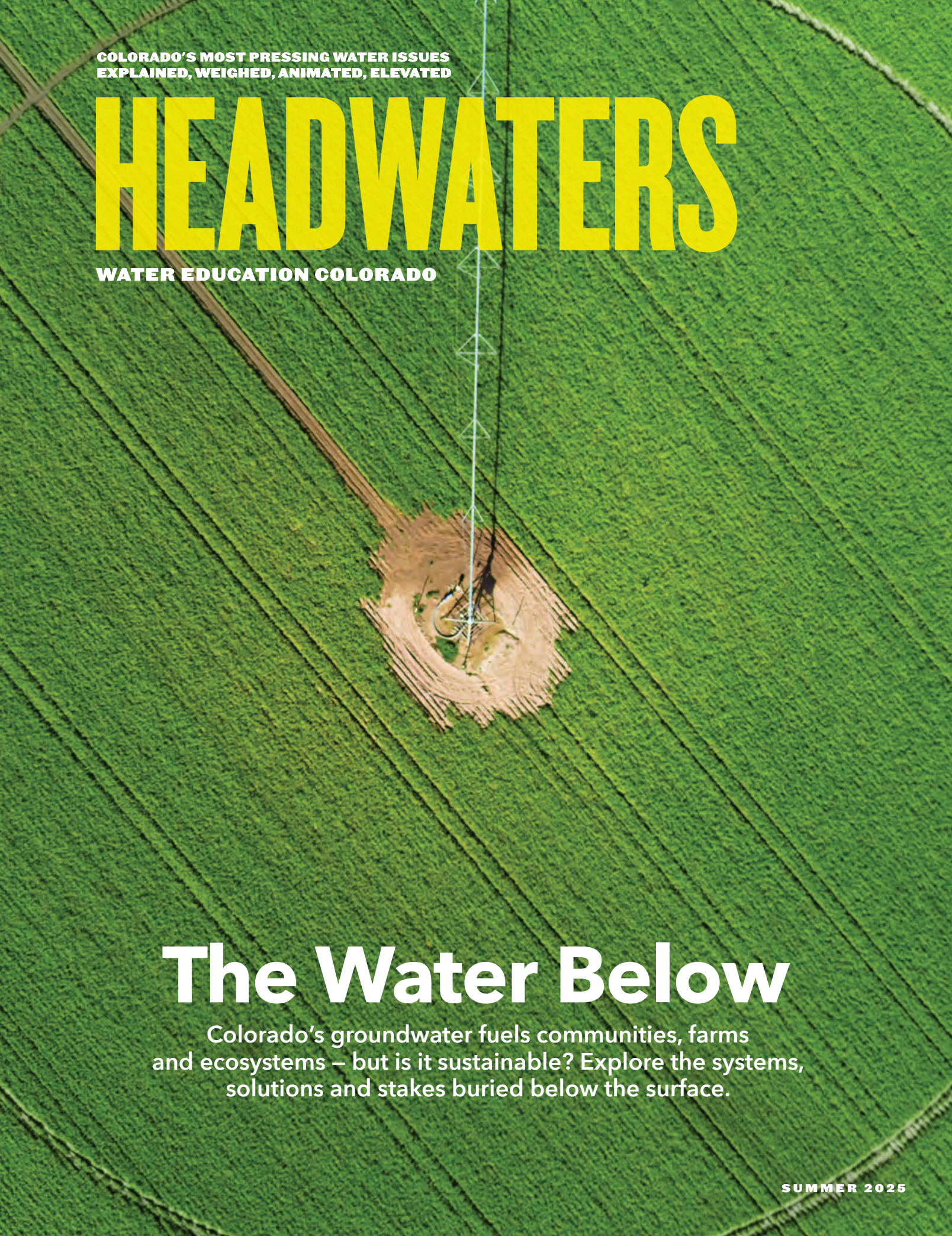
COLORADO'S MOST PRESSING WATER ISSUES
EXPLAINED, WEIGHED, ANIMATED, ELEVATED

HEADWATERS

WATER EDUCATION COLORADO



The Water Below

Colorado's groundwater fuels communities, farms and ecosystems – but is it sustainable? Explore the systems, solutions and stakes buried below the surface.

SUMMER 2025

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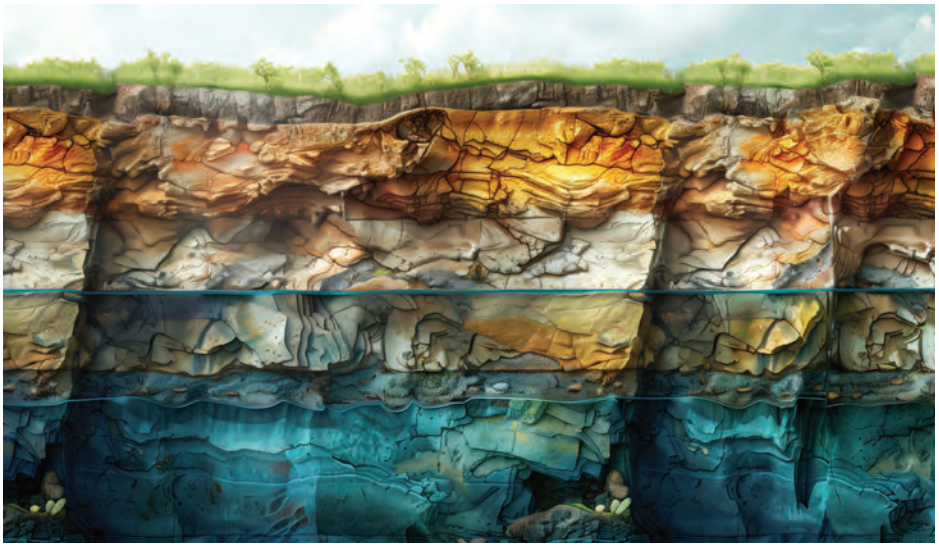
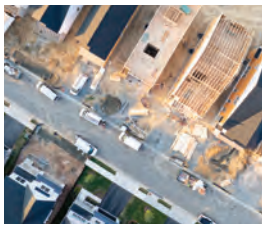
Summer 2025

FEATURES



ON THE COVER
A farm fueled by groundwater

INSIDE



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A Note From The Director

Grounded In Water

What lies beneath the ground, and how much do we actually know about Colorado's groundwater? It seems that many perceive groundwater to be a completely different element than surface water within the conversation and management of our precious water resources. However, in reality, groundwater and surface water are linked, as are the ways in which we use our water.

The history of how we manage groundwater and the lessons learned by experts across Colorado have made this edition of Headwaters Magazine one that you don't want to miss. The realities of the various water basins and the best practices that water stewards have learned over time offer readers a better understanding of the complex nature of groundwater and beyond.

WEco continues to dive into complex water topics — as you'll see in this issue — and highlight them for water experts, leaders, decision makers and other interested Coloradans.

We do this important work through all of our programs. Already this summer, we completed our 2025 Basin Tour in the southwest and also launched our 2025 Water Leaders and Water Fluency classes. Our signature programs are in full swing, and the intersection between our publications and leadership programs continues to offer a one-of-a-kind space to educate Coloradans so they can make informed decisions around water.

During the second half of 2025, we are co-creating our brand new strategic plan, and in partnership with many of you, we will design the roadmap for how the next 5 years for WEco will look. I invite you to engage with our team and board members, and I can't wait to share, in early 2026, some of the exciting initiatives that we will embark on together.

I also would like to welcome David Grimsland to our team. David is the new membership and development director, he brings vast experience in philanthropy and leadership in the nonprofit and philanthropic sector. Please join me in welcoming him into the water space.

Lastly, I hope to see you at this year's President's Reception, "Flowing Forward Together." This year's event will take place on Wednesday, September 10th, at Balistreri Vineyards, from 5 pm to 9 pm. Join us to celebrate leaders in the water community, learn about WEco's programs and our impact, and support water education at WEco's largest fundraising event of the year.

WEco continues to learn more about our impact, our community, and the ways how water should be front and center for the sustainable development of our state, as we "flow forward together," because we can't achieve our mission without you all.

Onward and upwards,

Executive Director

WATER EDUCATION COLORADO

THE MISSION of Water Education Colorado is to ensure Coloradans are informed on water issues and equipped to make decisions that guide our state to a sustainable water future. WEco is a non-advocacy organization committed to providing educational opportunities that consider diverse perspectives and facilitate dialogue in order to advance the conversation about water.

HEADWATERS magazine is published three times each year by Water Education Colorado. Its goals are to raise awareness of current water issues, and to provide opportunities for engagement and further learning.

THANK YOU to all who assisted in the development of this issue. Headwaters' reputation for balance and accuracy in reporting is achieved through rigorous consultation with experts and an extensive peer review process, helping to make it Colorado's leading publication on water.

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COURTESY OF JUAN PEREZ SAEZ

Touring the Southwestern Basins

In June, we hit the road through southwestern Colorado with a bus full of legislators, water professionals, and engaged community members. Along the way, we visited the Ute Mountain Ute Farm and Ranch Enterprise, Lake Nighthorse, a pump station, a mining site, and several other key locations that highlight the region's water challenges and innovations.

CLOCKWISE FROM TOP: COURTESY OF WATER EDUCATION COLORADO; COURTESY OF KAREN MCCORMICK; COURTESY OF DAVID GRIMSLAND

WELCOME TO THE TEAM

Water Education Colorado welcomes David Grimsland as our new Membership and Development Manager. David brings a background in media and nonprofit leadership, with past roles including director of sales and marketing at the Boulder Weekly and executive director of the Imagine! Foundation. His passion for community impact began with board service at the Autism Society of Boulder County and has grown ever since. Outside of work, David enjoys exploring Colorado's great outdoors with his wife and their adventurous triplet boys. We're thrilled to have him on the team and look forward to the energy and insight he brings to our work.

ONLINE

New Community Guide

Visit our shop to order the new, updated guide to Colorado Water Conservation & Efficiency!

A Conversation With

REPRESENTATIVE KAREN MCCORMICK

"It is [also] my role to bring in those experts to talk to us and to give us a little bit of the 60,000-foot view of things so that if a policy matter comes to our committee in the form of a bill, or there's a budgetary concern that we have to look at, at least the committee members have been introduced to the idea or know who to go to to find out more. That is a big part of how I see my role in conversations around water."

We spoke with Representative Karen McCormick, a member of the WEco Board of Trustees and Colorado State Representative. Read more on the blog at watereducationcolorado.org.

From The Editor

Digging Deep Together

There's something extra special about groundwater and those who use it, provide it, and push to sustain it in Colorado. Just look at the entities sponsoring and advertising in this issue of Headwaters magazine — there are a lot of them! And they all quickly, generously stepped up in support of groundwater education. Many others helped fact check this issue with great integrity. This topic matters to a lot of people.

Think of the work that those same folks, and many, many others, are doing on the ground. These people are devotedly doing their very best to address the groundwater sustainability challenges their regions face — for many they aren't just talking about water, but also about their farm, local economy, tax base, and community vibrancy. They're getting creative, working to retire or transform irrigated acres by assessing fees and taxes on groundwater use and acreage. Farmers are using less water. Utility managers are finding alternative water sources for their communities. They're building partnerships and working together to solve these big challenges, and they're making progress. Without a plan for sustainable water use, even more wells will be retired and communities will be in trouble. Read about groundwater sustainability in Allen Best's "Three Basins, One Challenge," page 16. I admire and celebrate those who are working on groundwater in Colorado — they are true water leaders.

Colorado is also a groundwater leader when it comes to administration — the state has been administering groundwater and surface water together since 1969. We are ahead of many other states with strict laws around groundwater administration. Here, all groundwater is presumed to be tributary (meaning it is connected to a natural stream system through surface or underground flows), and is regulated like surface water, until determined otherwise.

