ARROYO 2025

Expanding and Diversifying Arizona's Water Portfolio

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INTRODUCTION

Arizona relies on a diverse portfolio of water resources to meet its overall water needs, including groundwater, Colorado River water, in-state rivers, and reclaimed water. While all that water may meet our needs today, there is uncertainty about the future.

Today, Arizona's water resources already are strained by prolonged drought, changing climate, and chronic overuse. Drought conditions have persisted for two decades, making water in our desert environment all the more precious. Parts of the state rely entirely on a finite supply of groundwater, raising concerns about its long-term availability. In addition, the amount of water Arizona receives each year from the Colorado River is subject to river conditions, which have been deteriorating for more than a decade.

Arizona needs water to thrive, but water supplies are limited. Until now, Arizona has been resilient in the face of water supply challenges. This *Arroyo* examines current water challenges and where Arizona might turn for more water. It begins with an overview of the challenges facing the state's water supplies. Subsequent pages explore how Arizona might add to its water portfolio by accessing "new" sources of water or expanding existing sources. Drawing from the WRRC 2024 Annual Conference, *Implementing Water Solutions Through Partnerships*, the *Arroyo* highlights opportunities and the collaborations needed to turn opportunities into reality.

THE UNIVERSITY OF ARIZONA
COOPERATIVE EXTENSION
WATER RESOURCES RESEARCH CENTER

The *Arroyo* is published by the Water Resources Research Center
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Four broad strategies are discussed:

- Treating water
- Capturing water
- Transporting water
- Exchanging water

Each of these is examined more closely through real-world examples.

A central theme of the 2024 conference and this *Arroyo* is the importance of collaboration and partnerships. Working together, Arizona achieved greater water security than could be accomplished through unilateral actions. The real-world examples below are testaments to the value of working with partners.

CHALLENGES FACING ARIZONA'S WATER SUPPLIES

Arizona faces a wide range of challenges that threaten its long-term water security, including drought, increased demand, population growth, costs, and environmental degradation.

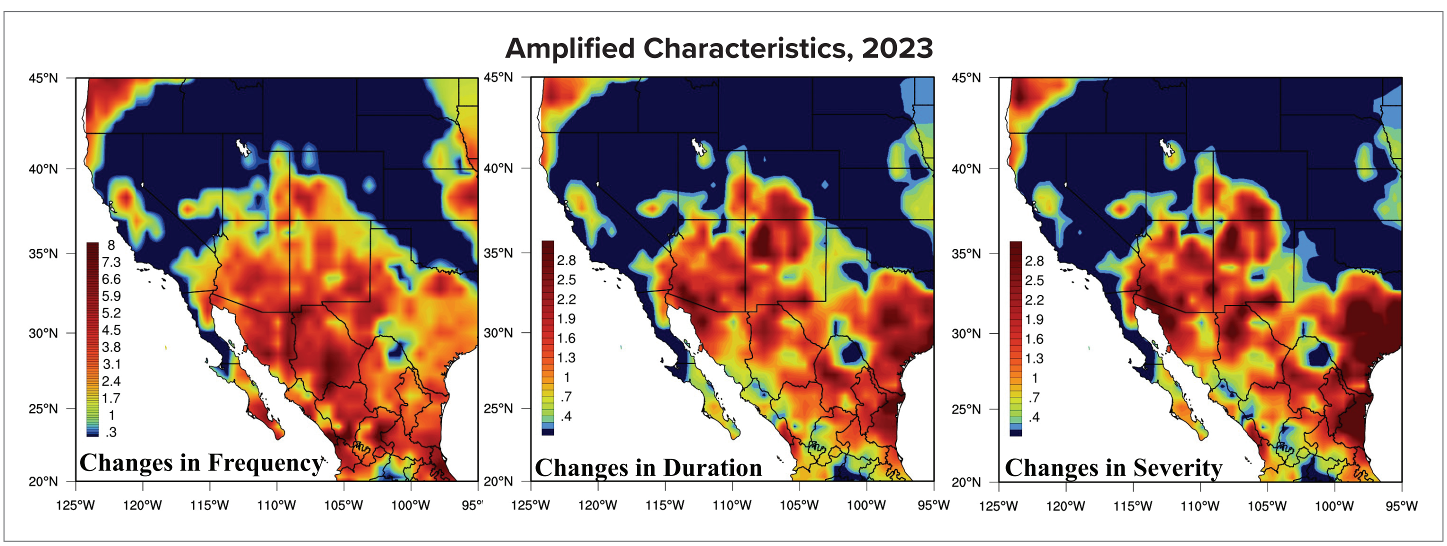
Megadrought

Perhaps the most salient of these challenges is the ongoing megadrought affecting not just Arizona, but the entire U.S. Southwest. Local drought and Colorado River basin-wide drought are related but distinct phenomena with related but distinct consequences. In Arizona, the multi-state Colorado River system operations are central to drought mitigation responses.

While frequent dry spells are common across the Southwest, the severity of the ongoing drought stands out. Research published by A.P. Williams and colleagues in 2022 by *Nature Climate Change* found the 22 years between 2000 and 2021 to be the driest period in at least 1,200 years. The research also found that the drought is made more severe by the influence of human-caused climate change. A hotter climate reduces effective snowpack and runoff from mountain snowmelt, dries soil, and increases plant water demand and evaporation. Precipitation becomes more variable, marked with more intense storms followed by frequent extended dry periods. Dry periods coupled with intense heat are known as compound drought and heatwave (CDHW) events. Research suggests that CDHW events, particularly those occurring at night, are increasing in the Southwest. According to research presented at the 2024 WRRC conference, CDHWs were eight times more frequent in 2023 than average conditions since 1980, and both CDHW duration and severity were up to three times greater than the long-term average as well.

Arizona's Rivers

Arizona's in-state rivers typically supply about 17% of the state's water demand. Yet these rivers are diminished by diversions, drought, and the drawdown of baseflow-supporting groundwater. Important sources of surface water supply in central Arizona include the Salt, Verde, and Agua Fria rivers, with their series of water storage and flood control reservoirs. Even these managed river systems experience drought impacts that reduce deliveries to water users. In addition, many of the state's former perennial streams no longer flow year-round. The San Pedro River, a critical riparian corridor and Gila



Changes in frequency, duration, and severity from long-term (44-year) averages of compound drought and heatwaves for 2023.
Source: Somnath Mondal https://wrrc.arizona.edu/sites/wrrc.arizona.edu/files/2024-03/somnath-mondal.pdf

River tributary, is just one example of a river that has faced pressure from over-pumping for decades. The Gila River itself flows only intermittently in its journey from New Mexico in the east to the Colorado River at Yuma. In many areas, riverbeds are dry for parts of each year, and drought conditions and/or groundwater demand have extended the length and duration of surface dryness. In Arizona, a state focused on water scarcity, however, destructive river flooding from intense rainstorms still occurs and may occur more frequently in the future due to climate change.

