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Half Empty or Half Full?

Water managers are looking for ways to supply enough water to the thirsty — and booming — West.

By Allen Best

It's impossible to stand atop Hoover Dam, looking at the Colorado River 565 feet below, without being struck by the great cleverness of your own species. Consider the audacity of plugging this giant chasm on the Nevada-Arizona border with concrete, producing as much electricity as two large coal-fired power plants, and creating a giant pond in the sweltering desert that has enabled the tremendous explosion of cities and farms from Tucson, Arizona, to Los Angeles, California.

But whether Hoover Dam will remain useful is another matter. At the beginning of this summer, Lake Mead, the reservoir created by the dam, was only half full. The dipstick upstream at Utah's Lake Powell was even lower. The reservoirs by now are both above average again, thanks to snowpack in the mountains of Colorado, Wyoming, and Utah. It is, however, only the second above-average runoff the river has experienced in the 21st century.

Two scientists from the Scripps Institution of Oceanography say it could get worse. The researchers, Tim P. Barnett and David W. Pierce, in February reported a 50 percent chance that Lake Mead could become functionally worthless within 13 years. They based their findings on increasing demand coupled with climate change models showing increasing drought.

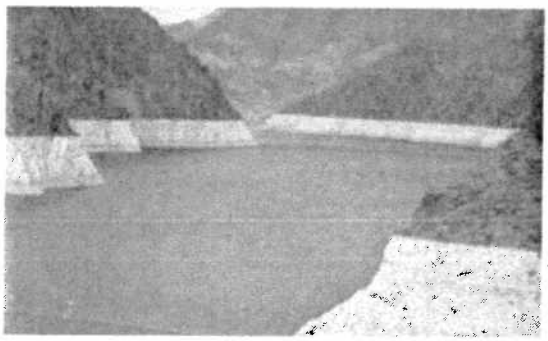
Most water experts say that prediction is unjustifiably grim. Still, if dour, the study does jibe with what water managers and climate experts from Seattle to Denver are saying: The past is no guide to the future.

Hoover Dam was a testament to determination and brilliant engineering when it began producing electricity in 1936. The nation's total population then was 128 million. Of that, eight million lived in the seven states drained by the Colorado River. Today, dams aren't obsolete, but many water experts say dams alone won't solve our water and energy needs at a time when the population of the states in the Colorado River Basin has grown to 55 million — and with a projected increase to nearly 73 million by the year 2030.

Conservation is crucial. Alternatives may include mass-distributed, low-flow showerheads, stormwater systems that help recharge underground aquifers, or domestic rainwater collection systems. The future is likely to bring different landscaping requirements and aesthetics, greater water recycling, and more aggressive pricing schedules. Tucson already gives customers incentives to use water sparingly.

Other choices include drip-irrigation technology, which may be embraced more broadly by the agriculture sector. And desalination, while still extremely energy intensive, may play a broader role in creating freshwater as membrane technology is improved. Technology can certainly help the West, says Stacy Tellinghuisen, water and energy analyst with a nonprofit group called Western Resource Advocates: "A lot of technological processes can improve our water efficiency, both at home and in commercial applications and industrial operations."

Climate change



Growing populations are a given. Climate change is more of a wild card. The Southwest is already getting hotter, and is forecast to get much, much hotter, but precipitation is a question mark. Even so, hotter conditions almost certainly will mean drier conditions. And that may force improved cooperation between water managers and planners as they seek to adapt to rapidly changing climates.

The instinct of many communities is to expand their water supplies. Douglas Kenney, director of the Western Water Policy

Program at the University of Colorado at Boulder, notes at least four different proposals for new pipelines that would transport water hundreds of miles from the Colorado River and its tributaries to serve rapidly growing urban populations. He says that it's common for water managers in dry areas to hunt for remote water sources, but he favors another approach.

"I am just convinced that augmenting supplies is not the first place to look," Kenney says. "You have to reduce demand. If that's where you start, there has to be a stronger connection between land-use planning and water planning."

But any solution to climate change should offer multiple benefits, says Paul Fleming, manager of climate and sustainability for Seattle Public Utilities. "As we try to address the challenge of climate change, it's worth thinking about the opportunities of how to shape our cities, so that the approaches we pursue are multifaceted."

Consider one aspect of global warming. Warmer clouds can carry up to 30 percent more precipitation. Nearly all climate change models predict more intense, if perhaps less frequent, storms. Existing storm sewers might well be overwhelmed by such storms. The expense of replacing them would be enormous. One solution might be to integrate marshy swale areas into urban landscapes, providing a means to absorb stormwater but also delivering other benefits to green-starved city dwellers.

"The effects of climate change are real and getting worse," says Peter Gleick, president of the nonprofit Pacific Institute, based in Oakland, California. For all the progress made in the last century, he says, we now need new answers. "The old ways of thinking about water — the tools, the technologies, the messages we used to talk about water in the 20th century — aren't adequate."