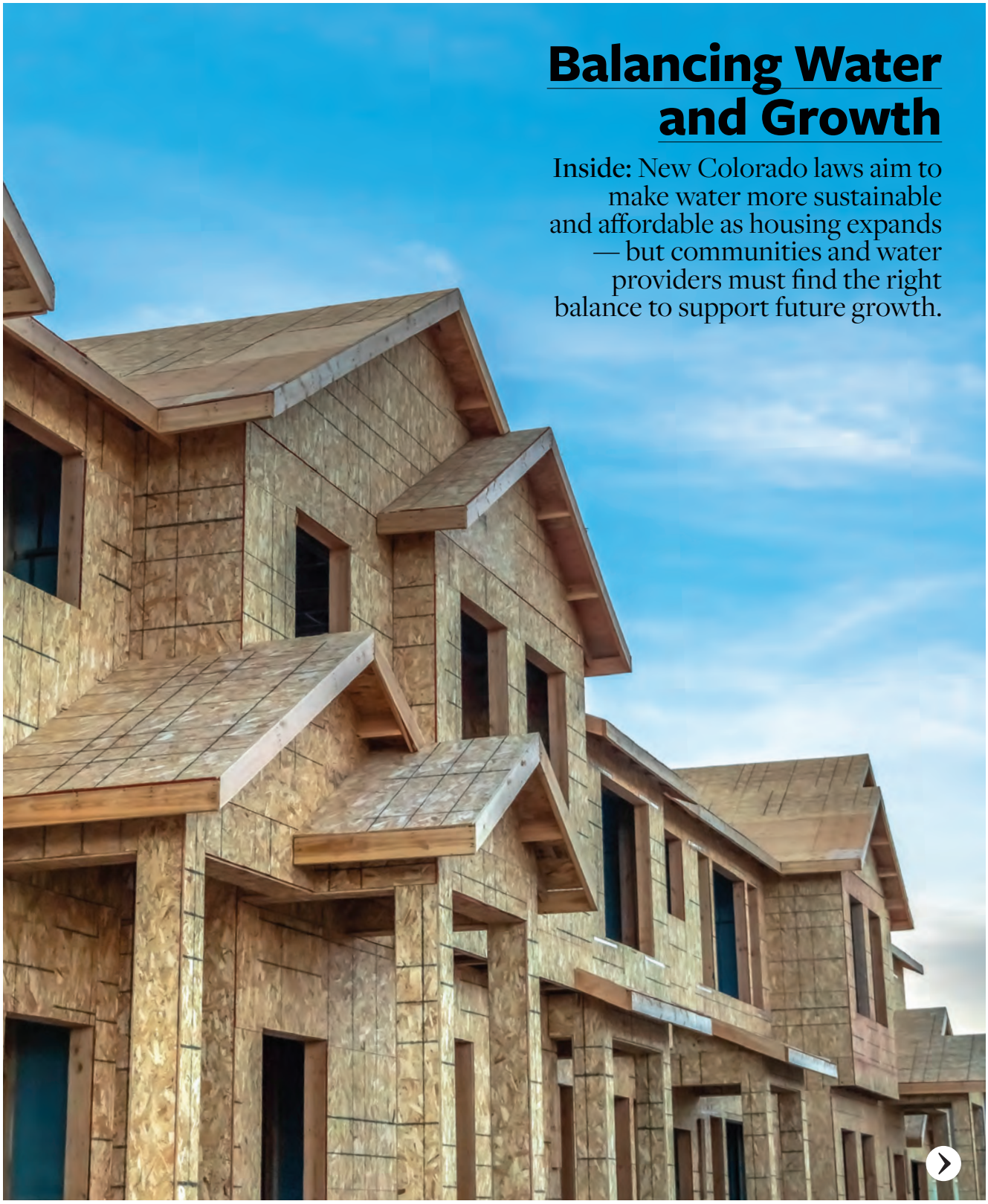
As some towns and cities are newly turning to groundwater, they're striving to operate within their water-supply means. At the same time, changing administration in other Western states means that they are following Colorado's lead and reckoning with groundwater use (see "New Thinking for an Old Resource," page 23).

There's a lot to be proud of when it comes to groundwater, but overwhelming challenges are still upon us, as are opportunities. Explore water quality in "Invisible Threats," page 28, and the possibility of storing water underground in "Innovation in the Subsurface," page 26. And while brilliant leaders are tackling groundwater sustainability, "the harder work lies ahead," writes Allen Best.

I'm proud of what Colorado has accomplished, and the role that Headwaters magazine plays in highlighting and advancing the conversation around groundwater. I look forward to seeing and supporting efforts as Coloradans continue to be creative and collaborative when it comes to our precious water resources beneath the surface.

Editor

COURTESY OF CAITLIN COLEMAN



Balancing Water and Growth

Inside: New Colorado laws aim to make water more sustainable and affordable as housing expands — but communities and water providers must find the right balance to support future growth.

ISTOCK

Tap Fees Overhauled

A new Colorado law will lower waterline connection fees to promote affordable housing and conservation, while some water districts worry about covering future costs.

BY SHANNON MULLANE

ISTOCK

Coloradans will see discounts for the waterline connection fees that come with new houses and commercial buildings because of a newly signed — and much-contested — law.

The legislation, House Bill 1211, focuses on tap fees, one-time charges that developers and property owners pay when they want to connect a new building to an existing water system. The connection fees vary widely — from a few hundred to hundreds of thousands of dollars — based on the location and type of development.

The law's supporters, including developers and housing officials, say the fees are too expensive for people to build affordable housing, like apartments, condo buildings, or small houses in backyards. Its opponents, including many water districts, say the fees are set to cover the costs of building pipes out to new houses and paying for more water — both of which are increasingly expensive.

Colorado Gov. Jared Polis signed the bill into law during a ceremony in May 2025, touting it as part of a broader effort to create more affordable housing.

"These laws break down cost barriers to make it cheaper to build housing and ensure fees don't impede new housing opportunities," Polis said in a news release. "In Colorado, we are looking at every solution to lower the cost of housing, and I am proud to continue that important work today."

Most tap fees are charged at flat rates based on meter size. Starting in August, the new law requires water districts to consider offering discounts for water conservation measures, like expected long-term water usage, and the use of water-efficient appliances and gray water systems. Or, districts could tie their fees to home size based on square footage, or the number of bedrooms and bathrooms.

Districts don't make a profit on tap fees, and they're legally required to make sure the calculations reasonably compare to the actual costs. This new law puts the requirement into state statute. It also says water districts have a duty to provide water if they have the capacity to do so.

The bipartisan law, which passed the state Senate and House by wide majorities, focuses on special districts that manage water systems, not other water providers, like cities and towns. During the legislative session, the bill's sponsors claimed that cities and towns have more accountability and are already doing most of the actions that the bill calls for.

Western Resource Advocates, an environmental organization, offered steady support for the legislation. The new law draws from the organization's recent study, which found that conservation-oriented tap fees more fairly price tap fees based on water demand at new sites.

"Reducing water demand in new development helps save water and money for both developers and special districts," Chelsea Benjamin, a Western Resource Advocates policy advisor, said in a written statement. That will trickle down to housing prices and monthly water bills, she said.

That's not necessarily the case, according to some water districts who say the money for infrastructure might end up coming from monthly water bills.

For Ty Jones, district manager for the Clifton Water District, the criteria for reducing tap fees aren't realistic. Clifton Water serves 12,300 taps across about 10,720 acres around Clifton, located between Palisade and Grand Junction.

A new home might include a graywater system or a certain square footage at the beginning, but new owners can change all of that, Jones says.

Lawmakers amended the bill to allow districts to recoup lost income from discounted tap fees when conservation measures are modified or the building's structure changes.

But special districts aren't involved in permitting, and they're not updated when changes are made to buildings or landscaping, Jones says.

Now, special district water providers around the state are analyzing the new law to understand its impacts and whether they need to change their tap fees.

This story originally appeared in Fresh Water News, an initiative of Water Education Colorado published in collaboration with The Colorado Sun. Read Fresh Water News online at watereducationcolorado.org.

Shannon Mullane writes about the Colorado River Basin and Western water issues for The Colorado Sun.

Cleaner Rules Ahead

Senate Bill 305 will tighten timelines, improve communication, and help small towns balance water quality goals with the cost of upgrades.

BY JERD SMITH

State health officials will face tighter deadlines and more scrutiny of a water quality permitting program that has been plagued by massive backlogs and criticized by some small communities who say they can't afford their state-mandated water treatment systems.

The changes will come under a new bipartisan law, Senate Bill 305, which Gov. Jared Polis signed into law in June 2025.

"This bill is a reset in the relationship between the Colorado Department of Public Health and Environment (CDPHE) and local governments that both sides believe will result in better communication, collaboration and ultimately better water quality," says Sen. Jeff Bridges, a Democrat from Greenwood Village who is one of the bill's sponsors and chairs the Joint Budget Committee.

The permits are required under the federal Clean Water Act and are designed to protect Colorado's rivers and streams from contaminants contained in wastewater. The state is required to enforce the federal law.

The measure is designed to help the CDPHE battle a permitting backlog that has left dozens of communities without a current wastewater discharge permit. Those communities can still discharge under a special administrative rule, but the backlog means the communities aren't complying with the most current wastewater treatment standards that seek to reduce the various contaminants, such as ammonia and nitrates, being discharged into streams.

Earlier this year, as the state sought to fast-track permit approvals, small towns revolted, saying the new permits that were issued were too tough and that it was too expensive to upgrade treatment systems to comply.

The controversy comes as climate change and drought reduce streamflows and cause water temperatures to rise, and as population growth increases the amount of wastewater being discharged to Colorado's rivers.

In response to the towns' concerns, CDPHE's Water Quality Control Division took the unusual step in March of holding off on taking enforcement action against some of the towns that say they can't comply with the new regulations.

Senate Bill 305 will allow communities to hire outside engineers and consultants to help speed permit processing times. It also requires the CDPHE to develop new rules establishing clear timeframes for granting or denying different types of permits by Dec. 31, 2027.

In addition, according to Nicole Rowan, director of the Water Quality Control Division, they will set a schedule by Dec. 31, 2026, for reducing the backlog.

The changes aren't likely to help Ault, a community of 2,350 people on the Eastern Plains that finally received a new permit in March. The permit, however, contains standards the town's 9-year-old wastewater treatment plant can't meet. The CDPHE has agreed to suspend any enforcement action against the community until it can do additional analysis to see if it can comply with the new rules simply by upgrading its treatment plant, according to Grant Ruff, who oversees the town's treatment system.

The town still owes $1.2 million on the existing plant. Building a new one would likely cost more than $20 million, Ruff says.

"We hope it is feasible [to comply] by making minor upgrades," he says. "Otherwise we will have to spend $20 million to $30 million."

That won't be the case for towns seeking new permits in the years ahead.

"The new standards will be tremendously helpful in the future because the state will have to take into consideration the community's ability to pay," he says.

This story originally appeared in Fresh Water News, an initiative of Water Education Colorado published in collaboration with The Colorado Sun. Read Fresh Water News online at watereducationcolorado.org.

Jerd Smith is editor of Fresh Water News.

ISTOCK

Around The State: Quick Updates From Colorado's Major Watersheds

ARKANSAS RIVER BASIN

According to Colorado Public Radio, a new whitewater park in Pueblo officially opened in late May. Pueblo Water spent about $11 million to turn a dangerous, century-old diversion dam on the Arkansas River into Water Works Park, which is a free, family-friendly area with wading ponds, tubing areas, and whitewater. Thanks to this project, the river is now floatable for about eight miles.

COLORADO RIVER BASIN

Fresh Water News reports that the Colorado River District and partners who have been working to buy the water rights tied to the Shoshone Power Plant are awaiting the results of a Colorado Water Conservation Board decision. In May, the River District officially proposed that the state use Shoshone's water rights to keep water in the Colorado River for ecosystem health through an instream flow when the hydroelectric plant isn't in use. The CWCB has 120 days, starting May 21, to determine whether to accept the River District's instream flow proposal. If accepted, the River District would still need to bring the rights to water court. While there is support for the idea, Front Range water operators are voicing opposition, citing concern that it could harm their ability to provide water for essential use during drought. A hearing to air concerns will take place at the CWCB September board meeting.

GUNNISON RIVER BASIN

The Gunnison Country Times reports on the successes of the Upper Gunnison River Water Conservancy District's grant program. The district started making grants in 2009 and has since awarded $2.4 million for projects throughout the basin. Over the years, the grant program has funded the development of a watershed management plan, numerous ditch headgate and diversion replacements, water-wise plantings, engineering for a new water system at a Lake City campground, a harmful algal bloom study in Blue Mesa Reservoir, a project to improve the municipal outdoor irrigation system in Crested Butte, and more.

NORTH PLATTE RIVER BASIN

Snowpack in the North Platte Basin was grim this year, noted Barbara Vasquez at the Colorado Water Conservation Board's May board meeting. Vasquez represents the North Platte Basin on the board. As of June 1, the North Platte's snowpack levels measured at 54% of median, according to the Natural Resources Conservation Service. Statewide snowpack was also 54% of normal. Some river basins were measuring worse than the North Platte — the Upper Rio Grande was just 1% of median — while others fared better, with the Arkansas at 93% of normal. However the North Platte has little reservoir storage — it has the capacity for 39,861 acre-feet of storage, Vasquez says, but under a Supreme Court Decree, the basin can store a maximum of 17,000 acre-feet of water for irrigation every year.

