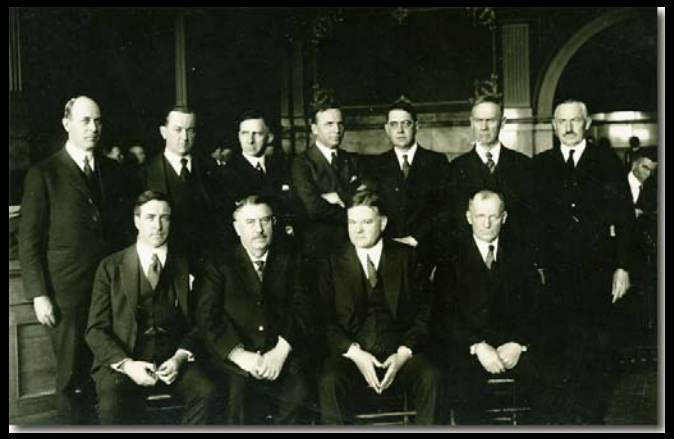
Applications to Water Management: examples from Colorado

Photo: NOAA/CIRES Western Water Assessment web site



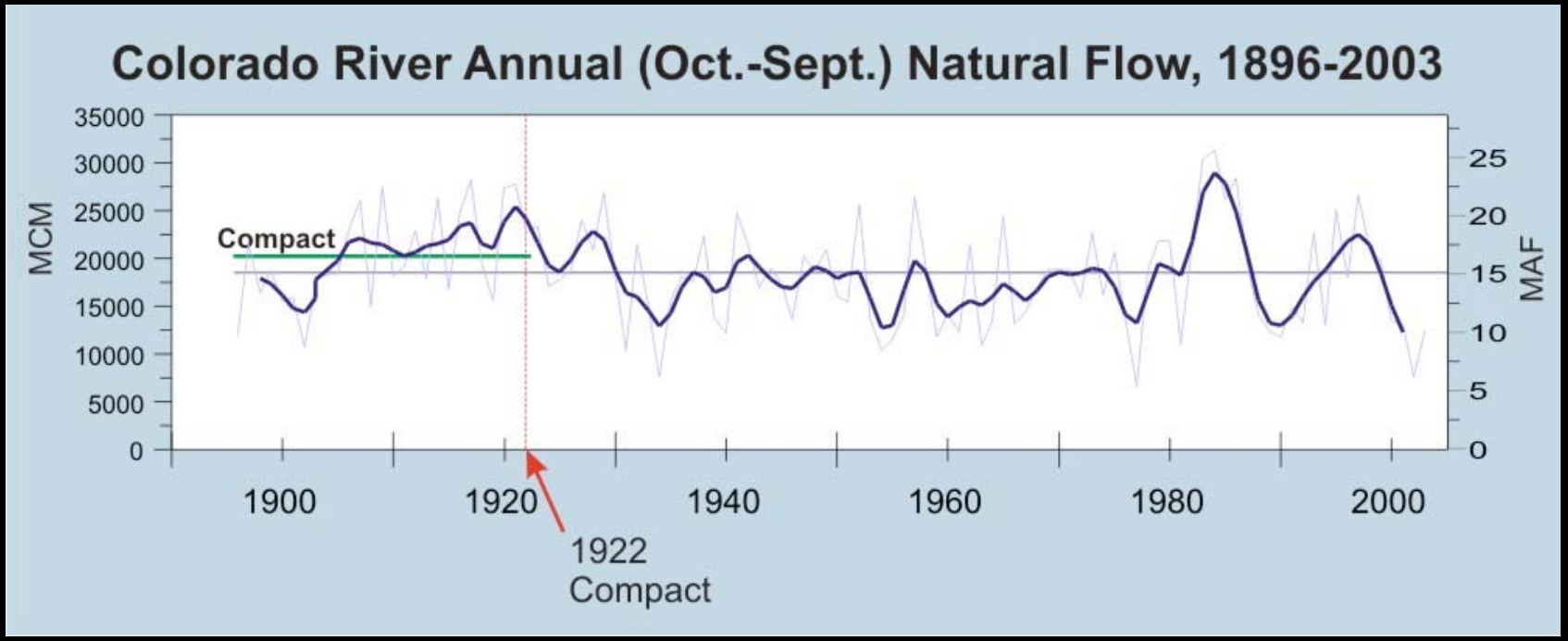
Colorado River Commission, 1922, from Water Resources Archive, CSU

The Colorado River Compact, signed in 1922, divided Colorado River flows at Lees Ferry, between Upper and Lower Basin states, with 7.5 MAF to each basin.

Allocations were based on an assumed flow of 16.4 million acre feet (MAF) per year.

In 1944, the Mexican Water Treaty allocated 1.5 MAF to Mexico.

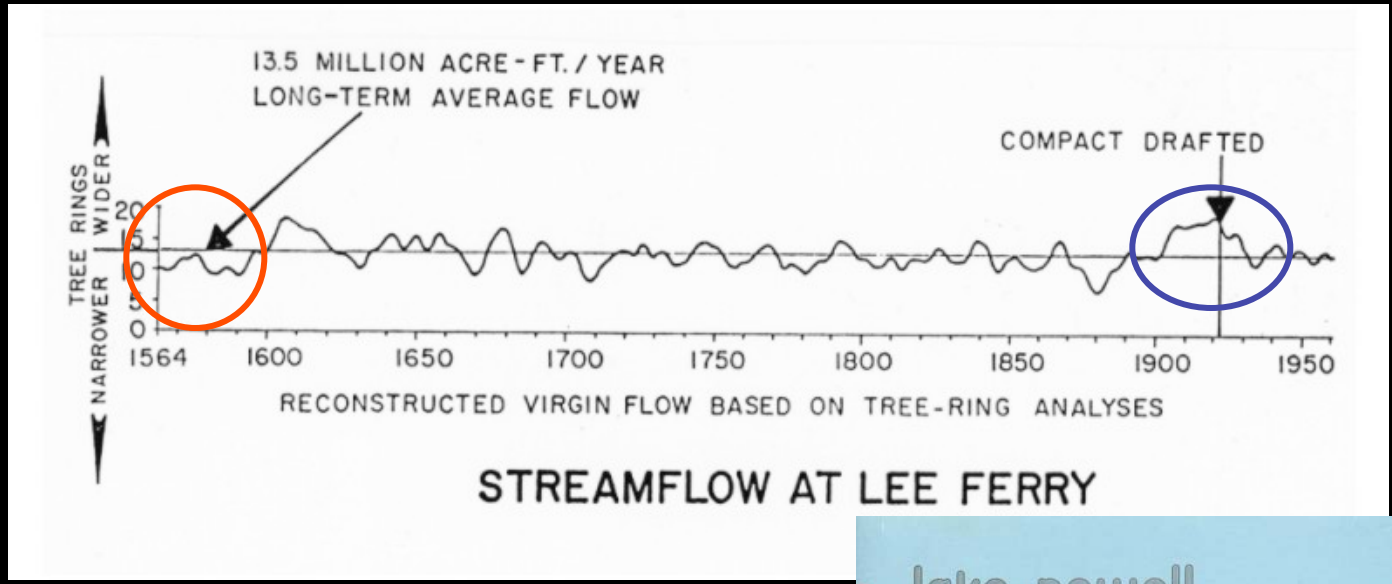
16.4 MAF was considered a conservative estimate at the time of the Compact. However, the average annual flow over the 20th century has been only 15 MAF.



