

Climate Change and the Colorado River: Implications for Nevada

Nevada Water Resources Association
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Reno, Nevada

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Lake Powell Summer 2004, 120'
low, ~ 10 maf remaining, 15 maf
gone. B. Udall photo



Outline

- Water Cycle Changes
- Climate Change Studies
- Colorado River Conditions
- Closing Thoughts



Kanin

"Whoa, wbooa, wbooa, hold the phone. You're telling me that this whole time you've just been making up the boroscopes?"



globalchange.gov/usimpacts

This report summarizes the science and impacts of climate change in the U.S.

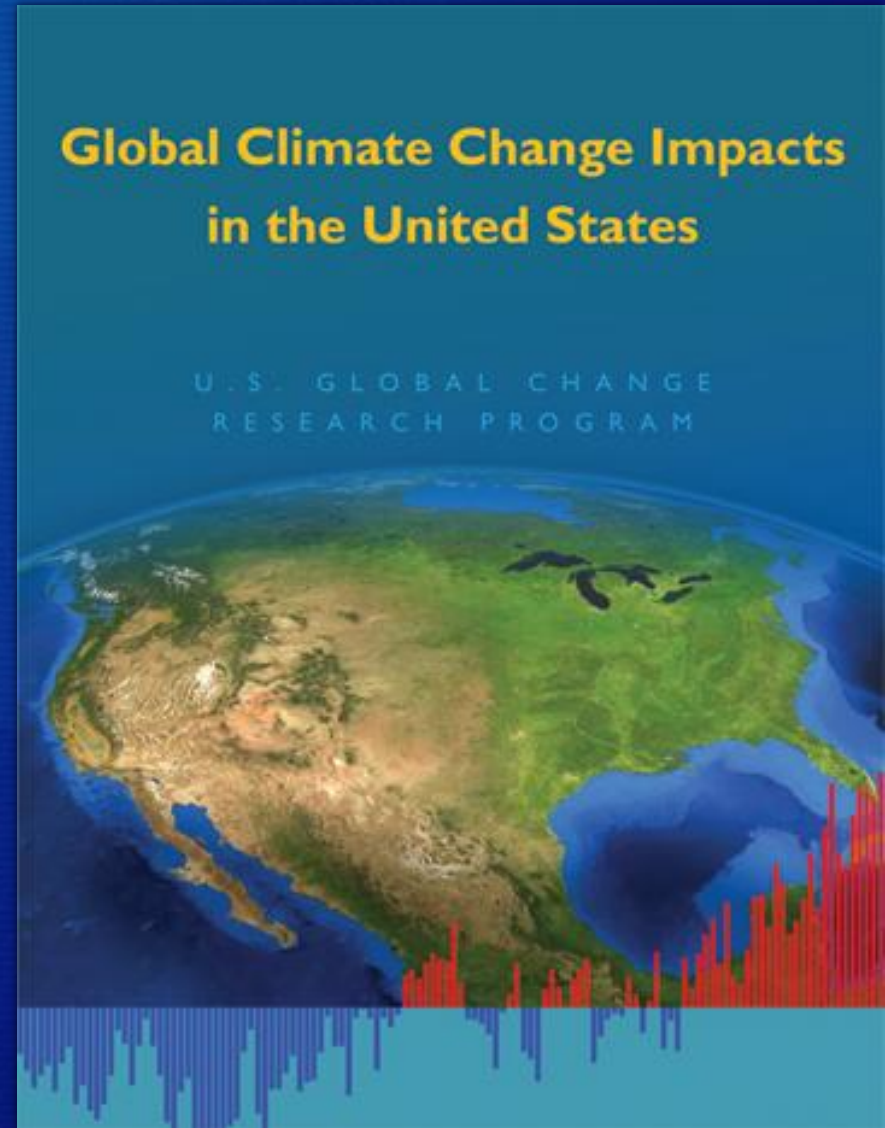
Plain language, authoritative

US Global Change Research Program report, led by NOAA

Extensive review: public reviews (2), blue ribbon expert review, federal agency (GCRP) review

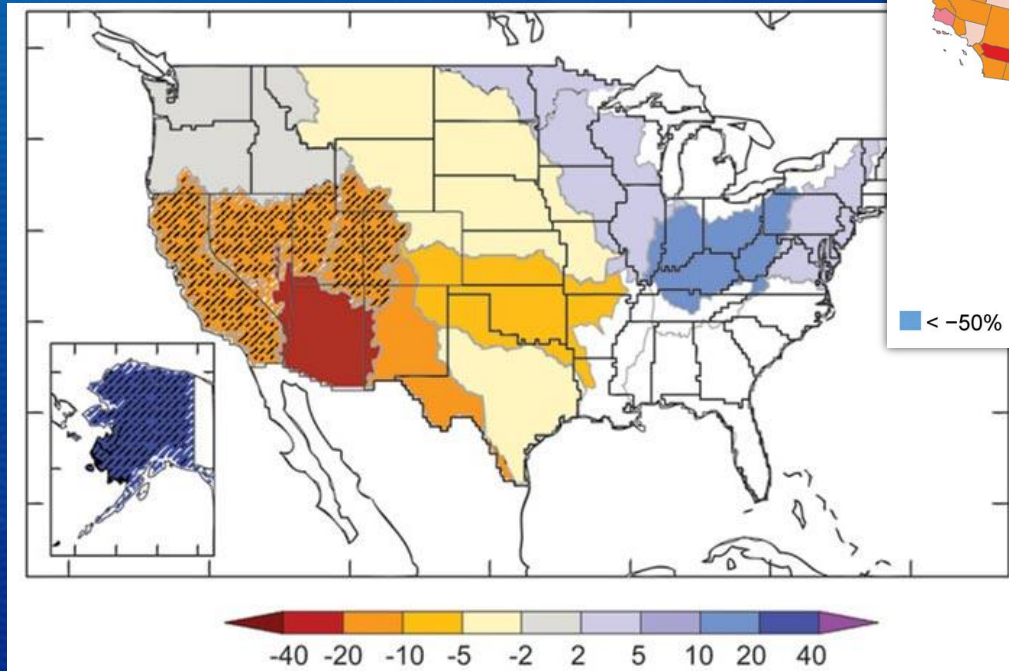
Draws from all previous assessments, global and national (IPCC, CCSP etc)