RIO GRANDE BASIN

A new study from American Rivers and One Water ECON reports on the value of water in the San Luis Valley, according to the Valley Courier. The study found that irrigated agriculture in the valley consumes 75% of the Rio Grande's flow and waters 400,000 acres of land. Among other findings, the study reports that the valley contributes 39% of Colorado's total agricultural output and generates $100 million in economic output annually. The population is less than 1% of the state's total population. The study also found that water-related recreation provides $213.7 million in revenue annually and an additional $365.9 million in direct sales.

SAN JUAN/DOLORES RIVER BASIN

Fresh Water News reports that the Colorado Water Conservation Board, Colorado's top water policy agency, has a new leader: Southern Ute tribal member Lorelei Cloud. On May 21, board members elected Cloud to serve a one-year term as chair, making her the first Indigenous person to hold the position since the board was formed in 1937. Cloud said her new role gives Indigenous people a long-sought seat at the table where water decisions are made. Cloud represents the San Miguel-Dolores-San Juan basins in southwestern Colorado.

SOUTH PLATTE RIVER BASIN

The Denver Post reports that the construction of two large-scale data centers in the metro Denver area are raising concerns and questions about the impact of such development on Colorado's shrinking water supplies and demand for electricity. When complete, one data center in Aurora will be a 160-megawatt facility that could consume as much power as 176,000 homes. The other data center in Denver's Elyria-Swansea neighborhood could use a maximum of 805,000 gallons of water a day for cooling, or about 2.5 acre-feet.

YAMPA RIVER BASIN

Fresh Water News reports that a popular .6-mile stretch of the Yampa River, below Stagecoach Dam, was closed to anglers and recreators in May as water and wildlife managers try to save water to prevent overfishing in dry conditions. When the river becomes too shallow, wildlife managers close this fishery to protect fish — this is the third closure on this stretch of river in three years, according to Colorado Parks and Wildlife — with the Yampa flowing into Stagecoach at about one-third of its normal level.

—**Caitlin Coleman**

PRESERVING EASTERN COLORADO FARMING FOR GENERATIONS TO COME.

Safeguarding Colorado's Water Commitments

Republican River Water Conservation District

(970) 332-3552 republicanriver.com info@rrwcd.com

Agricultural producers in the basin impose assessments on themselves to support initiatives to maintain compliance.

Producers voluntarily retired over 75,900 acres of irrigated land throughout the basin in an effort to extend the life of the aquifer.

Producers funded the Compact Compliance Pipeline to sustain our rural economies and ensure the long-term viability of irrigated agriculture.


BENEATH THE

SURFACE

Colorado's groundwater is vital, vulnerable, and often misunderstood. As water levels decline and demands grow, communities across the state — and the West — are reckoning with how to manage this invisible, invaluable resource.

1

Groundwater 101

THE WATER BELOW

What is groundwater? Where does it come from? And why is it so important to Colorado's water future? A primer on the essential — but hidden — source beneath our feet.

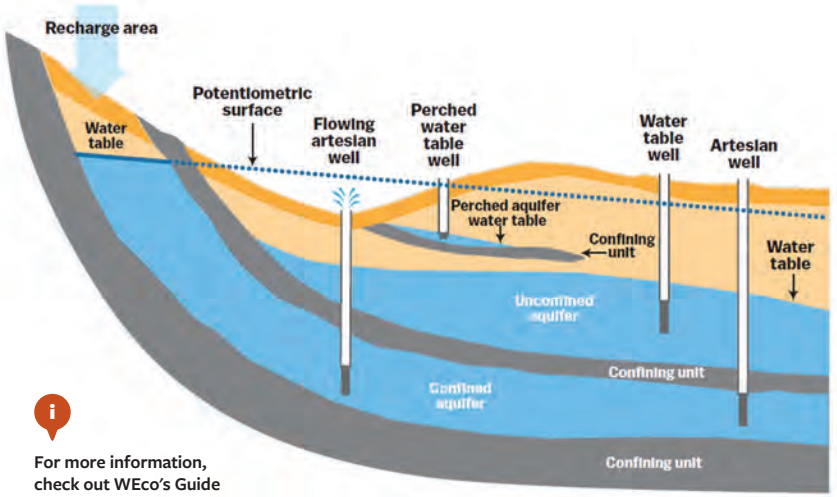
WHAT IS GROUNDWATER?

Groundwater is water that occupies the empty spaces in the soil, sand and rocks beneath our feet. An aquifer is a groundwater reservoir composed of geologic materials that are saturated with water and sufficiently permeable to yield usable quantities of water to wells and springs. Aquifers both transmit groundwater from areas of recharge to areas of discharge, and they provide a storage medium for groundwater.

CONFINED VS UNCONFINED

Unconfined aquifers have no confining beds between the zone of saturation and the surface. Examples of unconfined aquifers include the saturated alluvial deposits associated with many river systems including the South Platte, Arkansas and Colorado Rivers. They also include valley-fill deposits such as in the San Luis and Wet Mountain valleys.

Confined aquifers are completely saturated geologic units overlain by confining layers of low permeability that prevent free movement of air and water. For the most part, the Denver, Arapahoe, and Laramie-Fox Hills aquifers of the Denver Basin are examples of confined aquifers.



Source: Modified after Harlan and others, 1989

For more information, check out WEco's Guide to Colorado Groundwater on our website.

COLORADO'S GROUNDWATER REGIONS

Denver Basin Aquifer

These four aquifers underlie a 6,500 square-mile area from Greeley to Colorado Springs and from Limon to Jefferson County: the Dawson, Denver, Arapahoe and Laramie-Fox Hills aquifers. This water is found in sandstone beds. Natural recharge is very slow, making them essentially nonrenewable.

South Platte Alluvial Aquifer

A vast tributary aquifer that ranges from 20 feet deep under Denver to 200 feet deep in eastern Colorado. The aquifer contains about 8.3 million acre-feet of water, and it feeds — and is fed by — return flows from South Platte River diversions.

San Luis Valley Aquifers

The valley is home to a shallow unconfined aquifer, about 12 feet below ground, whose flows are connected to the Rio Grande and a deeper confined aquifer beneath it. Groundwater in the confined aquifer occurs under almost half of the valley and is tapped by deeper wells. Most of these wells are less than 400 feet deep, while some are more than 1,000 feet deep. The unconfined aquifer lies below much of the valley.

High Plains Aquifer

Often called the Ogallala aquifer, this aquifer underlies about 174,000 square miles of the central United States, including about 14% of eastern Colorado. In heavily used parts of the aquifer, water levels have dropped 50 to 100 feet since 1950; shallow wells are completely dry; lighter-use areas have dropped less.

BY THE NUMBERS

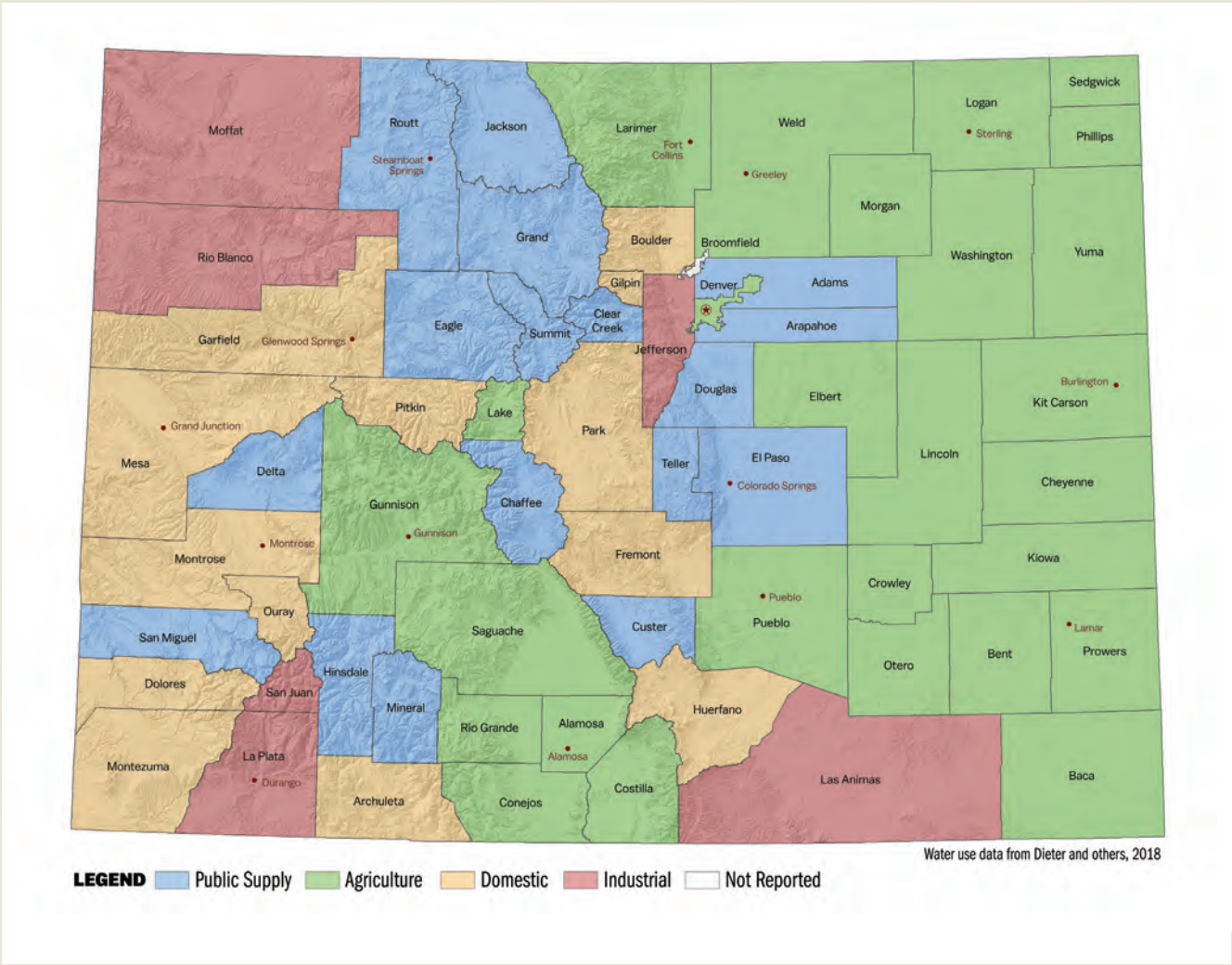
20-30X

The National Groundwater Association indicates that groundwater is 20-30 times more plentiful than the water in all the lakes, streams and rivers of the United States combined

CHAS CHAMBERLIN. PREVIOUS SPREAD: ADOBE STOCK.

The Principal Uses of Groundwater for Each Colorado County

Around 244,000 wells in Colorado, or 79%, are for domestic water supply. Domestic wells supply groundwater for about 11% of the state's population. As with surface water, the dominant use of groundwater in Colorado, is for agricultural irrigation. Groundwater supplies less than 10% of total water use in 36 of the state's 64 counties. At the other end of the spectrum, eight counties rely on groundwater for 80% or more of their total water supply.



MAP: COURTESY OF COLORADO DIVISION OF WATER RESOURCES

284,000+

Groundwater wells in Colorado have been constructed for domestic, irrigation, stock watering, commercial and industrial uses

740

Million acre-feet of water are estimated to be stored in Colorado's primary bedrock aquifers

200-300

Million acre-feet of recoverable groundwater reserves are estimated to exist in the Denver Basin aquifer system alone

79%

Of all constructed groundwater wells are for domestic water supply

2

Regional Realities

THREE BASINS, ONE CHALLENGE

In the Republican River Basin, Denver Basin, and San Luis Valley, communities are working to curb their reliance on groundwater. But the road to sustainability is steep — and urgent.

by Allen Best

To understand the predicament in the Republican River Basin of eastern Colorado, you need to appreciate the volume of water being hoisted from the underlying High Plains Aquifer, which includes the Ogallala formation.

Farmers and the few small towns in the Republican River Basin average 720,000 acre-feet of withdrawals annually. In one hot and dry year, 2012, they pumped 940,000 acre-feet. As a point of reference, Blue Mesa Reservoir, the largest water body in the state, can hold 947,435 acre-feet.