Relative to the gage record today, flows in the early 20th century appear to be unusually high. How unusual is this period in a longer-term context?

Tree rings placed the gage record in a long-term context

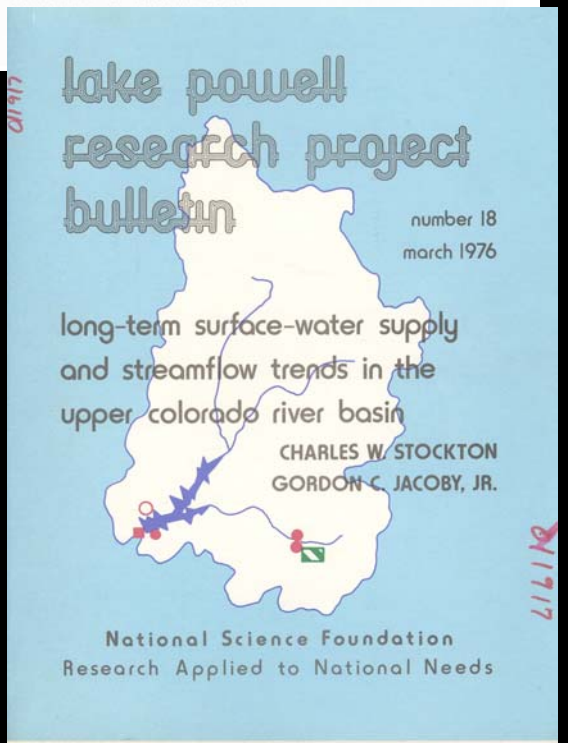
Colorado River flow, reconstructed by Stockton and Jacoby, 1976



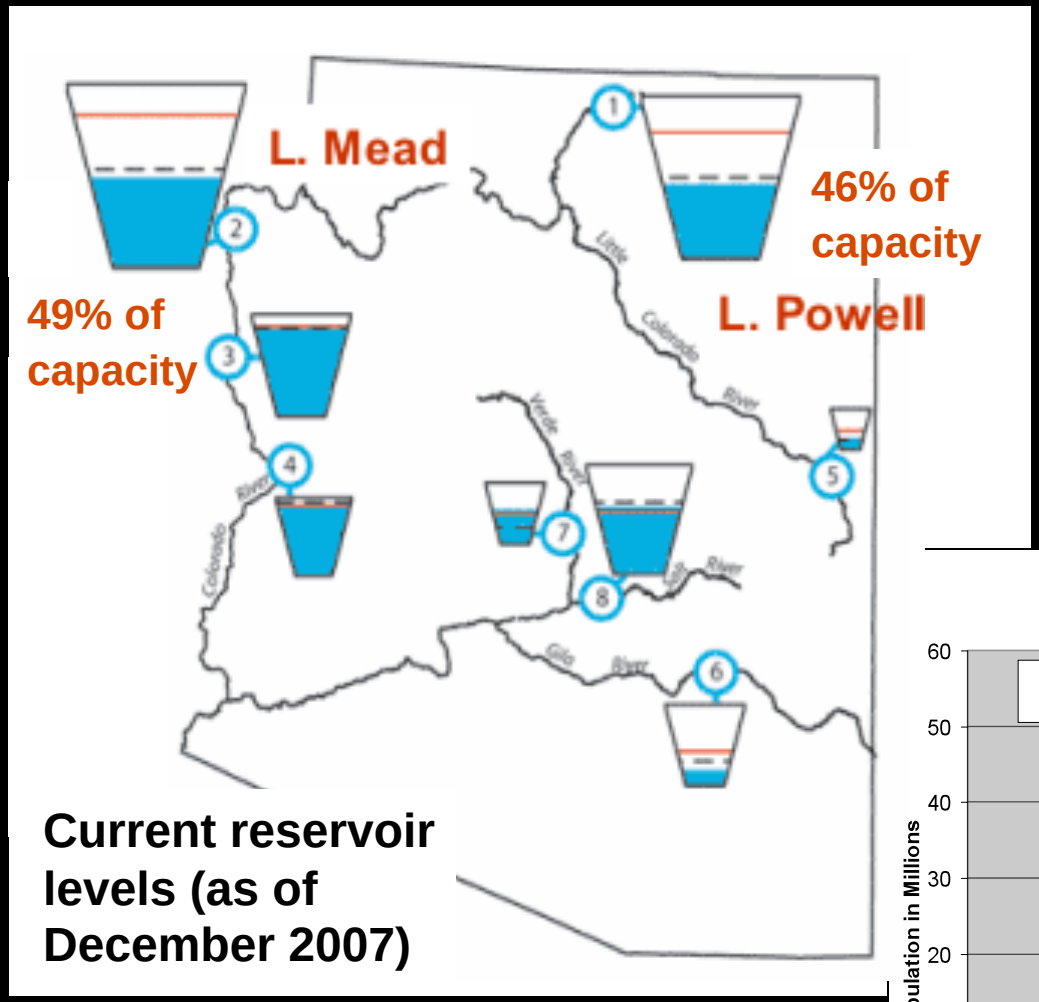
"…the timing of the drafting of the Compact was an unfortunate event, in that it did not occur during a representative flow period."

"The general picture of a collision between water demand and supply in the UCRB in the not-too-distant future is all too apparent."