Author team was 31-members and included federal, academic and private sector experts

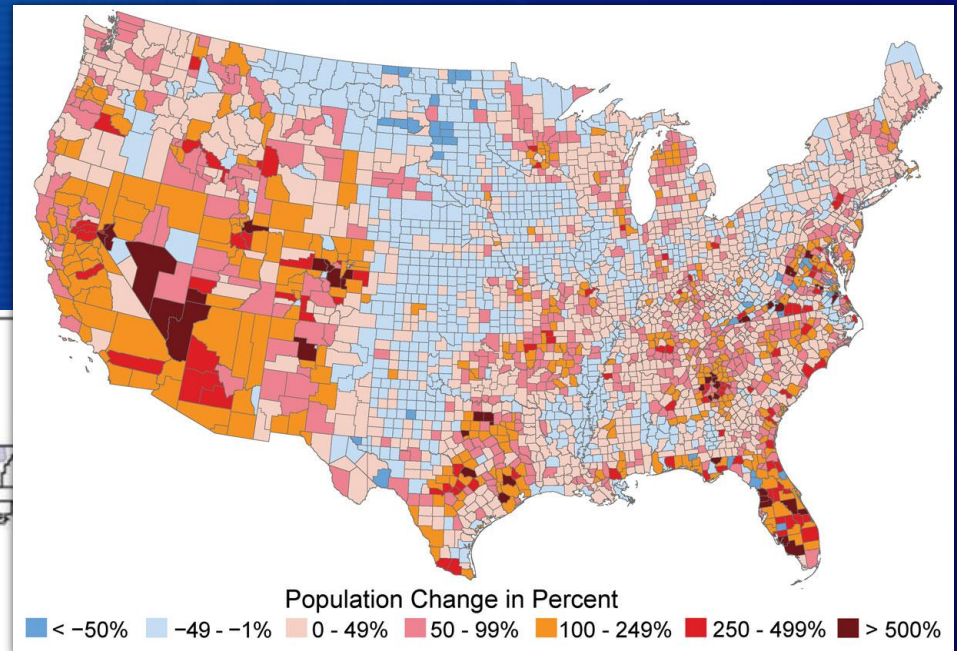


Climate change will stress water resources

Projected Changes in Annual Runoff

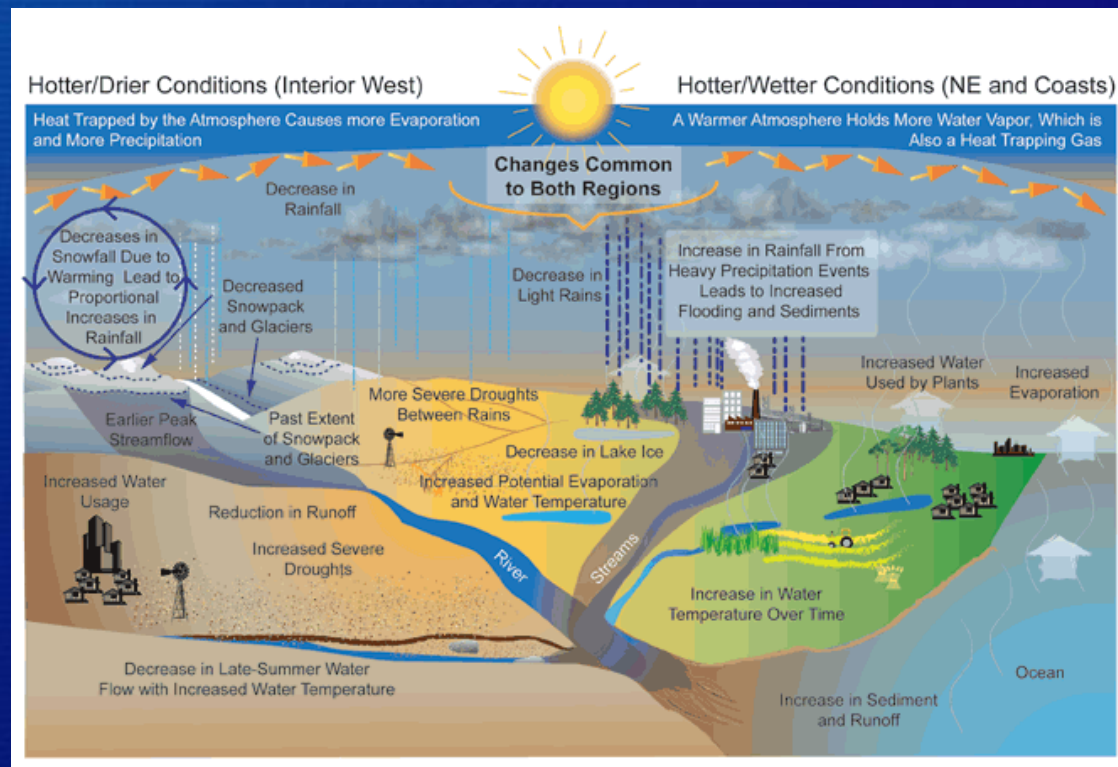


Change in Population from 1970 to 2008



The water cycle will change in fundamental ways

- The water cycle is a primary mechanism by which the Earth moves heat from areas with too much to areas with too little.
- A warmer climate means more water vapor in the atmosphere - every 1F increase means 4% increase in moisture holding.
- A warmer climate also means more evaporation, more precipitation GLOBALLY but regional losers.
- Storm tracks expected to move northward.
- Wet gets Wetter, Dry gets Drier.



