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ARIZONA WATER BANKING, RECHARGE, AND RECOVERY

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Cover Photo: Agua Fria Recharge Basins. Central Arizona Project

Throughout this Arroyo, water banking refers to the storage of water underground in natural aquifers for future use. In Arizona, this underground storage is achieved through recharge projects permitted by the Arizona Department of Water Resources (ADWR) through the Underground Storage, Savings and Replenishment Program. When there is a need to use stored water, it is recovered through wells permitted for recovery also by ADWR. While simple in concept, the actual functioning of water banking, recharge, and recovery in Arizona can be very complicated. The purpose of this Arroyo is to describe, in a clear and straight forward way, how water banking, recharge, and recovery actually work.

A decade ago, the Arroyo examined the issue of artificial recharge, reviewing the status of legislation, regulation, and recharge projects in Arizona. While covering some of the same background information, this issue has a broader goal—to describe how all the elements of water banking, recharge, and recovery operate to provide future water security to Arizona's water users. This Arroyo is organized into seven major sections, beginning with this introduction. The second section discusses groundwater management in Arizona and the Groundwater Management Act of 1980, subsequent amendments and legislation. In the third section, the laws related to water banking, recharge, and recovery are examined. The fourth section provides an overview of the ways in which the laws are translated in practice, drawing on both aggregate statistics and specific examples. The fifth section looks at two important entities in water banking, recharge, and recovery efforts—the Central Arizona Groundwater Replenishment District (CAGRD) and the Arizona Water Banking Authority (AWBA). As explained in that section, these two entities serve different purposes and operate according to very different models. The sixth section

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explores the question of recovery of stored water; that is, how to bring water into use after it has been stored underground. The Arroyo concludes that important questions related to the sustainability of water in Arizona can be addressed through a better understanding of how water banking, recharge, and recovery work.

Sources for this issue include annual reports and plans of operation for the AWBA and CAGRD, other agency resources, and news and journal articles. While some sources are cited in the text, others are not. Please see the suggested reading section for further information.

Background on Groundwater Management in Arizona

In 1980 Arizona's legislature passed the Groundwater Management Act (GMA), a landmark piece of legislation. The GMA and the rules that it established are a key part of the framework for water banking, recharge, and recovery. Although infrastructure projects on Arizona's rivers (notably the Salt River Project and projects on the Gila River) played an important role in the state's history, it was another source of water - that naturally accumulated underground in permeable deposits of sand and rock called aquifers - that enabled growth of agriculture and cities to soar in the 20th century. While groundwater had been an important water source since the 19th century, it was not used in large volumes until the invention of the high-speed centrifugal turbine pump in 1937. Along with several other factors, this fueled a boom in irrigated agriculture in Arizona and elsewhere in the arid West, with groundwater use increasing threefold between 1940 and 1953. From then until 1980, as much as 60 to 70 percent of the water withdrawn in Arizona in any given year was groundwater. With increased use of Colorado River water made possible by the Central Arizona Project (CAP), that amount has fallen to 40 percent, still a substantial proportion of Arizona's water withdrawals.

Much of the water stored in Arizona's aquifers accumulated over millions of years and is only naturally recharged very slowly. As farms, mines, and cities pumped more and more groundwater, people began to realize that the aquifers were being "overdrafted". In other words, more water was being pumped out than was being naturally recharged - by a large margin.

There are many problems caused by overdrafting an aquifer. Besides the basic problem of pumping water faster than it is recharged, more energy is required to pump the same amount of water as water levels drop further below the earth's surface. Using more energy means higher costs. As water levels drop, the overlying ground can sometimes settle above it (called subsidence). Layers of loose sediment that were previously saturated can become compressed and can no longer store the same amount of water. Uneven settling can damage buildings and other infrastructure, as well as causing earth fissures and cracks to form. Streams that once flowed year-round, like the Santa Cruz River in Tucson, can dry up as lowering the water table severs the connection between the river and the groundwater that once fed it.

The problems caused by overdraft were known and recognized in Arizona as early as the 1940s. Yet efforts to curb overdraft resulted in only weak restrictions on groundwater use and overdraft worsened. Efforts continued throughout the 1970s to address these problems, but meaningful action was not taken for a decade until the U.S. Secretary of the Interior threatened to cut off funding for CAP if the state did not come up with a solution to its groundwater problem. Following this late 1979 ultimatum, Governor Bruce Babbitt convened a commission that laid the groundwork for what would become the GMA. The Act established ADWR and in effect, divided the state based on level of regulation into three zones: Active Management Areas (AMAs), Irrigation Non-Expansion Areas (INAs), and the rest of the state.

