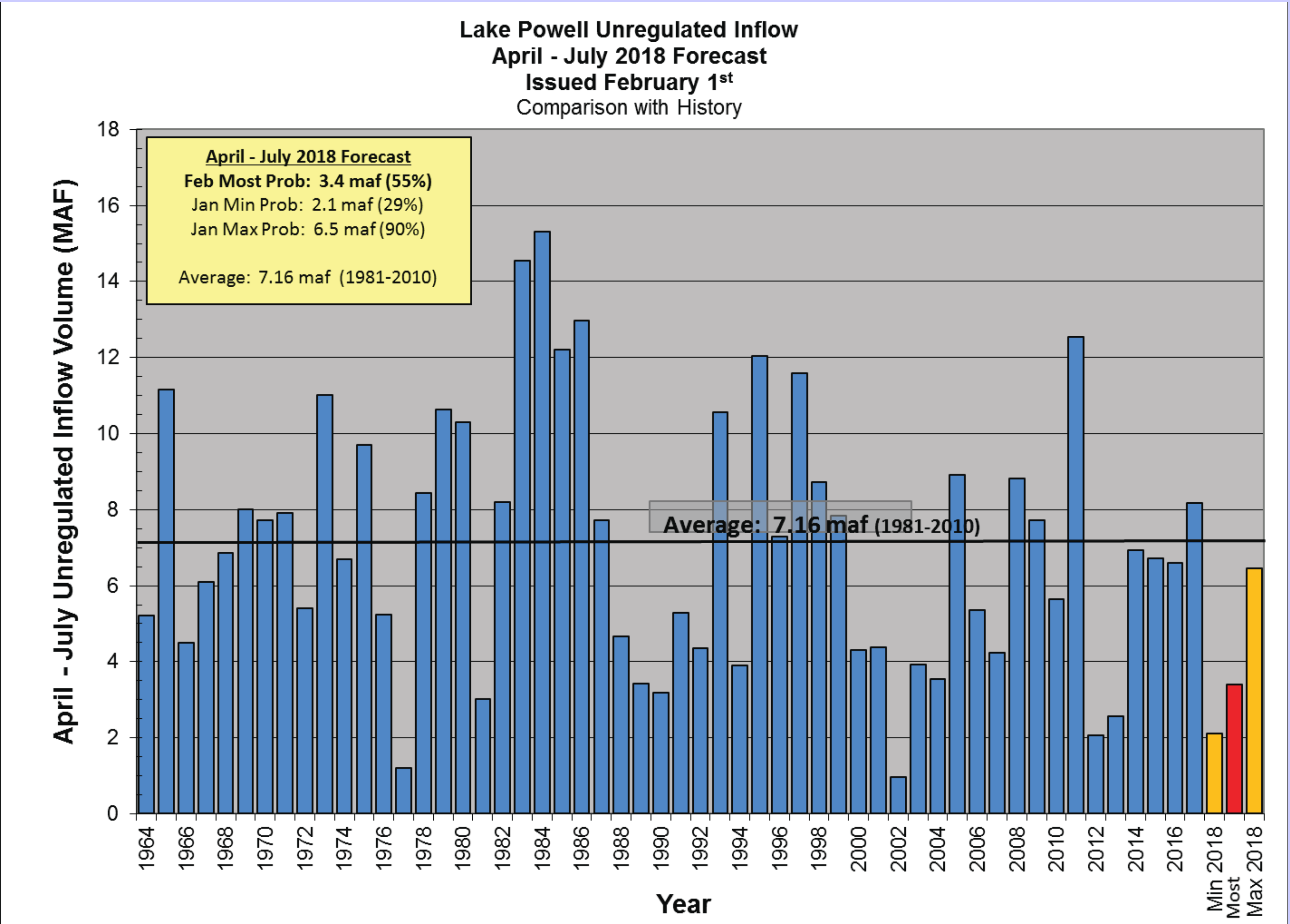
Data source: Work performed by the University of Arizona under contract to the California Department of Water Resources. CDWR Agreements 4600003882 (David Meko, 2006) and 4600008850 (David Meko, Connie Woodhouse, Ramzi Touchan, 2014)