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"Perhaps you'd like a second opinion?"



At Least 7 Colorado River Studies Since 2004...

....Runoff Declines Range from -6% to -45% by 2050

....Best guess now -10% to -20% by 2050



Climate Change in Colorado

A Synthesis to Support Water Resources Management and Adaptation

A REPORT FOR THE COLORADO WATER CONSERVATION BOARD



Colorado
University of Colorado at Boulder

TABLE 5-1. Projected Changes in Colorado River Basin Runoff or Streamflow in the Mid-21st Century from Recent Studies

Study	GCMs (runs)	Spatial Scale	Temperature	Precipitation	Year	Runoff (Flow)	Risk Estimate
Christensen et al. 2004	1 (3)	VIC model grid (~8 mi)	+3.1°F	-6%	2040-69	-18%	Yes
Milly 2005, replotted by P.C.D. Milly	12 (24) (~100-300 mi)	GCM grids —	—	—	2041-60	-10 to -20% 96% model agreement	No
Hoerling and Eischeid 2006	18 (42)	NCDC Climate Division	+5.0°F	~0%	2035-60	-45%	No
Christensen and Lettenmaier 2007	11 (22)	VIC model grid (~8 mi)	+4.5°F (+1.8 to +5.0)	-1% (-21% to +13%)	2040-69	-6% (-40% to +18%)	Yes
Seager et al. 2007*	19 (49)	GCM grids (~100-300 mi)	—	—	2050	-16% (-8% to -25%)	No
McCabe and Wolock 2008	—	USGS HUC8 units (~25-65 mi)	Assumed +3.6°F	0%	—	-17 %	Yes
Barnett and Pierce 2008*	—	—	—	—	2057	Assumed -10% to -30%	Yes

Values and ranges (where available) were extracted from the text and figures of the references shown. Columns provide the number of climate models and individual model runs used to drive the hydrology models, the spatial scale of the hydrology, the temperature and precipitation changes that drive the runoff projections, and whether or not the study quantified the risk these changes pose to water supply (e.g., the risk of a compact call or of significantly depleting reservoir storage).

When Will Lake Mead Go Dry?

Water Resources Research, 2008, Barnett and Pearce

- Water Budget Analysis
 - One 50 maf reservoir, increasing UB demands (13.5 in 2008 ->14.1 maf/yr in 2030, 15 maf /yr inflows, current starting contents
 - Linear Climate Change Reduction in Flows w/ some natural variability
- Results With Linear 20% Reduction in mean flows Over 50 years
 - 10% Chance Live Storage Gone by 2013
 - 50% Chance Live Storage Gone by 2021
 - 50% Chance Loss of Power by 2017
- Problems
 - 1.7 maf/year fixed evaporation plus bank storage
 - Missing 850 kaf/yr inflows below Lees Ferry
 - Reservoirs can and do recover, even with declining flows
- Critical Issues Regardless of these Results
 - System is close to Demand = Supply which has big implications
 - Normal climate variability can push us over the edge without climate change



Climate Change and Water in Southwestern North America Special Feature (free online)

Water, climate change, and sustainability in the southwest

Glen MacDonald

Roadmap for sustainable water resources in southwestern North America

Peter H. Gleick

Reclaiming freshwater sustainability in the Cadillac Desert

Sabo et al.

Future dryness in the southwest US and the hydrology of the early 21st century drought

Cayan et al.

Greenhouse warming and the 21st century hydroclimate of southwestern North America

Seager and Vecchi

A 1,200-year perspective of 21st century drought in southwestern North America

Woodhouse et al.

Forest responses to increasing aridity and warmth in the southwestern United States

Williams et al.

Vulnerability assessment of climate-induced water shortage in Phoenix

Gober and Kirkwood



“Paleoclimatic evidence suggests drought in the mid-12th century far exceeded the severity, duration, and extent of subsequent droughts... The convergence of prolonged warming and arid conditions suggests the mid-12th century may serve as a conservative analogue for severe droughts that might occur in the future.” ~Woodhouse et al.