The Colorado River

Drought and chronic overuse have had significant impacts on the Colorado River—a major lifeline of the Southwest. In recent decades, water levels in Colorado

Lake Mead in June 2022 with "bathtub rings" indicating previous water levels. Source: Martin Lobel, WRRC Photo Contest

River reservoirs have declined. Lake Mead, the largest constructed reservoir in the U.S., is the principal storage reservoir for the Lower Basin states, including Arizona. The reservoir experienced a 150-foot drop in water elevation between 2000 and 2022, when the water elevation reached a critically low point. In 2021, the U.S. Bureau of Reclamation (Reclamation), which operates the Colorado River system of dams and diversions, declared the first-ever Tier 1 Shortage condition in the Lower Basin. This translates to a reduction of Arizona's Colorado River water allocation by 512,000 acre-feet, or approximately 18% of the state's allocation in previous years. Further declines led to the declaration of a Tier 2a Shortage for 2023 and steeper reductions.

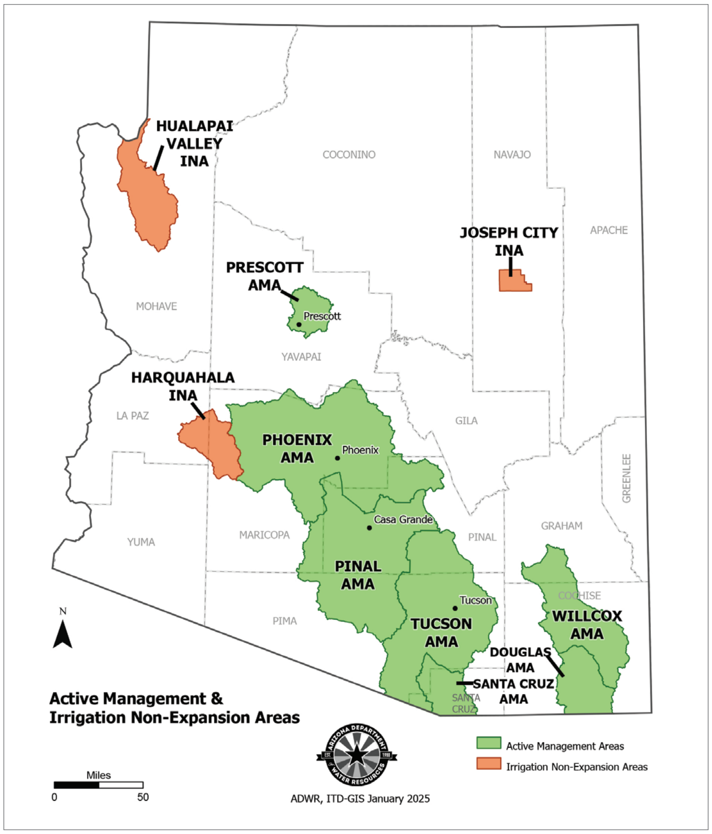
Reservoir levels rebounded slightly following an especially wet winter in 2023 and significant federal investments in system conservation. In August 2023, Reclamation announced a return to Tier 1 Shortage operations in the Lower Basin for 2024. By the end of 2024, the water level in Lake Mead was up nearly 20 feet from 2022, but as of February 2025, Reclamation's most probable water level projection for December 2025 shows continued decline.

Reclamation, a bureau within the U.S. Department of the Interior, has been working with the seven basin states to develop new guidelines to replace the 2007 operating guidelines, which together with the 2019 Drought Contingency Plan, expire in 2026. The seven basin states are Arizona, California, Colorado, Nevada, New Mexico, Utah, and Wyoming. In November 2024, Reclamation released five proposed alternatives for the river's operation going forward. These alternative plans include a wide range of possible actions formulated from input provided by stakeholders, including the Lower Basin states, the Upper Basin states, Tribal nations, and conservation groups. While each plan differs in specifics, they all share the understanding that additional cuts to Colorado River water users will be necessary if river conditions worsen. A draft Environmental Impact Statement (DEIS), required under the National Environmental Policy Act, is expected to be released for comment in summer 2025.

Negotiations between the Lower and Upper Basin states have been ongoing, and coordination with the Tribes of the Colorado River Basin, which hold significant water rights, is important to these discussions. Representatives from the basin states have said publicly that they would prefer a negotiated outcome. Stakeholders are watching the DEIS process closely to prepare for the next steps. While Reclamation is not required to select a Preferred Alternative in the DEIS, and is unlikely to do so, the analysis in the draft may affect interstate negotiations and could motivate cooperation to forestall a solution imposed by Reclamation.

Groundwater

Groundwater, the largest component of Arizona's current water portfolio, also faces an uncertain future. Many aquifers in the state are under stress from increasing groundwater extraction and drought. In some places, water is being withdrawn from aquifers faster than it can be replenished, or "recharged." Though recharge can occur naturally and be augmented artificially through recharge projects, it may not be enough to keep up with demands. Excessive underground water withdrawal can produce other problems. For example, the pores in the aquifer material (rock, sand, silt, and clay) that were kept



Arizona's Active Management Areas and Irrigation Non-Expansion Areas. Source: ADWR

open by water can collapse when the water is removed. The aquifer materials become compacted, causing the ground to subside. This process may permanently reduce the aquifer's storage capacity.

One strategy for moderating the use of groundwater is regulation. The Groundwater Management Act (GMA) of 1980 created Active Management Areas (AMAs) where groundwater management regulations mandate conservation actions and promote the use of renewable water supplies for new municipal development. Over 75% of Arizona's population lives in AMAs. The legislation also created Irrigation Non-Expansion Areas (INAs) where the number of acres of irrigated agriculture may not increase. The 1980 GMA created four AMAs and three INAs; 45 years later, seven AMAs and three INAs exist across the state.

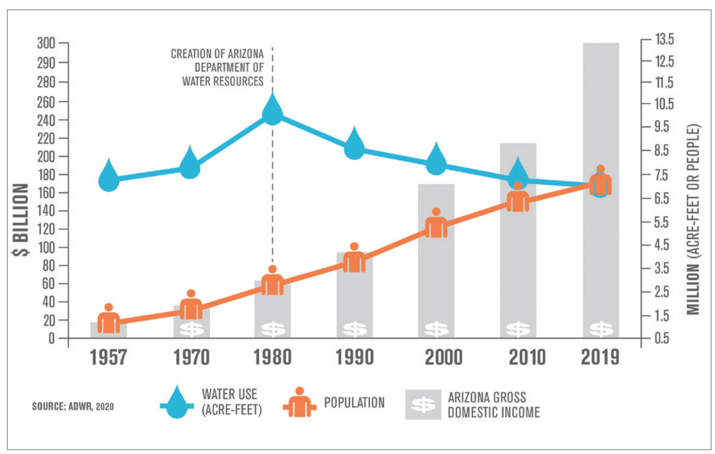
Even within AMAs, issues related to local imbalances between aquifer depletion and replenishment remain. Rules limiting the use of groundwater for residential development took effect in the late 1980s, and aquifer recharge and replenishment laws and policies were developed in the 1990s to address excessive groundwater use. Since then, updating and refining groundwater management in AMAs has continued.

Aside from the limit on irrigated acreage in INAs, groundwater use in rural Arizona remains largely unregulated, despite the fact that many rural areas rely on groundwater as their main source of water. These areas are facing challenges from the expansion of large extractive industries, including agricultural enterprises. Processes exist for such areas to become AMAs, but because existing AMA groundwater management regulations were designed primarily for urban and urbanizing areas, they may not be suitable for rural areas.