Arizona's AMAs and INAs. Source: ADWR

With respect to AMAs, which were established in areas experiencing severe overdraft, the GMA contains a number of important provisions. First, it created a system of groundwater rights and permits, which were based on lawful withdrawals and use of groundwater during the five years preceding January 1, 1980 for the initial active management areas. The groundwater rights had the effect of limiting the amount of water that could be legally pumped within an AMA. In addition, bringing new agricultural land under irrigation was prohibited in both AMAs and INAs.

Each AMA has a management plan, updated every decade, which becomes more restrictive of groundwater use over time. New housing developments within the AMAs have to prove that they have access to an "Assured Water Supply" for 100 years, consistent with AMA goals. Finally, for the first time, all users of groundwater have to measure and report their pumping to ADWR, except for relatively small domestic wells with a capacity of 35 gallons per minute or less.

The five AMAs contain over 80 percent of the state's population, as well as a significant portion of its irrigated agriculture. The Phoenix AMA contains a large urban metropolis of over four million people, while the Tucson AMA contains a metropolitan area of nearly one million people. The Pinal AMA - located between Phoenix and Tucson - is largely rural and agricultural, but is on the cusp of expanding urban development. The GMA sets Pinal apart from the other AMAs in an important way. Each of the others has a goal to achieve "safe yield" by 2025. Safe yield is a long-term balance between groundwater withdrawal and recharge within the AMA. The goal for the Pinal AMA, on the other hand, emphasizes maintaining the agricultural economy as long as possible while urban growth must comply with requirements similar to safe yield AMAs.

Each of these three AMAs, Phoenix, Tucson, and Pinal, receives Colorado River water from the CAP, a system of canals, pumps, and tunnels that moves water uphill from Lake Havasu through the population centers of Phoenix and Tucson. Two additional AMAs, Prescott and Santa Cruz, are outside of the CAP service area. The Prescott AMA, located in the Central Highlands north of Phoenix, has seen significant exurban growth in recent years, much of which relies on unregulated small wells for water supply. The Santa Cruz AMA, which was split off from the Tucson AMA in 1994, is largely rural and relies mostly on water from wells. It has the unique feature of abutting the international border with Mexico, which shares the Santa Cruz River watershed.

Background on Recharge in Arizona

One of the main ways that the GMA sought to reduce groundwater overdraft was substituting "renewable" water supplies for groundwater, especially those coming from the Colorado River via the CAP canal. When it began delivering water to central Arizona in the late 1980s, a significant portion of CAP's available supply was not used. Thus, water resource managers proposed to support the groundwater management goals and use Arizona's full Colorado River allocation of 2.8 million acre-feet by storing that otherwise unused water underground. This strategy also pre-empted other states from using Arizona's unused entitlement. Legislation in 1986 and 1994 (the Underground Water Storage and Recovery Act and the Underground Water Storage and Replenishment Act, respectively) laid the groundwork for this practice by setting up the legislative framework that would guide it. Other water sources, such as treated wastewater (effluent), were also included in this legislation.

Among the issues resolved by the underground storage legislation was ownership of the stored water. Entities that store water may recover that water in the same calendar year (Annual Storage and Recovery) or may receive long term storage credits (LTSC) that entitle them to recover the same amount of water at a later date anywhere within the same AMA, as long as the area groundwater table is not experiencing an average annual rate of decline of four feet or more. Allowing for storage in one site and recovery in another promotes ADWR's goal of encouraging more efficient water use. On one hand, by allowing this spatial disconnect, groundwater recharge can be used more flexibly. On the other hand, the policy allows recovery to contribute to localized groundwater depletion. Although hydrologically connected, an AMA's aquifers do not benefit uniformly from recharge because water usually flows relatively slowly underground both vertically and horizontally. Areas near recharge facilities may see water tables rise - to the point of affecting sand and gravel mines in some instances - while other areas within the same AMA see declining water levels.

Under the terms of the underground storage legislation, ADWR is responsible for issuing permits for constructing and operating water storage facilities, storing water at those facilities, and using wells to pump stored water out of the ground. The ADWR tracks how much water a given permittee has stored and recovered and maintains LTSC accounts.