Stockton and Jacoby 1976



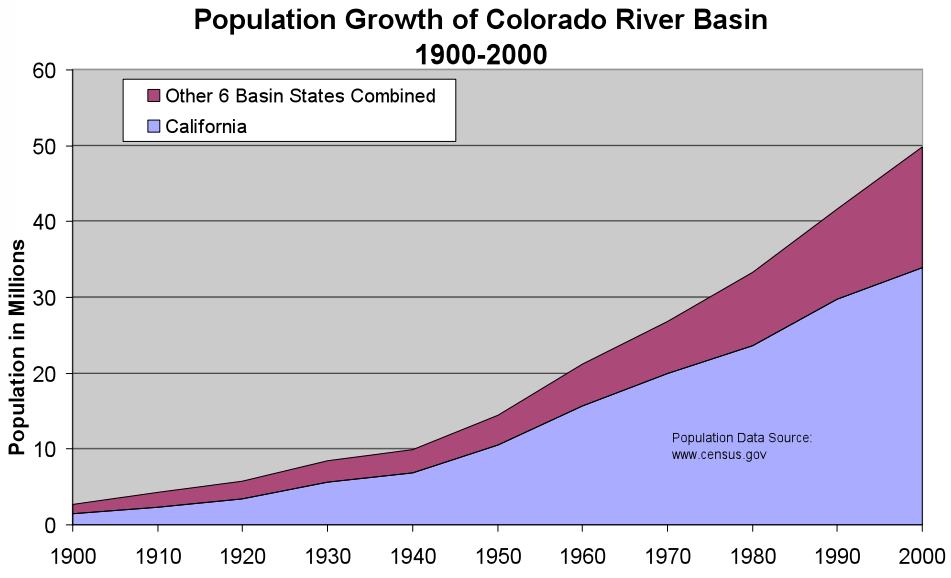
Stockton and Jacoby's predicted collision is here.



Current reservoir levels (as of December 2007)

CLIMAS, Southwest Climate Outlook: http://www.climas.arizona.edu/forecasts/swoutlook.html

National Geographic Image Collection/Vincent Laforet



How are reconstructions of streamflow being used in water resource planning and management?

A variety of levels and stages of application are being employed:

- Information is ***consulted***; looked up or received in a briefing (awareness)
- After consulted, it is ***considered*** in management (how to use?)
- Some form of the information is ***incorporated*** into operations (modeling challenges)
- Information is used in the ***communication of risk***, and ultimately may play a part in decision making (who makes the decisions and upon what are they based?)

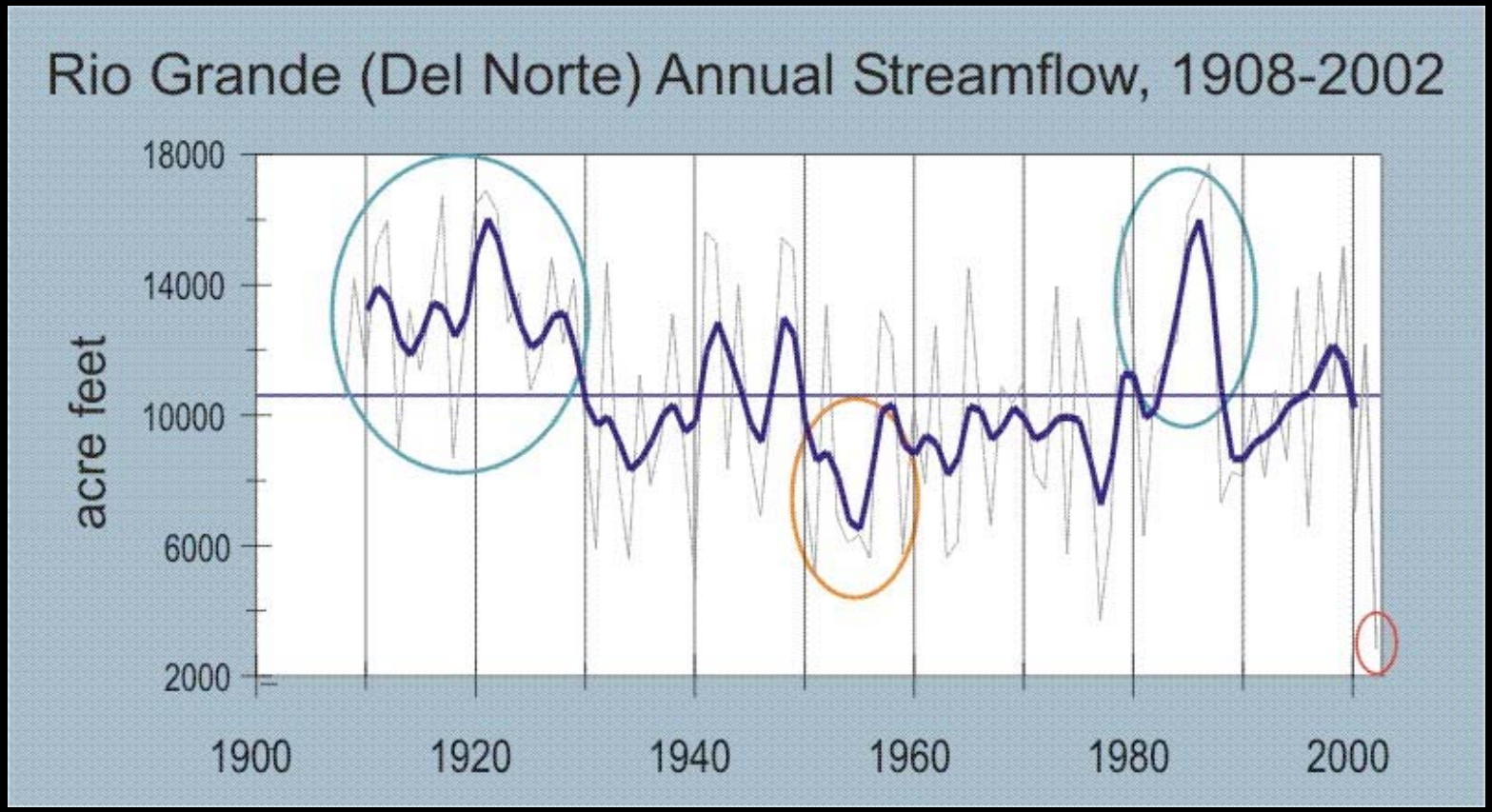
Based on Ray 2007

• After it is consulted, it is ***considered*** in management.