Rural areas have few tools for groundwater management, and the complicated issue of assuring a long-term future for Arizona's groundwater remains a challenge, especially where groundwater is the only economically accessible water source. Local stakeholders and elected officials have been working for years on crafting a rural groundwater management framework that protects groundwater, allows for growth, and respects the rights of existing water users. However, as of the date of publication, a consensus approach has not emerged.

Population Growth

Between 1950 and 2010, the population in the desert Southwest grew at more than twice the national rate. According to the U.S. Census Bureau, Arizona's population grew by 11.9% between 2010 and 2020, and the state ranked seventh among the top 10 fastest-growing states



Historic changes to Arizona' water usage charted against population and economic growth. Source: ADWR

between 2022 and 2023. Arizona's economy continues to grow, with residential, commercial, and industrial development in the Phoenix and Tucson metropolitan areas, including water-using industries such as semiconductor manufacturing and data centers, playing major roles in the state's economy.

Despite large population growth, Arizona has managed to reduce its per capita water usage over the past few decades to 1950s levels. While this is a success worth celebrating, shrinking water supplies present a long-term threat. With a population of more than 7 million people, a host of growing businesses, and a strong agriculture sector, Arizona must contend with balancing the water needs of today with the potential needs of tomorrow.

Affordability and Security

At the same time, many residents must contend with rising water prices and are asking suppliers to keep water affordable and, ultimately, available. Suppliers, in turn, need fiscally responsible strategies to continue meeting demands without pricing water beyond the means of their customers.

Scarcity can drive up costs and make water less affordable to the everyday user. Industries that rely on an ample water supply could also be hard hit. Agriculture accounted for 72% of Arizona's total water demand in 2020, making it the state's largest water user. While the agricultural industry has learned to do more with less over the years, crops still require water to grow, and insufficient water supplies could threaten production and lead to higher consumer prices for water, food, and other goods. Beyond economics, reliable access to clean water is essential for public health, economic resilience, and environmental sustainability.

Environmental Impacts

Changes in the amount of available water also impact the health of the natural environment and its non-human flora and fauna. As more water is diverted for human uses, aquatic and riparian ecosystems suffer from increasing water-related stresses that can ultimately destroy them. Even though it is beneath the surface, groundwater helps support the flow of rivers, streams, and springs and the ecosystems that depend on them. Groundwater depletion eventually lowers surface water levels in wetlands, ponds and lakes and reduces river, stream, and spring flows. Higher temperatures could further exacerbate this effect. Without intentional efforts to protect environmental water, Arizona could see a marked loss in biodiversity. Maintaining Arizona's natural places is important to the health and economic well-being of its people.

Governance Silos

In his presentation at the 2024 WRRC conference, David Wegner, a natural resource policy expert, recommended breaking down silos that impede communication and coordination. Problem-solving efforts should be aligned across the various fields of science, decision making, governance, and policy. Wegner said science must be used to inform and support the development of solutions; decision-making processes must be robust and responsive and establish clear commitments for action; and governance needs to provide the authority for pursuing solutions and the policies that help guide their implementation to an effective endpoint. Achieving this level of alignment is no small feat.

He added that partnerships are key to developing comprehensive solutions, because they facilitate coordination and open lines of communication. From the outset, partners must commit to open information exchange, cooperation, and transparency. Even after partnerships have formed, they must continue to be developed, nurtured, and maintained.

AVENUES FOR EXPANDING AND DIVERSIFYING WATER SUPPLY

Change is coming to Arizona's water supplies, and our choice now is what to do about it. Continuing to rely on the same sources of water that are already under stress is no longer an option. The Southwest requires new strategies to supplement and expand supplies for the future. We have a range of options available to access "new" water resources.

Research and investment by many organizations, public and private, are addressing the need for more water. The Water Infrastructure Finance Authority of Arizona (WIFA), an independent state authority authorized to finance the construction, rehabilitation, acquisition, and improvement of water infrastructure throughout the state, is at the heart of these efforts. At the 2024 WRRC conference, a WIFA representative explained that the agency administers several funding programs including the Long-Term Water Augmentation Fund, which financially supports the development of projects intended to add to Arizona's water supplies either by importation or in-state activities. Universities, municipalities, NGOs, and other entities also are working on strategies to move the state and region toward water security.

The remainder of this *Arroyo* examines examples, in four areas where Arizona could find "new" water:

Treating water: Improving the quality of water so it can be used or reused for new or different purposes.

Capturing water: Collecting and storing stormwater and rainwater for current and future use.

Transporting water: Moving water from one place, either outside of or within Arizona, to another place where additional usable supplies are needed.

Exchanging water: Transferring water between two or more parties to take advantage of differences in source, timing, or quality for increased water-use efficiencies.

It is important to note that, while focusing on ways Arizona may increase supplies, this *Arroyo* avoids using the word "augmentation" due to the term's definition within state law. According to A.R.S. § 45-801.01, augmentation means supplementing the existing water supply of an AMA. In addition, the term has been used commonly in the limited sense of importing water from outside the state. Because these usages limit discussion, this *Arroyo* uses other terms, such as adding to, supplementing, or expanding water supplies.

In addition, the strategies discussed in this *Arroyo* do not include demand management. Conservation of water and improving water use efficiencies are important ways to stretch existing supplies. However, this *Arroyo* focuses on options for expanding water sources, recognizing that these are not the only tools for achieving water sustainability.

Treating Water

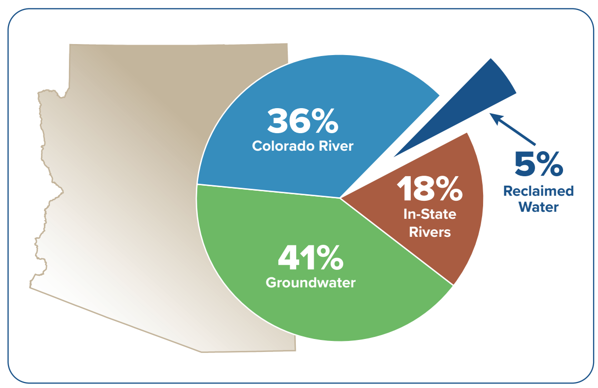
While some water is safe for human consumption, water from other sources is not. Water quality issues can arise due to an abundance of salt or other minerals, the presence of bacteria or other contaminants, or some combination of factors. The reduction or removal of these impurities could unlock new water sources to address Arizona's growing needs.

This section explores four ways water can be treated to improve its usability: reclaimed water, advanced water purification, desalination, and decentralized treatment.

Reclaimed Water

Not all water used by humans needs to be potable. Reclaimed water is an option for many non-potable uses and its use can offset demand for potable water.

Reclaimed water is defined as wastewater treated for uses that do not require drinking water quality. In Arizona, reclaimed water is permitted by the Arizona Department of Environmental Quality (ADEQ) for specific uses depending on its level of treatment. Higher quality reclaimed water, classed A or A+ by ADEQ, can be used for irrigating food crops and residential landscaping, fire protection, and snow making. On the lower end of the quality spectrum, Class B or C reclaimed water use may be restricted to activities such as watering pasture for non-dairy animals and irrigating fiber, seed, forage, and similar crops.