Dry Times Ahead

Jonathan Overpeck¹ and Bradley Udall²

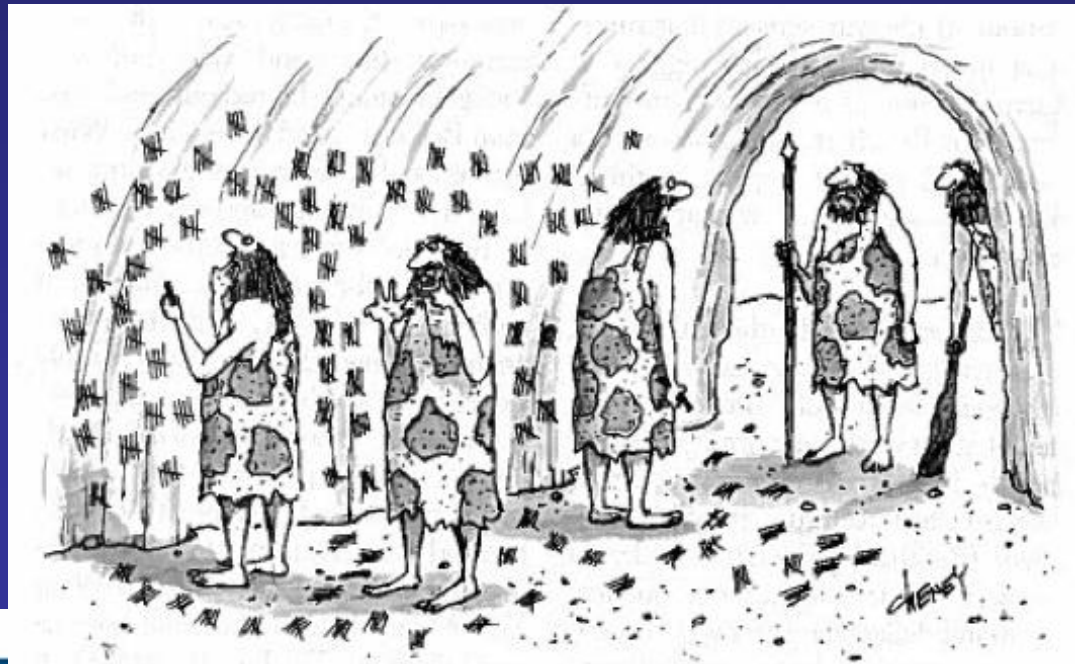
Science, June 25,
2010

The climate of the western United States could become much drier over the course of this century.

- 2F Warming since 1900
- Snowpack Reductions and Changes in Runoff Timing
- Most Severe Drought since records kept
- Powell and Mead at 50% of capacity now, full 2000
- Tree Mortality Rates High
- Increase in Wildfire Frequency
- Drought may be natural, but exacerbated by higher temperatures
- Snowpack Reductions and Runoff Timing attributed to climate change
- Continued drying likely as temperatures increase and storm tracks shift
- Megadroughts independent of climate change a possibility with severe consequences if combined with warming

