



From:

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The West is  
the fastest-growing part  
of the country.

It's also the driest.

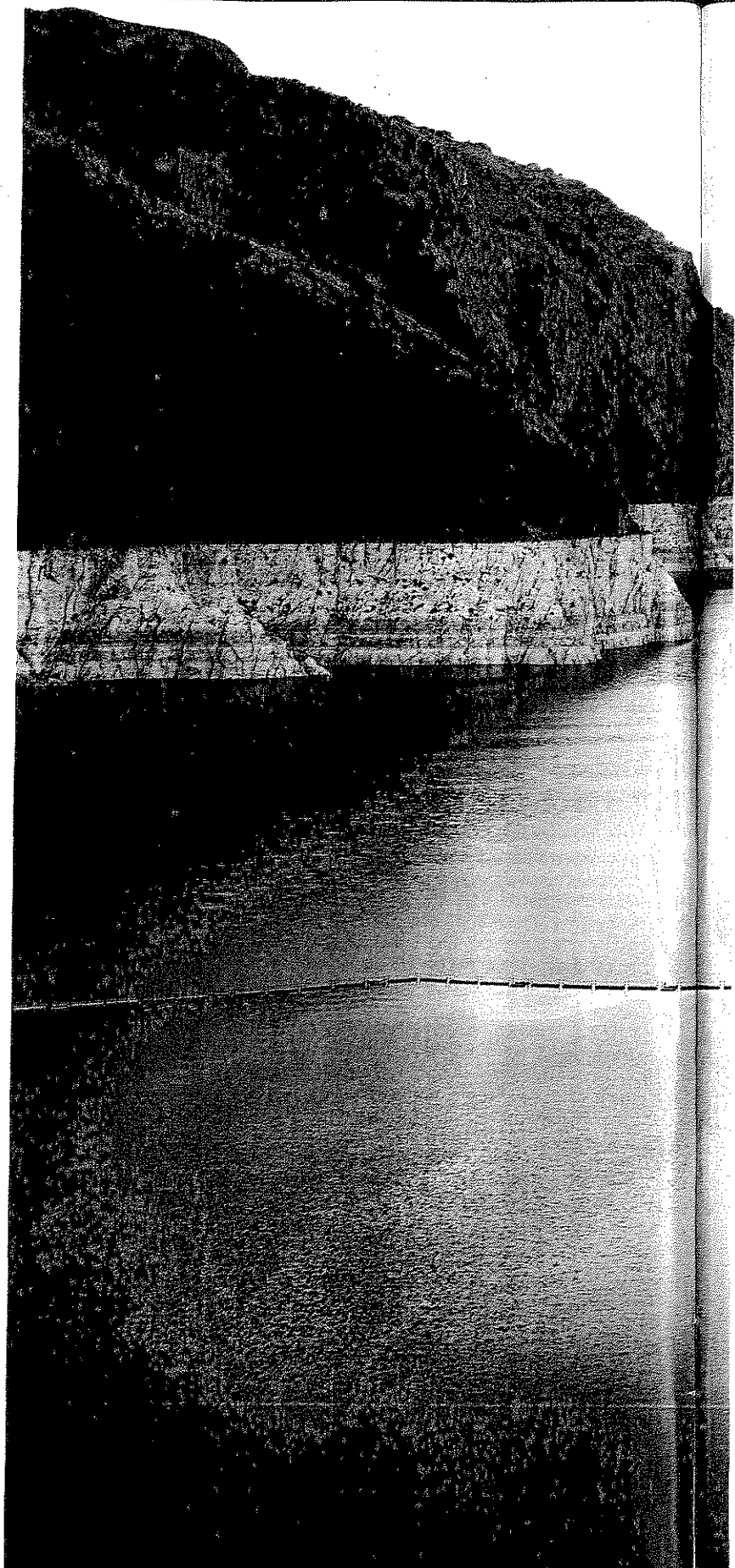
And climate change could be  
making matters much,  
much worse.

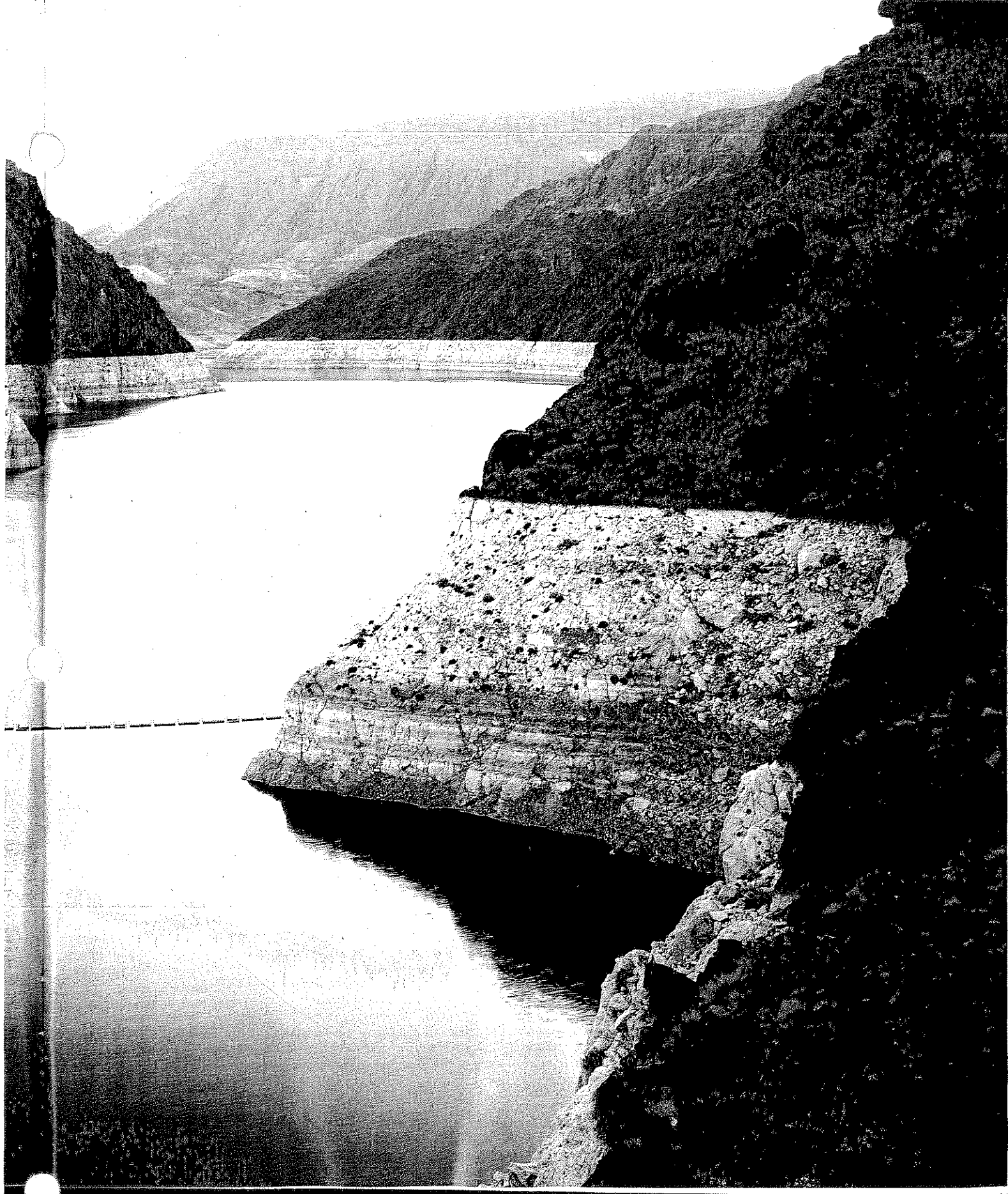
## The Future Is Drying Up

BY JON GERTNER

Photographs by Simon Norfolk

**Draining** The 100-foot-high bathtub ring left by the dwindling waters of Lake Mead, behind Hoover Dam.





# Scientists sometimes refer to the effect a hotter world will have on this country's fresh water as the *other* water problem, because global warming more commonly evokes the specter of rising oceans submerging our great coastal cities. By comparison,