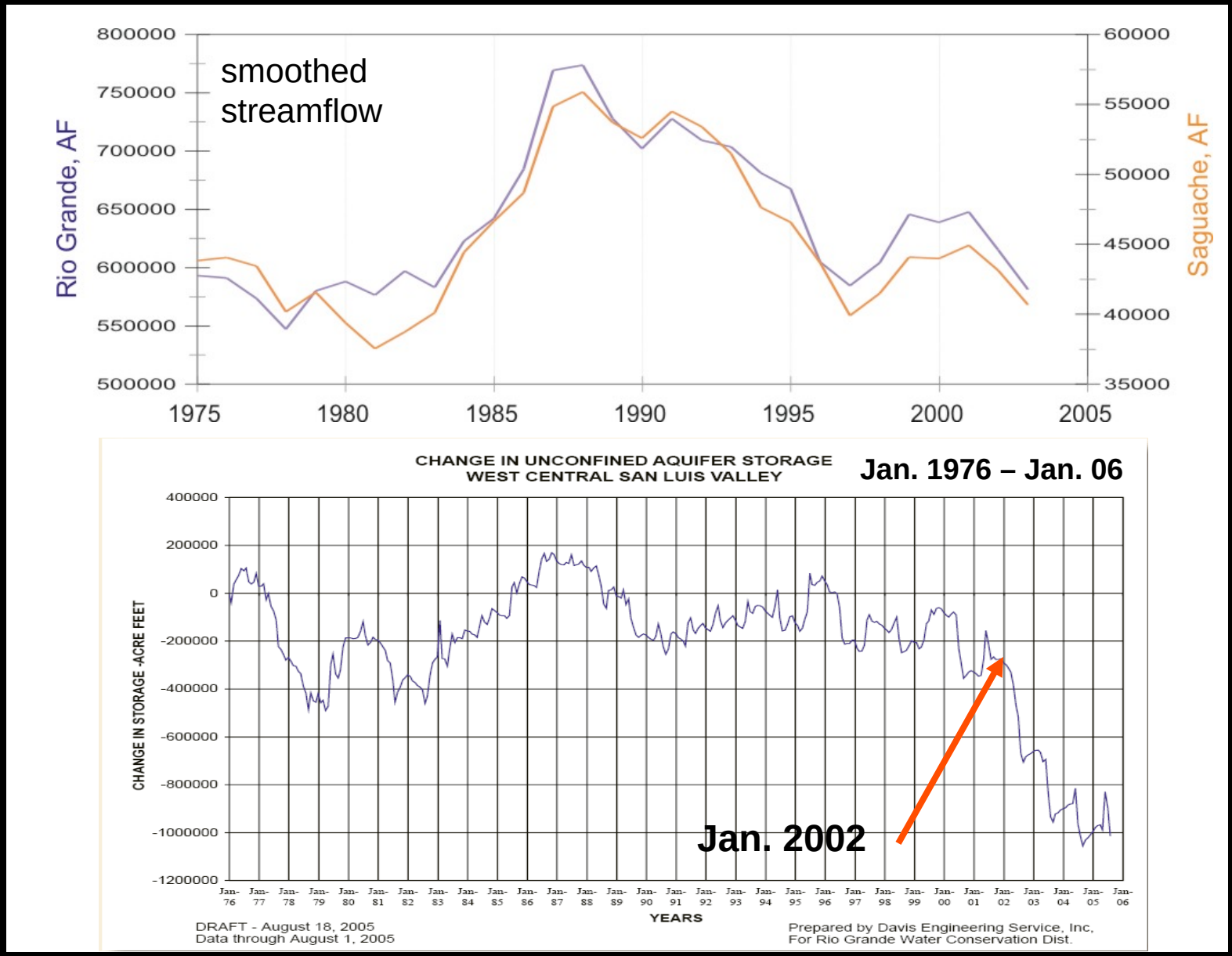
Rio Grande Water Conservation District: Are the wet periods experienced in the 20th century record the "normal" state?

What is the character of long-term, low-frequency variations in water supply that affect aquifer levels?

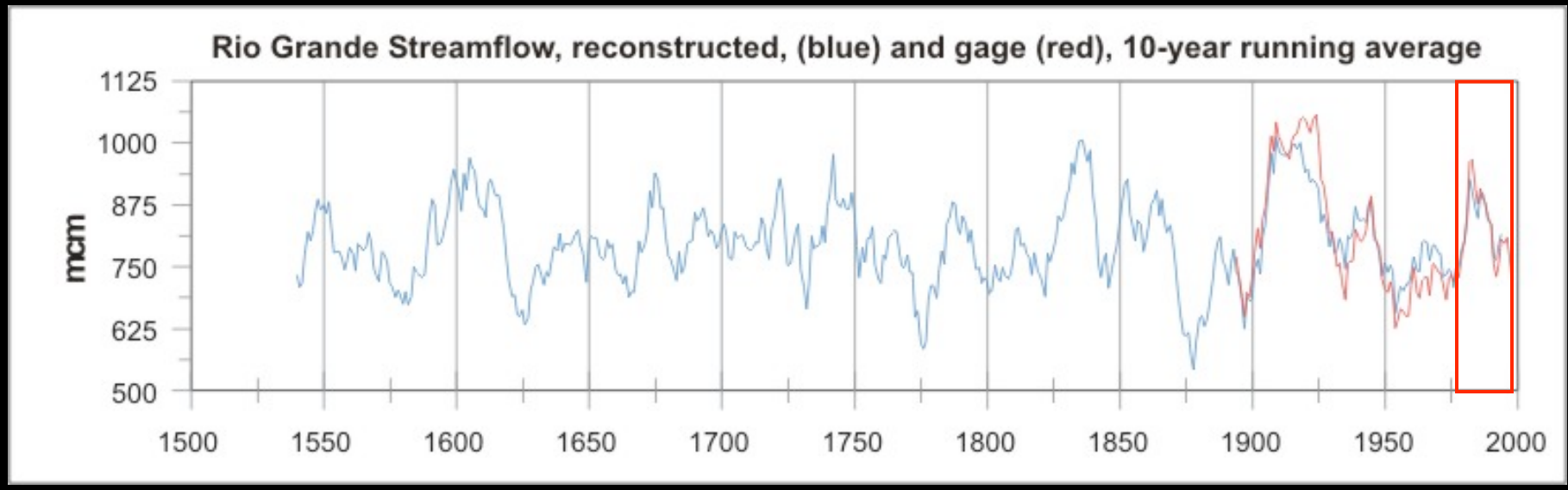

Photo: NPS



Comparison of Annual Flow and Changes in Unconfined Aquifer Storage, 1976-2003



Reconstructed Rio Grande Streamflow, 1536-1999



Comparing the short period of instrumental record with the long-term record from the tree-ring data:

Implications for long-term groundwater management?