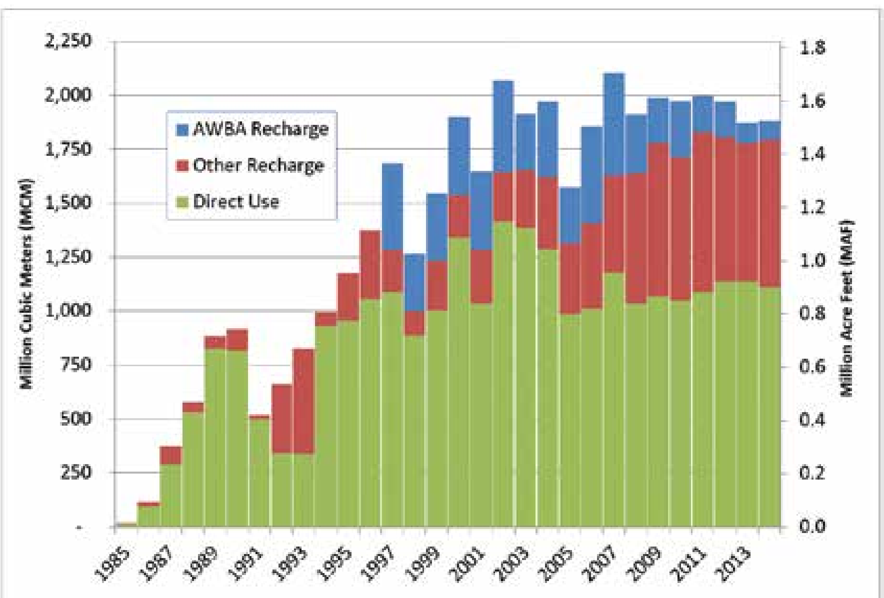
There are a number of ways to accomplish underground storage. Water may be stored through direct or indirect recharge. Direct recharge means adding new water directly into an aquifer through one of several recharge methods. These include spreading basins -

CAP canal. Source: CAP

essentially large areas where top layers of soil are scraped off to allow water to seep into the ground - and smaller-scale alternatives like relatively shallow vadose zone wells, injection wells, and aquifer storage and recovery wells. Each of these methods is considered a "constructed" Underground Storage Facility (USF). Constructed USFs incorporate constructed devices to direct and increase infiltration of the source water, which can include in-channel modifications such as constructed berms. Alternatively, water can be discharged into an existing, unmodified dry stream bed, which is called "managed" recharge.

While conceptually simple, direct recharge facilities are often technically complex works of civil engineering that require careful planning and monitoring, as well as considerable investment, to construct and maintain. Many of the largest USFs in Arizona were built under the State Demonstration Recharge Program from 1991 to 2004. These six projects in the Phoenix and Tucson AMAs were built by the Central Arizona Water Conservation District (CAWCD), the federal contractor and state taxing district created to operate and repay the cost of CAP.

Indirect recharge, also called "in-lieu" recharge, permits an entity to deliver water from a non-groundwater source (e.g. the CAP or a wastewater treatment plant) to a farm or irrigation district that holds a quantified groundwater right. A farm or irrigation district where this takes place is referred to as a Groundwater Savings Facility (GSF). The entity that provides water to a GSF, for example a municipal water provider, receives LTSCs in the amount of the groundwater pumping that is reduced at the GSF through the use of the non-groundwater source.



CAP deliveries by type, 1985 - 2014. Source: CAP

This form of recharge considers the water GSF farmers do not pump out of the ground as water "saved" in the aquifer. One would not expect to increase the water level in an aquifer by using a GSF. However, in the Pinal AMA, for example, the combination of reduced pumping stress due to GSFs and use of imported CAP water saw the groundwater level rise by as much as 65 feet between the early 1990s and 2015.

Several Arizona water utilities use Annual Storage and Recovery to offset seasonal fluctuations in their supply or avoid the need to build costly conveyance structures or surface water treatment plants. Tucson Water uses Annual Storage and Recovery to comply with the requirements of a 1995 voter initiative that prohibited direct delivery of CAP water, despite the construction of a water treatment facility. Tucson stores its CAP supply in a USF as it is delivered and uses recovery wells connected to its distribution system to deliver it as needed throughout the year.

When water is stored for more than one year, the storing entity is assigned LTSCs, where one credit equals one acre-foot of water. The LTSCs can be recovered anywhere in the same AMA that is not experiencing an average annual rate of decline of four feet or more. Aside from a restriction on transfer outside of the AMA where the water was stored and some restrictions on the eligibility of an entity to buy them, LTSCs can be transferred freely to other entities. Importantly, when water is recovered, it retains the same legal characteristics as the water that was stored. This means that when a credit is recovered by pumping water out of the ground, it is not considered groundwater for purposes of the GMA, but rather CAP or effluent depending on the source of the recharged water. This distinction is important in complying with GMA rules.

Not all of the water sent to a storage facility earns storage credits. Under current statute, when CAP water is sent to a recharge facility, ADWR subtracts water lost through evaporation and other factors, as well as a 5 percent "cut to the aquifer."