Reclaimed water was 5% of Arizona's water portfolio in 2020.
Data source: ADWR

With such a variety of uses, it is easy to see how reclaimed water can expand Arizona's future water portfolio. Reclaimed water is the only water supply that increases with household demand. When households use more water indoors, more wastewater is produced, making reclaimed water a reliable resource that does not seem to be impacted by drought. By using reclaimed water instead of drinking water for certain activities, we can save potable water for drinking, cooking, and other uses that require higher quality.

It is worth noting that centralized reclaimed water systems require significant investments in the purple pipe infrastructure that carries only reclaimed water. These single-purpose systems can limit flexibility in the use of the reclaimed water resource. This caveat applies to all kinds of water infrastructure investment in an environment where technology changes rapidly.

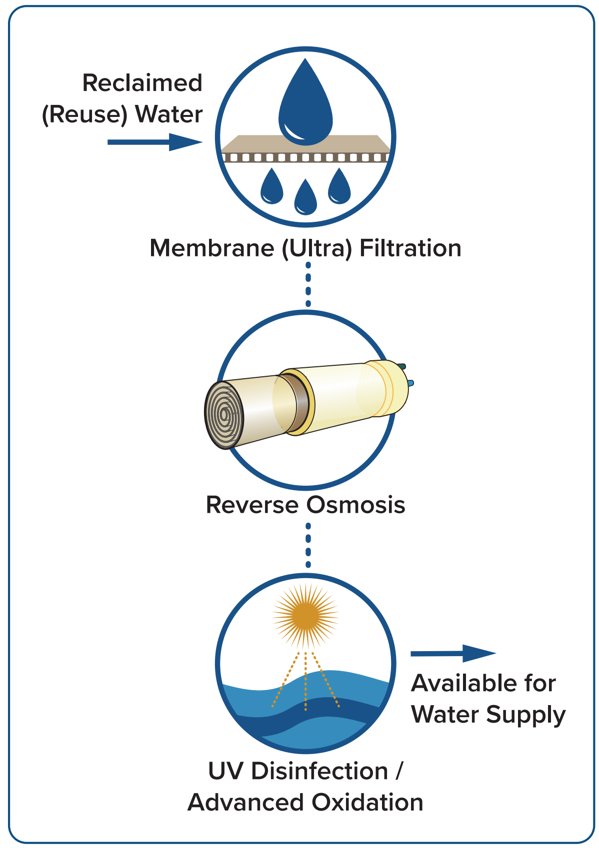
The use of reclaimed water has been growing in Arizona for quite some time. The City of Flagstaff has been using reclaimed water for irrigation since 1965, and today, reclaimed water fulfills about 20% of its total water demand. Tucson has invested in a reclaimed water system since the 1980s and uses reclaimed water for landscape irrigation, offsetting 4.7 billion gallons of potable water every year. Other cities such as Chandler, Cottonwood, Peoria, Phoenix, and Scottsdale also take advantage of reclaimed water. As a result of such efforts, reclaimed water made up around 5% of Arizona's total water portfolio in 2020.

Advanced Water Purification

Technology exists to reclaim water through advanced treatment to drinking water standards and beyond to the ultrapure water required by some industries. Advanced water purification (AWP), formerly known as direct potable reuse, can treat wastewater to levels of purity even higher than pristine fresh water. AWP relies on cutting-edge technology and often involves running wastewater through multiple treatment and filtration processes, such as, oxidation, reverse osmosis, and ultraviolet disinfection, which remove dissolved solids, pathogens, and other contaminants. In the past, Arizona's regulations required an environmental buffer such as a river, lake, or aquifer between the treatment plant and a drinking water system. However, many locations lack access to an environmental buffer of the appropriate size for large-scale facilities. An ADEQ rule change removed the buffer requirement for AWP.

While some people may squirm at the idea of drinking treated wastewater, ADEQ regulations ensure that wastewater treated through AWP meets and exceeds state and federal health-based standards. Since 2022, ADEQ has worked to establish an AWP program for the state through its rulemaking process. The department proposed strict water treatment standards for the removal of pathogens and other contaminants, as well as new permitting, compliance, and certification requirements for AWP. ADEQ has been using stakeholder forums, technical sessions, and public comments throughout the process to develop, refine, and implement the program. The public comment period for the proposed rule ended in early December 2024. On March 4, 2025, the Governor's Regulatory Review Council approved the AWP rule, establishing a comprehensive regulatory framework that ensures the safe and reliable purification of treated water for potable use. The AWP rule took effect upon approval.

While AWP is attractive to many municipal water providers, infrastructure costs are an important factor in deciding to adopt this strategy for expanding water supplies. The potential value of AWP will be weighed against its costs and the affordability of the water produced. In addition, economic and environmental cost considerations must include disposal of process waste—a concentrated brine.



Example of the multi-barrier treatment train process.

Desalination

Desalination is another option for making more water usable. Several different methods can achieve desalination, and they all remove salt and other minerals from saline water, either seawater or other salt-laden sources such as inland brackish groundwater. However, desalination has its drawbacks. Though new desalination technology has reduced its energy demand, it remains energy-intensive and requires costly infrastructure; as a result, it produces expensive water. High costs may place this option among the solutions for the more distant future.

Desalination also raises environmental concerns. As with advanced purification methods, desalination using reverse osmosis forces saltwater through a series of membranes that separate water molecules from salts. This results in two water products: desalted water and brine. This concentrate must be disposed of, and it often goes back into the environment where it may pollute land and water resources. Inland, brine injection through wells into deep, saline aquifers has been a successful disposal method in Texas. More commonly, however, brine is discharged into ponds and left to evaporate. The concentrated brine from seawater desalination is typically returned to the ocean. Sufficient care of brine disposal is required.

Arizona-Mexico Desalination Proposal

Oceans are obvious candidates for sources of water for desalination projects, but transporting that water hundreds of miles into land-locked Arizona is a daunting prospect. If ocean-based desalination is to benefit the state, careful planning, management, and funding is essential.

In Arizona, WIFA is helping guide the state's water investments in desalination. In recent years, WIFA has considered desalination projects. One plan proposed by Israel-based IDE Technologies involved building a desalination plant near Puerto Peñasco, Mexico, along the Sea of Cortéz. Seawater would be desalinated at the Mexico plant, and once free of salt, the water would be pumped 200 miles through a newly constructed pipeline into Arizona. While this plan initially gained some traction, WIFA has moved toward a competitive solicitation process that will allow it to compare different importation projects, including any desalination proposals, to determine which project or projects represent the most sustainable and effective water investment for Arizona.

In November 2024, WIFA issued a solicitation for Long Term Water Importation Projects to import water from outside the state. Project proposals are expected to be evaluated in 2025, with final decisions to be made sometime later. If WIFA ultimately decides to pursue desalination projects in Mexico, strong binational cooperation will be essential to success. As mentioned before, the desalination process is costly, requiring large investments of time and money in infrastructure and energy. Before these investments are made, partnerships need to be in place to facilitate collaboration between parties on both sides of the border.