Groundwater mining cannot be sustained far into the future in many areas of the Republican River Basin. Water levels have been dropping at varying rates in different parts of the basin — from no decline to a drop of 13 feet in 10 years. Pumping at existing rates cannot be maintained. Within 25 years, about a third of land that's now irrigated will have no water. In other places, pumps already sputter.

"Sustainable" and "pumping" do not belong in the same sentence in this basin.

The water of the Republican River Basin infiltrated the High Plains aquifer as the formation was deposited some 18 to 4 million years ago. Far from the snowmelt of the Rocky Mountains, it is recharged by minimal surface water. For every six gallons of groundwater extracted, only one gallon of recharge occurs. It's mostly an ancient bank account with now small deposits and fast-and-furious withdrawals.

The Republican River Basin and several other regions of the state rely largely on groundwater. In a 2024 decision, Colorado Supreme Court justices pointed out that it would be difficult to overstate the importance of groundwater given the state's population and arid climate. The 285,000 wells poked into the earth across the state deliver 18% of Colorado's water.

The Republican River Basin, the San Luis Valley, and the south-metro area of the Denver Basin are all, to varying degrees, rethinking water — both its sources and uses. All three have historically relied heavily on groundwater, and all have made at least limited progress in shifting toward more sustainable groundwater use in the last 20 years. The cities have adopted policies that foster smaller, less water-intensive lawns. They have diversified their sources. Two south-metro water utilities that 20 years ago pulled nearly all their water from wells, today have lessened that dependency to 60% to 65%.

Farmers in the Republican River Basin and San Luis Valley have somewhat different challenges. They have taken action to use less water and to save their communities, but whether those actions match the scale of the challenges they face is another matter. Changes can best be achieved before emergency sirens wail. In the Republican River Basin, some already see a swirl of red lights warning of catastrophe ahead.

REPUBLICAN RIVER BASIN

The Republican River Basin consists of 7,000 square miles, an area slightly smaller than New Jersey. It is largely located within a triangle between Julesburg, Limon and Cheyenne Wells. A few businesses cater to travelers, but agriculture constitutes nearly all the basin's economic foundation.

An average 17 inches of precipitation falls per year across the basin, less in some areas.

BY THE NUMBERS

8,000

Number of additional acres in the Republican River Basin that must be retired by December 2029, as outlined in a multi-state agreement.

High-dollar agriculture depends almost entirely upon water drawn from the underlying Ogallala aquifer to irrigate the basin's 600,000 acres.

Dryland farming prevailed until high-capacity pumps and rural electrification arrived in the 1940s. Farmers in the 1950s began converting dryland areas to irrigation, dramatically expanding crop yields. Twice in the 1970s, groundwater extraction

exceeded a million acre-feet per year.

Groundwater drafting via 5,000 wells today produces a bounty of herbaceous crops. Most end up in the bellies of animals. The basin has three hog farms, several dairies, an ethanol plant, and several feedlots that can each hold more than 150,000 cattle.

In 1942, Colorado, Nebraska and Kansas allocated the waters of the Republican River and its tributaries in an interstate compact. In the 1990s, Kansas complained that it was getting shorted by Nebraska. Nebraska, in turn, blamed Colorado. A 2002 settlement stipulation among the three states represented a new line in the sand. By whatever means, Colorado had to figure out how to deliver water to the downriver states.

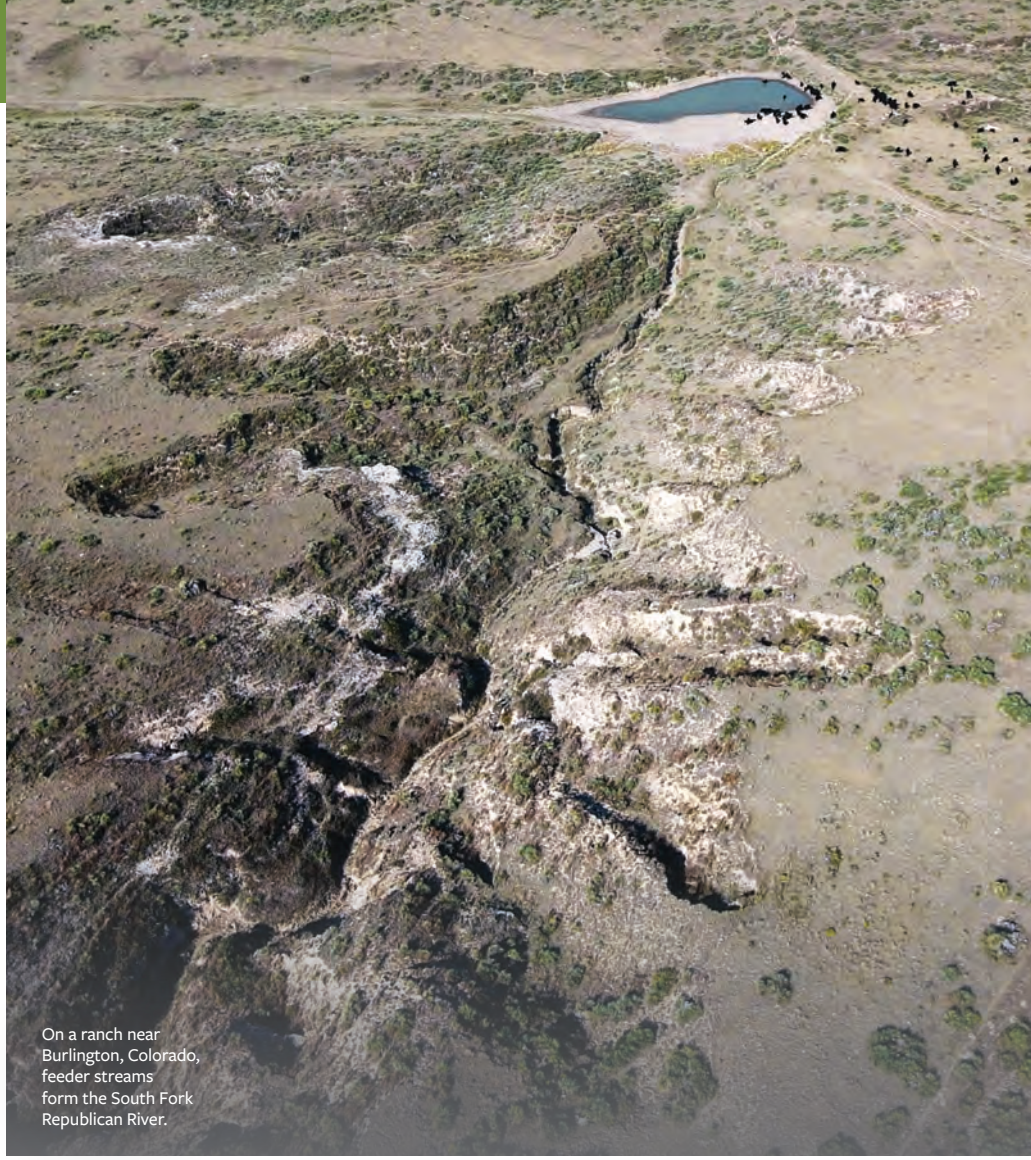
Colorado responded by forming the Republican River Water Conservation District. In effect, the state gave farmers and others in the eight-county district responsibility for figuring out how to comply with the compact. To help achieve compliance, legislators gave the district authority to levy fees on irrigators. The fee, originally $5 per acre, has been boosted twice and is now $30 per irrigated acre annually.

This $15 million in annual revenue is used in several ways. An early project yielded a pipeline to boost the amount of water flowing into Nebraska. Amid hills composed of sugar-like sand between Wray and Holyoke, water from eight wells, formerly used for irrigating crops in the deepest part of the aquifer, flows 12.6 miles through the pipeline and into the North Fork near where the river flows into Nebraska.

This pipeline, since its completion in 2012, has allowed Colorado to meet its compact delivery requirements. The cost of the wells, pipeline, and water rights was $72 million. Faced with declining production from these wells, the district in 2025 is planning four more wells and 9.5 miles of piping at an estimated added cost of $14 million.

In another move toward compact compliance, Bonny Reservoir, a 165,238 acre-foot impoundment on the South Fork of the Republican, was drained. Prior to the 2011 draining, Bonny had delighted boaters and anglers but lost too much water to evaporation and seepage.

More actions were needed to ensure Nebraska and Kansas received their apportioned water. Beginning in 2006, Colorado removed 30,000 to 35,000 acres from irrigation. A multi-state agreement in 2016 specified that Colorado would remove an additional 25,000 acres in the South Fork drainage by 2029.



On a ranch near Burlington, Colorado, feeder streams form the South Fork Republican River.

RJ SANGOSTI/THE DENVER POST

This permanent retirement of irrigated acreage has been encouraged with financial incentives assembled from pots of local, state and federal funds. The money is delivered via two federal programs: the Conservation Reserve Enhancement Program (CREP), and the Environmental Quality Incentives Program (EQIP). The latter allows farmers to use the land for dryland farming or grazing.

By early 2025, the Republican River Water Conservation District had retired 17,120 of the 25,000 acres as required by the 2016 settlement. It was a milestone, a time for momentary celebration. The harder work lies ahead. Nearly 8,000 additional acres must be retired to meet the December 2029 deadline. If the goal is not met, the state engineer has authority to shut down wells. Nobody wants that, least of all the state engineer. To help sweeten the incentives in 2025, state legislators appropriated $6 million. This adds $750 to the $4,500 per acre paid to farmers participating in CREP and $750 to the $3,500 per acre in EQIP.

Using less water is the paramount challenge. This has been accomplished almost exclusively by taking land out of irrigation There are other ways, too. Today, corn is king, responsible for about 85% of irrigated acres in the basin. It commonly receives 20 to 22 inches of supplemental water. A growing realization of late is that less can be more. Planting fewer seeds — say 18,000 per acre instead of 30,000 — will save money and require less fertilizer. Fewer seeds will then require only 12 to 14 inches of supplemental water, meaning less pumping, which cuts electricity

Castle Rock Water relies, in part, on Denver Basin groundwater.

bills. Lesser crop yields can counterintuitively produce better profit margins.

Conversations are also underway about water-conserving crop alternatives: milo, millet and wheat, kidney and pinto beans, even black-eyed peas. It's partly a matter of developing markets. Deb Daniel, the general manager of the district since 2011, has been toying with how to emphasize productivity strategies with the phrase "crop per drop."

None of this adds up to the scale of the challenge, though.

Kenny Helling, a fourth-generation farmer from the Idalia area of Yuma County, believes more is needed than financial incentives to take land out of production. "Continuing to throw money at the problem won't fix the problem," he says. Land must be kept in irrigation, because irrigated land pays more in property taxes. Those taxes are crucial for operating fire departments, schools and other community purposes. "It's a very big concern to me."

Helling was a member of the Republican River Water Conservation District Board of Directors for nine years. He says the district needs other tools. The true authority for limiting pumping belongs to the eight groundwater subdistricts within the basin. They do not use it. Why?

"Everybody on those groundwater management districts are generally irrigators," says Helling. "Most of them are neighbors. A lot of them go to church together ... Nobody wants to make anybody mad. And so, unfortunately, the groundwater management districts do not use all the authority they could to restrict the amount of water used."

Colorado legislators, he says, need to give the Republican River Water Conservation District more authority. It needs sticks, not just carrots. "We need to use less water."

Tim Pautler told members of the Colorado Groundwater Commission something similar in May 2025. A dryland farmer from the Stratton area, he has served on the Republican River Water Conservation District's Board of Directors for 21 years. He says that the board has accomplished almost no basin-wide conservation. It hasn't figured out how to substantially reduce water use. Landowners taking advantage of the incentives mostly have been irrigators who have less groundwater available — their wells were already sputtering. He says the fees charged to farmers must be based on acre-feet of water pumped and not just on irrigated acres. Reduced water use is the goal.

There's no pretense of sustainability in the Republican River Basin. The water deposited over millions of years is now being mined. The task is to maximize the value of the remaining water, to prolong the availability of the High Plains Aquifer. Few have yet been willing to talk about the gravity of the challenge.

"I hope enough water remains in the hole to sustain society," says Pautler. "I hope we don't go completely dry."

SOUTH METRO DENVER

Unlike the sparsely populated Republican River Basin, the south metro area of the Denver Basin has large and still-growing cities. Most of the south metro area lies within Douglas County, whose population ballooned between 1980 and 2025 from 25,200 to nearly 400,000.