The aquifer's cut is meant to provide a net gain to the aquifer from recharge. To address concerns about groundwater level declines in areas distant from recharge projects, ADWR proposed a policy change that would increase the cut to the aquifer for water being stored far from where it is likely to be recovered. While the problem of local depletion is widely recognized, the proposal did not generate sufficient support to move forward.

This cut to the aquifer requirement has a couple of exceptions. Effluent sent to a GSF or constructed USF is not subject to any cut to the aquifer, which encourages the recharge of treated effluent that would otherwise go unstored. Effluent recharged at a managed (riverbed) facility is subject to a 50-percent cut. Before the managed recharge statute was in place, no credit was assigned for releasing effluent into a stream bed. Providing some storage credit for effluent used in this way reflects a shift in the value of wastewater, from being seen as a noxious byproduct to being seen as an important resource. In the upper Santa Cruz River, stream flows and riparian gallery forests are supported by the discharge of effluent from the Nogales International Wastewater Treatment Plant. Yet, this stretch of the river has no permitted storage facilities, meaning that no credit is earned. This has led some to suggest that more opportunities to earn storage credits by releasing effluent into streams should be offered as a way to create an incentive for leaving the effluent in the stream channel rather than diverting it to other uses.

Recharge Facilities - Who, What, Where, How?

Much of this information is drawn from ADWR data from records of recharge facilities, storage agreements, and LTSC accounts.

Groundwater Savings Facilities

In the basic arrangement between a GSF and an entity that wants to store water, the storer provides water to the GSF on terms agreed upon between the parties. The storer can earn LTSCs for GSF use of the water in lieu of groundwater. This arrangement provides tangible benefits to the GSF and the storer, as well as contributing to AMA goals.

There are 17 total permitted GSFs in the Phoenix, Pinal, and Tucson AMAs, with a total permitted storage capacity of just over 780,000 acre-feet of water per year. Phoenix accounts for 50 percent of this capacity, distributed across eight sites. Tucson has six GSFs, but only 10 percent of the permitted capacity. Pinal, with only three sites, accounts for the remaining 40 percent.

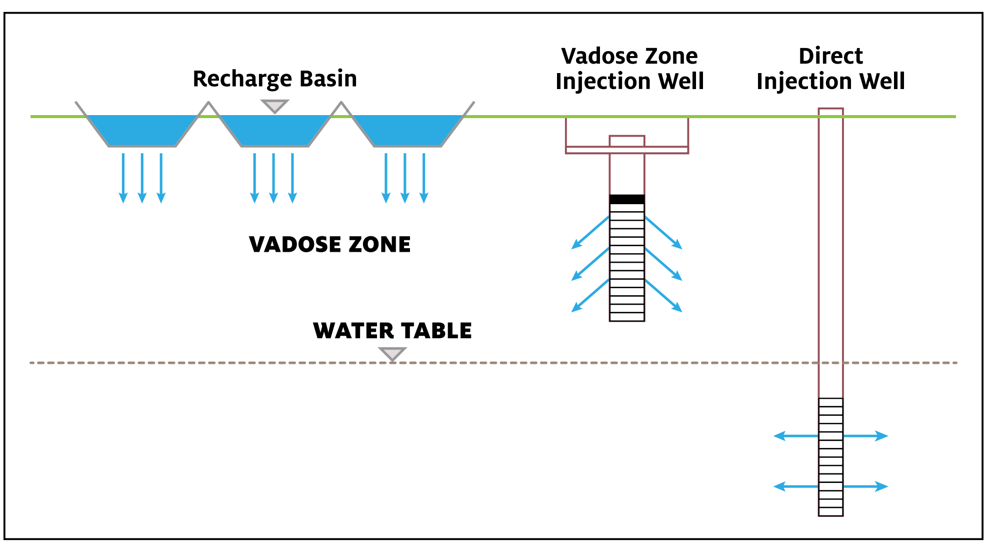
One of the largest GSFs, with a permitted storage capacity of 85,000 acre-feet per year, is the Roosevelt Water Conservation District (RWCD). Located in the east side of the Phoenix Valley, RWCD is an irrigation district formed in 1920 to serve farms covering roughly 40,000 acres. Originally, RWCD received its water supply from groundwater wells and the Salt River Project, but it is now also served from the CAP canal. Because RWCD was using groundwater to irrigate prior to implementation of the GMA in 1980, their right to continue doing so was grandfathered. Now that roughly 14,000 acres of RWCD farmland is connected to the CAP delivery network, they can reduce groundwater use in those areas. From 1992, when they began operating as a GSF, through 2015, RWCD had reduced groundwater use by 972,900 acre-feet by using CAP and treated wastewater in lieu of pumping groundwater. They receive this water from several different entities - the Town of Gilbert, the Gila River Indian Community, and the Bureau of Reclamation and Arizona Water Company among them

One of the smaller GSFs, with just less than 15,000 acre-feet per year of permitted storage, is BKW Farms in Marana, located in the Tucson AMA. BKW is owned by the Wong family, which has been farming in the area for three generations. The GSF was the first in Pima County and since 1995 the farm's groundwater pumping has been reduced by over 95 percent. Two local utilities, Tucson Water and Metro Water, and AWBA have all sent CAP water to BKW Farms.