the steady decrease in mountain snowpack — the loss of the deep accumulation of high-altitude winter snow that melts each spring to provide the American West with most of its water — seems to be a more modest worry. But not all researchers agree with this ranking of dangers. Last May, for instance, Steven Chu, a Nobel laureate and the director of the Lawrence Berkeley National Laboratory, one of the United States government's pre-eminent research facilities, remarked that diminished supplies of fresh water might prove a far more serious problem than slowly rising seas. When I met with Chu last summer in Berkeley, the snowpack in the Sierra Nevada, which provides most of the water for Northern California, was at its lowest level in 20 years. Chu noted that even the most optimistic climate models for the second half of this century suggest that 30 to 70 percent of the snowpack will disappear. "There's a two-thirds chance there will be a disaster," Chu said, "and that's in the best scenario."

In the Southwest this past summer, the outlook was equally sobering. A catastrophic reduction in the flow of the Colorado River — which mostly consists of snowmelt from the Rocky Mountains — has always served as a kind of thought experiment for water engineers, a risk situation from the outer edge of their practical imaginations. Some 30 million people depend on that water. A greatly reduced river would wreak chaos in seven states: Colorado, Utah, Wyoming, New Mexico, Arizona, Nevada and California. An almost unfathomable legal morass might well result, with farmers suing the federal government; cities suing cities; states suing states; Indian nations suing state officials; and foreign nations (by treaty, Mexico has a small claim on the river) bringing international law to bear on the United States government. In addition, a lesser Colorado River would almost certainly lead to a considerable amount of economic havoc, as the future water supplies for the West's industries, agriculture and growing municipalities are threatened. As one prominent Western water official described the possible future to me, if some of the Southwest's largest reservoirs empty out, the region would experience an apocalypse, "an Armageddon."

One day last June, an environmental engineer named Bradley Udall appeared before a Senate subcommittee that was seeking to understand how severe the country's fresh-water problems might become in an era of global warming. As far as Washington hearings go, the testimony was an obscure affair, which was perhaps fitting: Udall is the head of an obscure organization, the Western Water Assessment. The bureau is located in the

Boulder, Colo., offices of the National Oceanographic and Atmospheric Administration, the government agency that collects obscure data about the sky and seas. Still, Udall has a name that commands some attention, at least within the Beltway. His father was Morris Udall, the congressman and onetime presidential candidate, and his uncle was Stewart Udall, the secretary of the interior under Presidents John F. Kennedy and Lyndon Johnson. Bradley Udall's great-great-grandfather, John D. Lee, moreover, was the founder of Lee's Ferry, a flyspeck spot in northern Arizona that means nothing to most Americans but holds near-mythic status to those who work with water for a living. Near Lee's Ferry is where the annual flow of the Colorado River is measured in order to divvy up its water among the seven states that depend on it. To many politicians, economists and climatologists, there are few things more important than what has happened at Lee's Ferry in the past, just as there are few things more important than what will happen at Lee's Ferry in the future.

The importance of the water there was essentially what Udall came to talk about. A report by the National Academies on the Colorado River basin had recently concluded that the combination of limited Colorado River water supplies, increasing demands, warmer temperatures and the prospect of recurrent droughts "point to a future in which the potential for conflict" among those who use the river will be ever-present. Over the past few decades, the driest states in the United States have become some of our fastest-growing; meanwhile, an ongoing drought has brought the flow of the Colorado to its lowest levels since measurements at Lee's Ferry began 85 years ago. At the Senate hearing, Udall stated that the Colorado River basin is already two degrees warmer than it was in 1976 and that it is foolhardy to imagine that the next 50 years will resemble the last 50. Lake Mead, the enormous reservoir in Arizona and Nevada that supplies nearly all the water for Las Vegas, is half-empty, and statistical models indicate that it will never be full again. "As we move forward," Udall told his audience, "all water-management actions based on 'normal' as defined by the 20th century will increasingly turn out to be bad bets."

A few weeks after his testimony, I flew to Boulder to meet with Udall, and we spent a day driving switchback roads high in the Rockies in his old Subaru. It had been a wet season on the east slope of the Rockies, but the farther west we went, the drier it became. Udall wanted to show me some of the local reservoirs and water systems that were built over the past century, so I could get a sense of their complexity as well as their vulnerability. As he put it, he wants to connect the disparate members of the water economy in a way that has never really been done before, so that

*Jon Gertner is a contributing writer for the magazine.*

h utility executives, scientists, environmentalists, business leaders, farmers and politicians can begin discussing how to cope with the inevitable shortages of fresh water. In the American West, whose huge economy and political power derive from the ability of 20th-century engineers to conquer rivers like the Colorado and establish a reliable water supply, the prospect that there will be less water in the future, rather than the same amount, is unnerving. "We have a very short period of time here to get people educated on what this means," Udall told me as we drove through the mountains. "Then once that occurs, perhaps we can start talking about how do we deal with it."

Udall suggested that I meet a water manager named Peter Binney, who works for Aurora, Colo., a city — the 60th-largest in the United States — that sprawls over an enormous swath of flat, postagricultural land south of the Denver airport. It may be difficult for residents of the East Coast to understand the political celebrity of some Western water managers, but in a place like Aurora, where water, not available land, limits economic growth, Binney has enormous responsibilities. In effect, the city's viability depends on his wherewithal to conjure new sources of water or increase the output of old ones. As Binney told me when we first spoke, "We have to find a new way of meeting the needs of all this population that's turning up and still satisfy all of our recreational and environmental demands." Aurora has a population of 310,000 now, Binney said, but that figure is projected to surpass 500,000 by 2035.

I asked if he had enough water for that many people. "Oh, no," he replied. He seemed surprised that someone could even presume that he might. In fact, he explained, his job is to figure out how to find more water in a region where every drop is already spoken for and at a moment when there is little possibility that any more will ever be discovered.

**B**inney and I got together outside Dillon, a village in the Colorado Rockies 75 miles from Aurora and just a few miles west of the Continental Divide. We met in a small parking lot beside Dillon Reservoir, which sits at the bottom of a bowl of snow-capped mountains. Binney, a thickset 54-year-old with dark red hair and a fair complexion, had driven up in a large S.U.V. He still carries a strong accent from his native New Zealand, and in conversation he comes across as less a utility manager than a polymath with the combined savvy of an engineer, an economist and a politician. As we moved to a picnic table, Binney told me that we were looking at Denver's water, not Aurora's, and that it would eventually travel 70 miles through tunnels under the mountains to Denver's taps. He admitted that he would love to have this water, which is pure snowmelt. To people in his job, snowmelt is the best source of water because it requires little chemical treatment to bring it up to federal drinking standards. But this water wasn't available. Denver got here before him. And in Colorado, like most Western states, the rights to water follow a bloodline back to whoever got to it first.