Even a few years ago, most water providers scoffed at the notion of climate change. But that has changed, as indicated by the coalescing of eight of the nation's largest water providers, seven of them in the West, into a group called the Water Utility Climate Alliance. The alliance, which includes Denver, Metro Water District of Southern California, New York City, Portland, San Diego, San Francisco, Seattle, and Las Vegas, hopes to improve research into the impacts of climate change on water utilities, develop strategies for adaptation, and implement tactics to reduce greenhouse-gas emissions.

"Our systems are facing risk due to diminishing snowpack, bigger storms, more frequent drought, and rising sea levels," says Susan Leal, former general manger of the San Francisco Public Utilities Commission. "We need to be organized to respond to these risks. That's why we've formed this alliance."

In May, the alliance and seven other water agencies, including the American Water Works Association and the Association of Metropolitan Water Agencies, called on Congress to "ensure that water resources are a central element of any federal legislation that establishes a framework for comprehensive national responses to climate change." The existing needs for investment, said the agencies, will only be exacerbated by a changing climate.

What the models say

If the past is no sure indicator of the future, it's still worth looking at. The beginning and end of the 20th century were unusually wet in the Colorado River Basin. High water levels from 1905 to 1920 were an assumption behind the compact that governs allocation of the river between the lower-basin states of Nevada, Arizona, and California and the four upper-basin states of Utah, Wyoming, Colorado, and New Mexico. In fact, the 16.5 million acre-feet of average annual flow of the Colorado River presumed by that document has rarely occurred.

Another exception took place late in the century. Heavy spring runoff nearly tore out Glen Canyon Dam in 1984. Water surpluses by the late 1990s were such that federal and state officials in the basin began devising criteria to govern water allocation.

Then came drought as the 21st century began. The drought has been uneven across the basin, but in its totality is now beginning to resemble droughts of long ago, calculated from the study of tree rings.

Connie Woodhouse and David Meko of the University of Arizona and other dendrochronologists have used the tree rings to reconstruct stream flows back to 762 A.D. — and to figure out when droughts occurred.

One intense drought from 1276 to 1300 helped persuade Native Americans to abandon their Four Corners cliff dwellings for homes both east and south, says Jeff Dean, professor of dendrochronology at the University of Arizona's Laboratory of Tree Ring Research.

What caused those ancient droughts is unclear. The concern is that lengthy droughts, with flows reduced by as much as 15 percent for extended periods, could empty lakes Mead and Powell.

Looking forward, global climate change models are predicting a change in regional weather patterns: The American West will get hotter, a trend already observed during the last 50 years. This will be especially true in the Southwest. Few places in the globe are expected to see such accelerated heating. Also, winter will be shorter and the snowline in the mountain ranges will rise. More precipitation will arrive as rain, not snow.

Western river systems currently depend on winter snowpack — 70 percent, in the case of the Colorado River. Already, runoff arrives 20 days earlier than it did a half-century ago in some places. The effect is more pronounced on the West Coast. "We are already seeing evidence that the peak may be migrating into March. So our snowpack-building season is compressed," says Mike Anderson, state climatologist in California.

Earlier springs are a headache for water managers. To prepare for late winter floods, they will need lower reservoirs when runoff begins. That may leave them less prepared for the longer, dry summers. Water management in local areas, and across the West, will be trickier.

Changes in the annual cycle can cause problems even in areas without reservoirs. Kenneth Strzepek, an associate professor of water resources engineering at the University of Colorado at Boulder, has done modeling for the Boulder Creek watershed. Some 75 percent of the precipitation comes in the form of snow generated in a very small area near the Continental Divide. The water is used to nourish Boulder, a city of 100,000, but also farmers on the high plains.

Snowmelt runoff by 2050 is likely to occur perhaps a month earlier, Strzepek adds. In turn, summers will be hotter, longer, and drier, with a one to two percent loss of water to evaporation for every one degree Fahrenheit increase in temperature. While older, senior water rights were traditionally worth more money to farmers, there may be too little water left in creeks and rivers by late summer to bring crops to harvest. Agriculturalists with storage rights in reservoirs may be the winners, says Strzepek.

His research underscores the point made by Douglas Kenney of the Western Water Policy Program. "In western water law, the priority system of allocation is all about winners and losers. And when it comes to climate change adaptation, there will be winners — those places with resources to invest in infrastructure," says Kenney. Cities like Las Vegas aren't going to suffer because they have the money to buy their way out of trouble, he says. "But the environment may suffer," he adds. "Some rural areas will suffer. Some tribal areas might suffer. But what we know is that we're not in this together."