Outline

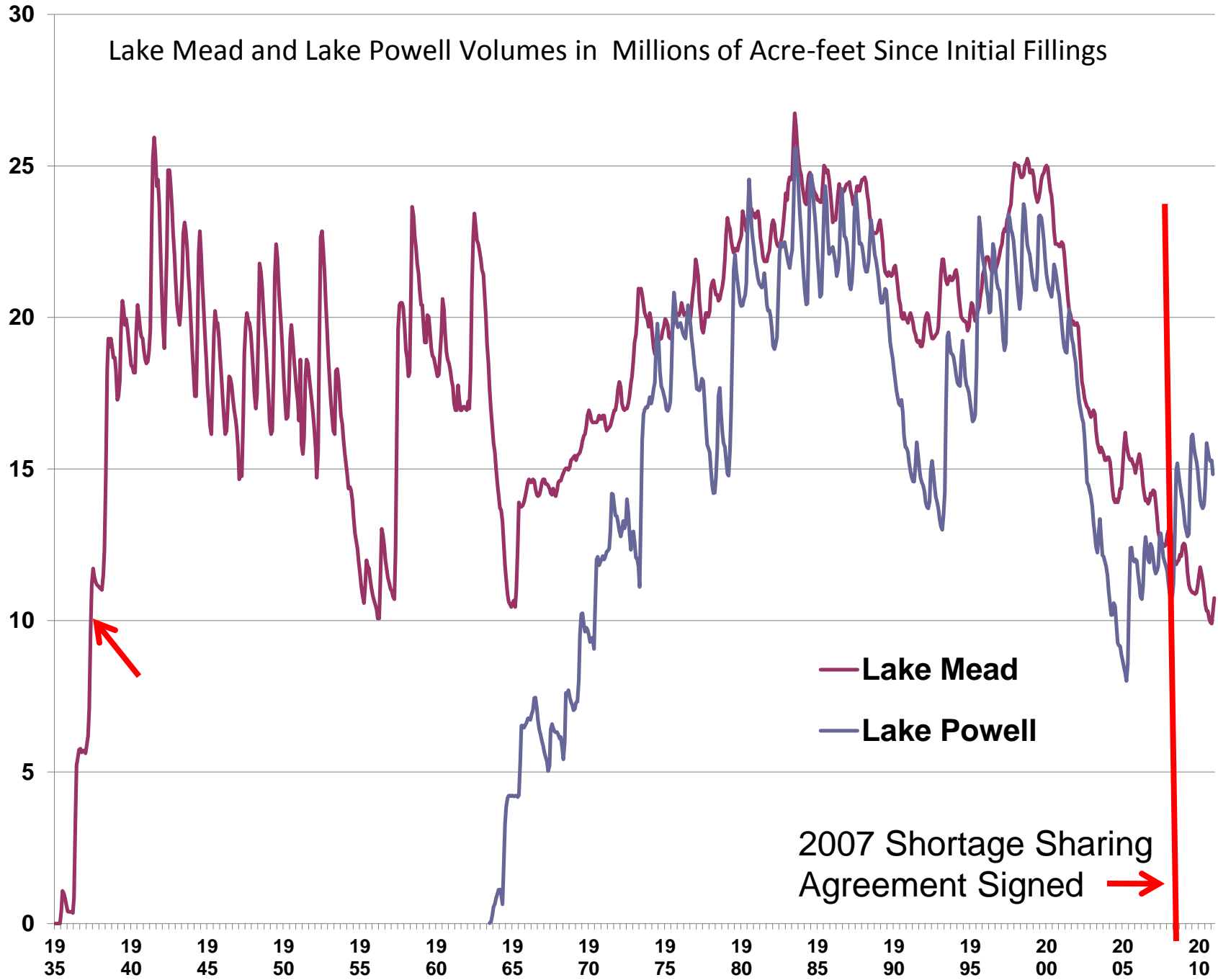
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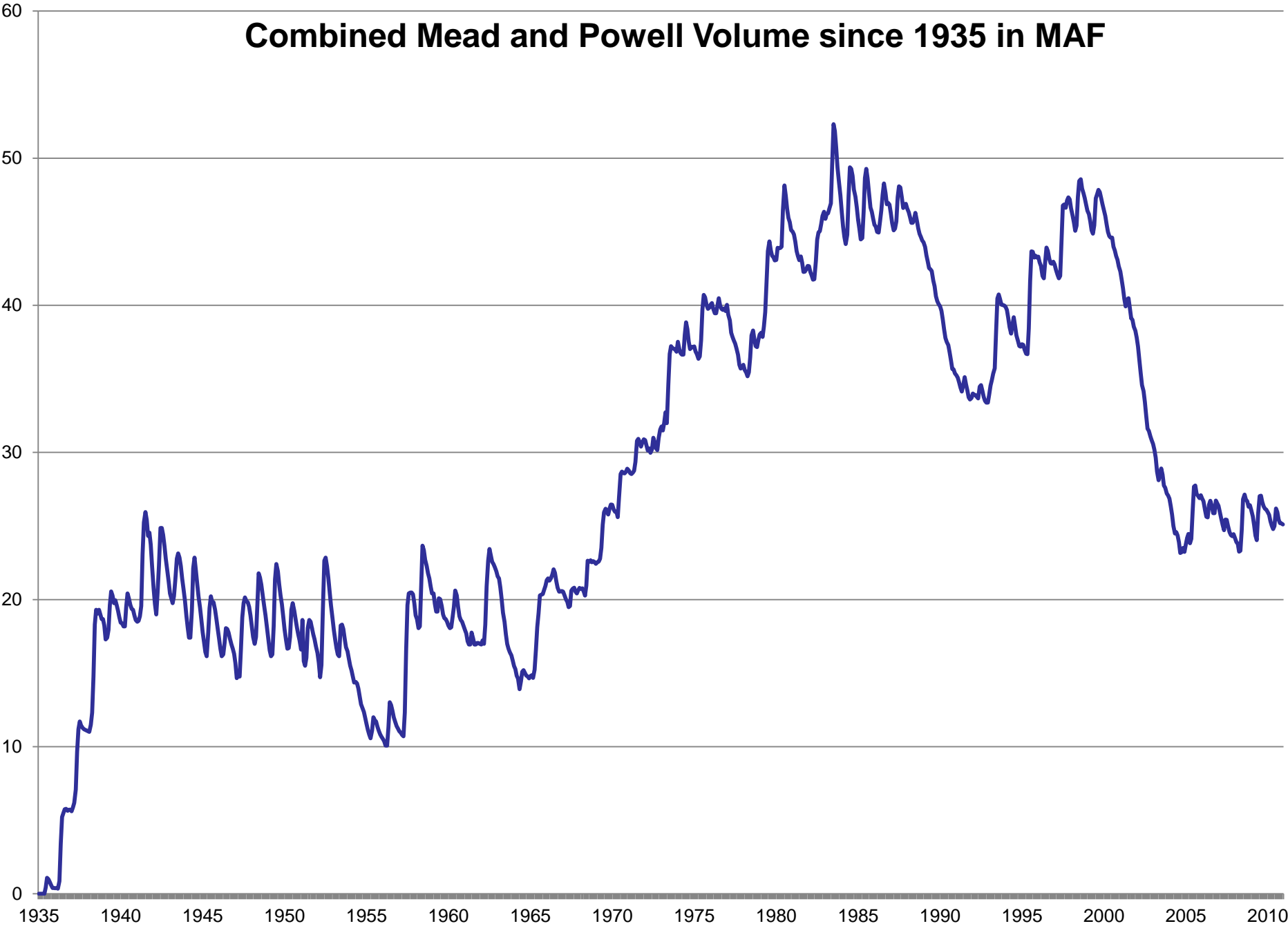
"It will take longer than we thought to go digital."



Lake Mead and Lake Powell Volumes in Millions of Acre-feet Since Initial Fillings