One way to view the history of the American West is as a series of important moments in exploration or migration; another is to consider it, as Binney does, in terms of its water. In the 20th century, for example, all of our great dams and reservoirs were built — "heroic man-over-nature" achieve-

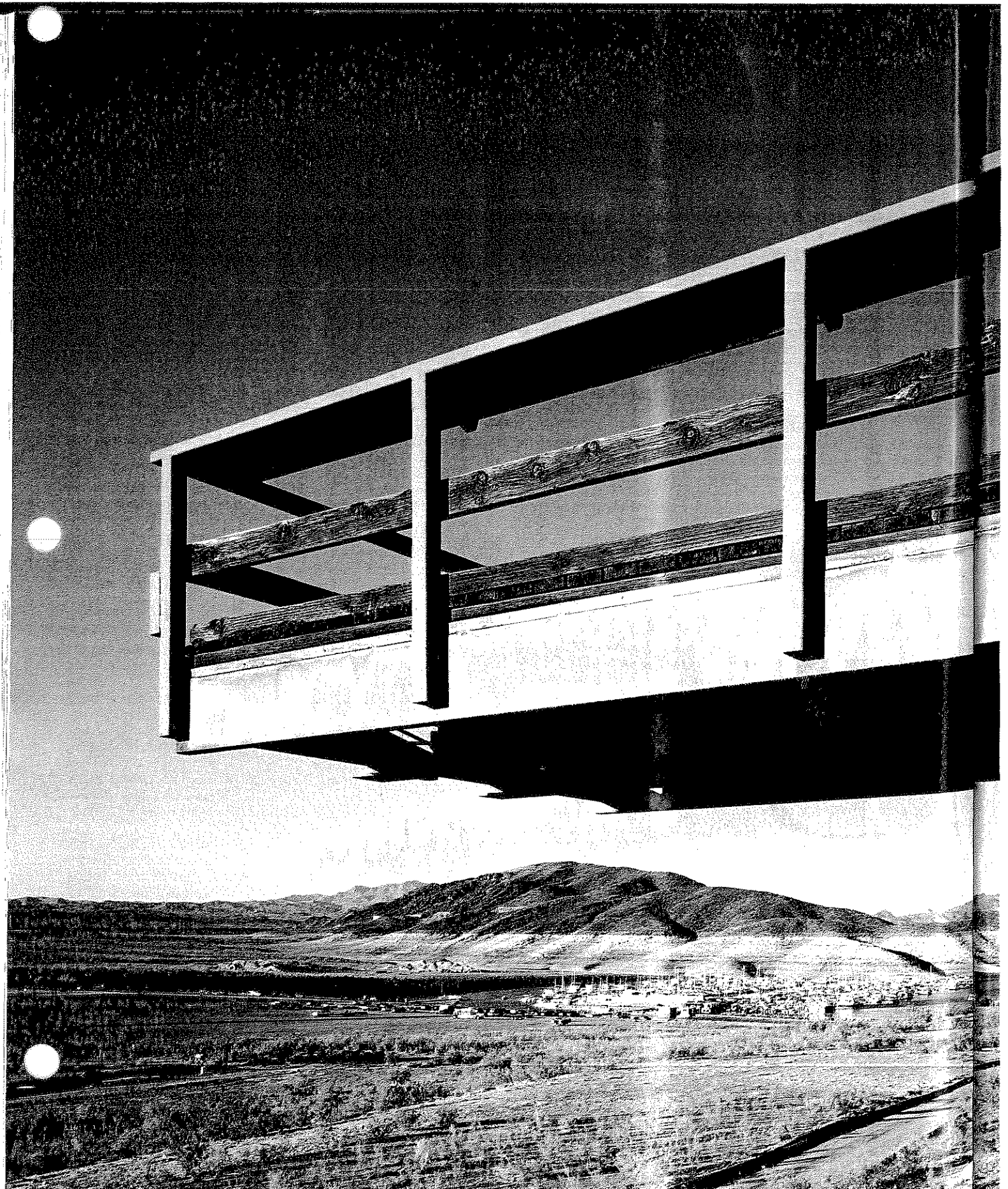
ments, in Binney's words, that control floods, store water for droughts, generate vast amounts of hydroelectric power and enable agriculture to flourish in a region where the low annual rainfall otherwise makes it difficult. And in constructing projects like the Glen Canyon Dam — which backs up water to create Lake Powell, the vast reservoir in Arizona and Utah that feeds Lake Mead — the builders went beyond the needs of the moment. "They gave us about 40 to 50 years of excess capacity," Binney says. "Now we've gotten to the end of that era." At this point, every available gallon of the Colorado River has been appropriated by farmers, industries and municipalities. And yet, he pointed out, the region's population is expected to keep booming. California's Department of Finance recently predicted that there will be 60 million Californians by midcentury, up from 36 million today. "In Colorado, we're sitting at a little under five million people now, on our way to eight million people," Binney said. Western settlers, who apportioned the region's water long ago, never could have foreseen the thirst of its cities. Nor, he said, could they have anticipated our environmental mandates to keep water "in stream" for the benefit of fish and wildlife, as well as for rafters and kayakers.

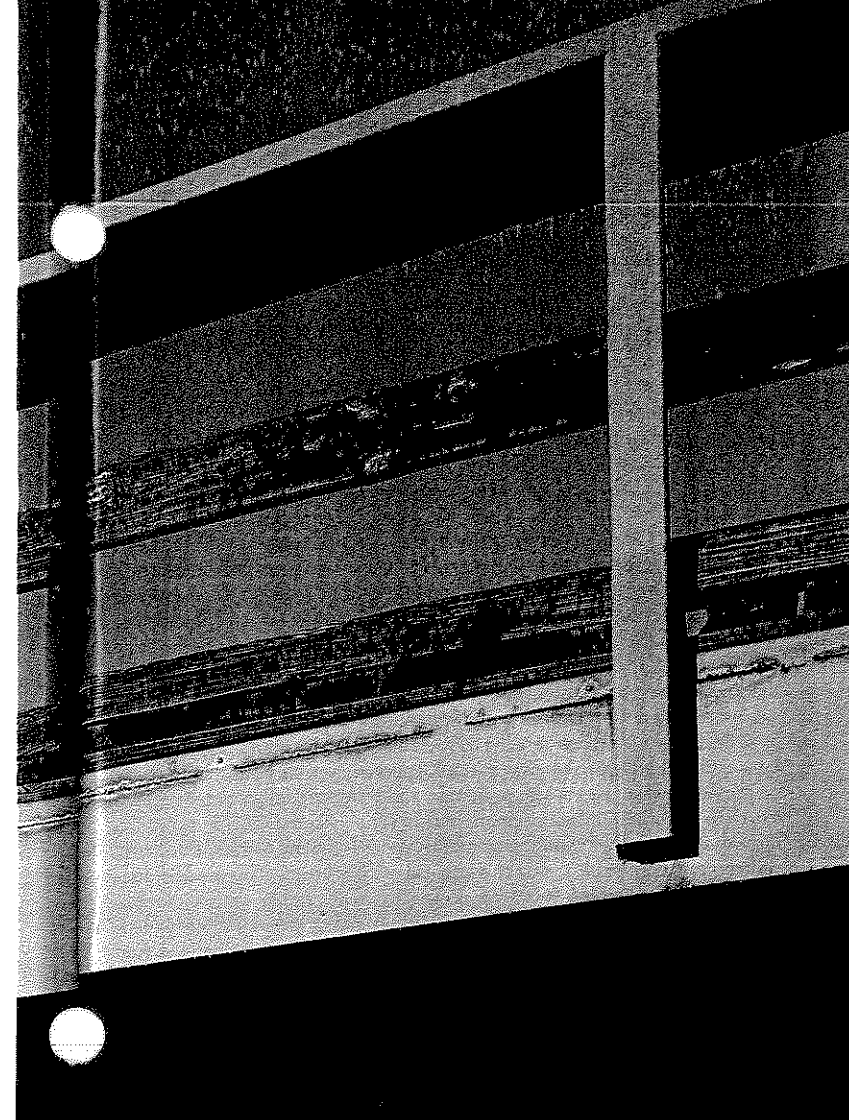
The West's predicament, though, isn't just a matter of limited capacity, bigger populations and environmental regulations. It's also a distributional one. Seventy-five years ago, cities like Denver made claims on — and from the state of Colorado received rights to — water in the mountains; those cities in turn built reservoirs for their water. As a result, older cities have access to more surface water (that is, water that comes from rivers and streams) than newer cities like Aurora, which have been forced to purchase existing water rights from farmers and mining companies. Towns that rely on groundwater (water pumped from deep underground) face an even bigger disadvantage. Water tables all over the United States have been dropping, sometimes drastically, from overuse. In the Denver area, some cities that use only groundwater will almost certainly exhaust their accessible supplies by 2050.