The trouble with precipitation

Just how much snow and rain will fall is unknown, partly because scientists do not fully understand how clouds work. In general, climate models show more precipitation in the northern reaches of the West. In the Southwest, climate models are all over the map. But even center-of-the-road projections see at least a modest decrease, if only because of a greater evapotranspiration rate.

U.S. Secretary of the Interior Dirk Kempthorne, in a speech last December in Las Vegas, predicted a 15 percent decline in Colorado River flows. Research released this year by two University of Washington researchers, Niklas Christensen and Dennis Lettenmaier, found a smaller decrease in runoff, but also noted that any decrease would have exaggerated consequences for the reservoirs.

That's why the predictions about Lake Mead going dry cannot be ignored. Reservoirs in the Colorado River Basin can collectively hold up to four times the river's annual average flow, and 85 percent of that storage is in Mead and its companion, Lake Powell. Yet, as demonstrated by the current drought, during which Lake Powell at one point fell to just 33 percent of capacity, the reservoirs provide only a cushion, not a fail-safe

backup.

Making this point is Brad Udall, managing director for the Western Water Assessment. "The system as it is now is on a knife-edge, even with existing flows. That is the key point. Even normal climate variability can push it over the edge," he says.

Udall is the nephew of Stewart Udall, interior secretary in the 1960s, when Glen Canyon Dam was built, and son of the late Morris "Mo" Udall, a former Arizona congressman who lobbied for the Central Arizona Project. The giant dams of the West are part of Brad Udall's family legacy. But he also sees the limitations of that vision. The past remedies, he says, cannot solve today's problems because additional storage will be only a minor part of adaptation to climate change. "My advice is don't think you're going to build our way out of this, because you're not."

The Pacific Institute's Peter Gleick also advises that we rethink water supplies. "To those who think the solution to our water problems is doing more of what we've already done, I would like to argue that they're wrong," he says. Instead, he offers another idea: The best reservoirs of the future might be those aquifers being depleted today.

"We need to be thinking about conjunctive use of groundwater and surface water," Gleick says. In wet years, water can be pumped into the aquifers, a practice already under way in parts of the West. Then, in dry years, those aquifers of semiporous sandstone can be sucked for their moisture.

Gleick also urges greater reuse of water — to irrigate parks, farms, and golf courses, and to create additional sources of drinking water. California may be on the forefront of recycling wastewater. (See "Spigot to Spigot" in this issue.)

Crimping the demand curve

Water demand is always a knotty issue. Many argue that the extensive system of reservoirs in the West, built with generous federal subsidies, has resulted in our putting too low a value on water there.

Gleick says this attitude is changing and can change even more. "The U.S. today uses less water than we did 25 years ago — for everything — and our population has grown 35 percent and our economy has gone up exponentially," says Gleick. "We have broken the curve between water use and population growth and economics, and we can do a lot more."

It used to take 200 tons of water to make a ton of steel. Now, it takes 10 to 15 tons. It used to take 30 gallons of water to make a square inch of semiconductor, and now it takes five or six gallons. "We have barely scratched the surface in efficient toilets and showerheads and all kinds of things," says Gleick. Drip irrigation is used in 70 percent of California vineyards. "We're even starting to grow cotton with drip irrigation," he says.

Greater water scarcity may also shift crop and hence food selection. "It takes 1,000 tons of water to grow a ton of grain," Gleick says. "It takes 18,000 to 20,000 tons of water to grow a ton of beef." Water officials in Colorado say 85 to 90 percent of the state's water is still used for agriculture in some form, a majority of it to grow corn that is used to feed cattle — or, more recently, to make ethanol.

Some pain, some gain

Even without the specter of a changing climate, water allocations in the West have been shifting from farm to city for decades. In many of these cases, farmland has dried up. But increasingly, cities and farms have invested in more efficient water delivery and irrigation practices, with the savings being transferred to growing cities.

Urban landscapes could use less water, too. Irrigation of lawns remains the top water use in most cities. In response, many cities promote what is generically called climate-appropriate landscaping. Denver, which gets only 13 to 15 inches of precipitation a year, created a xeriscaping program in the late 1970s.

Liz Gardener, suburban conservation coordinator for Denver Water, says that with careful planning, home owners can reduce their water use by 30 to 60 percent and still have fantastic landscapes. The key, she adds, is using regionally appropriate plants and designs.

Xeriscaping need not be just rocks and cactus plants, and can include grass, Gardener says. It is important that landscapes remain viable for decades. "The big shrubs and things like that will probably last — if they are planted in the right places. And I don't mean in a three-foot median," she adds.

Coping with uncertainties

Computer models calculate precipitation levels, among other things, but until recently those models were so coarse that the Sierra Nevada, Cascade Range, and Rocky Mountains — with strings of 14,000-foot peaks — have been nothing more than tiny bumps in the computer simulations. In reality, of course, dramatic changes in topography can produce similarly stark variations in precipitation within just a few miles. The effects of a changing climate could well be uneven.