Castle Rock, the county's largest city, has 87,000 residents. Based on approved development, the city expects to grow to a population of 120,000 to 140,000. Parker, the second largest city, has 68,000 residents and has zoning for 80,000. Utilities serving these two cities in 2005 were almost 100% dependent upon extractions from the underlying Dawson, Denver, Arapahoe and Laramie-Fox Hills aquifers. Both cities as well as other jurisdictions have lessened their dependence, but they have much work to do.

How much water remains? That's not an easy answer to deliver. That absence of total certainty was at the heart of a Colorado Supreme Court decision handed down in late 2024. Parker Water and Sanitation District, Castle Rock Water and others had squared

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off in water court beginning in 2021 with the Colorado Division of Water Resources. Parker Water has 33 wells that are 515 to 2,745 feet deep. State-issued permits for the newest five wells state that the total withdrawals are limited to what could be withdrawn during 100 years at a rate of 1% a year. Parker Water and several other south-metro jurisdictions disputed the state's authority to attach this stipulation.

The stipulation was premised on a 1973 law in which state legislators ordered a "slow sip" of Denver Basin aquifers. Later legislation and rulemaking clarified that withdrawals were not to exceed 1% of total recoverable water in that portion underlying the land of the permittee's well in any given year.

This dispute is about the future. When those 100-year limits have been reached, will the cities be able to continue to pump groundwater after they have reached the total volumetric limits associated with their wells? Must they cease pumping even if water remains in the aquifer?

Aurora, which lies within a half-mile of Parker Water wells, argued its water rights could be harmed if Parker pumped more than the total volume of water found to be available for its wells. It is crucial to understand that water underground knows no property lines, no signs saying "Welcome to Parker." Water could, in theory, flow from below Aurora's land to Parker's wells. Underground, there are no fences.

Colorado Supreme Court justices, in their November 2024 majority opinion, warned of a "race to the bottom of the aquifer, with earlier permittees receiving a significant head start." What would happen if Parker Water, Castle Rock Water and others had their druthers? "Absent a total volumetric limit, a permittee who continues to pump at the maximum permitted rate for more than 100 years would end up pulling water to its well that would not otherwise be underlying its land," said the justices in their majority opinion.

In his dissent, Justice Brian Boatright came to the opposite conclusion, siding with the south-metro jurisdictions.

Some south-metro entities may seek state legislation that reflects what they believe is the best policy. As it stands now, a permit-holder that has withdrawn the total volumetric amount identified on a well permit must cease pumping, says Jason Ullmann, the state engineer and director of the Colorado Division of Water Resources. He has authority to notify users in writing of their violations. Could he shut down wells? They would be given "time as may reasonably be necessary to correct deficiencies," he says. But yes, they would be "subject to enforcement."

Just how much water remains in the Denver Basin aquifers? The Division of Water Resources issues well permits, and in doing so, estimates the potential volume of water underlying the applicant's parcel. But the state agency does not track changes in volume over time, nor does it track the amount of water that wells pump. It requires well owners to maintain pumping records.

When asked how much water remains in Castle Rock's wells, Mark Marlowe, director of the city's water utility, suggested consulting a hydrogeologist, perhaps from the U.S. Geological Survey. Pressed further, he said Castle Rock's groundwater supply will last more than 300 years "from a legal standpoint" based on current rates of use.

BY THE NUMBERS

69%

The amount of Castle Rock's water supply that currently comes from groundwater. By 2050, the city plans to lessen groundwater to 25% of its total water supply.

The practical effect of the Supreme Court ruling on Castle Rock? Very little in the short term, Marlowe says. In 2005, Castle Rock set out to create a pathway to dramatically lessen groundwater dependence. "We've been headed down this road for a long time," he says. So why participate in Parker's lawsuit? Because, he replied, the city wants to make long-term use of its investment in groundwater extraction. And as a practical matter, the city commonly extracts less than the 1% allowed annually.

Marlowe's answer is not totally satisfying, but the work done by Castle Rock since 2005 must be acknowledged. It was 100% dependent on groundwater extraction then. It is adding new impoundments to store surface water, pumping back water from Chatfield Reservoir, and doubling the daily capacity for treating wastewater. Castle Rock already has lessened its dependence on groundwater to less than 69% over the last four years and Marlowe says he's confident that by 2050 it will lessen to 25%.

Several of Castle Rock's successes have involved working with other south-metro jurisdictions, including the Parker Water and Sanitation District. In 2013, when Ron Redd was hired by Parker Water as general manager, the utility was still 90% groundwater reliant. He was given a mission: transition to renewable sources.

A key project has been water reuse. Water introduced into the South Platte River from other basins or from groundwater can be reused. Aurora Water set out to do so in 2003. The $680 million Prairie Waters Project pumps water from the aquifer near Fort Lupton to a reservoir in the southeast metropolitan area. From there, in 2010, Parker Water, Castle Rock and eight other south-metro communities joined Denver Water and Aurora Water in a partnership called WISE (Water Infrastructure and Supply Efficiency) to further manage infrastructure cooperatively and deliver the reclaimed water to their members.

Making this possible was a new 75,000 acre-foot impoundment called Rueter-Hess Reservoir. Completed in 2012, it is a core asset for Parker Water and three other utilities who share its use.

The Platte Valley Water Partnership is even more ambitious. Parker Water and Castle Rock Water have joined with the Lower South Platte Water Conservancy District. They plan to detain South Platte River water that currently flows downstream into Nebraska during winter and spring runoff. The South Platte River Compact allows the use of this water. There is little excess in many years, but when there is, such as in 2023, no place exists to store that water. The project will use new and existing infrastructure to capture and store those flows before pumping some of that water 125 miles to Rueter-Hess Reservoir. Farmers will also have access to a cut of this "new" water — with agricultural users receiving 50% of the captured water and municipalities receiving

50%. Construction is set to begin around 2035, at an anticipated cost of $780 million.

A final important component of the path forward for the water utilities who mine Denver Basin aquifers lies in conservation, particularly for outdoor landscaping. The prevailing theme at one time was use as much as you want — but pay for it. That thinking has shifted to goals of reduced use. Parker has reduced groundwater dependence to 60% and has goals to reduce it to 25%.

SAN LUIS VALLEY

Center, as its name implies, lies at the center of the San Luis Valley. The valley is among the nation's two most prominent places for growing potatoes. Among the growers is a fourth-generation family operation, Aspen Produce LLC.

Jake Burris married into the family. In addition to spuds, the family grows barley and alfalfa on 3,500 acres. Burris is president of the board of managers of one of six subdistricts in the San Luis Valley's Rio Grande Water Conservation District. His subdistrict — called Subdistrict No. 1 — was formed in 2006 in response to a declining water table. What's known as the unconfined aquifer supports this area, the most agriculturally productive in the San Luis Valley. With just seven inches of annual precipitation, irrigation in the San Luis Valley is everything. And in Subdistrict 1, much of that water comes from 3,617 wells, both active and inactive.

Alfalfa is the thirstiest crop, using 24 to 36 inches of water to get three cuttings. The strong sunshine and cooler temperatures found above elevations of 7,000 feet produce a high-quality hay that draws orders from dairies as far as California. Alfalfa is grown on 21,100 acres in the district. Potatoes cover 51,100 acres. Barley is grown on 28,000 acres. Some have replaced barley with rye. Several thousand acres have together been devoted to canola, lettuce, and other crops. A recent census found about 25,000 acres had been fallowed.

The San Luis Valley has two primary aquifers. Lower in the ground, separated by relatively impermeable beds of clay from what lies above, is the confined aquifer. The first well into the confined aquifer was bored in 1887. Because of the pressure underground, it was an artesian well. No pumping was needed to bring water to the surface. According to a 1958 report by the U.S. Geological Survey, Louis Carpenter, a professor at the Colorado Agriculture College (now Colorado State University), estimated the valley had 2,000 artesian wells when he visited in 1891.

The unconfined aquifer lies above the confined aquifer. The unconfined aquifer existed prior to major water development in the valley but water volumes rose greatly when farms began using Rio Grande water in the 1880s. Introduction of high-capacity pumps in the 1950s and center-pivot sprinklers in the 1970s accelerated groundwater extraction. In 1972, the state engineer imposed a moratorium on new wells from the confined aquifer, followed in 1981 by a moratorium on new wells in the unconfined aquifer. These moratoria acknowledge that groundwater drafting had to be limited.

Then came 2002, hot and dry, escalating the challenge. Impact to the unconfined aquifer was drastic with rising temperatures causing growing water demand even as snowpack declined.

The unconfined aquifer "has been dropping overall since about 2002," says Craig Cotten, the Colorado Division of Water Resources engineer for Division 3, which encompasses the San Luis Valley. "We just have not had a real good series of years as far as the surface water."

In 2004, state legislators passed a law that sets the San Luis Valley's aquifers apart from those in the Republican and Denver basins. That law, SB04-222, explicitly orders that both the confined and unconfined aquifers be managed for sustainability. The Colorado law governing the Denver Basin aquifers requires a "slow sip" but does not imagine sustainability. In the Republican River Basin, no law speaks to sustainability. There, only the interstate compact insists upon limits.

This same 2004 law also encouraged the formation of groundwater subdistricts within the Rio Grande Water Conservation District. The thinking was that very local groups of farmers could work together to figure out how to keep their portions of the aquifers sustainable. They could also be more effective in this pursuit by working together than doing so individually.

IN THE FIELD

NEW DATA IN SOUTHEASTERN COLORADO

No interstate compacts complicate extraction of water from the Ogallala and other aquifers in far southeastern Colorado around the towns of Springfield and Walsh. Some wells have run dry, while others continue to produce tolerably well. How exactly is the groundwater holding up in Baca County and a small adjoining area of Prowers County?

The Division of Water Resources, using a $250,000 appropriation from state legislators in 2023, has contracted with Wilson Water Group to provide scenario analyses for future groundwater use and, through community input, to identify and establish groundwater resource goals for basin residents. The report is due in 2026.

The state's last study of aquifers in that corner of Colorado was completed in 2002. McLaughlin Water Engineers estimated the various formations altogether held 22 million acre-feet of recoverable water.

This study will employ new technology to gain an improved understanding of what lies underground in the Southern High Plains Aquifer and how the various formations are connected. Tracy Kosloff, the deputy director of the Colorado Division of Water Resources, reports a complex hydrogeology that is only partly understood. That complexity explains why some pumps can be sputtering, delivering miniscule amounts of water, while other pumps nearby still deliver robust quantities. The study will clarify this complexity and provide greater insights into the deeper formations that were not well understood in 2002.

Wilson Water Group will present this new information to groundwater users and help facilitate discussions about how best to manage the resources. Baca County residents have had disagreements in the past about the best path forward, with some wanting an end to any new permits and others believing that no moratorium is necessary.

In the San Luis Valley, water from two aquifers — the confined and unconfined aquifers — irrigates crops including alfalfa, potatoes, barley and more.

ALLEN BEST

Six subdistricts have been created in the Rio Grande Water Conservation District and one in the Trinchera Water Conservancy District. Subdistrict No. 1 began operations in 2012 after the state approved its operating plan.

All of these groundwater districts have the goal of reducing water consumption as necessary to replenish the aquifers or by introducing water into the aquifer from the Rio Grande or other sources.

Exactly how much restoration of the aquifers is needed? The state law specified a return to volumes that approximate those of 1976 to 2001 in the confined aquifer. But there's some guesswork about how much water the confined aquifer had then. Detailed records on Subdistrict No. 1 were not kept until 1976.

In August 2024 the unconfined aquifer in Subdistrict 1 was estimated to have averaged almost 1.2 million acre-feet less water during the five preceding years than it had in 1976. The rules approved by the Colorado Supreme Court in 2011 in a document called the Plan for Water Management call for the recovery of the unconfined aquifer within 200,000 to 400,000 acre-feet of where it was in 1976. That would be deemed sustainable, as ordered by the 2004 law.

To achieve this, the state engineer said that Subdistrict No. 1 would need to recover 170,000 acre-feet each year between now and 2031. Initially, Subdistrict No. 1 aimed to take 40,000 acres out of irrigation per year, or about 80,000 acre-feet of annual groundwater pumping, to allow the unconfined aquifer to recover. That goal is unattainable, say water officials, and hence a rethink is needed. Success has occurred, though. In 2024, for example, roughly 176,000 acre-feet were pumped from the confined and unconfined aquifers in Subdistrict No. 1, the fewest since groundwater metering began in 2009. That's about a 30% reduction.