The biggest issue is that agriculture consumes most of the water, as much as 90 percent of it, in a state like Colorado. "The West has gone from a fur-trapping, to a mining, to an agricultural, to a manufacturing, to an urban-centric economy," Binney explained. As the region evolved, however, its water ownership for the most part did not. "There's no magical locked box of water that we can turn to," Binney says of cities like Aurora, "so it's going to have to come from an existing use." Because the supply of water in the West can't really change, water managers spend their time looking for ways to adjust its allocation in their favor.

Binney knew all this back in 2002, when he took the job in Aurora after a long career at an engineering firm. Over the course of a century, the city had established a reasonable water supply. About a quarter of its water is piped in from the Colorado River basin about 70 miles away; another quarter is taken from reservoirs in the Arkansas River basin far to the south. The rest comes from the South Platte, a lazy, meandering river that runs north through Aurora on its way toward Nebraska. Binney says he believes that a city like his needs at least five years of water in storage in case of drought; his first year there turned out to be one of the worst years for water managers in recorded history, and the town's reservoirs dropped to 26 percent of capacity, meaning Aurora had at most nine months of reserves and could not endure another dry spring. During the summer and fall, Binney focused on both supply and demand. He negotiated with neighboring towns to buy water and accelerated a program to pay local farmers to fallow their fields so the city could lease their water rights. Meanwhile, the town asked residents to limit their showers and had water cops enforce new rules against lawn sprinklers. ("It's interesting how many people were watering lawns in the middle of the night," Binney said.)

Water use in the United States varies widely by region, influenced by

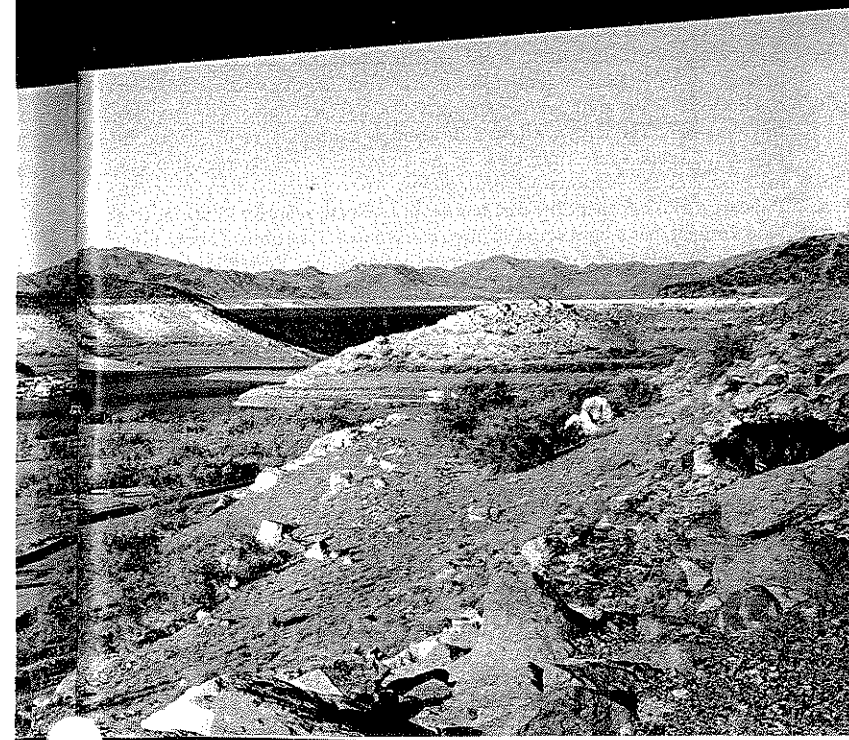




**No Diving** A pier to nowhere at Lake Mead Marina. Water levels in the lake are near historic lows and getting lower.

climate, neighborhood density and landscaping, among other things. In the West, Los Angelenos use about 125 gallons per person per day in their homes, compared with 114 for Tucson residents. Binney's customers generally use about 160 gallons per person per day. "In the depths of the drought," he said, "we got down to about 123 gallons."

Part of the cruelty of a Western drought is that a water manager never knows if it will last 1 year or 10. In 2002, Binney was at the earliest stages of what has since become a nearly continuous dry spell. Though he couldn't see that at the time, he realized Aurora faced a permanent state of emergency if it didn't boost its water supplies. But how? One option was to try to buy water rights in the mountains (most likely from farmers who were looking to quit agriculture), then build a new reservoir and a long supply line to Aurora. Obvious hurdles included environmental and political resistance, as well as an engineering difficulty: water is heavy, far heavier than oil, and incompressible; a system to move it long distances (especially if it involves tunneling through mountains or pumping water over them) can cost billions. Binney figured that without the help of the federal government, which has largely gotten out of the Western dam-and-reservoir-building business, Aurora would be unwise to pursue such a project. Even if the money could be raised, building a system would take decades. Aurora needed a solution within five years.



Another practice, sometimes used in Europe, is to drill wells alongside a river and pull river water up through them, using the gravel of the riverbank as a natural filter — sort of like digging a hole in the sand near the ocean's edge as it fills from below. Half of Aurora's water rights were on the South Platte already; the city also pours its treated wastewater back into the river, as do other cities in the Denver metro area. This gives the South Platte a steady, dependable flow. Binney and the township reasoned that they could conceivably, and legally, go some 20 or 30 miles downstream on the South Platte, buy agricultural land near the river, install wells there and retrieve their wastewater. Thus they could create a system whereby Aurora would use South Platte water; send it to a treatment plant that would discharge it back into the river; go downstream to recapture water from the same river; then pump it back to the city for purification and further use. The process would repeat, ad infinitum. Aurora would use its share of South Platte water "to extinction," in the argot of water managers. A drop of the South Platte used by an Aurora resident would find its way back to the city's taps as a half-drop in 45 to 60 days, a quarter-drop 45 to 60 days after that and so on. For every drop the town used from the South Platte, over time it would almost — as all the fractional drops added up — get another.

Many towns have a supply that includes previously treated water. The water from the Mississippi River, for instance, is reused many times by municipalities as it flows southward. But as far as Binney knew, no municipality in the United States had built the kind of closed loop that Aurora envisioned. Water from wells in the South Platte would taste dif-

ferent, because of its mineral and organic content, so Binney's engineers would have to make it mimic mountain snowmelt. More delicate challenges involved selling local taxpayers on authorizing a project, marketed to them as "Prairie Waters," that would capitalize on their own wastewater. The system, which meant building a 34-mile-long pipeline from the downstream South Platte riverbanks to a treatment facility in Aurora, would cost three-quarters of a billion dollars, making it one of the most expensive municipal infrastructure projects in the country.

When Binney and I chatted at the reservoir outside Dillon, he had already finished discussions with Moody's and Fitch, the bond-rating agencies whose evaluations would help the town finance the project. Groundbreaking, which would be the next occasion we would see each other, was still a month away. "What we're doing now is trading high levels of treatment and purification for building tunnels and chasing whatever remaining snowmelt there is in the hills, which I think isn't a wise investment for the city," he told me. "I would expect that what we're going to do is the blueprint for a lot of cities in California, Arizona, Nevada — even the Carolinas and the Gulf states. They're all going to be doing this in the future."

