

The future Colorado River: Will it deliver?

Rising temperatures will put stress on both supply and demand

BY MELANIE LENART

Climate change could further humble the mighty Colorado, already bowed by the ongoing drought and shrunk by a growing population of Arizona users.

Currently, the Colorado River meets about two-fifths of Arizona's water needs, with groundwater providing another two-fifths and other rivers supplying most of the remaining demand. But the potential for rising temperatures to decrease the amount of water supplied by the Colorado while simultaneously increasing overall water demand has spread ripples of concern among those who monitor and model the Colorado and other Arizona water sources.

Much of Arizona's Colorado water flows through an open canal system known as the Central Arizona Project (CAP), which delivers river water to Phoenix, Tucson, and other cities, explained Katharine Jacobs during a December press briefing on warming and water supply that was organized by two University of Arizona groups: the Center for Sustainability of semi-Arid Hydrology and Riparian Areas (SAHRA) and the Climate Assessment for the Southwest (CLIMAS).

"In the context of Assured Water Supply determinations, the Arizona Department of Water Resources uses an assumption that the CAP is a reliable supply," said Jacobs, who worked for the ADWR for more than 20 years before joining the UA faculty last year. Under the Assured Water Supply determinations that apply to new subdivisions in central Arizona metropolitan areas, developers must show on paper that there's enough water to support their proposed subdivisions for 100 years.

The current drought already is challenging that assumption, as CAP water users would be the first to have their water supply reduced if a shortage were declared in the Lower Basin states of Arizona, Nevada, and California. The ongoing warming of the atmosphere adds to the uncertainty of the Southwest's water future, Jacobs explained.

"The big issue is whether we can store enough water to offset longer drought periods than we previously anticipated," she said.

Reservoir storage in Lake Powell and Lake Mead totaled about 23 million acre-feet as of Dec. 15, although only about three-fourths of what remains is accessible. In addition, Arizona has "banked" about 2 million acre-feet of Colorado water via groundwater recharge and other programs since 1996, said Timothy Henley, manager of the Arizona Water Banking Authority.

Reconstructions of past droughts based on tree-ring records indicate that two rivers supplying Phoenix with water, the Colorado and the Salt, can be in drought simultaneously, as CLIMAS Project Manager Gregg Garfin noted during the briefing, showing preliminary results of an analysis by Katherine Hirschboeck and David Meko of the University of Arizona Laboratory of Tree-Ring Research. The final results of the study are expected to be released publicly in early 2005 by the Salt River Project.

Governor Janet Napolitano also sees a connection between warming temperatures and regional water supplies and noted her concern in an aside following a Water Listening Session in Tucson last week.

"I'm concerned about climate change in a lot of different ways. I think the drought is certainly an outgrowth of

climate change," the governor said, adding that she believed national legislation was needed to address the problem. Nationally, the bipartisan "Climate Stewardship Act," cosponsored by Arizona Senator John McCain, calls for reduced emissions of carbon dioxide and other greenhouse gases that trap heat at the surface.

Greenhouse warming is expected to bump up the average annual temperature in the Southwest by about 3 to 4 degrees Fahrenheit over the next 45 years, according to an analysis by Martin Hoerling, Jon Eiseid, and Gary Bates of the National Oceanic and Atmospheric Administration (NOAA) that involved averaging four different global climate models.

The link between greenhouse gases and temperature is fairly predictable. Long-term temperature fluctuations tend to go up and down with atmospheric carbon dioxide levels in time, and temperature projections for the future mirror the growing accumulation of carbon dioxide and other greenhouse gases in the atmosphere.

The relationship between temperature increases and precipitation is less certain. While some climate models predict an increase in precipitation for the Southwest, others predict a decrease or a lack of change. However, most predict a greater proportion of rain compared to snow as spring arrives earlier in the year and fall lingers later. The decline in snow days could affect overall streamflow, as the Colorado River depends upon spring snowmelt for much of its annual volume (Figure 1).

But even if precipitation rates remained the same—or increased only somewhat—the projected change in temperature alone would impact water supplies, Jacobs noted at the briefing. An increase

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in annual temperature by 4 degrees Fahrenheit, as predicted by the NOAA analysis, could translate into a 5 percent or more increase in evaporation rates, based on calculations by Paul Brown of the UA's Arizona Meteorological Network, she pointed out.

Evaporation from streams and reservoirs consumed about 113 billion gallons (0.35 million acre-feet) in the Lower Basin from Hoover Dam on down during 2002, not counting the CAP system, based on figures in a U.S. Bureau of Reclamation report. A 5 percent increase would boost the amount lost to evaporation by another 5.6 billion gallons annually, enough water to theoretically support 70,000 southwestern residents. (There are about 326,000 gallons in each acre-foot of water, enough to support an average family of four for a year.)