More sustained success will be necessary. "You don't recover that unconfined aquifer through single years of good runoff," says Ullmann, the state engineer. "There are difficult decisions that have to be made in order to recover and restore the aquifers, but that's what these subdistricts are trying to do."

This success is at least partly due to efforts to modify irrigation practices and also taking land out of production. Amber Pacheco, deputy general manager of the Rio Grande Water Conservation District, explains that it's difficult to quantify the reductions. "Some farmers, for example, have simply reduced the number of alfalfa cuttings [and hence the irrigation required], for example. Or they only irrigate when they need to do so. Others have changed the cover crops planted after a potato harvest to reduce the amount of water needed."

As in the Republican River District, local efforts to take land out of production uses the foundation of federal programs, particularly CREP, or Conservation Reserve Enhancement Program. The subdistrict provides 20% of funds and the federal government 80%.

As did the Republican district in 2022, the Rio Grande district got an additional $30 million allocation of federal money funneled through the state. That money allows the

payment of $3,000 per acre-foot of curtailed groundwater use.

More must be done to recover the aquifer. The current proposal assembled by Burris and other directors of Subdistrict No. 1 would require aquifer recharge as a condition of pumping on a one-to-one basis. Water for recharge would come from water secured from the Rio Grande or native flows into the unconfined aquifer. This new plan allows subdistrict members with surface water credits to pump from the aquifer because they are resupplying it.

The pumping allowed under the plan would be cut drastically. The Rio Grande district does not have authority to shut down wells, but it does have authority to assess fees for over-pumping. That fee is $150 per acre-foot, which the plan would elevate to $500. And, if aquifer recovery is not achieved, it would rise to $1,000.

Ultimately, the state engineer has authority to curtail wells that do not provide replacement water pursuant to an approved groundwater management plan or some other augmentation plan.

Some farmers in the subdistrict disagree with this plan. Opponents banded together as the Sustainable Water Augmentation Group, or SWAG, and filed a lawsuit to block the plan's implementation. A five-week trial is scheduled for early 2026. Nobody expects the court's decision to be the end of it. Whoever loses might appeal the decision, a process likely to continue into 2028.

Might the problem of the depleted unconfined aquifer be resolved by diverting more water from the Rio Grande? The river has long been over-appropriated. This year, for example, rights junior to 1880 were curtailed in May. And water must be allowed to flow downstream to comply with the Rio Grande Compact.

For the unconfined aquifer to recover quickly, Mother Nature would need to quickly step up. "It would take multiple years of above-average flows [in the Rio Grande] to recover to the level that we need," says Pacheco. In fact, 19 of the last 20 years have been sub-average as compared to 1970 to 2000. This year's runoff in mid-May was forecast to be 61% of the average from 1890 through 2024.

PARTING THOUGHTS

The San Luis Valley, like the Republican River Basin, has almost no tax base other than irrigated agriculture. "Nearly everything in the valley is somehow related to agriculture. Our hospital, our schools — everything is dependent on agriculture's existence in the valley," says Pacheco from her office in Alamosa. From her office in Wray, Daniel has a parallel observation.

CONSIDER THIS

"IT WOULD TAKE MULTIPLE YEARS OF ABOVE-AVERAGE FLOWS [IN THE RIO GRANDE] TO RECOVER TO THE LEVEL THAT WE NEED."

—Amber Pacheco, Rio Grande Water Conservation District

What then constitutes sustainability of the water that is foundational to agriculture or, in the case of south metro communities, their economic vitality? What decisions should be made now to foster that vitality through the 21st century?

Thoughts about conservation have shifted over time. When Colorado's gold and silver miners arrived, they had no goal of conserving. They mined the veins to exhaustion or it became too costly to continue. In a sense, that has happened in the Republican River Basin. The only limits to this groundwater mining are those triggered by the interstate compact. Because the water in the Republican River and its tributaries is from the Ogallala aquifer, pumping must be limited — or supplemented.

In the last 20 years, the Republican River Water Conservation District has done some of both. It has or soon will have committed $80 million to pump water from wells expressly to deliver water to the Nebraska state line. One of the directors, Tim Pautler, has called this a strategy of kicking the can down the road. Other directors have started to agree.

"It's like the clock is ticking when it comes to sustainability," said Rod Lenz, the board chair, at the board's quarterly meeting in May 2025. "What more can we do with the tools we have? Do we dare ask for more tools such [as would be delivered by] statute changes? Do we really want all the groundwater districts in the basin to ask the state engineer to reconsider how much we're allowed to pump, or do we just stay in compliance until we can't?"

In the San Luis Valley, coming off the century-defining drought of 2002, state legislators went in exactly the opposite direction. They said that the unconfined aquifer was to be managed sustainably. Granted, that's easier s aid if you have a major river flowing nearby, even if that river has been hammered hard by the warming, drying climate of the 21st century.

The south metro area falls somewhere between these extremes. State legislators nearly a half-century ago ordered a "slow sip" of the groundwater to preserve it for a century. In some places, there seems to be sufficient water to slow sip for another 300 years. In other places, the aquifer might have enough water for a few decades. Some water utilities hope for a completely sustainable water supply in decades ahead. Much work has been done. The harder work lies yet ahead.

We need aspirations premised not on entitlement and enrichments solely for today, but instead to build economies and cultures that more comprehensively look several generations ahead. That should be the question in all of these meetings, all of these court cases, all of these individual actions. Based on what we know and understand today, what should we be doing for the kids, grandkids and their grandkids, too? Are we doing better than kicking the can down the road?

Allen Best is a frequent contributor to Headwaters magazine. He publishes Big Pivots, an e-journal that chronicles the enegy and water transitions in Colorado and beyond.

3

Lessons Learned and the Road Ahead

NEW THINKING FOR AN OLD RESOURCE

From Greeley to California's Central Valley, Western communities are reimagining groundwater use for a hotter, drier future — and learning tough lessons about resilience, risk and responsibility along the way.

by Elizabeth Miller

The City of Greeley built a redundant water system that draws from four river basins, hoping that diversity would spare the city any single disaster. But in 2020, all four of those watersheds burned. The city was able to turn off intakes and make use of settling ponds to keep mud and ash out of the drinking water supply.

"It would have been a good time to have a reservoir underground," says Kelen Dowdy, who was water resource planning manager then and still works as a water planning manager for the city. Now, Greeley is moving that way with its Terry Ranch Project, developing an underground water supply and storage project in an aquifer with an estimated 1.2 million acre-feet of water to support a population that's expected to double — to reach more than 260,000 people — between now and 2065.

But they're taking the same ethos of resiliency to the Terry Ranch Project, developing guidelines to limit drawing down the aquifer by less than 20% of its current level and, crucially, planning injection wells for pumping treated surface water into what will essentially be an underground reservoir free of evaporative loss and shielded from wildfire.

"It provides a third place for us to pull water from in the event of a catastrophe," Dowdy says.

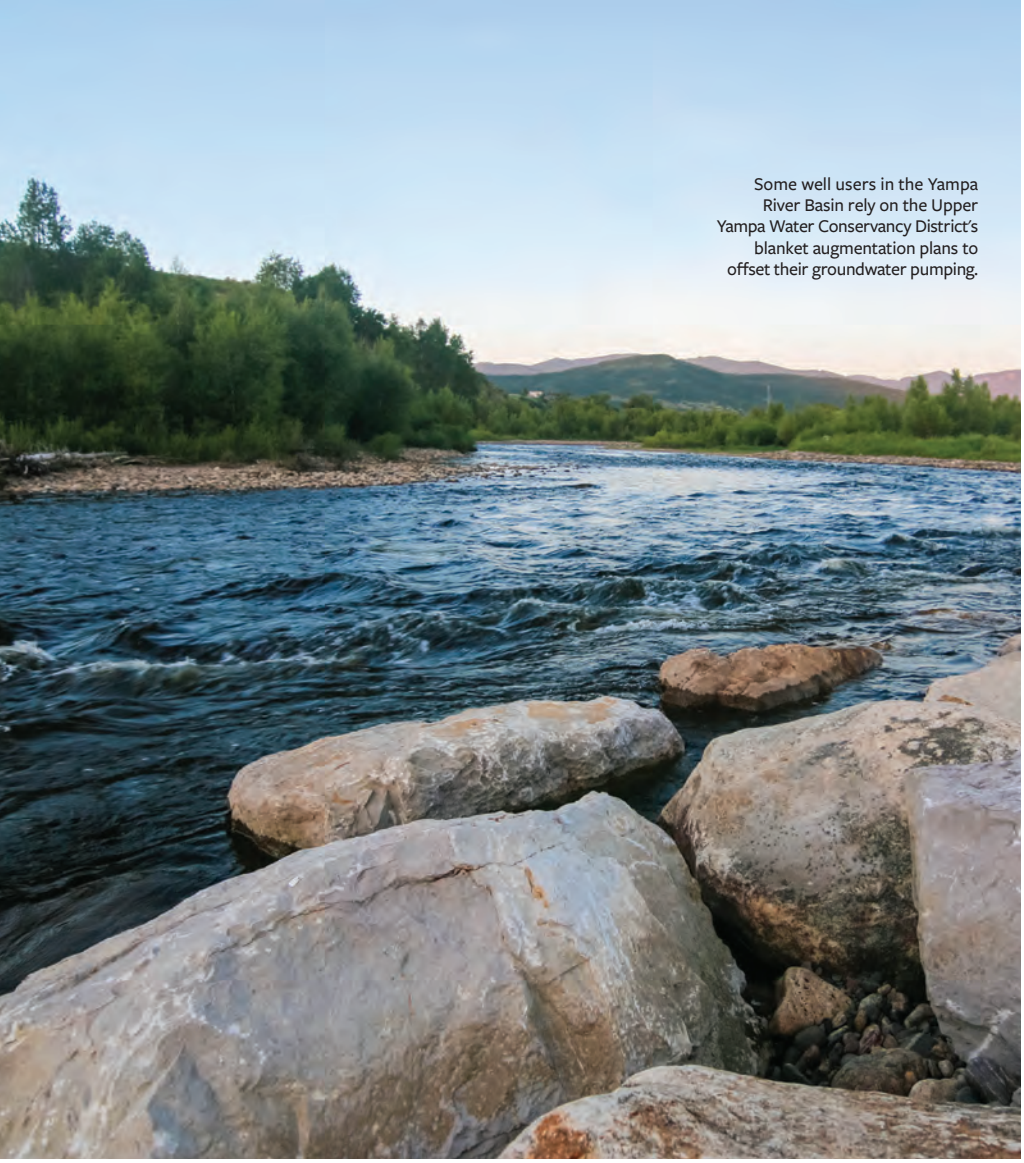
The approach reflects a growing awareness among water managers in the West that groundwater resources once thought to be oceanic and impossible to over-tap are, in fact, limited. In Greeley, where 25,000 acre-feet of annual use makes an aquifer with total storage of about 1.2 million acre-feet sound bottomless, water planners like Dowdy are aware that there is actually a bottom. Groundwater still makes a critical addition to the supply, but communities are rethinking how and where it fits and exploring models to balance use with preservation. Robust data collection is crucial, but so is understanding that management choices are as much social and political as scientific.

SUSTAINING GROUNDWATER

The City of Greeley initially sought to expand Milton Seaman Reservoir on the North Fork of the Cache la Poudre River, but federal agencies required a search for less environmentally damaging options. The Terry Ranch aquifer storage project rose to the top of the list. The first 16 wells that the city drilled into the aquifer will be used to characterize the supply, and assist in future monitoring for signs of aquifer depletion in the relatively less-tapped Upper Laramie aquifer underlying the project. The city's water resource portfolio aims to be big enough to accommodate bold jumps, like the proposed West Greeley 300-acre multi-use development with a hockey arena and water park. Eventually, when population growth requires it, the aquifer will be used to store water from wet or average years to be recovered during dry years. City leaders have been adamant, Dowdy says, about using this aquifer sustainably and steering clear of the aquifer mining that has happened elsewhere in the state.

"The whole recharge component of [Terry Ranch] is to ensure that we're really just depleting at a small percentage or not even depleting at all, over the long term, because we want to use this in perpetuity," says Matt Sparacino, water resource planning manager for the City of Greeley.

COURTESY OF THE CITY OF GREELEY



Some well users in the Yampa River Basin rely on the Upper Yampa Water Conservancy District's blanket augmentation plans to offset their groundwater pumping.

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While Greeley expects that recharge and careful monitoring will sustain groundwater levels in the Upper Laramie aquifer, other groundwater sources in the state are considered tributary and connected to surface streams. One of the keys to sustainable groundwater use in Colorado, experts say, lies in acknowledging the interconnections between tributary groundwater and surface water — that if one is drained, the other suffers.