**W**

ater managers in the West tend to think in terms of "acre-feet." One acre-foot, equal to about 326,000 gallons, is

enough to serve two typical Colorado families for one year. When measurements of the Colorado River began near Lee's Ferry in the early 1920s, the region happened to be in the midst of an extremely wet series of years, and the river was famously misjudged to have an average flow of 17 million acre-feet per year — when in fact its average flow would often prove to be significantly less. Part of the legacy of that misjudgment is that the seven states that divided the water in the 1920s entered into a legal partnership that created unrealistic expectations about the river's capacity. But there is another, lesser-known legacy too. As the 20th century progressed, many water managers came to believe that the 1950s, which included the most severe drought years since measurement of the river began, were the marker for a worst-case situation.

But recent studies of tree rings, in which academics drill core samples from the oldest Ponderosa pines or Douglas firs they can find in order to determine moisture levels hundreds of years ago, indicate that the dry times of the 1950s were mild and brief compared with other historical droughts. The latest research effort, published in the journal *Geophysical Research Letters* in late May, identified the existence of an epochal Southwestern megadrought that, if it recurred, would prove calamitous.

When Binney and I met at Dillon Reservoir, he brought graphs of Colorado River flows that go back nearly a thousand years. "There was this one in the 1150s," he said, tracing a jagged line downward with his finger. "They think that's when the Anasazi Indians were forced out. We see drought cycles here that can go up to 60 years of below-average precipitation." What that would mean today, he said, is that states would have to make a sudden choice between agriculture and people, which would lead to bruising political debates and an unavoidable blow to the former. Binney says that as much as he believes that some farmers' water is ultimately destined for the cities anyway, a big jolt like this would be tragic. "You hope you never get to that point," he told me, "where you force those kinds of discussions, because they will change for hundreds of years the way that people live in the Western U.S. If you have to switch off agriculture, it's not like you can get back into it readily. It took decades

for the agricultural industry to establish itself. It may never come back."

An even darker possibility is that a Western drought caused by climatic variation and a drought caused by global warming could arrive at the same time. Or perhaps they already have. This coming spring, the United Nations' Intergovernmental Panel on Climate Change will issue a report identifying areas of the world most at risk of droughts and floods as the earth warms. Fresh-water shortages are already a global concern, especially in China, India and Africa. But the I.P.C.C., which along with Al Gore received the 2007 Nobel Peace Prize earlier this month for its work on global-warming issues, will note that many problem zones are located within the United States, including California (where the Sierra Nevada snowpack is threatened) and the Colorado River basin. These assessments follow on the heels of a number of recent studies that analyze mountain snowpack and future Colorado River flows. Almost without exception, recent climate models envision reductions that range from the modest to the catastrophic by the second half of this century. One study in particular, by Martin Hoerling and Jon Eischeid, suggests the region is already "past peak water," a milestone that means the river's water supply will now forever trend downward.

Climatologists seem to agree that global warming means the earth will, on average, get wetter. According to Richard Seager, a scientist at Columbia University's Lamont Doherty Earth Observatory who published a study on the Southwest last spring, more rain and snow will fall in those regions closer to the poles and more precipitation is likely to fall during sporadic, intense storms rather than from smaller, more frequent storms. But many subtropical regions closer to the equator will dry out. The models analyzed by Seager, which focus on regional climate rather than Colorado River flows, show that the Southwest will ultimately be subject to significant atmospheric and weather alterations. More alarming, perhaps, is that the models do not only concern the coming decades; they also address the present. "You know, it's like, O.K., there's trouble in the future, but how near in the future does it set in?" he told me. "In this case, it appears that it's happening right now." When I asked if the drought in his models would be permanent, he pondered the question for a moment, then replied: "You can't call it a drought anymore, because it's going over to a drier climate. No one says the Sahara is in drought."

Climate models tend to be more accurate at predicting temperature than precipitation. Still, it's hard to avoid the conclusion that "something is happening," as Peter Binney gently puts it. Everyone I spoke with in the West has noticed — less snow, earlier spring melts, warmer nights. Los Angeles this year went 150 days without a measurable rainfall. One afternoon in Boulder, I spent some time with Roger Pulwarty, a highly regarded climatologist at the National Oceanographic Atmospheric Administration. Pulwarty, who has spent the past few years assessing adaptive solutions to a long drought, has a light sense of humor and an air of optimism about him, but he acknowledged that the big picture is worrisome. Even if the precipitation in the West does not decrease, higher temperatures by themselves create huge complications. Snowmelt runoff decreases. The immense reservoirs lose far more water to evaporation. Meanwhile, demand increases because crops are thirstier. Yet importing water from other river basins becomes more difficult, because those basins may face shortages, too.

"You don't need to know all the numbers of the future exactly," Pulwarty told me over lunch in a local Vietnamese restaurant. "You just need to know that we're drying. And so the argument over whether it's 15 percent drier or 20 percent drier? It's irrelevant. Because in the long run, that decrease, accumulated over time, is going to dry out the system." Pulwarty asked if I knew the projections for what it would take to refill Lake Powell, which is at about 50 percent of capacity. Twenty years of average flow on the Colorado River, he told me. "Good luck," he said. "Even in normal conditions we don't get 20 years of average flow. People are calling for more

Speaking of the Southwest, one scientist said: 'You can't call it a drought anymore, because it's going over to a drier climate. No one says the Sahara is in drought.'

storage on the system, but if you can't fill the reservoirs you have, I don't know how more storage, or more dams, is going to help you. One has to ask if the normal strategies that we have are actually viable anymore."

Pulwarty is convinced that the economic impacts could be profound. The worst outcome, he suggested, would be mass migrations out of the region, along with bitter interstate court battles over the dwindling water supplies. But well before that, if too much water is siphoned from agriculture, farm towns and ranch towns will wither. Meanwhile, Colorado's largest industry, tourism, might collapse if river flows became a trickle during summertime. Already, warmer temperatures have brought on an outbreak of pine beetles that are destroying pine forests; Pulwarty wonders how many tourists will want to visit a state full of dead trees. "A crisis is an interesting thing," he said. In his view, a crisis is a point in a story, a moment in a narrative, that presents an opportunity for characters to think their way through a problem. A catastrophe, on the other hand, is something different: it is one of several possible outcomes that follow from a crisis. "We're at the point of crisis on the Colorado," Pulwarty concluded. "And it's at this point that we decide, O.K., which way are we going to go?"

**I**t is all but impossible to look into the future of the Western states without calling on Pat Mulroy, the head of the Southern Nevada Water Authority. Mulroy has no real counterpart on the East Coast; her nearest analog might be Robert Moses, the notorious New York City planner who built massive infrastructure projects and who almost always found a way around institutional obstructions and financing constraints. She is arguably the most influential and outspoken water manager in the country — a "woman without fear," as

Pulwarty describes her. Pulwarty and Peter Binney respect her willingness to challenge historical water-sharing agreements that, in Mulroy's view, no longer suit the modern West (meaning they don't suit Las Vegas). According to Binney, however, Nevada's scant resources give Mulroy little choice. She has to keep her city from drying out. That makes hers the most difficult job in the water business, he told me.