Combined Mead and Powell Volume since 1935 in MAF

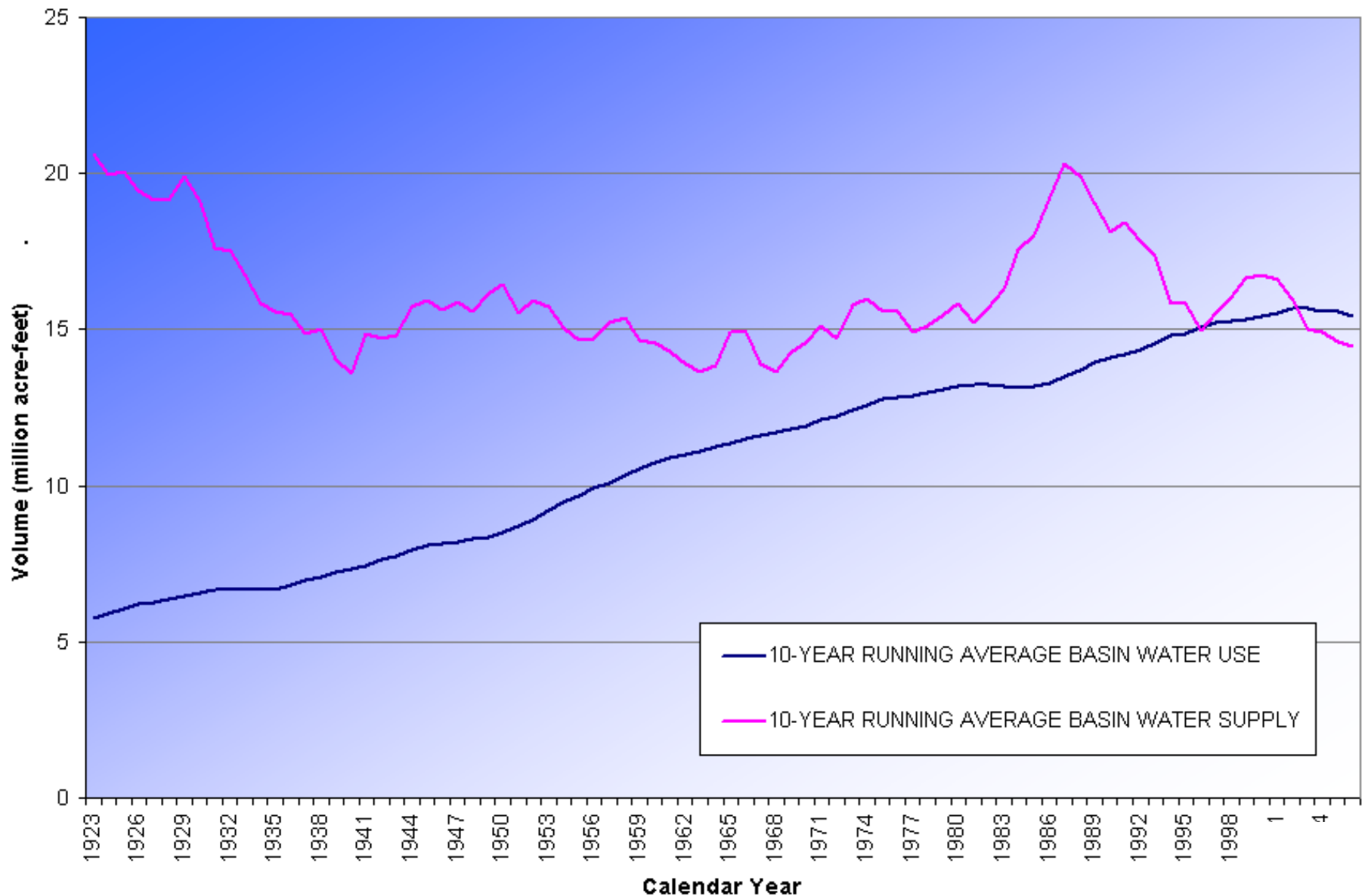


Colorado River Ten-Year Droughts Since 1906 at Lees Ferry

Take Home Message: This is by far the most serious 10-year drought in the historic record. 3.4 % Difference = 5 maf

Rank	% Average	10-Year Total	Start Yr	End Year
1	79.7%	119,081,504	2001	2010
2	80.0%	119,483,455	2000	2009
3	81.7%	122,048,340	1999	2008
4	82.5%	123,302,369	1998	2007
5	83.1%	124,090,505	1959	1968
6	83.1%	124,212,410	1954	1963
7	83.6%	124,880,374	1931	1940
8	84.4%	126,156,961	1953	1962
9	84.8%	126,645,471	1955	1964
10	85.3%	127,482,205	1958	1967

Colorado River Water Supply & Use



A Current Problem in the Lower Basin

- Avg Lake Mead Inflows = 9.0 maf
 - 8.23 maf from Powell (Current Operating Rules)
 - 0.77 maf tributaries below Powell
 - 9 maf is all the LB is legally entitled to
- Avg Lake Mead Outflows = 10.2 maf
 - 7.5 maf LB States (4.4 CA, 2.8 AZ, 0.3 NV maf)
 - 1.5 maf Mexico
 - 1.2 maf Evap + Delivery Losses
- Net Balance = **-1.2 maf/year**



October 18, 2010, 2:05 PM

Lake Mead Hits Record Low Level

By FELICITY BARRINGER



Jim Wilson/The New York Times

Bleached rock indicating a former high-water mark on outcroppings surrounding Lake Mead.

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- Water Cycle Changes
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- Science Issues
- Closing Thoughts



"You will make the same foolish mistakes you have made before, not only once but many, many times again."