"You don't get any of the detail in the global climate models that exists in the Rocky Mountains and the rest of the West, so to capture that detail, you need downscaling," says Michael Anderson, the California climatologist. "I think this is one of the biggest issues."

In downscaling, statistical techniques are used to reduce broad trends to localized situations. Even better would be data-intensive computer models that include the more localized topographical and other conditions that have a bearing on tomorrow's weather and the long-term climate. Scientists with access to a new, more powerful computer at the National Center for Atmospheric Research in Boulder hope to deliver crystal-ball predictions within five years.

This lack of a clear future has water utilities, forced to invest in infrastructure now, grappling with how best to make decisions. The uncertainty clearly frustrates water but also environmental managers. "How do you know you have the data you need for the next decade or two decades, when the changes could be greater than seen in millennia?" asked Jay Slack, deputy regional director of the U.S. Fish and Wildlife Service, at a meeting last year in Steamboat Springs, Colorado.

"We are going beyond looking at just past hydrology, but there isn't a clear methodology out there," says Marc Waage, manager of water resource planning for Denver Water. Denver Water and other water providers along Colorado's urbanized Front Range have now engaged the Rand Corporation to apply its process of robust decision making to water issues. This process embraces a wider range of possibilities: faster and slower population growth, wetter and dryer, hotter and even hotter. Everything that is now taken for granted is open to question.

David Groves, policy researcher at the Rand Corporation in Oakland, California, explains the process this way: "A water planner will want to take climate change into account, but will want to do things that are not regretted later, if climate change results in changes that are not expected."

For example, groundwater is already a major resource in the Southwest. But even if future precipitation and temperature changes are unknown, how will the precipitation patterns affect those groundwater basins? "We don't have a lot of information about that," Groves says.

Instead of simple hydrographs showing past stream flow volumes, the new robust decision-making process relies heavily on computers, with dozens of variables considered — including the variables of climate — and dozens of possible outcomes produced. No probabilities are assigned; all outcomes are weighted equally.

In the case of a fast-growing area of Southern California called the Inland Empire, the decision-making model showed that the 25-year water plan was vulnerable to a certain set of climate circumstances. "In such a rapid growth area, a great focus on efficiency will help in reducing their vulnerability to climate change and maximizing the runoff available to them," says Groves. The message, he adds, is that "we should be doing something now, and we shouldn't let uncertainty stop us, because there are ways around these uncertainties."

Water experts in the West are not succumbing to a doom-and-gloom outlook. They do worry about the viability of the region's giant reservoirs and discuss the possibility of replacing the Colorado River Compact with a new law that recognizes climate change and a booming population. But they also have many tools at

their command — and goals that will still be of value should 95 percent of climate scientists be proven wrong in their grim predictions.

Allen Best is a freelance writer based in Colorado. He has written extensively about water, climate change, and other issues of the West.

Sidebar: Shortage in a Land of Plenty

Resources

Images: Top — A red buoy line to keep boats from Hoover Dam seems to stretch out from the 'bathtub ring' that has been evident since 2002 at Lake Mead, one of two giant reservoirs on the Colorado River. Photo by Allen Best. Middle — The Green River originates in the Wind River Mountains of Wyoming and flows into Utah. There it is joined by the Yampa River, one of the West's few undammed rivers. Photo Andy Pernick, U.S. Bureau of Reclamation. Bottom — On the Front Range of the Rocky Mountains, the Colorado River supplies water to both farms and subdivisions. Photo by Allan Best.

International Panel on Climate Change 2007 report: www.ipcc.ch. In particular, see Working Group II Report "Impacts, Adaptation and Vulnerability."

Western Water Assessment: http://wwa.colorado.edu

Western Resource Advocates: www.westernresourceadvocates.org/water

Pacific Institute: www.pacinst.org

Western Progress: www.westernprogress.org/new-western-water-agenda

Rocky Mountain Climate Organization: www.rockymountainclimate.org. Also at this site are links to other reports about water and the West

King County (Seattle): http://dnr.metrokc.gov/dnrp/climate-change/conference-2005.htm

The U.S. Environmental Protection Agency website has a variety of information and portals to other sources: www.epa.gov/climatechange/effects/water

"Stationarity is Dead: Whither Water Management," *Science* magazine, February 2008. The authors, P.C.D. Milly and others, argue it's time to abandon stationarity, the idea that natural systems fluctuate within an unchanging envelope of variability.

For a discussion of western water policy, see *Cadillac Desert: The American West and Its Disappearing Water,* by Marc Reisner, 1986.

A recent book about bottled water versus tap water is *Bottlemania: How Water Went on Sale and Why We Bought It,* by Elizabeth Royte, 2008.