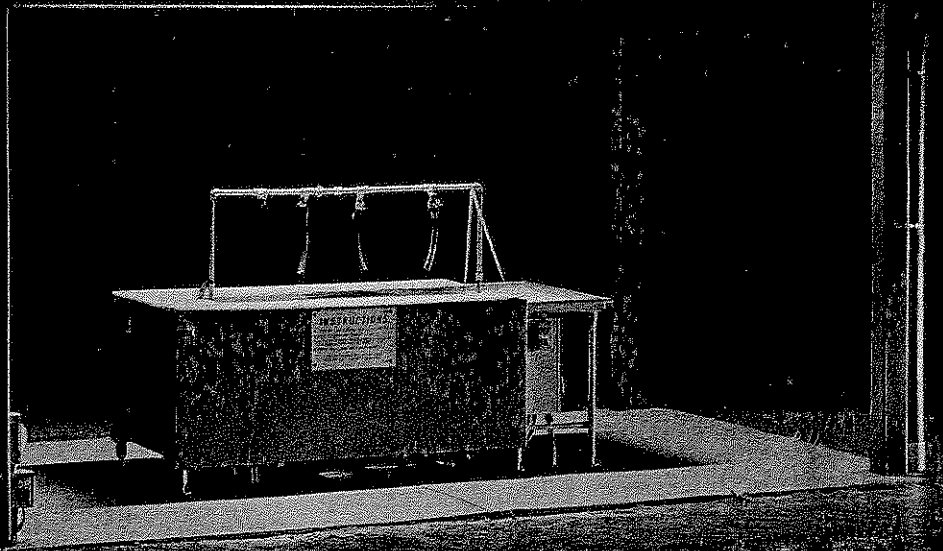
Las Vegas is almost certainly more vulnerable to water shortages than any metro area in the country. Partly that's a result of the city's explosive growth. But the state of Nevada has the historical misfortune of receiving a smaller share of Colorado River water (300,000 acre-feet annually) than the other six states with which it signed a water-sharing compact in the 1920s. That modest share, stored in Lake Mead along with water destined for Southern California, Arizona and northern Mexico, now means everything to Las Vegas. I traveled to Lake Mead on a 99-degree day last June. The narrow, 110-mile-long lake, which at full capacity holds 28 million acre-feet of water (making it the largest reservoir in the United States), was at 49 percent of capacity. When riding into the valley and glimpsing it from afar — an astonishing slash of blue in the desert — my guide for the day, Bronson Mack of the Southern Nevada Water Authority, remarked that he had never seen it so low. The white bathtub ring on the sides of the canyon that marks the level of full capacity was visible about 100 feet above the water. "I have a photograph of my mother on her honeymoon, standing in front of the lake," Mack, a Las Vegas native, said. That was in 1970. "It was almost that low, but not quite."

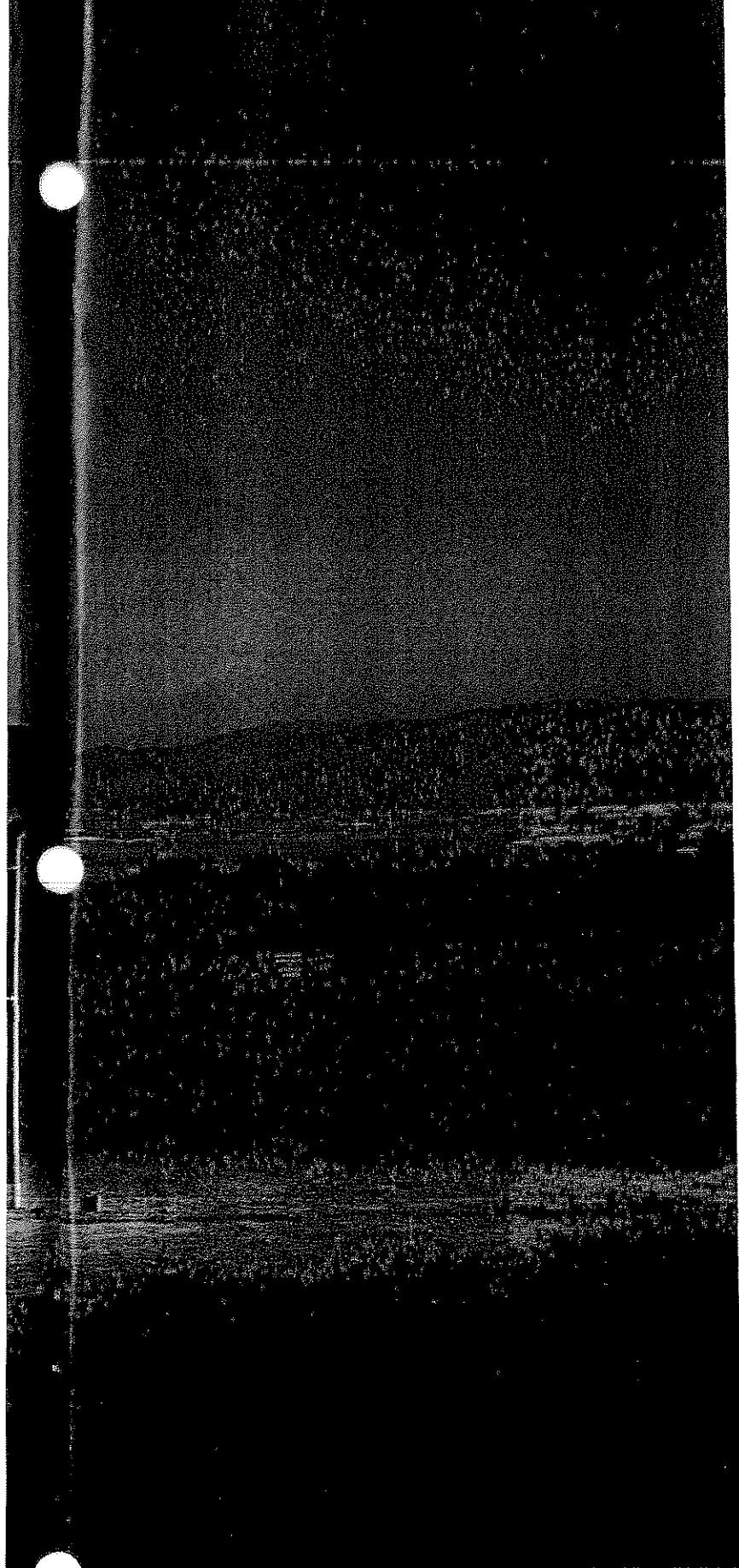
Over the past year, it has become conceivable that the lake could eventually drop below the level of the water authority's intake pipes, the straws that suck the water out for the Las Vegas Valley. The authority recently hired an engineering firm to drill through several miles of rock and create a deeper intake pipe near the bottom of the lake. To say the project is being fast-tracked is an understatement. The day after visiting Lake Mead, I met with Mulroy in her Las Vegas office. "We have everything in line to get it running by 2012," she said of the new intake. But she added that she is looking to cut as much time off construction as possible. Building the new intake is a race against the clock, or rather a race against a lake that keeps going down, down, down.

Mulroy is not gambling the entire future of Las Vegas on this project. One catchphrase of the water trade is that water flows uphill toward money, which is another way of saying that a city with ample funds can, at least theoretically, augment its supplies indefinitely. In a tight water market like that of the West, this isn't an absolute truth, but in many instances money can move rivers. The trade-off is that new water tends to be of lower quality (requiring more expensive purification) or far away (requiring more expensive transport). Thanks to Las Vegas's growth — the metro area is now at 1.8 million people — cost is currently no object. The city's cash reserves have made it possible for Mulroy to pay Arizona \$330 million for water she can use in emergencies and to plan a controversial multibillion-dollar pipeline to east-central Nevada, where the water authority has identified groundwater it wants to extract and transport. Wealth allows for the additional possibility of a sophisticated trading scheme whereby Las Vegas might pay for a desalination plant on the Pacific Coast that would transform seawater into potable water for use in California and Mexico. In exchange, Nevada could get a portion of their Colorado River water in Lake Mead.