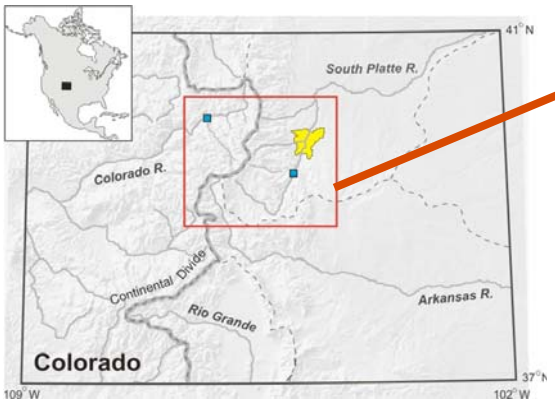
- Some form of the information is ***incorporated*** into operations.

Denver Water

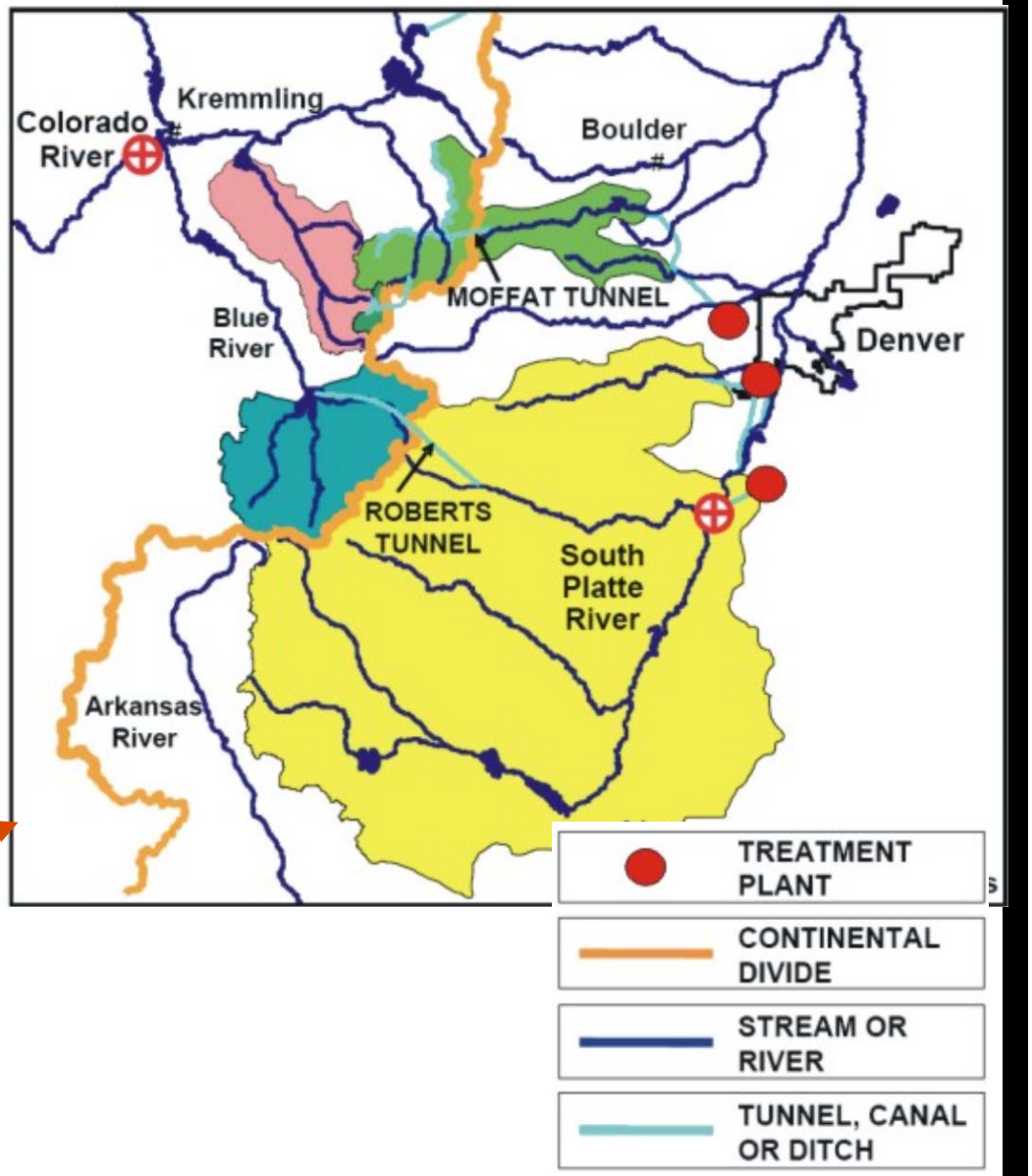
Denver Water uses a water system model called the Platte and Colorado Simulation Model (PACSM)

PACSM is an integrated system of computer programs that simulate streamflows, reservoir operations and water supply in the South Platte and Colorado River basins.