Underground Storage Facilities

Existing USFs are permitted to store roughly 1.3 million acre-feet of water per year in at least 70 different sites. Of this, 70 percent of the storage capacity is in 48 permitted facilities in the Phoenix AMA, 20 percent is in 18 permitted sites in the Tucson AMA, 2 percent in 12 sites in the Pinal AMA, and less than 1 percent in three sites in the Prescott AMA. The remaining storage capacity (about 7 percent of the total) is outside of the AMAs. The vast majority of USFs are constructed. Only a handful of USFs are "managed" recharge in river beds (three in Phoenix, one in Pinal, and two in Tucson).

As suggested by its dominant share of USF capacity, the Phoenix AMA contains some of the largest USF projects. Four of these, Tonopah Desert, Agua Fria, Hieroglyphic Mountains and Superstition Mountains, are operated by CAWCD with a permitted capacity of 341,500 acre-feet per year. Two additional large storage facilities, Granite Reef and New River Agua Fria, with a



Methods of groundwater recharge. Source: WRRC

Storage Capacity in GSFs and USFs as of March 2017						
AMA	**GSFs**			**USFs**		
	Number	**Capacity**	**Type**	**Number**	**Capacity**	**Type**
Phoenix	8	50%	50% CAP 26% Effluent 24% Both/other	48	61%	40% CAP 13% Effluent 47% Both/other
Pinal	3	40%	CAP only	12	2%	Effluent
Tucson	6	10%	CAP only	18	28%	80% CAP 20% Effluent
Prescott	None			3	1%	Effluent/other
Non-AMA	None			4	8%	Effluent/other
Total	**17**	**780,000 AF**		**85**	**1.3 MAF**	

Source: ADWR

total permitted capacity of 168,000 acre-feet per year are located in the Phoenix AMA. These six sites alone make up nearly one third of the USF storage capacity in Arizona. However, it is useful to distinguish between permitted capacity and actual capacity, as several of the larger projects have permitted capacity that substantially exceeds the actual/operational capacity of the facility.

The largest USF is the Tonopah Desert Recharge Project, constructed by CAWCD. Located some 40 miles west of Phoenix, Tonopah Desert is permitted to store 150,000 acre-feet of water annually. Unlike most recharge projects, Tonopah is located in a relatively remote area with few wells nearby. The facility was idled in 2015 due in large part to the significant decline in excess CAP water available to the AWBA and others that resulted in declining orders to store there. Idled to save operational costs, it is still permitted and could be brought back into service relatively easily if circumstances change.

Another CAWCD facility, Agua Fria, has a unique design combining managed recharge with a series of spreading basins. Water is released from the CAP system into the dry bed of the Agua Fria River, where a portion of it infiltrates into the aquifer as it makes its way four miles downstream. What is not recharged in the river bed is channeled into a series of basins at the end of the system. Storage permits for Agua Fria show that fifteen different entities have been allowed to store water there. Note, however, that while there are multiple permit holders, they may not all be storing each year,

Most of the other USFs are operated by municipalities and, in a few cases, private utilities. Many of these smaller

Tonopah Desert Recharge Project. Source: CAP

Gilbert Recharge Project

Efforts by the Town of Gilbert stand out as an example of how recharge can be integrated into wastewater management and other urban planning goals. Gilbert operates four different facilities that recharge wastewater from the city's wastewater reclamation plants. The smallest of these uses an injection well, while the other three use spreading basins. Two of the basin facilities are elaborately landscaped and provide public access. The South Recharge Site has a long canal running down the center and landscaping designed to create the feel of a European formal garden while also paying tribute to the agricultural heritage of the area. The Gilbert Riparian Preserve, on the other hand, creates a natural wetland, incorporating meandering paths and a public library overlooking the ponds. The wetland vegetation helps clean the water while providing wildlife habitat and recreational opportunities. Some of the recovered recharged water is used to fill artificial lakes in Gilbert's subdivisions, while much of it remains stored as LTSCs for future use. These facilities combine multiple public benefits, but they also provide additional challenges for recharge. The buildup of organic matter can inhibit water from infiltrating into the aquifer, while water is also lost to plant growth, factors that must be accounted for in ADWR's calculation of LTSCs.

sites are dedicated to recharging effluent; USFs for recharging effluent account for 65 percent of the number of permitted facilities, but only 15 percent of the storage capacity. Recharge has been a useful tool to account for the seasonality of effluent, which is recharged in winter months when there is supply but less demand and recovered in the summer when demand increases.