Doug Kenney Talk at CRWUA, 2010

‘The worst speech ever received’ ~ National Public Radio

http://www.snwa.com/assets/swf/flash_player/player.html?flvName=crwua_5.flv

Water worries

The drying of the West

The Colorado River and the civilisation it waters are in crisis

Jan 27th 2011 | HOOVER DAM | From *The Economist* print edition



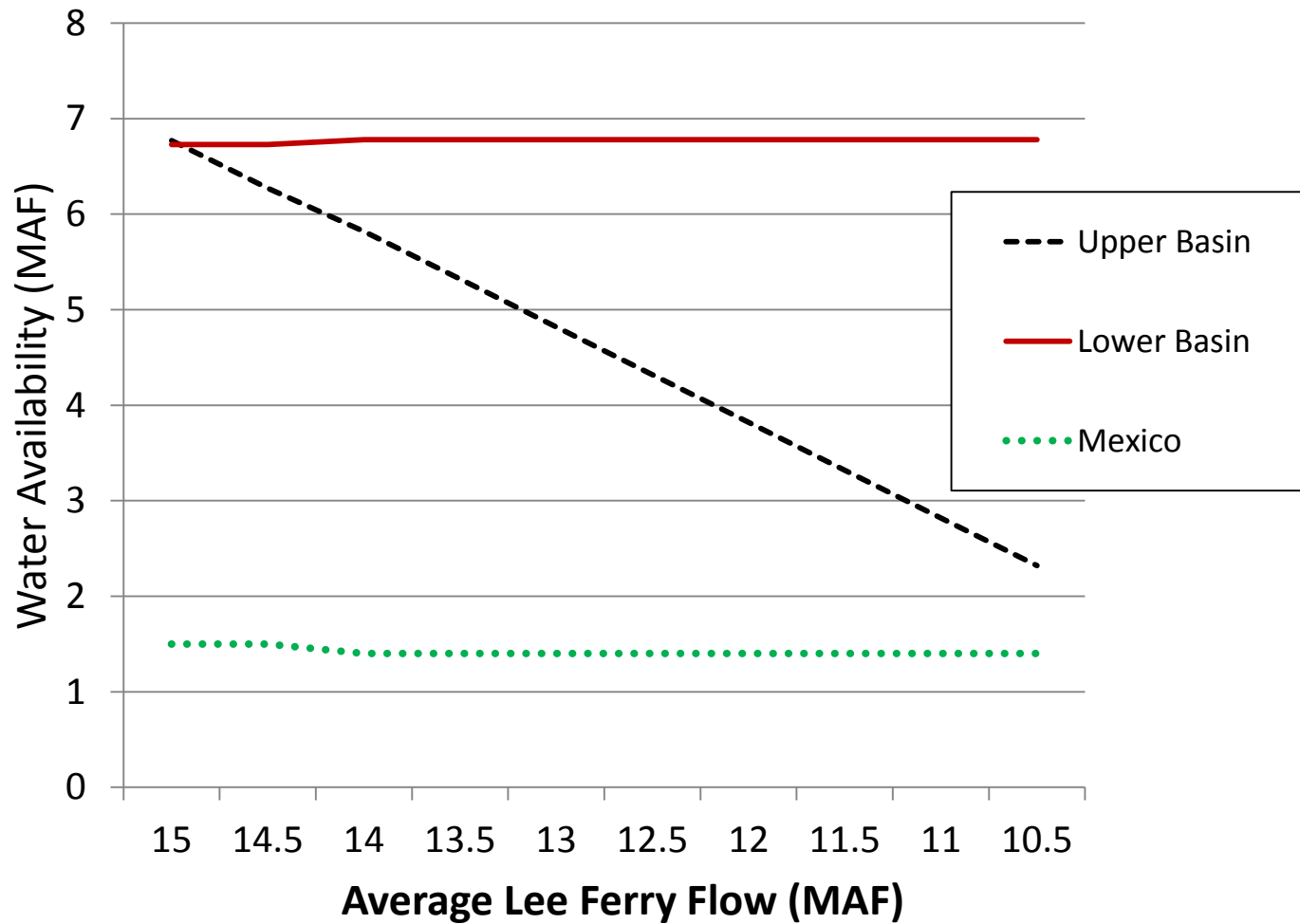
Alamy

That sinking feeling

STANDING on the Hoover Dam and looking upstream at Lake Mead, America's largest reservoir, the visitor notices a wide, white band ringing the cliffs. Nicknamed "the bathtub ring", this discolouration comes from minerals that were once deposited on the volcanic rock by the Colorado River and have become visible as its level has dropped. It is one sign of a water crisis that threatens America's south-west.

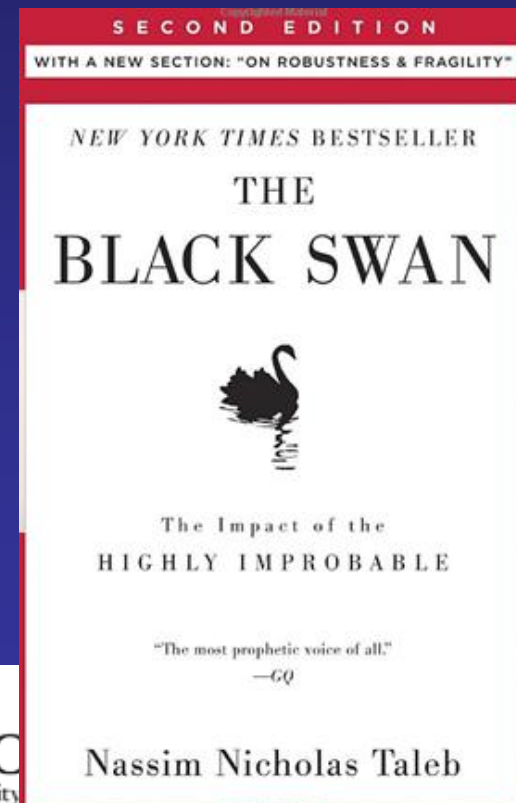


Upper Basin Climate Change Squeeze



Black Swans

- Society Changing Event – Outlier and Extreme
 - 2008 Market Crash
 - Gulf Oil Spill
 - 9/11
 - 2005 Tsunami
- Happen all the time and change history
- We fool ourselves into thinking that we can predict these
- Instead of predicting, need to adjust to existence
- We fixate on what we know, rather than what we don't know
 - Knowledge makes us more confident than we should be
- Will occur more frequently in 21st century
- Taleb loathes normal distribution
 - Poorly describes risk profile for many vulnerabilities
 - 'Fat Tails' Exist in many phenomenon
- Name comes from Australia and first sightings of Black Swans



Mysteries vs. Puzzles

Two Kinds of Problems

Malcolm Gladwell on Enron Collapse



Mystery: problem where the answer is obscured by lots of details. The answer is there but most of us can't see it.