Yuma Desalting Plant

While desalination may seem feasible only for ocean-front property, that is not always the case. A desalination facility already exists in Arizona that could play a role in the state's water future. The Yuma Desalting Plant was built to help the U.S. meet salinity requirements for water delivered to Mexico as established by Minute No. 242 of the U.S.-Mexico Water Treaty of 1944. It was built under the authority of the Colorado River Basin Salinity Control Act of 1974. Construction began in 1975 and was completed in 1992.

The plan for the plant involved desalinating the saline agricultural drainage water from the Wellton-Mohawk Irrigation and Drainage District in Arizona that was discharged into the Gila River and flowed into the Colorado River. The plant would treat it and discharge the treated water into the Colorado River for delivery to Mexico.

By the time the plant was completed in 1992, however, river conditions had changed. Several years of high flows in the Colorado River diluted the salts in the river, and the Yuma plant became unnecessary. The plant experienced operational issues and closed to avoid additional costs. It operated for three months in 2007 as part of a demonstration run, and in 2010-2011, Arizona partners collaborated with Reclamation on a year-long pilot run to test the feasibility of reoperation. That option has not been pursued. For all the years the plant went unused, the saline drain water was diverted through a drainage canal, away from the Colorado River. The salty water flowed instead to the Ciénega de Santa Clara in Mexico, which became a major environmental asset.

Despite its history, the Yuma Desalting Plant could still play a role in Arizona's water future. Perhaps the Yuma plant's greatest strength is that it already exists, but upgrading the old plant is a substantial challenge and may be more difficult and costly than building a new facility elsewhere. Even if plant operation could prove technically and economically feasible, it would have important environmental costs.

Deciding whether desalination is the right move for Arizona to help meet its water needs requires careful consideration of its benefits and costs.

Decentralized Treatment

Populations in remote locations typically lack reliable access to clean drinking water. On the Navajo Nation, for example, this is true for nearly one-third of homes. Compounding this problem, centralized water systems are not physically or economically viable in parts of the Navajo Nation due to the large distances between neighbors.

Various organizations have been working on decentralized solutions to provide clean water access to Tribal residents. A mobile solution offered by Apex Applied Technology, Inc. at the 2024 WRRC conference, starts with a retired school bus fitted with a water-filtration system and powered by solar panels. The "water bus" allows Apex and its partners to provide water filtration demonstrations for communities located in remote areas. Once the communities accept the technology, Apex and its partners will bring a "water box," a shipping container with a nanofiltration system inside. Nanofiltration removes dissolved salt, pathogens, particles, and other pollutants in a membrane-based system. Like the water bus, the water box is 100% solar powered. It can be installed at a groundwater well site and treat groundwater to drinking water quality. So far, Apex has deployed five water boxes within the Navajo Nation, and Hopi and San Carlos Apache Tribal lands.

Solar-powered water box setup. Source: Jing Luo
https://wrrc.arizona.edu/sites/wrrc.arizona.edu/files/2024-03/jing-luo.pdf

Establishing and maintaining good relationships with Native communities and governments are instrumental in project successes. Apex's partnerships with STAR Schools, the U.S. Department of Agriculture - Rural Development, North Leupp Family Farms, and the University of Arizona are pivotal to this effort.

Capturing Water

When it comes to water, nature operates on its own schedule. There are wet times, with too much water to be used fully, and there are drier times when needs surpass the available supply. The dry times can extend over months, years, or even decades, punctuated by occasional intense storms. For millennia, humanity evened out this variability by capturing and storing water, and this strategy could be expanded. Today, Arizona can capture and store additional water for future use through projects, large and small.

Dams

Large-scale dams are major structures for capturing the power and potential of water. Dams and their associated reservoirs can store massive amounts of water and release it for use when needed. Dams have been built for multiple purposes, including irrigation, power production, power plant cooling, transportation, flood control, and recreation. Capturing water behind dams can increase system flexibility and adaptability. Proposals and plans to expand the effectiveness of Arizona's dams are being explored.

Verde Reservoirs

The Salt River Project (SRP), which provides water and power to more than 2 million people in central Arizona, is composed of the Salt River Water Users' Association (an Arizona territorial corporation) and the Salt River Project Agricultural Improvement and Power District (a political subdivision of the State). At the 2024 WRRC conference, SRP representatives described some of the organization's water supply enhancement plans.

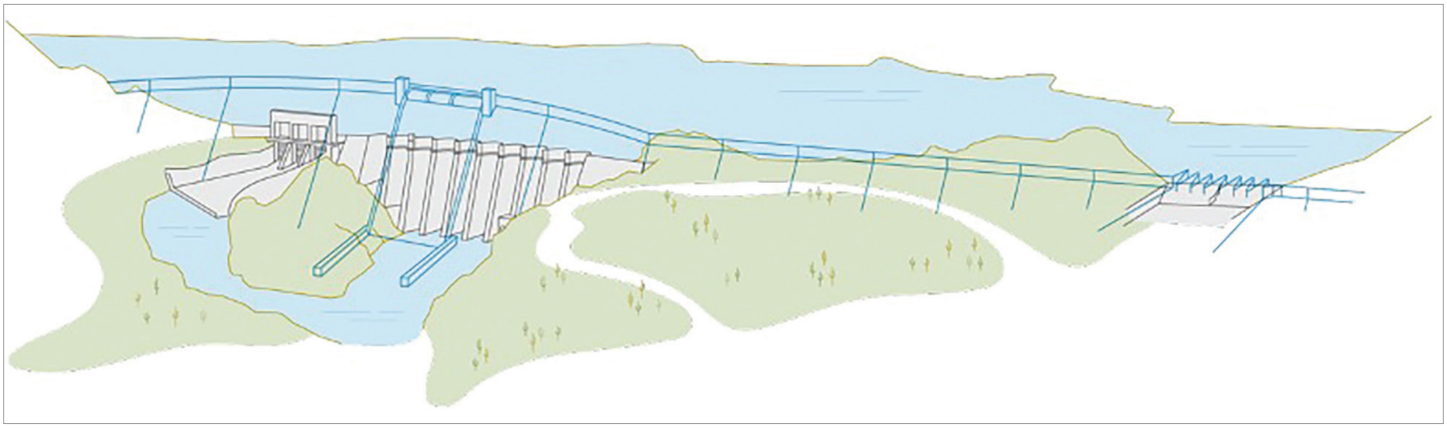
SRP maintains and operates the 13,000-square-mile watershed of the Salt River Federal Reclamation Project, which was built by Reclamation. The project delivers water from the Salt and Verde rivers and East Clear Creek to its shareholders, irrigation districts, municipalities, and Native communities.

As water flows into these reservoirs, it carries sediment. The sediment in water pooled in reservoirs falls out of suspension and can build up over time in the reservoir. This sedimentation eventually reduces the amount of water that the reservoir can store.

Sedimentation impacts the Bartlett and Horseshoe reservoirs on the Verde River. SRP has estimated that around 45,000 acre-feet of storage capacity (34.79%) has been lost in Verde River reservoirs due to sediment buildup. In 2023, SRP released water because Bartlett Reservoir had reached capacity after heavy winter precipitation. The released water—enough to meet the water needs of 1 million households for one year— could have been captured if a larger reservoir were in place.