"Colorado figured this out — you've got surface water rights and then you have groundwater rights that are subordinate to surface water rights," says Thomas Harter, a groundwater hydrology specialist with the University of California-Davis. Colorado and its water court system, he added, already know "how to deal with the most difficult part, which is the groundwater part that actually connects to the surface water."

The Upper Yampa Water Conservancy District had drafted a plan to reflect that reality even before the Yampa River was officially designated as over-appropriated in 2021. Groundwater supply in the Yampa Valley represents less than 10% of total water use. Still, for property owners to add a second well for more than domestic use, like a garden or a second dwelling unit, they must augment that well with more surface water releases from reservoirs upstream. To address that need, the conservancy district created a blanket augmentation plan and fronted the legal costs, sparing individuals a lengthy and potentially expensive process for what often amounts to less than a single acre-foot of water per year. The plan, too, has spared the basin the tight administration seen in other regions in the state that have struggled with sustainable groundwater use, says Holly Kirkpatrick, public information and external affairs manager for the Upper Yampa Water Conservancy District.

"I think it's important to look at our systems as a whole, really gaining that understanding that when you're pumping groundwater, that really does affect the quantity of the water in the system as a whole," Kirkpatrick says. "As we look toward a hotter, drier future and we look at the potential for population growth and further development, it's really important that we understand that and make decisions that allow us to operate within our means in terms of water supply."

Colorado learned some of these lessons the hard way: In 1985, Kansas filed an interstate lawsuit alleging that well-pumping in Colorado was depleting the Arkansas River in violation of that river compact. In 1995, the U.S. Supreme Court agreed. Wells were shut down, water pumping cut by a third, and Colorado was required to augment the water consumed by wells that continued to operate. The state also had to pay $34.5 million to Kansas for damages.

"The problem that got us out of compliance was not fully understanding and accounting for the relationship between groundwater and surface water use," says Hannah Holm, Southwest region director of strategic projects and partnerships with the nonprofit American Rivers. Holm co-authored a white paper on Colorado's experiences with interstate compacts. "That was pretty painful to rein in."

As a result, the state has taken measures to require water rights allocations for groundwater use in tributary aquifers — those with clear hydrological links to the streams and rivers nearby. Plus, there's now more, better groundwater data to support better planning.

But the way surface water and groundwater connect varies widely. Therefore, some waterways immediately change when groundwater nearby is drained, and others may take a century to reflect that depletion. Measuring exactly what's going on underground can be tricky, Holm adds, and that uncertainty leaves a space where a community's risk-tolerance level begins to play a role. Risk-averse assessments might want to err on the side of using lower estimates, even if those come at opportunity costs. Others might see benefit in taking higher estimates

on what's available and a more optimistic approach to use.

"It is really hard, reckoning with the limitations that exist, and also with the guesses, the uncertainty about what the future can hold," says Kelsea Macilroy, a project manager with The Langdon Group and a social scientist with ongoing research in sustainable water use who co-authored that paper on compacts with Holm. "That makes it hard for people to embrace change and engage in some of those more proactive behaviors."

That's particularly true when proactive behaviors are painful, like cutting back on use at a well that's flowing fine because nearby wells are running dry or reducing use when there's plenty of water out of fears for a future in which there won't be. She advocates for taking a more comprehensive view of groundwater management as more than just a plan for removing water from the ground, she says, "Because it touches on all aspects of peoples' lives and livelihoods and wellbeing, and the future."

ACROSS THE WEST

Throughout the West, people are reckoning with these coming changes and making tough choices as communities. Arizona has identified six areas, known as Arizona Active Management Areas, where heavy reliance on mined groundwater needed to be brought into check. Arizona's lawmakers established those areas with the 1980 Groundwater Management Act — they include the state's urban centers but few of its rural areas. Some of those management areas acknowledge a goal of preserving a primarily agricultural economy "for as long as feasible," while contemplating the need, in the future, to preserve groundwater for non-farming uses. Others are searching for ways to import additional supplies. These active management areas are also using aquifer replenishment, in this case, treating wastewater to recharge aquifers. But outside those areas and places where the state has expressly restricted irrigated agriculture, no regulatory framework guides sustainable use of the state's groundwater, which is both hugely important to its supply and tightly limited. More than 40% of demand in the state is supplied by groundwater, according to Arizona State University, and those aquifers filled over the course of thousands of years, so won't soon naturally replenish.

In California, as groundwater wells ran dry, both the land and water began to show signs of overuse. Seawater started seeping into freshwater aquifers and the ground above them started to sink, particularly in the Central Valley, compromising roads, rail lines, and homes. California passed the Sustainable Groundwater Management Act in 2014 to halt overdraft of its aquifers. The state is working now on supporting local agencies in choosing ways to end that overuse that meets their circumstances, land use, water supplies, and desired economic outcomes in that community.

BY THE NUMBERS

40%

The amount of demand supplied by groundwater in the state of Arizona, whose aquifers originally filled over the course of thousands of years.

"For a lot of basins this is an absolutely new concept, something that hadn't been done before," says Paul Gosselin, deputy director for sustainable water management with the California Department of Water Resources. "People hadn't imagined you'd be limiting groundwater use."

Eliminating overdraft will take some time — a glide path before leveling off — he adds, as these agencies wrangle with, in some cases, enormous challenges crafting plans for more sustainable water use. During that time, wells could continue to run dry. More than a thousand homes are on private wells that are no longer operable. In the most over-drafted basins, he adds, there's probably half a million to a million acres of land currently used for agriculture that will not have water in the future. That land might be repurposed with habitat restoration, or solar voltaic arrays. What he's learned so far is to see data acquisition as important, but to also recognize that it'll never feel like enough, and to center local control and local relationships.

"These are people's lives, communities, so that engagement and empowerment for people at the local level to have a voice and chart a course on how they're going to achieve groundwater sustainability is really important," he says. "Getting this right is really about building good relationships and engagement."

The overarching goal was to bring water law and policy to recognize the interdependence of groundwater and surface water resources, linked in the hydrologic cycle through which rainfall slowly seeps into the ground to supply aquifers. But California is also looking to speed up that process of moving rainwater into aquifers to ease or potentially end overdraft.

The hope is to stretch precipitation, which mostly falls between October and April but is most needed from April to October, and to take advantage of wet years and the handful of atmospheric river-infused storms so that moisture buffers the cuts otherwise expected in dry years. The empty spaces in drained aquifers, which are estimated at more than three-times the size of the reservoirs on-surface, could store enough water that some basins could fix their groundwater overdraft.

"Fundamentally, all water management in California and elsewhere is about fixing what I call the spatial and temporal disconnect, where the water actually becomes available as precipitation, and then where and when it's used," says Harter, with the University of California-Davis. Here, the hydrologic systems present a tougher challenge for California, where precipitation that falls can be a fraction of the annual average, then swing up to 300% of it, "so this really, really wide range, which Colorado doesn't have."

Independent journalist **Elizabeth Miller** has written about environmental issues around the American West for publications including The Washington Post, Scientific American, Outside, Backpacker and The Drake.

4

The Future of Groundwater

INNOVATION IN THE SUBSURFACE

As groundwater use declines, Colorado communities are testing new ways to store — not just extract — water in aquifers.

By Jennifer Oldham

To dispel a myth circulating among residents that the groundwater they rely on is running dry, Castle Rock sent a flier to 30,000 households that touts aquifer storage as part of a wholesale shift in the town's water supply from nonrenewable aquifers to replenishable sources.

Like many fast-growing Colorado cities, Castle Rock is slowly weaning itself off finite groundwater resources. The town reduced its reliance on water that fills cracks and other openings in beds of rock by 30% in the last 25 years. It hopes to rely 100% on renewable surface water by 2065, turning to aquifers only in times of drought.

To build a sustainable supply, the town amped up conservation and reuse efforts and purchased additional water to park in nearby reservoirs. It's also testing wells that allow it to inject treated stream water into aquifers during wet years and pull it back out in dry times. The process is known as aquifer storage and recovery, or ASR.

"Nature's storage tanks — that's what we call them," says Hannah Branning, the town's water quality regulatory compliance manager. Branning stood recently in a low-slung brick pump house next to several wells that pull water from the Denver and Arapahoe aquifers and send it to a nearby treatment plant. The system can be reversed, using a series of valves, to return treated water into the ground for storage.

BY THE NUMBERS

2065

The year that Castle Rock Water hopes to be able to rely 100% on renewable surface water, turning to aquifers only in times of drought.

Castle Rock is not alone. The West's worst drought in 1,200 years, mounting expenses and environmental hurdles to build new reservoirs, and groundwater decline prompted a growing number of Front Range municipalities to investigate the vast potential for storing water underground. Hydrogeologic studies determined groundwater systems across the state could store some 175 million acre-feet of the precious resource — an amount that dwarfs what's kept in reservoirs. Yet what the geology can hold and what Colorado water law allows are two different matters entirely.

About 13 ASR projects are now in various stages of development. These include a system operated by Highlands Ranch Water, which pioneered the use of aquifer storage in the Denver Basin. The agency injected 15,257 acre-feet into three aquifers from 1993 to 2023 – a fraction of what it stores in surface reservoirs. The agency continues to inject water when available and dips into its groundwater reserves during droughts and when its surface water treatment plant cannot meet demand, Rick McLoud, water resources manager said in a presentation at the water storage symposium in February 2024.

Others, such as the South Metro Water Supply Authority, are researching how members might, during times of drought, share water banked underground in wet years. Such systems, unlike surface reservoirs, do not incur evaporative losses, aren't exposed to pollution, are significantly cheaper to build, as well as scalable, and are readily available when needed.

Yet Colorado's complicated water rights system is hindering growth of the promising technology. Other states are further ahead, with larger and more comprehensive systems in California, Arizona, Texas and Florida. ASR nationwide has been used to reduce seawater intrusion, as well as ground subsidence, and to store treated wastewater. Many of these projects are substantially larger than those in Colorado, with the San Antonio Water System clocking 144,525 acre-feet stored in the Edwards aquifer as of December 2024.

Colorado has "the strictest groundwater administration in the world," says Dave Colvin, a hydrogeologist for the engineering consultancy firm LRE Water. "It does lead to limitations on using groundwater."

The legal status of each groundwater basin directs policies for ASR implementation, Kevin Donegan, chief of the Hydrogeology Section at the Colorado Division

John Kaufman, general manager of Centennial Water and Sanitation District, stands in front of the district's aquifer storage and recovery (ASR) well.

MATTHEW STAVER

of Water Resources, wrote in an email. Specific rules exist for aquifers that are not connected to surface water, known as non-tributary aquifers — this includes areas in the Denver Basin. Water can be stored indefinitely in these aquifers, which are nonrenewable. In other regions, water operators must complete an extensive scientific analysis to prove that a formation is not connected to surface water, he added.

Regions with little surface water that rely on groundwater, known as designated basins, also have their own ASR rules.

Outside of the designated basins, ASR is allowed in tributary, or alluvial, systems, which are connected to surface water, Donegan wrote, but "a decree or substitute water supply plan is needed to use the recharged water that surfaces at the stream."

ASR's expansion in Colorado is also stymied by a lack of sufficient water to store underground and infrastructure to store it with, as well as water quality concerns. Several agencies regulate its use, including the Environmental Protection Agency, which issues injection permits and requires testing to determine if injecting water into an aquifer alters water quality. The State of Colorado must also issue a permit.

Aquifer storage is not meant to replace the use of reservoirs, says Tom Sale, a hydrogeologist and emeritus professor of civil and environmental engineering at Colorado State University. Rather, the systems work together to help communities transition from pumping water out of nonrenewable aquifers to instead using sustainable surface water.

And, as the town of Castle Rock is discovering, this unprecedented change is difficult for Coloradans to fully grasp.

"It's a paradigm shift in the thinking," says Courtney Hemenway, consulting engineer at Hemenway Groundwater Engineering, Inc. "Mostly everything has been surface water related for storage — when you put it underground, you can't see it, you can't float a boat on it – there isn't a limitation on ASR."

Award-winning freelance journalist **Jennifer Oldham's** pieces appear in National Geographic, The Center for Investigative Reporting, The Washington Post, among others.

5

Looking Deeper

INVISIBLE THREATS

Even as aquifers dwindle, another question looms: What's in the water we're still drinking?