Puzzle: problem where we are missing a crucial piece of information. We need to search for the information.

The solutions required are very different.

View climate as a mystery, not as a puzzle.

WITH A NEW AFTERWORD BY THE AUTHOR

The TIPPING POINT

*How Little Things Can
Make a Big Difference*

MALCOLM
GLADWELL

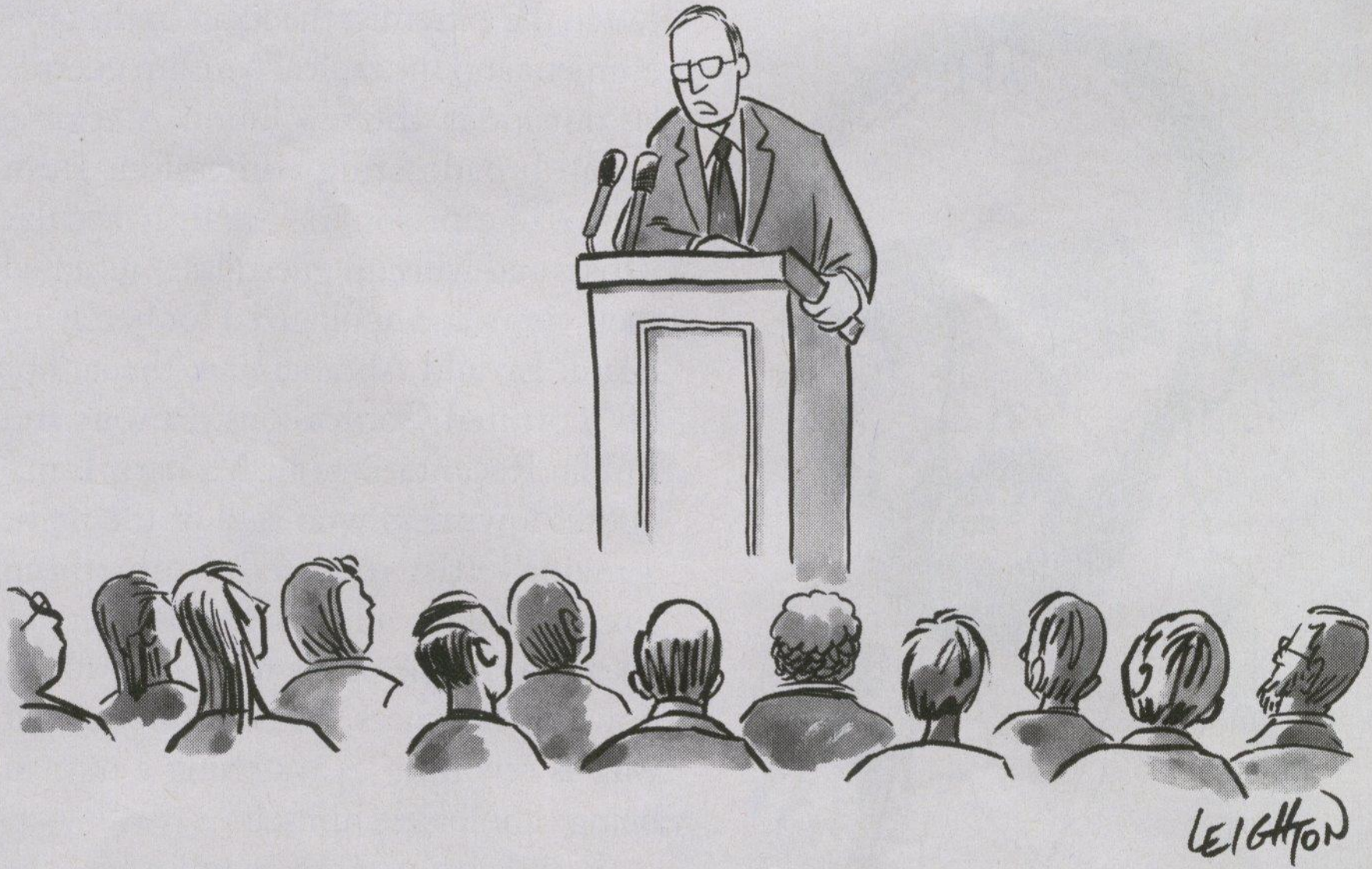
"A fascinating book that makes you see the world
in a different way." —FORTUNE

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Take Home Points

- Climate Change and the Water Cycle are Joined at the hip globally
- We expect fundamental changes in the water cycle with big implications for the American Southwest – think Hadley Cells, more floods and droughts
- Colorado River Flow is expected to decline in the 21st century
- Lake Mead likely to be at low levels
- Climate Modeling: Young science, critically important, can guide our thinking but not crystal balls
- Black Swans: Expect Surprises, think ‘fat’ tails
- Mysteries and Puzzles: Treat climate like a mystery when possible
- NV EPSCOR Program an important resource



"And now I'll open up the floor to softballs."

Models May Not Set Lower Bound on Future Runoff

Victorian Murray River inflows 1990–2055