In December 2021, Reclamation, in partnership with the SRP, completed the Verde Reservoirs Sediment Mitigation Study appraisal report. The objective of the study was to examine potential alternatives to resolve the issue of lost storage capacity in the Verde River reservoirs.

One solution proposed to address the loss of storage was to raise Bartlett Dam by 100 feet. Enlarging the dam and reservoir would more than double water storage capacity on the Verde River, replacing lost storage space and creating new capacity. This proposal is one of the possible solutions that Reclamation and SRP are evaluating as part of a federally authorized feasibility study. The study began in 2022 and is expected to run through 2028, contingent on the availability of federal funds approved for the study.



Proposed modification design for Barlett Dam. Source: Hannah Hansen
https://wrrc.arizona.edu/sites/wrrc.arizona.edu/files/2024-03/hannah_hansen-srp-initiatives.pdf

SRP and its non-federal partners, including 23 municipal, Tribal, and agricultural partners, support the feasibility study. These partners are interested in the benefits from the additional water captured by a higher dam because the water could be used outside of SRP's water service area. Access to the additional supplies captured by a new Bartlett Dam could help reduce reliance on groundwater and mitigate the impact of Colorado River shortages. If the feasibility study finds the expansion of Bartlett Dam to be the preferred alternative, Congress must approve it. The study is expected to be submitted to Congress in 2028. If Congress approves the study's finding, construction of the New Bartlett Dam and Reservoir may proceed and is estimated to take 10-15 years to complete.

Roosevelt Dam

In addition to the Verde River reservoirs, SRP manages five dams on the Salt River, including the Theodore Roosevelt Dam. Located northeast of Phoenix, the dam was completed in 1911 and, at the time, served largely to control erratic flows of the Salt River and provide irrigation water. SRP and Reclamation raised the dam to its current height of 357 feet in 1996. Use of the additional water is limited to the Phoenix-area cities and water districts that helped build this expansion. In addition to storing water for future use, Roosevelt Dam provides flood control and hydroelectricity, as well as the recreational use of Roosevelt Lake, the largest lake located entirely within Arizona.

In June 2024, the U.S. Army Corps of Engineers approved SRP's proposal for a pilot program to temporarily extend from 20 to 120 days how long water can be held in the first five feet in the dam's flood control space. An extension could occur once a year in three years of the pilot program's five-year period. The pilot program is a temporary deviation from the current water control manual, does not require any new infrastructure, and is not expected to present any safety issues. The small risk of flooding from an unusually high rainfall or runoff event occurring without warning is considered insignificant.

Overall, this relatively simple-sounding change addresses timing differences between periods of high floodwater inflows and high water demands. The Salt River typically floods between February and May, but high demand typically runs from May through September. Extending the flood water release period by 100 days allows flows to coincide with high demand. If this pilot program were in place in 2023, an estimated 109,000 acre-feet of the flood water could have been put to beneficial use. That amount of water is enough to satisfy the needs of about 330,000 households in the Phoenix metropolitan area for a whole year.

Rainwater Harvesting

Capturing water doesn't always require large-scale investments like dams in order to be effective. Smaller solutions can also work.

Rainwater harvesting is the practice of capturing and collecting rain and runoff from storms for local use. This is often achieved through systems that funnel water from rooftops into storage tanks or directly to rainwater harvesting landscapes. Passive harvesting systems deliver water directly to the soil. Land contouring and earthworks (berms, swales, basins, etc.) slow the flow of water and retain it so that it can infiltrate the ground, providing an immediate benefit to the landscape, reducing flooding, and potentially recharging groundwater. By contrast, active rainwater systems use rain barrels, cisterns, and other containers to store rainwater for later use. The storage of captured water can be especially useful in areas where wet seasons alternate with seasons when little or no rain falls.

Modified landscape at Las Sendas Elementary School showcasing rainwater principles. Source: Amy Flores and Charlie Alcorn https://wrrc.arizona.edu/sites/wrrc.arizona.edu/files/2024-03/amy-flores.pdf

Harvested rainwater can serve several purposes, both indoors and outdoors. Indoor uses include mainly toilet flushing, unless the captured rainwater is filtered and treated before potable use. The largest use of harvested rainwater is landscape irrigation. According to the Arizona Department of Water Resources (ADWR), landscape irrigation and related outdoor uses account for as much as 70% of residential water demand.

Storm Smart Schools

One program that utilizes rainwater harvesting was the recently completed Storm Smart Schools. Designed by Arizona State University Sustainability Teachers Academies in partnership with the Watershed Management Group, the year-long program sought to incorporate rainwater harvesting concepts and native landscaping into the curriculum in five schools across the Phoenix metropolitan area. Beyond incorporating these ideas into classroom learning, Storm Smart Schools also helped put learning into practice. It facilitated opportunities for students to design and create rain gardens on their own school grounds. For example, at Las Sendas Elementary School in Mesa, the program engaged over 2,200 participants—including students—to create an outdoor classroom with a vegetable garden. The project used contouring to revamp more than 24,000 square feet of landscape and captured and stored 443,000 gallons of rainwater from the roof for irrigation.

Storm-to-Shade

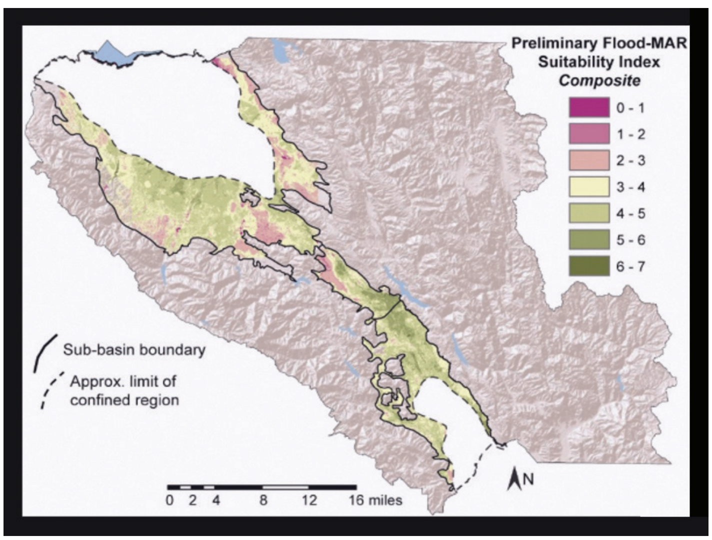
The City of Tucson captures stormwater and puts it to use through the Storm-to-Shade program. Funded through a small fee on city water bills, the program installs green stormwater infrastructure on public property throughout the city and maintains existing GSI. The GSI infrastructure directs stormwater runoff from streets, parking lots, and rooftops into specially designed landscaped areas that detain rain and storm flows, allowing the water to seep into the ground and irrigate trees and other plants. Establishing new trees requires some water from the city utility, but once established, the trees survive and grow on stormwater with only minimal supplementary irrigation. In addition to increasing shade and cooling the urban environment, GSI reduces street flooding. In fact, the Pima County Regional Flood Control District is considering constructing stormwater parks throughout Tucson for flood management benefits.