Hydrologic Period: 1947 – 1991
Daily data, 450 locations



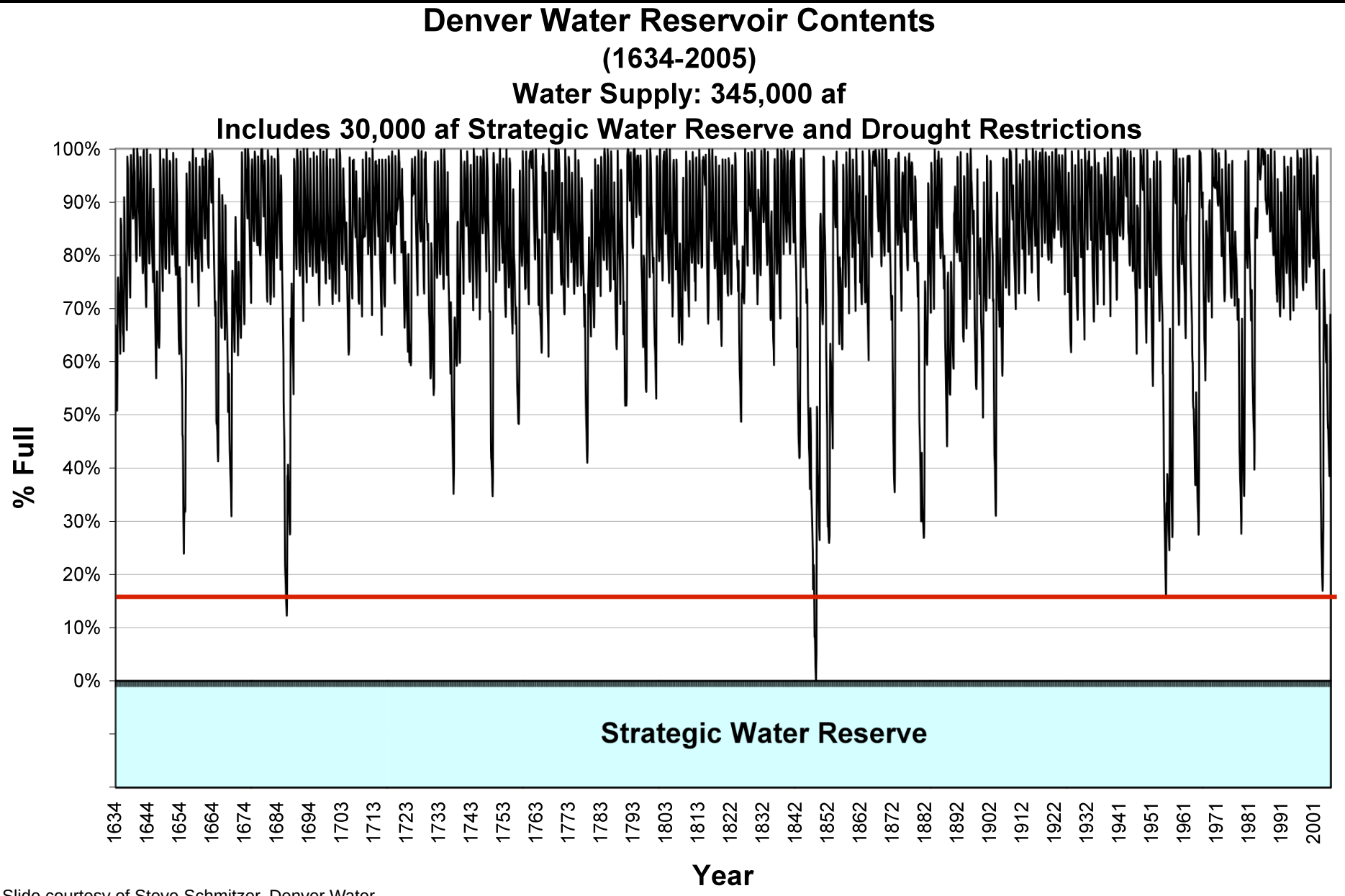
Denver Water Collection System



Denver Water – integrating tree-ring data into a water supply model

- Denver Water's Platte and Colorado Simulation Model (PACSM) requires daily model input from 450 locations
- An "analogue year" approach matched each year in the reconstructed flows (1634-2002) with one of the 45 model years (1947-1991) with known hydrology (e.g., 1654 is matched with 1963), and use that year's daily hydrology
- Reconstructed years with more extreme wet/dry values are scaled
- PACSM was then run to simulate the entire reconstruction period (1634-2002)

Denver Water - Water supply analysis



Slide courtesy of Steve Schmitzer, Denver Water

• Information is used in the ***communication of risk***, and ultimately may play a part in decision making

Worst case scenarios for drought planning:

An example from the City of Chandler (AZ)

• What should be the basis for a worst case scenario for drought?

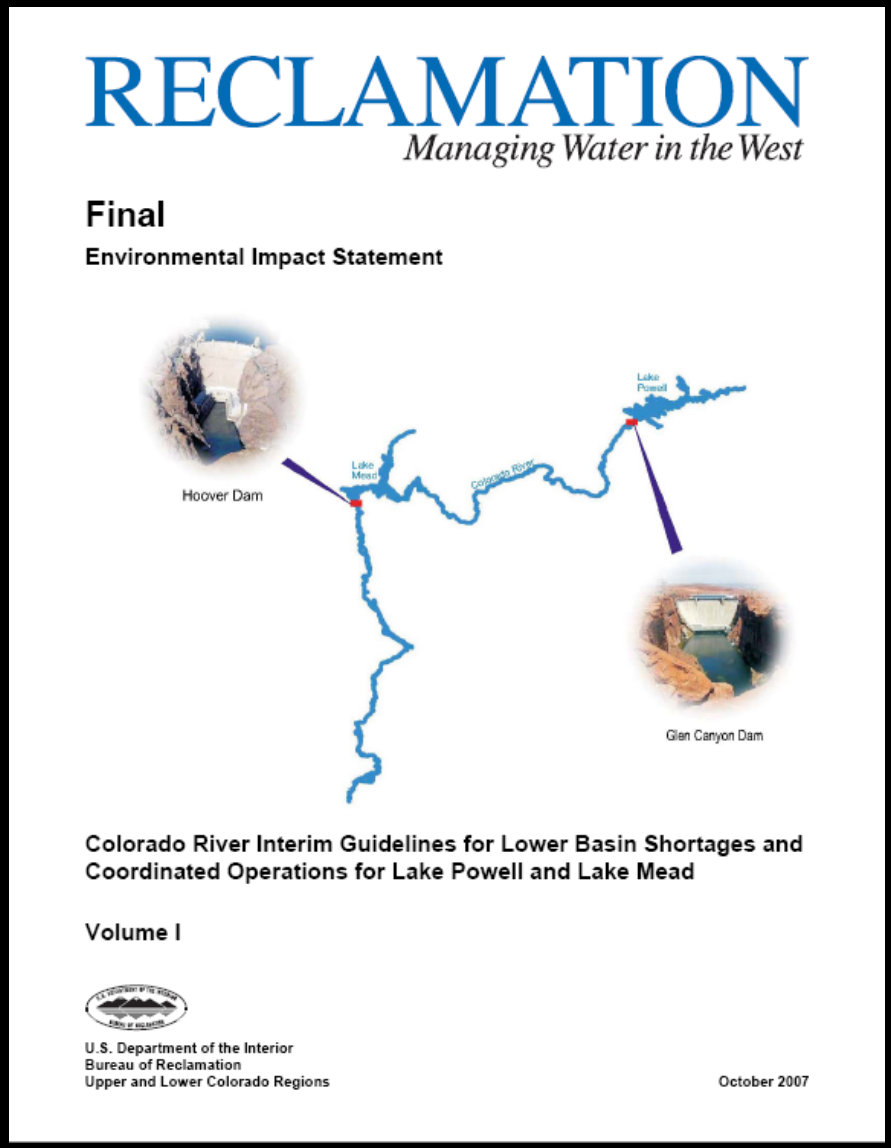
• One suggestion was to use the driest year on record, 2003, for 10 or 20 consecutive years.