CAGRD and AWBA – Two Ways to "Bank" Water

Two important entities in groundwater banking, recharge, and recovery are CAGRD and AWBA. These organizations operate according to two different models. The CAGRD replenishes groundwater supplies after the water is pumped - think of it as paying off a credit card. Replenishment does not fit within the commonly held concept of water banking and CAGRD does not accrue LTSCs for recovery. The AWBA, on the other hand, makes long-term investments by storing water against future need - think of it as depositing into a savings account.

Central Arizona Groundwater Replenishment District

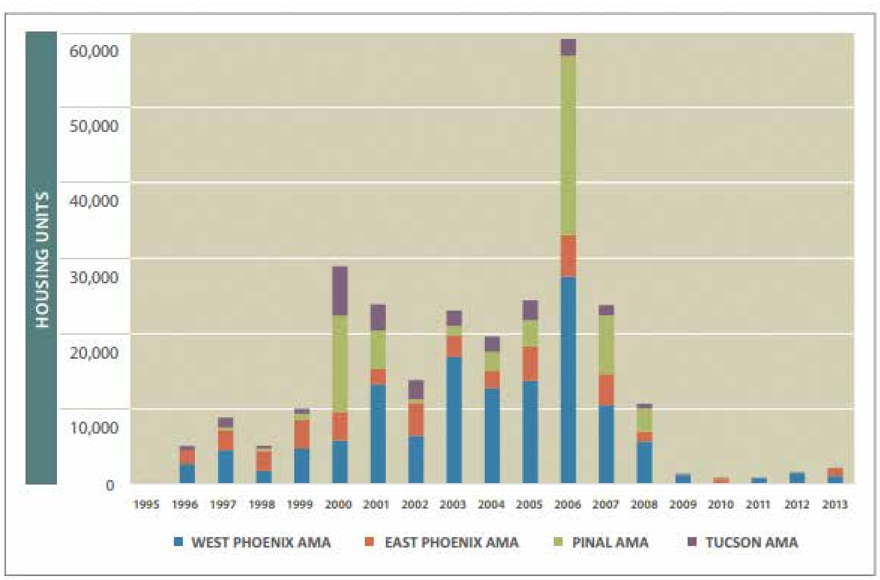
An important part of the GMA is the requirement that new housing developments within AMAs demonstrate continuous, physical, and legal access to water for 100 years and that any groundwater use must be consistent with the AMA's management goal. The ADWR's first proposed rules to implement the Assured Water Supply (AWS) requirements favored those with direct access to renewable supplies, which some viewed as a threat to new housing development within AMAs. Although CAP could provide the renewable water supply needed to meet AWS requirements, in reality, access to a CAP supply was not available to all municipal water providers and developers. When this situation threatened to slow new home construction - a major driver of the state's economy - policy-makers and developers struck upon a strategy that would allow development to continue.

The solution was the creation of CAGRD, which began operations in 1995. For a fee, new housing developments in the Phoenix, Pinal, and Tucson AMAs could enroll in CAGRD, which then became obligated to offset its members' "excess" groundwater pumping (pumping that exceeds the limitations imposed by AWS Rules). It does this by replenishing aquifers with equivalent amounts of renewable water (e.g., CAP or effluent) in the same AMA within three years after the obligation is incurred. This is known as its "replenishment obligation."

The CAGRD has two types of memberships. The first is a Member Service Area (MSA) — a public or private water utility that expects growth within its service area. The second is Member Lands (MLs) — developments planned outside the service area of a municipal provider with a designation of assured water supply (ADWR grants a designation of assured water supply when a municipal provider demonstrates compliance with AWS rules). In the case of an MSA, the utility pays a fee to CAGRD based on its use of excess groundwater. This fee is subsequently collected from the utility's water customers through rates. For MLs, on the other hand, homeowners are individually responsible for paying the fees for replenishment through a special assessment on their property tax bills.