Recharge

Opportunities also exist to bolster groundwater supplies through recharge projects. Recharge is the process of adding water to an aquifer. Natural recharge occurs when rain, snowmelt, and runoff seep into the ground. However, rain and snow events do not guarantee that recharge will occur. An estimated 90% of precipitation that falls as rain and snow in Arizona evaporates before it can enter a stream or recharge the groundwater. Also, natural recharge can take an exceedingly long time to fill an aquifer, in some cases tens of thousands of years. Most of the water in southern Arizona's large valley aquifers accumulated thousands of years ago. The drawdown of groundwater levels through pumping in these aquifers occurs much more rapidly than they can be refilled.

Artificial recharge can supplement and support natural recharge. This process involves increasing the amount of water that enters an aquifer by using human-controlled means such as recharge basins or injection wells. Various entities have operated large-scale recharge projects in Arizona for more than 30 years. Smaller-scale projects have been used to address local problems, such as threats to the San Pedro River base flow from groundwater pumping.

Since 2023, the 3.5-year Arizona Tri-University Recharge and Water Reliability Project has studied ways to enhance recharge. The late Dr. Thomas Meixner laid the foundation of the project, and the project team includes 30 faculty, students, and postdocs from the University of Arizona, Arizona State University, and Northern Arizona University. One of the project's goals is to identify ways to collect water lost through evaporation in order to recharge that water for future use — either for human activities or to support natural habitats. The project involves significant climate and hydrologic modeling, ecological and recharge suitability analysis, and an assessment of alternative recharge techniques. The team is evaluating an array of land management practices, including urban water harvesting that will contribute to recharge, and developing a prioritization framework to help decision makers assess their options.



Suitability index map for managed aquifer recharge, 0-7 = low to high suitability. Source: Ryan Lima and Hector Venegas-Quinones https://wrrc.arizona.edu/sites/wrrc.arizona.edu/files/2024-03/hector_venegas-quinones-ryan-lima-atur.pdf

Funded by the Arizona Board of Regents at the request of the ADWR, the project had been underway for two years when progress was reported at the WRRC conference. In that time, researchers tested the National Oceanic and Atmospheric Administration's National Water Model to see how well it matches historical Arizona conditions and found that it is surprisingly accurate. The project team developed an improved version and archived an array of data related to historic and future climate across the state. The team worked intensively on refining estimates of evapotranspiration using satellite data, machine learning, and on-the-ground measurements, and researchers developed a map of annual baseflow-derived recharge estimates for each basin. They have used mapping and modeling to study the effect of forest thinning and fire management on snow accumulation and associated runoff. Another sub-project involved investigating how much urban runoff could be recharged through green stormwater infrastructure, retention/detention basins, injection wells, and managed aquifer recharge techniques.

The project team engages with an array of interest groups and stakeholders and has been designing specific opportunities to work with Tribal environmental professionals and youth groups. Goals for the final 18 months of the project include completing a water budget for each watershed in the state under current and future conditions and a state-wide suitability analysis for capturing and recharging precipitation that is currently lost. Deliverables include a summary report, links to data and findings, story maps, and published peer-reviewed papers. Upon project completion, ADWR and water users can apply the project findings in ongoing water management programs and use the framework in planning for potential water supply investment.

Watershed Management

Watershed restoration and conservation efforts can achieve a range of goals, including increasing water supplies. Restoring watersheds has been shown to slow runoff by retaining water, thus increasing infiltration. It also reduces water losses from evaporation and plant respiration and reduces sediment runoff and erosion. One large cooperative effort is the Four Forest Restoration Initiative (4FRI).

The 4FRI is a collaborative landscape-scale effort to restore the structure and health of northern Arizona's ponderosa pine forests, reduce the risk of severe wildfires, and foster wildlife and plant diversity. It spans 2.4 million acres on the Apache-Sitgreaves, Coconino, Kaibab, and Tonto national forests, which are overgrown with thickets of thin, unhealthy trees. The 4FRI uses tree thinning, prescribed burns, and broader restoration efforts like reforestation and watershed restoration and stabilization. Preventing extraordinary wildfire protects the water supply functions of watersheds, as well as water quality, which is severely degraded by wildfire-scorched landscapes. The U.S. Forest Service carries out these efforts with the support of a diverse set of stakeholders, including industry representatives, environmental groups, and local, county, and state governments.

During the 2024 WRRC conference, representatives of the Arizona Cross-Watershed Network stated that grant dollars were available for restoration projects on a smaller scale. These include low-tech process-based restoration, agricultural practices, and environmental flow enhancement. This is good news for the many non-profit organizations across Arizona working at the local level to improve watershed functioning.

Transporting Water

As with building water retention structures such as dams, using canals and pipelines to alter the way nature distributes water has been practiced for millennia. This section explores recent projects that draw on this ancient tradition to move water, solving some of Arizona's water distribution inefficiencies.

Canals and pipelines transport water from its source to places it can be used. Infrastructure to carry water long distances is expensive. Pipelines cost more than canals, but their advantages, such as avoiding water losses through evaporation and enhanced compatibility with existing infrastructure in congested urban conditions, often make the additional cost worthwhile. Pipelines that connect existing distribution systems can introduce flexibility to respond to changing conditions, as the following examples illustrate.

Phoenix Drought Pipeline Project

Facing likely Colorado River water shortages, the City of Phoenix initiated the Drought Pipeline Project in 2018 to ensure that the more than 400,000 residents of North Phoenix have access to safe, reliable, clean drinking water. The project, a complex system of new pipelines and water pumps, transports treated water from the Salt and Verde rivers into areas of the city's water supply system that previously were supplied primarily by water from the Colorado River. The $280 million project, which wrapped up in 2023, includes a nine-mile concrete and steel pipeline that can move up to 75 million gallons of water each day into North Phoenix. Residents now have access to an alternative supply and Phoenix has greater redundancy within its water system to respond to a variety of water supply challenges.

Phoenix Drought Pipeline construction. Source: City of Phoenix

Central Mesa Reuse Pipeline

The 10.5-mile Central Mesa Reuse Pipeline is another key project moving water to serve regional needs. Based in the City of Mesa, just east of Phoenix, the pipeline will deliver recycled water to the nearby Gila River Indian Community (GRIC) for agricultural use, and in return, Mesa will receive a portion of GRIC's unused Colorado River water; for every 10 gallons of recycled water it supplies to GRIC, Mesa receives eight gallons of Colorado River water. A longstanding agreement between Mesa and GRIC facilitates such exchanges. (*See more on water exchanges below.*) While Mesa currently delivers some recycled water to GRIC, the new pipeline will double that amount.

Once the pipeline is operational, Mesa expects to net an additional 8,000 acre-feet of Colorado River water annually, while maximizing the use of recycled water. City water officials emphasize that this exchange will help Mesa meet its growing water demands without tapping into valuable groundwater resources. According to Mesa's website, construction is slated for completion by early 2026.

Exchanging Water

Fundamentally, exchanging water means trading water between two or more parties. Exchanges often aim to improve water-use efficiency by providing access to water where and when it is needed, without having to build major redistribution infrastructure. Water may be exchanged for water that is different in timing, quality, or legal status, as well as for financial resources to provide for other needs. Overall, exchanges offer water management flexibility through voluntary agreements. Several important exchanges have taken place in recent years.