So money does make a kind of sustainability possible for Las Vegas. On the other hand, buying water is quite unlike buying anything else. At the moment, water doesn't really function like a private good; its value, which Peter Binney calls "infinite," is often only vaguely related to its price, which can vary from 50 cents an acre-foot (what Mulroy pays to take water from Lake Mead) to \$12,000 an acre-foot (the most Binney has paid farmers in Colorado for their rights). Moreover, water is so necessary to human life,

Fish Cleaner





**Fishing Gone** A fish-cleaning station at Las Vegas Bay from which the shoreline — and the fish — have retreated.

and hence so heavily subsidized and regulated, that it can't really be bought and sold freely across state lines. (Enron tried to start a water market called Azurix in the late 1990s, only to see it fail spectacularly.) The more successful water markets have instead been local, like one in the late 1980s in California, where farmers agreed to reduce their water use and sell the savings to a state water bank. Mulroy and Binney each told me they think a true free-market water exchange would create too many winners and losers. "What you would have is affluent communities being able to buy the lifeblood right out from under those that are less well heeled," Mulroy said. More practical, in her mind, would be a regional market that gives states, cities and farmers greater freedom to strike mutually beneficial agreements, but with protections so that municipalities aren't pitted against one another.

More-efficient water markets might ease shortages, but they can't replace a big city's principal source. What if, I asked Mulroy, Lake Mead drained nearly to the bottom? Even if drought conditions ease over the next year or two, several people I spoke with think the odds are greater that Lake Powell, the 27-million-acre-foot reservoir that supplies Lake Mead, will drop to unusable levels before it ever fills again. Mulroy didn't immediately dismiss the possibility; she is certain that the reduced circumstances of the two big Western reservoirs are tied to global warming and that Las Vegas is this country's first victim of climate change. An empty Lake Mead, she began, would mean there is nothing in Lake Powell.

"It's well outside probabilities," she said — but it could happen. "In that case, it's not just a Las Vegas problem. You have three entire states wiped out: Arizona, California and Nevada. Because you can't replace those volumes with desalted ocean water." What seems more likely, she said, is that the legal framework governing the Colorado River would preclude such a dire turn of events. Recently, the states that use the Colorado reached a tentative agreement that guarantees Lake Mead will remain partly full under current conditions, even if upstream users have to cut back their withdrawals as a result. The deal supplements a more fundamental understanding that dates to the 1920s. If the river is failing to carry a certain, guaranteed volume of water to Lee's Ferry, which is just below Lake Powell, the river's lower-basin states (Nevada, Arizona and California) can legally force the upper-basin states (Colorado, Wyoming, New Mexico and Utah) to reduce or stop their water withdrawals. This contingency, known as a "compact call," sets the lower-basin states against the upper, but it has never occurred; it is deeply feared by many water managers, because it would ravage the fragile relationship among states and almost certainly lead to a scrum of lawsuits. Yet, last year water managers in Colorado began meeting for the first time to discuss the possibility. In our conversations, Mulroy denied that there would be a compact call, *Continued on Page 104*

**SURE SHOT** A multimedia feature on the photographer Simon Norfolk's work for the magazine. [nytimes.com/magazine](http://nytimes.com/magazine)

PHOTOGRAPH BY SIMON NORFOLK/NB PICTURES, FOR THE NEW YORK TIMES 77

## WATER

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but she pointed out that Las Vegas's groundwater and desalination plans were going ahead anyway for precautionary reasons.

I asked if limiting the growth of the Las Vegas metro area wouldn't help. Mulroy bristled. "This country is going to have 100 million additional people in it in the next 25 to 30 years," she replied. "Tell me where they're supposed to go. Seri-

ously. Every community says, 'Not here,' 'No growth here,' 'There's too many people here already.' For a large urban area that is the core economic hub of any particular area, to even attempt to throw up walls? I'm not sure it can be done."

Besides, she added, the problem isn't growth alone: "We have an exploding human population, and we have a shrinking clean-water supply. Those are on colliding paths. This is not just a Las Vegas issue. This is a microcosm of a much larger issue." Americans, she went on to say, are the most voracious users of natural resources in the world. Maybe we need to talk about that as well. "The people who move to the West today need to realize they're moving into a desert," Mulroy said. "If they want to live in a desert, they have to adapt to a desert lifestyle." That means a shift from the mindset of the 1930s, when the federal government encouraged people to settle in the West, plant water-intensive crops and make it look like the East Coast. It means landscapes of parched dirt. It means mesquite bushes and palo verde trees for vegetation. It means recycled water. It means gravel lawns. It is the West's new deal, she seemed to be saying, and I got the feeling that for Mulroy it means that every blade of grass in her state would soon be gone.

The first impulse when confronted with the West's water problems may be to wonder how, as scarcity becomes more acute, the region will engineer its way back to health. What can be built, what can technology accomplish, to ease any shortages? Yet this is almost certainly the wrong way to think about the situation. To be sure, construction projects like a pipeline from east-central Nevada could help Las Vegas. But the larger difficulty facing Pat Mulroy and Peter Binney, as they describe it, is re-engineering the culture and conventions of the West before it becomes too late. Whether or not there is enough water in the region for, say, the next 30 or 50 years isn't necessarily a question with a yes-or-no answer. The water managers I spoke with believe the total volume of available water could be great enough to sustain the cities, many farms and perhaps the natural flow of the area's rivers. But it's not unreasonable to assume that if things continue as they have — with so much water going to agriculture; with conservation only beginning to take hold among residents, industry and farmers; with supplies diminishing slowly but steadily as the Earth

Continued on Page 154



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## WATER

Continued from Page 104

warms; with the population growing faster than anywhere else in the United States; and with some of our most economically vital states constricted by antique water agreements — the region will become a topography of crisis and perhaps catastrophe. This is an old prophecy, dating back more than a century to one of the original American explorers of the West, John Wesley Powell, who doubted the territory could support large populations and intense development. (Powell presciently argued that river basins, not arbitrary mapmakers, should determine the boundaries of the Western states, in order to avoid inevitable conflicts over water.) An earlier explorer, J. C. Ives, visited the present location of Hoover Dam, between Arizona and Nevada, in 1857. The desiccated landscape was

“valueless,” Ives reported. “There is nothing there to do but leave.”

Roger Pulwarty, for his part, rejects the notion of environmental determinism. Nature, in other words, isn't inexorably pushing the region into a grim, suffering century. Things can be done. Redoubling efforts to prevent further climate change, Pulwarty says, is one place to start; another is getting the states that share the Colorado River to reach cooperative arrangements, as they have begun to discuss, for coping with long-term droughts. Other parts of the solution are less obvious. To Peter Gleick, head of the Pacific Institute, a nonprofit based in Oakland, Calif., that focuses on global water issues, whether we can adapt to a drier future depends on whether we can rethink the functions, and value, of fresh water. Can we can do the same things using less of it? How we use our water, Gleick believes, is consider-

ably more complex than it appears. First of all, there are consumptive and nonconsumptive uses of water. Consumptive use, roughly speaking, refers to water taken from a reservoir that cannot be recovered. “It's embedded in a product like a liter of Coca-Cola, or it's contaminated so badly we can't reuse it,” Gleick says. In agriculture, the vast majority of water use is also consumptive, because it evaporates or transpires from crops into the atmosphere. Evaporated water may fall as rain 1,000 miles away — but it is gone locally. A similar consumptive process characterizes the water we put on our lawns or gardens: it mostly disappears. Meanwhile, most of the water used by metropolitan areas is nonconsumptive. It goes down the drain and empties into nearby rivers, like Colorado's South Platte, as treated wastewater.