The amount of groundwater considered to be "excess" varies according to the rules set for each AMA. For instance, prior to 2007, developers in the Pinal AMA were allowed to rely almost entirely on groundwater. A rule change in that year required that new developments on desert land without quantified groundwater rights rely on groundwater for only 10 percent of their supply without replenishment, bringing the rules for the Pinal AMA in line with those for the other AMAs. On agricultural land, extinguishment of groundwater rights can produce groundwater credits that may be used in addition to the 10 percent.

The CAGRD uses the fees paid by MSAs and MLs to acquire and store renewable water to meet its replenishment obligation. The most common practice is to purchase excess CAP water and send it to one of the USFs operated by CAWCD or other parties, although it may also send other renewable water sources to a USF or send excess CAP or other renewable water to replenish at GSFs. Fees also pay for CAGRD to maintain a "replenishment



CAGRD member land enrollment through 2013 portrayed as residential units. Source: CAGRD

reserve" of LTSCs within each AMA to meet its future obligations in case of a shortage or service interruption in the CAP.

The history, policies, and important issues surrounding the CAGRD are addressed in a 2007 article in the Arizona Law Review by Avery, Consoli, Glennon, and Megdal. While much has changed over the past decade, many of the challenges and issues they outlined are still relevant. One key issue is where CAGRD will find the water to meet its replenishment obligations. Every ten years, the CAGRD must prepare a Plan of Operation that predicts its future obligations and the water sources that will be used to meet them. The main source for meeting its replenishment obligation, excess CAP water, has been decreasing in recent years. This situation may lead to difficulties for CAGRD in meeting its replenishment obligation.

Another issue is the potential for localized depletion of aquifers caused by disconnects between areas of groundwater withdrawal and the replenishment sites. The AWS rules allow for members to pump groundwater down to 1000 feet below the land surface in the Phoenix and Tucson AMAs and 1100 feet in the Pinal AMA. Because, subsidence and earth fissuring can occur with declines of only a couple hundred feet depending on local conditions, the 1000/1100 foot rule may not prevent significant damage. However, issues associated with localized drawdown are not unique to CAGRD members, and problems of localized drawdown generally continue to be a focus of ongoing criticism and concern. In the

Still from Drone video of an earth fissure in Tator Hills, Pinal County, Arizona. Source: Arizona Geological Survey

Tucson AMA, concerns have been mitigated somewhat by agreements that "wheel" or transport CAP water through Tucson Water's distribution system to outlying municipalities, such as Vail and Oro Valley. In parts of the Phoenix AMA, however, local drawdown of the aquifer continues to be a problem with no immediate solution.

Writing a decade ago, Avery and colleagues saw these issues unfolding in the context of unchecked growth in CAGRD membership. According to CAGRD's 2005 plan of operation, CAGRD expected its replenishment obligation to grow to 225,000 acre-feet by 2035.

As the economic collapse and housing crisis began to unfold in 2007, however, the drop in construction caused estimates to be revised downward. The most significant factor inflating the 2005 estimate of the future CAGRD replenishment obligation, however, was not actual construction but the policy of essentially free enrollment. This situation changed as a result of new policies and statutes that effectively discourage speculative enrollment.

The 2015 Plan of Operation predicts that CAGRD's replenishment obligation for 2034 will be 87,000 acre-feet - less than 40 percent of what had been forecast a decade earlier. Yet the 2015 Plan and comments from stakeholders suggest that the question of where CAGRD will find the water to meet this obligation is still relevant. Building a strategy of "aggressive acquisition" of new water sources, CAGRD has expanded beyond CAP water, including buying LTSCs from various entities such as Tucson Water, Mojave Ventures (a private water investment firm) and the Bureau of Reclamation. Many of the public comments on the plan, however, express skepticism about the potentially available water supplies listed by CAGRD. The City of Phoenix, for instance, called the projections of available water "speculative and unrealistic," while comments from the Inter-Tribal Council of Arizona caused CAGRD to amend its assertions regarding tribal water availability.

Arizona Water Banking Authority

With more than 4 million acre-feet of stored water, AWBA is a key tool for achieving the state's water security goals. Created in 1996, AWBA emerged out of a long history of contentious negotiations over Arizona's rights to water from the Colorado River. Today, as water managers look ahead to coming shortages on the Colorado, AWBA is likely to play an important role in responding to these new conditions.

At its inception, AWBA put Arizona's share of the Colorado River to use by storing the unused portion underground for future use. At the same time, storing the water limited the amount of Colorado River water available to California. At the signing of the bill authorizing the AWBA's creation, Arizona Governor Fyfe Symington declared, "If Californians want Arizona's water, they will have to move to Arizona."