Colorado River Indian Tribes Water Leasing

Established by the federal government in 1865, the Colorado River Indian Tribes (CRIT) reservation stretches along both the Arizona and California sides of the Colorado River. It includes approximately 300,000 acres of land, with the Colorado River serving as the focal point and lifeblood of the area.

CRIT plays an important role in the management of Colorado River water. With the right to divert 662,402 acre-feet per year to serve its lands in the state, it is the largest holder of first priority rights to Colorado River water in Arizona. This water supports CRIT's economy, which includes a strong agricultural industry that grows crops such as cotton, alfalfa, and sorghum.

L to R: CRIT Chairwoman Amelia Flores, U.S. Secretary of the Interior Deb Haaland (2021-2025), and Arizona Governor Katie Hobbs sign the agreements for reporting and accounting of CRIT leases as required by the CRIT Water Resiliency Act. Source: John Wright, Parker Pioneer

Unlike other Tribes in Arizona and the U.S. Southwest, until recently CRIT couldn't lease its water for off-reservation use without new federal legislation. The Colorado River Indian Tribes Water Resiliency Act of 2022, passed by Congress and signed into law by President Joe Biden, authorized CRIT to enter into lease, exchange, or storage agreements relating to their allocation of Colorado River water for off-reservation use. According to the CRIT Water Resiliency Act, CRIT can enter into agreements only with entities located in the Arizona portion of the Lower Colorado River Basin and not located in Navajo, Apache, or Cochise counties. Agreements must be approved by the U.S. Secretary of the Interior and cannot exceed 100 years.

In April 2024, Tribal, federal, and state leaders signed an agreement on implementing the Water Resiliency Act in Arizona. In a statement released by CRIT, they described the signed agreement as bringing it "one step closer to strengthening its sovereignty over its water resources to improve the lives of future generations of CRIT members while protecting the life of the river."

CRIT's new ability to enter into leasing agreements has several potential benefits. The Tribes now have more options for how their water is used. The money exchanged for leased water can support important Tribal initiatives and investments. The increased flexibility allows CRIT to play a greater role in water management in Arizona. For other water users in Arizona, CRIT agreements mean that they can potentially access a new secure water source to mitigate the impacts of drought and help meet their growing water demands with less risk of shortage.

Verde River Exchange

In central Arizona, the Verde River is a major tributary of the Salt River. The Verde River ecosystem holds a special place among Arizona's ecological assets. Fed by groundwater, it is one of the few remaining perennial rivers in the state, and supports a lush environment where biodiversity flourishes. Its watershed supports abundant wildlife, including 270 species of birds, 92 species of mammals, and 74 species of native amphibians and reptiles.

As in other parts of the state, communities in the Verde River Valley face population growth and associated water demands. Most development has relied on groundwater, causing river flows to decrease as pumping has intensified. Over time, the Verde River has lost five miles of flowing water, leading to declines in both river and groundwater levels.

To protect the river, The Nature Conservancy and its partners launched the Verde River Exchange in 2016 after several years of careful study. Not a direct water-for-water exchange, the program involves monetary payments: a Verde Valley water user (typically an agricultural producer) agrees not to use a specified amount of the water to which they hold rights (typically river water) in return for a modest payment. The portion of water that remains in the river is recorded as a credit. A groundwater-using Verde Valley business or resident who seeks to reduce the impact of their pumping on the river can buy credits to offset their groundwater withdrawals. In effect, they pay for others to use less water and keep the Verde River flowing. Exchanges are entirely voluntary. Between 2016 and 2022, the Verde River Exchange kept over 32 million gallons of water in the Verde River.

Thomas Meixner

The WRRC 2024 Annual Conference was dedicated to Thomas Meixner (1970-2022), Professor and Department Head of Hydrology and Atmospheric Sciences at the University of Arizona. He is remembered as a brilliant scientist, with special expertise in desert hydrology, hydrogeology, and biogeochemistry, who understood desert water issues, conservation, and their complex intersections. His generous interest in and commitment to students, colleagues, and community continue to inspire and drive progress in the work to which he was committed.

Beyond its innovative design, the Verde River Exchange highlights the role communities can play in shaping their own water futures. A local nonprofit, Friends of the Verde River, manages the exchange with a diverse group of partners, including community leaders, residents, and businesses. Knowing how important the Verde River is to the community and environment, local people and area businesses—Verde Valley vineyards, an aquaponics business, and a wildlife park, among others—have decided to participate. Without their dedication and boots-on-the-ground approach to protecting the river, the exchange program wouldn't exist, and the Verde River would have less water flowing in it.

Ultimately, exchange programs like the one in the Verde Valley may provide templates for helping meet Arizona's water needs while also protecting critical environmental resources. The Verde Valley Exchange also shows that solutions to maintaining Arizona's water don't have to come from the top down. Local initiatives can play an important role.

CONCLUSION

Arizona and the southwestern U.S. face significant water challenges that may seem insurmountable, but solutions in progress and in various stages of planning offer reasons for hope.

Options, both large and small, are available.

- By treating water, we can repurpose it to better suit our needs and preserve other resources.
- By capturing water, we can have greater access to this critical resource when it's needed.
- By transporting water, we can provide it to locations in need and build connections that strengthen water flexibility and diversification.
- By exchanging water we can increase distribution efficiencies and allow various parties to meet their unique needs through voluntary agreements.

Our past investments in water management have paid off significantly, and new tools are evolving. Through strategic initiatives, knowledge sharing, creative collaborations, innovative partnerships, and the power of human ingenuity, as showcased in this *Arroyo* and the conference upon which it is based, Arizona's water future can be bright.

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Land Acknowledgement

We respectfully acknowledge the University of Arizona is on the land and territories of Indigenous peoples. Today, Arizona is home to 22 federally recognized tribes, with Tucson being home to the O'odham and the Yaqui. The University strives to build sustainable relationships with sovereign Native Nations and Indigenous communities through education offerings, partnerships, and community service.

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Acknowledgements

Production of this *Arroyo* was supported in part by HDR, Southern Arizona Water Users Association, Stantec, Tucson Water (City of Tucson), funding from the Water Resources Research Act section 104(b) program, administered through the U.S. Geological Survey, and the Technology and Research Initiative Fund (TRIF)/Water, Environment and Energy Solutions Initiative, administered by the University of Arizona Office for Research, Innovation and Impact, funded under the 2000 Arizona Sales Tax for Education Act (Proposition 301 TRIF Initiative).

The authors thank the following reviewers for their comments and suggestions on this *Arroyo*. Any errors or misstatements are the authors' and cannot be attributed to these conscientious reviewers: Alma Suarez, Amy Flores, Anna Murveit, Charlie Alcorn, Chelsea McGuire, Christina Jovanovic, Clayton Freed, Cynthia Campbell, David Wegner, Hannah Hansen, Jimena Garrison, Jing Luo, Kathy Jacobs, Kristen Johnson, Linneth Lopez, Neha Gupta, Rhona Mallea, Somnath Mondal, and Weston Brown.

Suggested citation: Bauer, Austin and Susanna Eden, "Expanding and Diversifying Arizona's Water Portfolio," *Arroyo*, Tucson, AZ: University of Arizona Water Resources Research Center, 2025.