The State Water Project
Draft Delivery Capability Report 2017

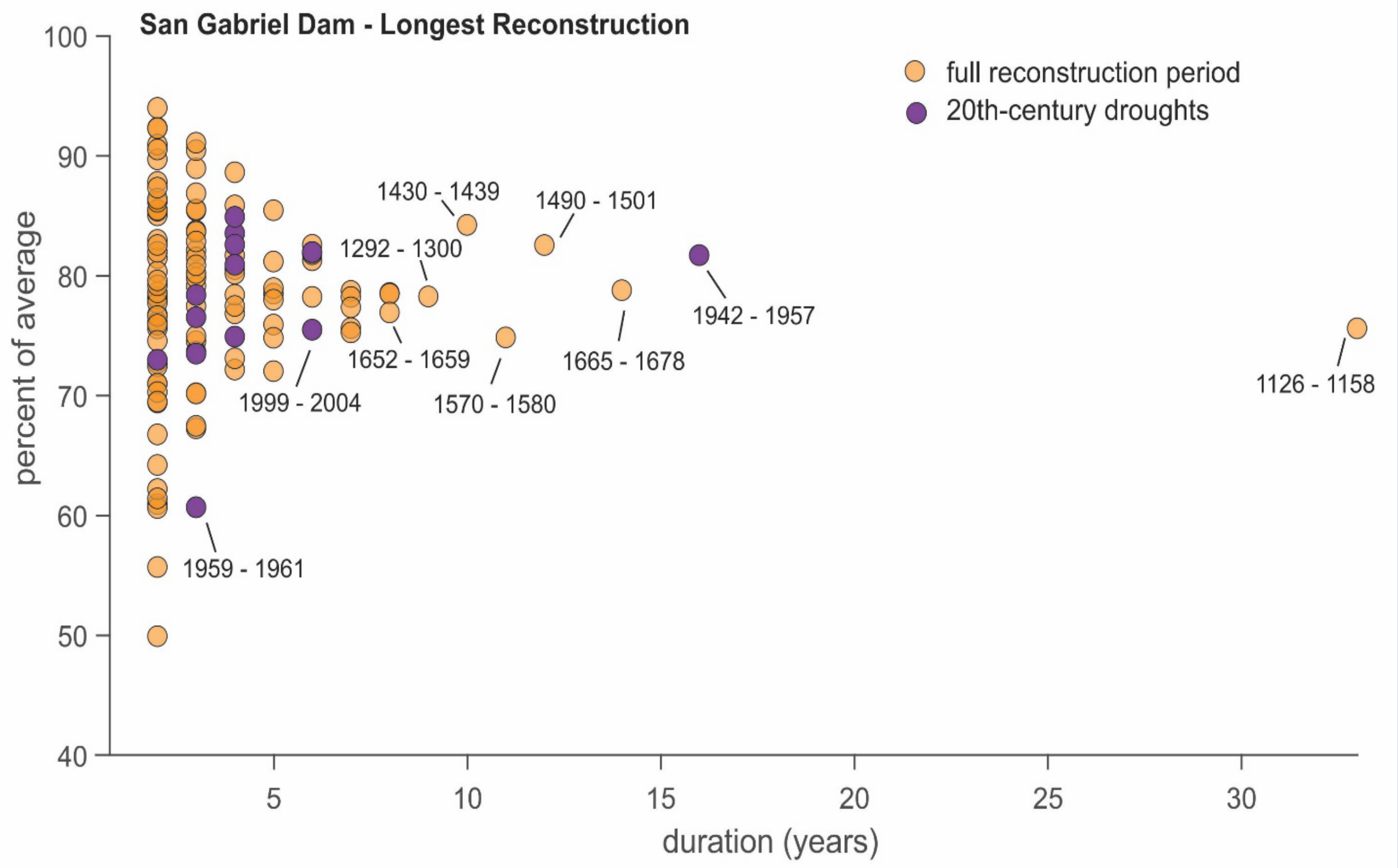
December 2017



State of California
Natural Resources Agency
Department of Water Resources

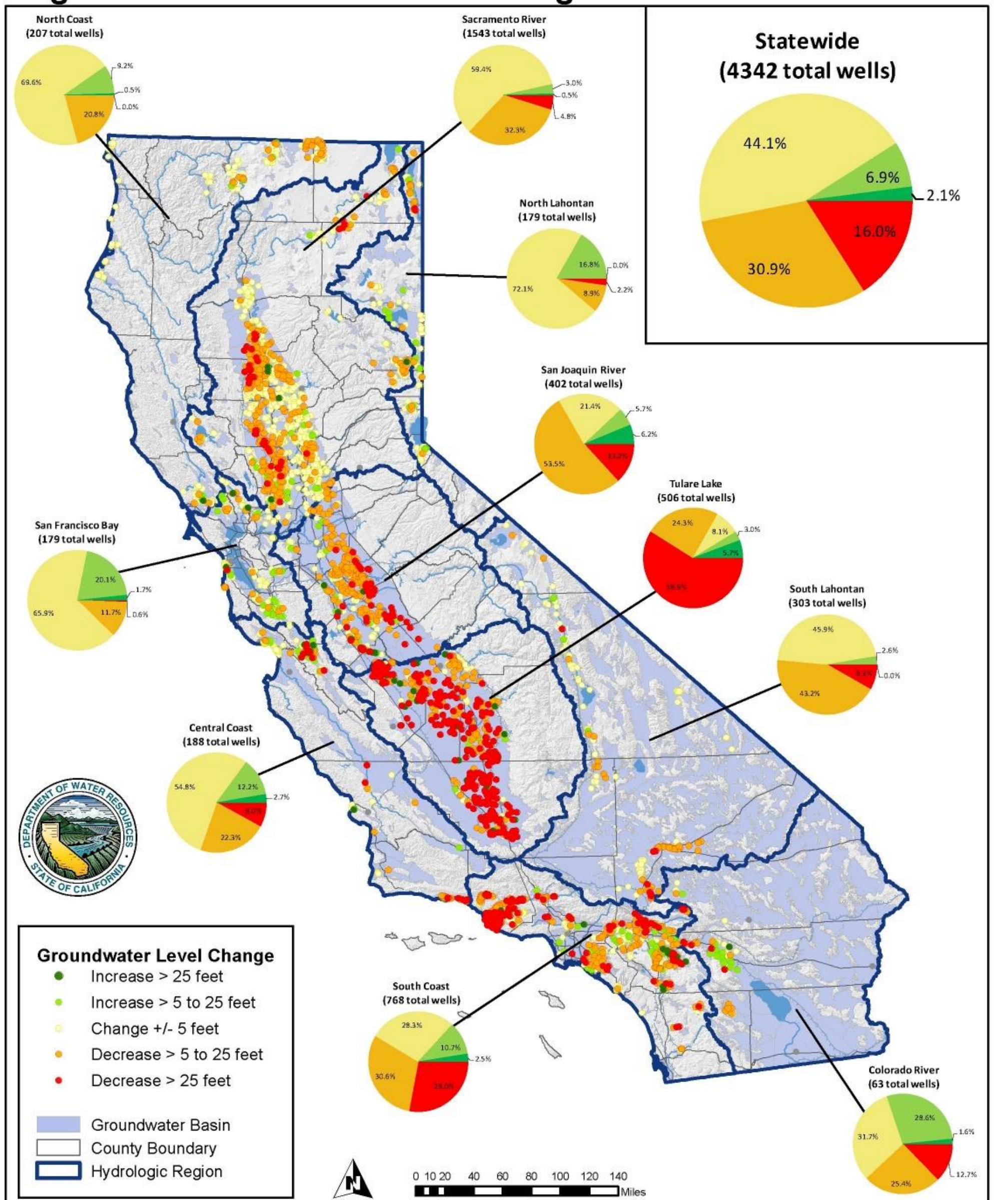

Lake Powell Unregulated Inflow
April - July 2018 Forecast
Issued February 1st
Comparison with History
April - July 2018 Forecast
Feb Most Prob: 3.4 maf (55%)
Jan Min Prob: 2.1 maf (29%)
Jan Max Prob: 6.5 maf (90%)
Average: 7.16 maf (1981-2010)
Average: 7.16 maf (1981-2010)
April - July Unregulated Inflow Volume (MAF)
0
2
4
6
8
10
12
14
16
18
1964
1966
1968
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
Min 2018
Most
Max 2018
Year

Drought Risk for Local Supplies?



Courtesy of University of Arizona

Figure 5. Groundwater Level Change* - Fall 2011 to Fall 2017



*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 02/21/2018. Document Name: PIEMAP_F1711_25ft
Updated: 2/26/2018. Data subject to change without notice.

Take-Home Points

- Understand your system's vulnerability to droughts of varying duration
- Evaluate your risk tolerance
- Take advantage of the UWMP process to improve your drought preparedness