Evaporation occurring before the water reaches the Colorado riverbed may prove even more important as climate warms. Evidence indicates the temperature increases will make the river more sensitive to changes in timing and amount of snow and rain, mainly by affecting the rate of water flowing from overland soils to streams, known as runoff.

Basically, drier soils tend to absorb more of the water inching toward streams, much as a dry sponge captures more moisture than a wet one.

For instance, a hydrological model developed by University of Washington researchers to represent the years 2010 to 2098 found allocations to the Lower Basin states could fall short one-fourth of the time in their climate change scenario. They paired the projected increasing temperatures with fluctuating precipitation rates that averaged about 4 percent lower than the norm for 1950 to 1999. This slight decline in precipitation yielded a 16 percent reduction in runoff.

The University of Washington model did not simulate a potential increase of rain-on-snow events, on the other hand. These events can cause floods that help fill reservoirs, although reservoir gains from these events tend to mean losses in groundwater recharge. At any rate, the sensitivity of the system should concern water managers, the authors note in their *Climatic Change* paper (March, 2004).

“The bottom line implication of the paper is that the system is in a very fragile equilibrium. Very small changes in precipitation are able to reduce the runoff so the system is no longer in equilibrium,” explained Professor Dennis Lettenmaier, one of the five researchers who designed and tested the model.

Runoff tends to decline at a faster rate than precipitation decreases, in reality as well as in their model. For instance, the mere 1 percent decrease in precipitation in the Colorado River Basin during 1995 that they cite in their paper translated into a roughly 7 percent drop in basin-wide streamflow that year, based on U.S. Bureau of Reclamation data.

Meanwhile, warming temperatures are likely to increase demand for water by both agricultural and urban users, as Jacobs and SAHRA colleague Gary Woodard noted during the briefing. Agriculture accounts for about 70 percent of Arizona's water use and 80 percent of the state's Colorado River use. Applying the 80 percent ratio to Arizona's annual allocation of 2.8 million acre-feet would make this about 730 billion gallons.

Of this, about 400 billion gallons of water a year evaporate from croplands, judging from USBR data for 2002. The 5 percent increase in evaporation

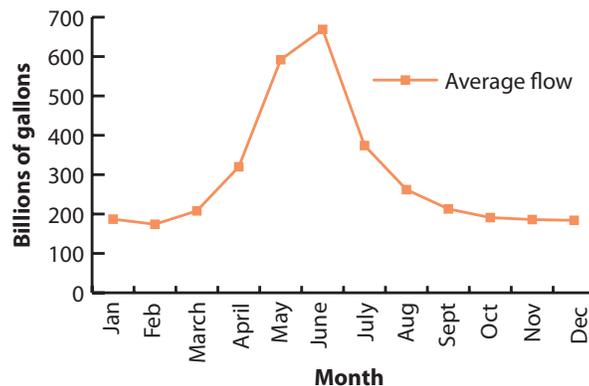


Figure 1. Values for average monthly flow of the Colorado River, above, are based on U.S. Bureau of Reclamation monthly reconstructions for 1922–2003, using actual measurements of streamflow at Lee's Ferry, Arizona, coupled with reports of withdrawals by Upper Basin users. Most of the Colorado's volume comes during spring and summer, as snow melts on the Rocky Mountain peaks that provide the bulk of the river's volume. This makes the river sensitive to changes in snow cover.

rates that could accompany a 4-degree-Fahrenheit temperature increase, then, could consume roughly 20 billion additional gallons.

At the same time, higher temperatures will stretch out the growing season, as spring comes earlier and fall stays later. This can lead to increased water demand for urban landscaping, Woodard said. Although the higher carbon dioxide levels actually improve the water efficiency of plants, the potential water savings from this factor may well be lost to the longer growing season, he said.

Higher evaporation rates will boost water demand among pool owners as well. Further, higher temperatures will increase the demand for electrical power, which consumes water through cooling towers, Woodard noted. Cooling towers become less efficient with warmer temperatures, he added.

The future Colorado River could be stretched thin for other reasons in addition to rising temperatures, including policy changes and growing population. At this point, Arizona is using all of its annual allocation (Figure 2), although some of it goes for groundwater recharge programs.

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Tribal needs will be a source of demand in years to come. This increase will expand as officials from many sides negotiate and litigate to implement a policy that has technically been on the books for decades: carrying out the promise to share Colorado River water with the American Indians living on Arizona's many reservations.