• After considering reconstructions of Colorado River basin streamflow, this seemed improbable

• Instead, a scenario of 10 dry years out of 25 years is being considered as being more realistic

• Although the City is not yet actually incorporating the streamflow reconstructions into a water supply model, they have found the tree-ring data valuable for decision making regarding drought.

Environmental Impact Statement for Colorado River Management Under Shortage (Drought)



A tree-ring based reconstruction of the Colorado River is part of a set of "alternative hydrologies" used to test the sensitivity of the several alternative management scenarios to hydrologic variability.

Record of Decision, signed December 2007

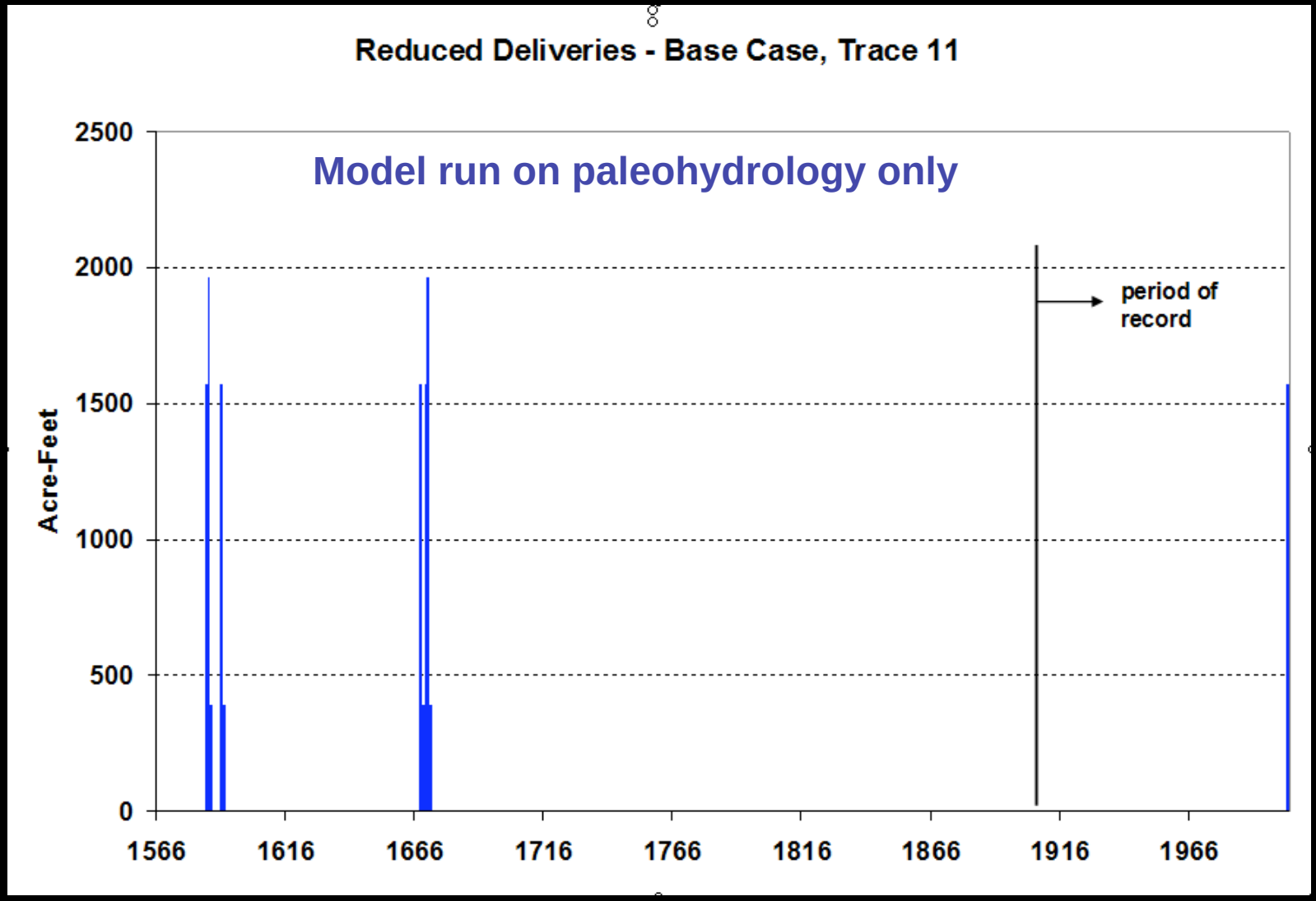
How relevant is the record of past streamflow to the future?

- The climate of the past is unlikely to be replicated in the future, but natural climate variability is likely to continue, underlying human-induced changes to climate.