Gleick calls the Colorado River “the most complicated water system in the world,” and he isn't convinced it will be easy, or practical, to change the laws that govern its usage. “But I think it's less hard to change how we use water,” he says. He accepts that climate change is confronting the West with serious problems. (He was also one of the country's first scientists, in the mid-1980s, to point out that reductions in mountain snowpack could present huge challenges.) He makes a persuasive case, however, that there are immense opportunities — even in cities like Las Vegas, which has made strides in conservation — to reduce both consumptive and nonconsumptive demand for water. These include installing more low-flow home appliances and adopting more efficient irrigation methods. And they include economic tools too: for example, many municipalities have reduced consumption by making water more expensive (the more you use, the higher your per-gallon rate). The United States uses less water than it did 25 years ago, Gleick points out: “We haven't even paid too much attention to it, and we've accomplished this.” To go further, he says he believes we could alter not only demand but also supply. “Treated wastewater isn't a liability, it's an asset,” he says. We don't need potable water to flush our toilets or water our lawns. “One might say that's a ridiculous use of potable water. In fact, I might say that. But that's the way we've set

## ANSWERS TO PUZZLES

OF OCTOBER 14, 2007

### GO WITH THE FLOW

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| B. Bobolink    | I. Earl Grey   | P. Wineglass    |
| C. Waffle iron | J. Rooftree    | Q. Yearling     |
| D. Hostelery   | K. Effluent    | R. Overjoyed    |
| E. Inscrutable | L. Iconography | S. Rhinoplasty  |
| F. Tiffany     | M. Saturday    | T. Knock off    |
| G. Executor    | N. “Notorious” |                 |

NOTE: 1-Across in this week's diagramless puzzle begins in the ninth square of the top row.

it up. And that's going to change, that's got to change, in this century."

Among Colorado's water managers, Peter Binney's Prairie Waters project is considered both innovative and important not on account of its technology but because it seems to mark a new era of finding water sources in the drying West. It also proves that the next generation's water will not come cheap, or come easy. In late July, I went to Aurora to meet up again with Binney. It was the groundbreaking day for Prairie Waters, which had been on the local television news: Binney and several other officials grinned for the cameras and signed a section of six-foot steel pipe, the same kind that would transport water from the South Platte wells to the Aurora treatment facility. That evening, Binney and I had dinner together at a steakhouse in an Aurora shopping mall. When he remarked that we may have exceeded what he calls the "carrying capacity" of the West, I asked him whether our desert civilizations could last. Binney seemed dubious. "Not the way we've got it set up," he said. "We've decoupled land use from water use. Water is the limiting resource in the West. I think we need to match them back together again." There was a decent amount of water out there, he went on to explain, but it was a false presumption that it could sustain all the farms, all the cities, all the rivers. Something will have to give. It was also wrong to assume, he said, that cities could continue to grow without experiencing something akin to a religious awakening about the scarcity of water. Soon, he predicted, we would talk about our "water footprint" just as we now talk about our carbon footprint.

Indeed, any conversations about the one will in short order expand to include the other, Binney went on to say. Many water managers have

known this for a while. The two problems — water and energy — are so intimately linked as to make it exceedingly difficult to tackle one without the other. It isn't just the matter of growing corn for ethanol, which is already straining water supplies. The less water in our rivers, for instance, the less hydropower our dams produce. The further the water tables sink, the more power it takes to pump water up. The more we depend on coal and nuclear power plants, which require huge amounts of water for cooling, the larger the burden we place on supplies.

Meanwhile, it is a perverse side effect of global warming that we may have to emit large volumes of carbon dioxide to obtain the clean water that is becoming scarcer because of the carbon dioxide we've already put into the atmosphere. A dry region that turns to desalination, for example, would need vast amounts of energy (and money) to purify its water. While wind-powered desalination could perhaps meet this challenge — such a plant was recently built outside Perth, Australia — it isn't clear that coastal residents in, say, California would welcome such projects. Unclear, too, is how dumping the brine that is a by-product of the process back into the ocean would affect ecosystems.

Similar energy challenges face other plans. In past years, various schemes have arisen to move water from Canada or the Great Lakes to arid parts of the United States. Beyond the environmental implications and construction costs (probably hundreds of billions of dollars), such continental-scale plumbing would require stupendous amounts of electricity. And yet, fears that such plans will resurface in a drier, more populous world are partly behind current efforts by the Great Lakes states to certify a pact that protects their fresh water

from outside exploitation.

Just pumping water from the Prairie Waters site to Aurora will cost a small fortune. Binney told me this the day after the groundbreaking, as we drove north from Aurora to the site. Along the 45-minute journey, Binney narrated where his pipeline would go — along the edge of the highway here, over in that field there and so on. Eventually we turned off the highway and onto a small country road, and Binney slowed down so I could take in the surroundings. "Here's where you see it all coming together and all of it coming into conflict," he told me. To him, it was a perfect tableau of the West in the 21st century. There was a housing development on one side of the road and fields of irrigated crops on the other. Farther ahead was a gravel pit, a remnant of the old Colorado mineral-extraction economy.

He drove on, and soon we turned onto a dirt road that bisected some open fields. We rumbled along for a quarter mile or so, spewing dust and passing over the South Platte in the process. Binney parked by a wire fence near a sign marking it as Aurora property. We got out of the truck, hopped over a locked gate and walked into a farm field.

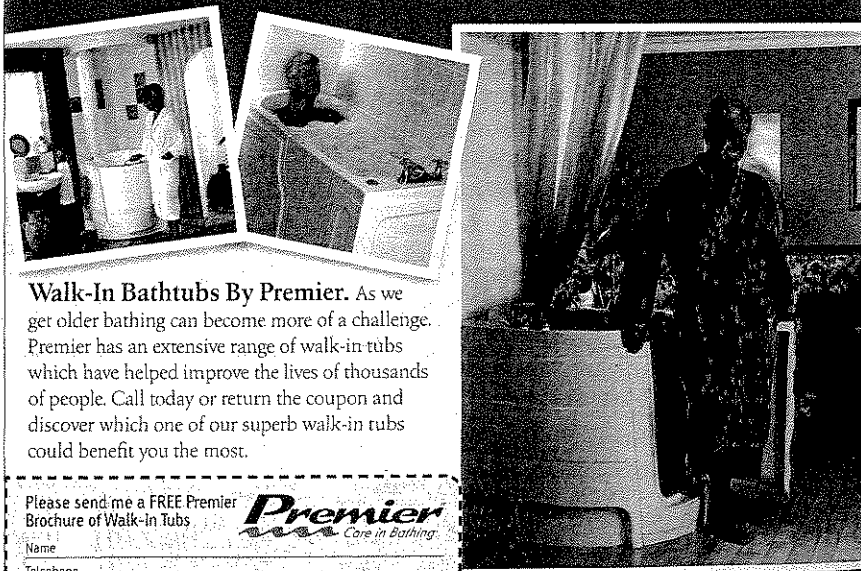
For miles along the highway, we passed barren acreage that formerly grew winter wheat but was now slated for new houses. The land we stood on once grew corn, but tangles of weeds covered it now. As we walked, Binney explained that the collection wells on the South Platte would soon be dug a few hundred yards away; that water would be pumped into collection basins on this field, where sand and gravel would purify it further. Then it would be pumped back to the chemi-

cal treatment plants in Aurora before being piped to residents. "We're standing 34 miles from there," Binney said.

It was a location as ordinary as I could have imagined, an empty place, far from anything, and yet Binney saw it as something else. Earlier, when we crossed over the gravel banks of the South Platte, I found the river disappointing: broad and shallow, dun-colored and slow-moving, its unimpressive flow somehow incorporating water Aurora had already used upstream. James Michener, in writing about this region years ago, was dead-on in calling it "a sad, bewildered nothing of a river." Still, the South Platte was dependable. It was also Aurora's lifeline, buying the city 20 or 30 years of time. "What I really like about it," Binney said, smiling as we walked from the field back to his truck, "is that it's wet." ■

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