By some accounts, the annual amount of Colorado water owed to the various tribes surpasses the 2.8 million acre-feet allocated to the entire state. By all accounts, tribal rights to a share of the Colorado can only increase in years to come. Legal wrangling continues while some reservation residents continue to haul water to their homes.

When groundwater is factored in, most of the increasing demand for water in the future seems likely to come from population growth as developers build new subdivisions around the state.

"We anticipate that the Arizona population will continue to grow at the rate it has in the last decade," the governor told those attending the Water Listening Session in Tucson. A repeat of the last decade's 37 percent increase would grow the state population to about 8 million people by 2014, up from 5.8 million in 2004, according to statistics from the Arizona Department of Economic Security.

Although public officials tend to talk about population growth as though it's unavoidable, some area residents aim to slow the pace to a "managed growth."

For instance, 6 of the 17 people who addressed the governor during the listening session cited concerns that nearby developments were threatening local groundwater stores, and most of these comments received a hearty round of applause from the 100-plus people in attendance. Conservation of water and riparian areas was the only theme that

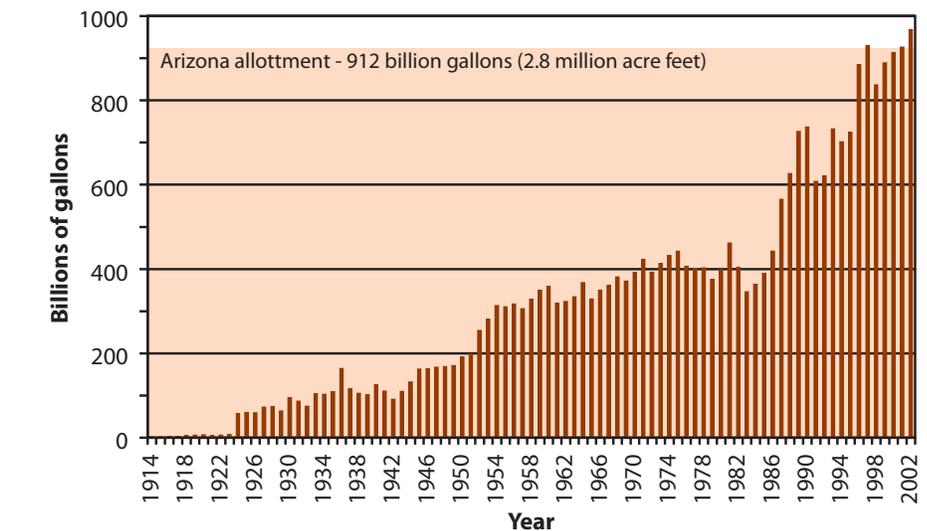


Figure 2. The proportion that Arizona uses of its 2.8-million-acre-foot Colorado River allocation has climbed in recent years. In years of declared surplus, it can even exceed the allocation. Some of the increase in use since 1996, however, relates to "banked" Colorado water as part of an Arizona program to recharge groundwater. Source: U.S. Bureau of Reclamation data.

received more commentary, with nine people weighing in, not counting those who pointed accusing fingers at golf courses. A few tackled both conservation and population growth.

"Existing people have to reduce their existing use in order to allow other people to come in," said area resident Tricia Gerrodette, who likened living amid the limited resources in the desert to being on a lifeboat. "At some point, if you allow too many people on that lifeboat, everyone will die."

Humans have the advantage of being able to walk, drive, or fly away from a region with dwindling water resources, but many other species are less fortunate. The ongoing climate change could prove fatal for some native riparian species, especially when coupled with the continuing diversion of water out of the river and into cities and croplands.

For human residents of the Southwest, the likely outcome of future shortages is an increase in the cost of water as the regional bidding for a scarce resource becomes more competitive.

As Robert Glennon, a UA law professor and the author of "Water Follies" noted, planners of a resort near the Grand

Canyon would have been willing to shell out \$20,000 to buy and transport each acre-foot of delivered surface water. (The deal fell through following a Sierra Club lawsuit.) That's quite an increase from the \$15 an acre-foot typically paid by an Arizona farmer, he pointed out.

"This development offers a clear vision of what lies ahead. Water is worth a lot more money than people have realized," he wrote in his 2002 book. "Even though water is a scarce commodity, most Americans have not yet faced the conditions that economists call scarcity, which occurs when people alter their consumption patterns in response to price increases."

Southwesterners can expect the era of cheap water to end in the next decade or so, given the guaranteed increase in demand and the likely decrease in supply facing the growing number of users of the Colorado River in Arizona.

Melanie Lenart is a postdoctoral research associate with CLIMAS. For more on the connection between climate change and western drought, see the December 2003 feature article at http://www.ispe.arizona.edu/climas/forecasts/articles/climatechange_Dec2003.pdf.