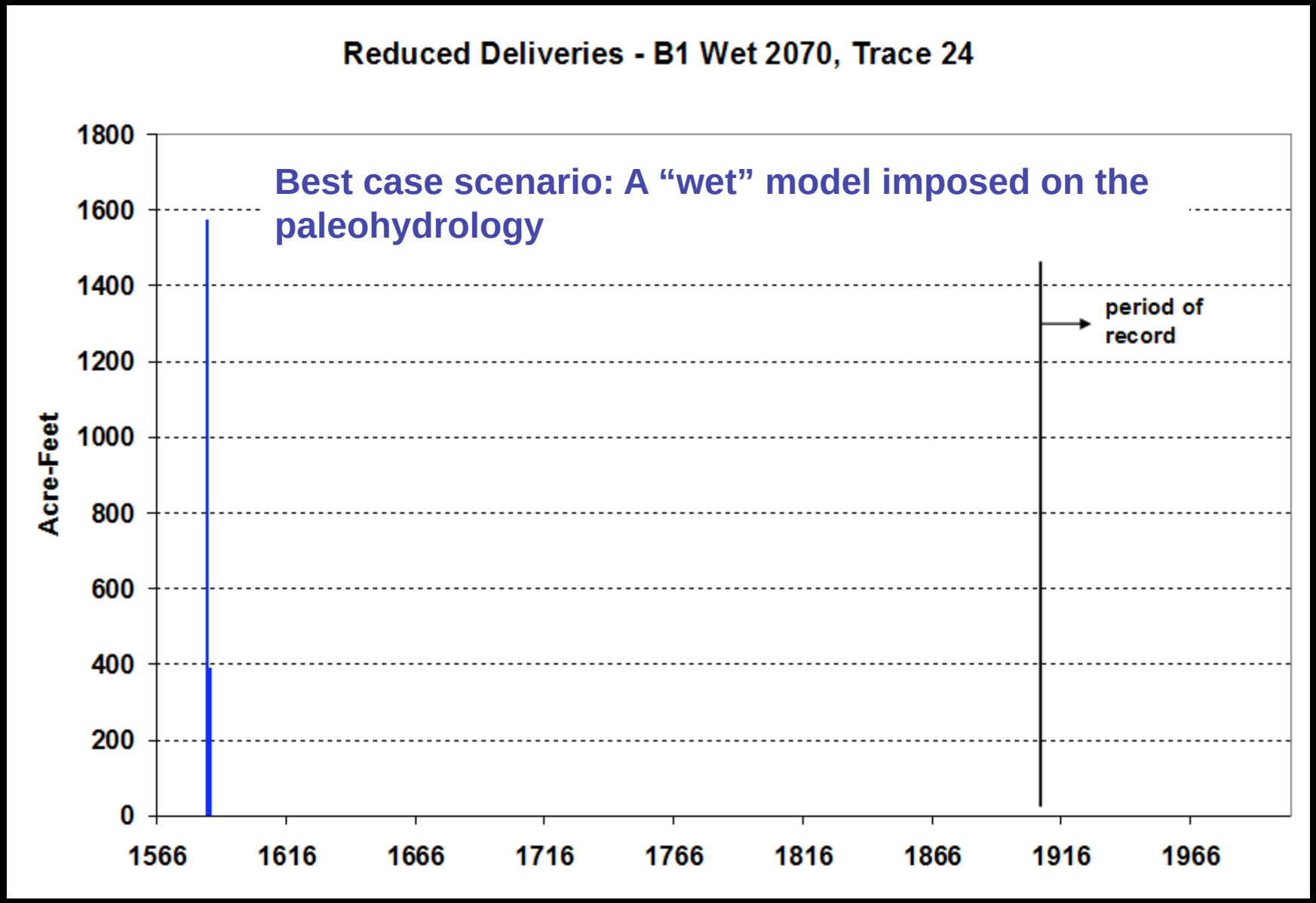
- Information about past natural hydrologic variability may be useful to plan for a future that includes climate change along with and increased demands on water resources.

- Combining paleohydrologic data and model projections can produce plausible scenarios for the future

Combining Paleohydrology and Climate Change Projections: an Example from the City of Boulder



Lee Rozaklis, AMEC Earth and Environmental



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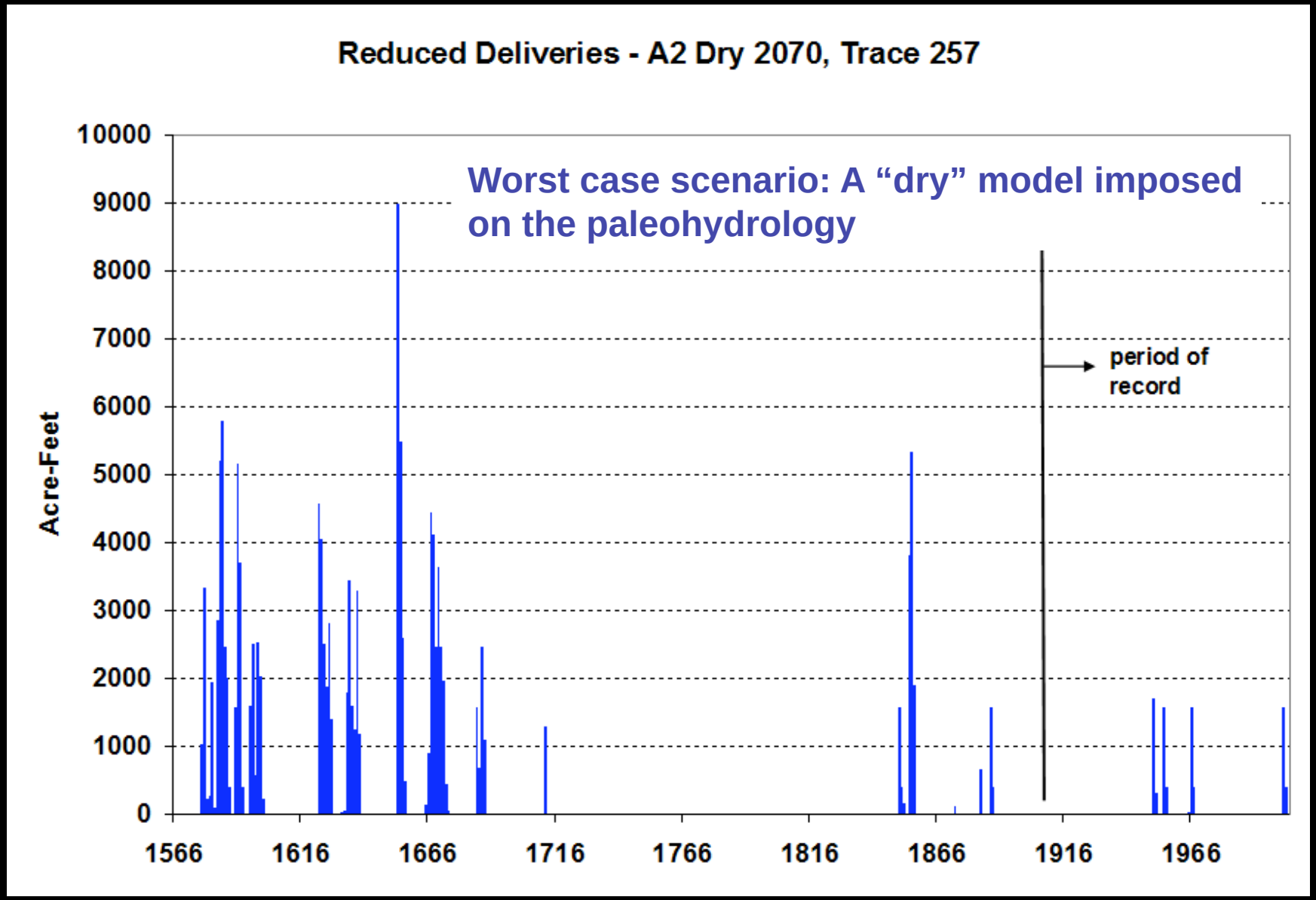
Reduced Deliveries - A2 Dry 2070, Trace 257
Worst case scenario: A "dry" model imposed on the paleohydrology
Acre-Feet
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
1566
1616
1666
1716
1766
1816
1866
1916
1966
period of record