By Emily Payne

Like much of the Eastern Plains, no river systems run through the Upper Black Squirrel Creek Designated Ground Water Basin (UBS) in El Paso County. It is nearly 100% reliant on groundwater. So when the county's population grew by almost 58% between 1990 and 2010, UBS district managers started to pay attention.

"As the growth started coming, we started to really be concerned about what that was doing to the water quality in the aquifer," says UBS president Dave Doran.

UBS invested in a long-term water quality study with the El Paso County Commissioners and U.S. Geological Survey (USGS). It became one of the most comprehensive aquifer characterization efforts in Colorado — and it's still collecting data 15 years later. It uncovered issues in several parts of the basin, such as high concentrations of nitrates and the presence of pharmaceutical compounds. Today the insights are used to inform local municipalities and new construction.

But the study also pointed to a larger truth: maintaining groundwater quality is uniquely complex, and little is known about the impacts of urbanization and a changing climate across the state.

SHIFTING GEOCHEMISTRY

Common human-caused groundwater contaminants include nitrates from fertilizers, metals from abandoned and active mine waste, pharmaceutical compounds, personal-care products, and PFAS, according to the Colorado Department of Public Health and Environment (CDPHE). But groundwater quality is often impacted by naturally occurring compounds like arsenic, iron, manganese, selenium and radionuclides, too.

As water is pumped out of aquifers, different minerals and compounds are extracted, accumulate on land, and are fed back to aquifers. For example, certain rocks like shale have higher levels of salt ions that, over time, get weathered out into groundwater and contribute to increasing levels of salinity in places like the South Platte River Valley.

Colorado is also becoming warmer, drier and more populated, decreasing its aquifer levels. The geochemistry of the water shifts as it sinks farther from the ground's surface, explains Katherine James, associate professor at Colorado School of Public Health. More aerobic conditions are created, and these conditions can cause naturally occurring metals, such as uranium, to dissolve into the water.

Groundwater recharge can impact aquifer water quality, too, even if the water has met regulatory standards. Mike Wireman, a retired hydrogeologist and consultant to UBS, explains that more research is needed.

"If you have groundwater in the aquifer of chemistry A, now you put water from the treatment plant of chemistry B into the aquifer with chemistry A, you end up with chemistry C. That fact is not adequately considered in state discharge regulations," says Wireman. "It's a problem."

A COMMUNITY APPROACH

Nationally, groundwater has been less studied than surface water, says Karen Schlatter, director at the Colorado Water Center. "It's invisible to us ... we can't see the immediate impact of our uses on it," says Schlatter. "So there's just been less monitoring, less regulation on this, unfortunately."

For James, "it's a nearly impossible ask" for regulations to keep up with new and emerging contaminants, which scientists are still actively studying and understanding.

"When most people were using plastic grocery bags ... we never would have thought that microplastics were going to be a problem in water systems, and they are," says James. "And we still don't know a whole lot about it."

Proper statistical analyses on water quality require large datasets, explains Zachary Kisfalusi, USGS Hydrologist working with UBS. More data is needed to provide a baseline across the state: "Even at the 50 wells we've sampled, some of these have only had two, three, or four data points. It's hard to really say what is truly happening when you have such little data."

Experts agree that there's no one-size-fits-all solution, and heavy stakeholder engagement is necessary to tackle groundwater quality issues. UBS and other highly engaged communities serve as models for effective grassroots efforts to protect water resources.

"[Water] needs to be evaluated and considered in a way that respects the fact that the quality and the quantity [are] not guaranteed," says James.

Emily Payne is a freelance writer who focuses on agriculture, food, health and climate.

Home Well Safety — Up Your Standards

If you rely on a private well for drinking water, the responsibility for its safety falls on you. From proper construction to annual testing and ongoing maintenance, here's what every well owner in Colorado should know to ensure clean, reliable groundwater at home.

An estimated 20% of Coloradans depend on groundwater resources. The state is home to more than a quarter million wells, the majority of which are domestic household wells. While public water sources are regulated by the Colorado Department of Public Health and Environment (CDPHE), private well owners are responsible for ensuring their wells are running correctly and water is healthy to drink.

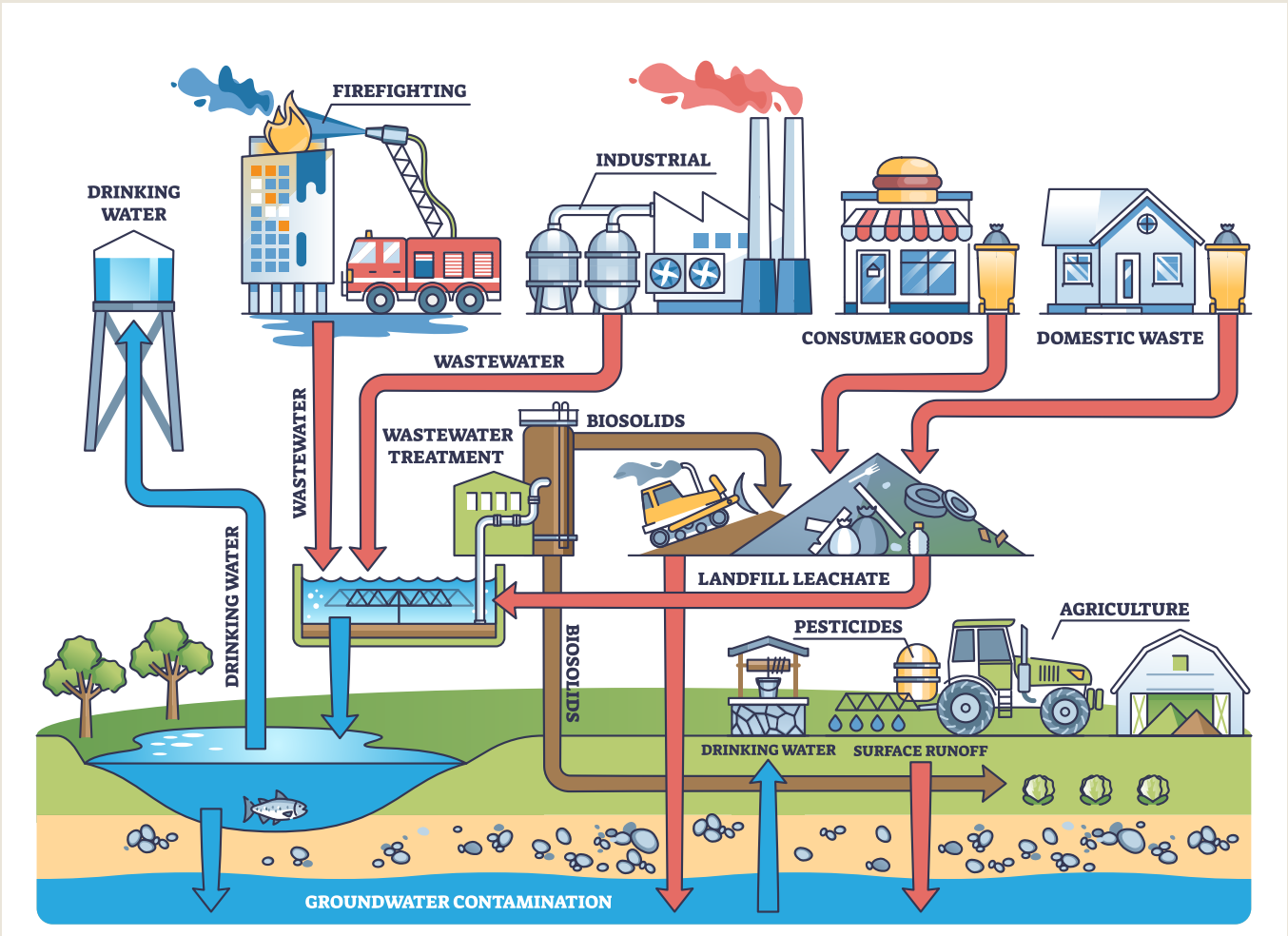
Well safety starts before construction: how and where it is built both affect potential pollution. CDPHE recommends identifying potential problem sources on and off the user's property, including fuel tanks, septic tanks, swimming pools, lawn chemicals, new construction, factories, agricultural activities, and even cemeteries. Any new construction or modification must be done by a licensed well driller. Set a regular maintenance schedule for the well and keep accurate, up-to-date records on it.

The U.S. Environmental Protection Agency (EPA) recommends home well users test their well water annually for contaminants using a state-certified laboratory. CDPHE maintains a list of Colorado's certified testing services at www.cdphe.colorado.gov/dwlabs.

Well owners should not be surprised if many substances are found and reported in the water test — this is common, and risk level depends not only on the type and amount of a substance but also the individual's health. Water experts at Colorado State University developed a Water Quality Interpretation Tool with input from other Western U.S. land-grant schools to help users evaluate water quality test results: www.erams.com/wqtool.

If contaminant levels do exceed drinking water standards, users should retest the water supply immediately and contact their local health department.

Groundwater quality is highly dependent on local conditions. Talk with county health professionals, water district managers, or geologists at local universities about specific well-care guidance for your local area's geology and climate. For general drinking water questions, users can also call the EPA Safe Drinking Water Hotline at (800) 426-4791.



ISTOCK

A Community Of People Who Care About Water

IN THE SPOTLIGHT: HEATHER JUSTUS

Our Members Provide Water Solutions

In this issue, we're proud to spotlight Heather Justus, Water Resources Manager at Parker Water and Sanitation District (PWSD), a long-time WEco supporter.

Founded in 1962, PWSD is a water and wastewater utility serving the southeastern Denver metro area. The district has been a WEco member since 2018, and Heather became an individual member in 2023 when she stepped into her current role.

With more than 25 years of experience in water resources, Heather has held roles at Leonard Rice Engineers (LREWater), Castle Rock Water, and now PWSD. She brings her deep expertise and collaborative spirit to WEco as a valued member of the Program Development Committee, regularly volunteers her time on alumni panels for the Water Leaders Program, and remains broadly engaged with our work. Heather also actively serves the broader water community, including on the Metro Roundtable.

At PWSD, Heather leads the implementation of the District's Long-Term Water Program — the Platte Valley Water Partnership. This forward-looking project represents a groundbreaking collaboration to develop sustainable water supplies that benefit both municipal and agricultural users in the South Platte River Basin.

Heather joined WEco to stay connected with Colorado's water education community and was drawn to membership. "I believe that the more people know about water in their communities and in our state, the better chance we have of making wise decisions with water stewardship to meet a sustainable future," she says. She also actively shares WEco's resources with "Parker Water's residents, audiences that I have the opportunity to speak with, and anyone interested in learning more about water."

Heather exemplifies the kind of leadership and innovation that drives Colorado's water future — and we're proud to have her as part of the WEco community.

COURTESY OF HEATHER JUSTUS

Misson: IMPACT

Water Education Colorado is the leading organization for informing and engaging Coloradans on water. Through leadership training, educational resources, and programming, we are working toward a vibrant, sustainable and water-aware Colorado.

300

The number of Water Fluency graduates since the program launched in 2015 — now celebrating its 10th anniversary of advancing water literacy and leadership across Colorado.

Get Involved!

ENGAGE

Dive into our diverse programming.

Find more information on our website. A few ideas to pique your interest:

1. Gather for a fun-filled evening of celebration, networking and awards at the 2025 President's Reception. The party starts at 5 p.m. on September 10. Learn more at wateredco.org/reception.
2. Are you an educator or outreach professional? Become an affiliate of the Water Educator Network for trainings, networking and collaborations.
3. Make your voice heard! Visit our social media pages or craft a letter to the Fresh Water News editor to share your thoughts, opinions or experiences.

VOLUNTEER

We rely on our volunteers!

Email us at info@wateredco.org to express interest:

1. Share your expertise and we'll plug you in — as a blog contributor, a speaker, or a peer reviewer for publications.
2. Join a contact list to provide local support when we bring one of our programs to your area.
3. Help us connect with Colorado's Spanish-speaking communities to provide new educational resources and opportunities tailored to them.

Not a member yet? Join the WEco community at watereducationcolorado.org.

GIVE

Your gift advances an engaged Colorado, leading to informed decisions and sustainable solutions.

Three ways to give:

1. Sponsor an upcoming program or event to showcase your organization's support for water education. Visit wateredco.org/get-involved/sponsorship-opportunities to learn more.
2. WEco accepts charitable gifts of appreciated stock — you get double the tax benefit! Contact John@wateredco.org.
3. You can donate year-round to support WEco's ability to provide Fresh Water News reporting and other valuable learning experiences to diverse audiences across the state. Visit wateredco.org/donate today.

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