A 1998 article by M.B. LaBianca in the Arizona Law Review provides some historical context. Ever since California proposed large-scale diversion of the Colorado River for irrigation and urban development in the 1920s, other states along the river feared California would establish a right to most of the flow. The Colorado River Compact of 1922 split the river's water between upper (Colorado, Wyoming, Utah, New Mexico) and lower basin states (California, Nevada, Arizona), but it did not allocate the water among the states in each basin. Federal legislation in 1928 provided a way of dividing water among the lower basin states, but Arizona had to argue before the Supreme Court on four occasions before its allocation of 2.8 million acre-feet per year was finally upheld in 1963. At the time, the state had no infrastructure to convey water from the Colorado River to the agricultural areas and fast-growing cities in the center of the state. A project supported by federal dollars was needed. In 1968, after more than two decades of lobbying and negotiation, Congress approved plans for the Central Arizona Project.

As the CAP was nearing completion in the 1990s, it became clear that agriculture would not be using as much Colorado River water as initially projected. The high cost of taking CAP water, including the need to build canal systems to convey it to farms, put this new water source out of reach for many farmers. When the CAP failed to withdraw its full share from the Colorado River, the state feared the loss of the unused water to California. In this context the AWBA was created.

AWBA Water Storage Deliveries for 2016

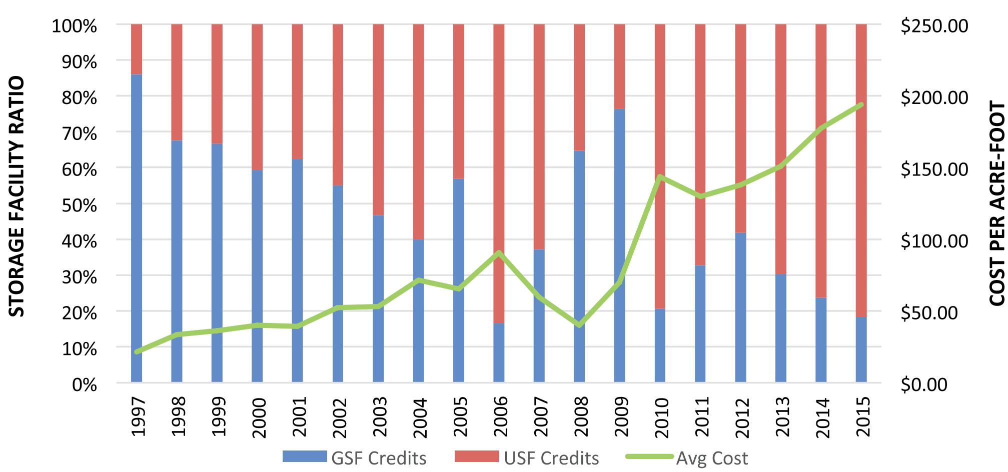
AMA	Facility	Type	AWBA Permit Capacity (acre-feet)	Delivered* (acre-feet)
PHOENIX AMA	Agua Fria	USF	100,000	5,754
	Hieroglyphic Mtns.	USF	35,000	4,907
	Superstition Mtns.	USF	25,000	7,174
	GRUSP	USF	93,000	10,120
	Queen Creek ID	GSF	28,000	6,033
	Phoenix AMA Subtotal			**33,988**
PINAL AMA	Central Arizona IDD	GSF	110,000	5,840
	Hohokam IDD	GSF	55,000	5,840
	Maricopa-Stanfield IDD	GSF	120,000	5,840
	Pinal AMA Subtotal			**17,520**
TUCSON AMA	Avra Valley	USF	11,000	1.150
	Lower Santa Cruz	USF	50,000	1,850
	SAVSARP	USF	60,000	8,160
	Cortaro-Marana ID	GSF	20,000	1,500
	BKW Farms	GSF	14,316	1,000
	KAI Farms - Red Rock	GSF	11,231	540
	Tucson AMA Subtotal			**14,200**
TOTAL RECHARGE DELIVERIES				**65,708**

*November and December deliveries estimated

Source: AWBA

The AWBA stores excess CAP water to meet four objectives: to insure against future Colorado River shortages to the Municipal and Industrial (M&I) sector—mostly cities and private water companies within CAWCD's service area and along the Colorado River, to help meet AMA groundwater management goals, to meet the state's obligations to Indian tribes, and to bank water for California and Nevada. The first goal is called 'firming' because it shores up, or firms, Colorado River water deliveries.

The four million acre-feet of stored water came largely from excess CAP water, which the AWBA bought and sent to either a USF for direct recharge or to a GSF as a substitute for groundwater irrigation. Between 2013 and 2015 about 75 percent of AWBA water went to USFs, 25 percent to GSFs. Funding for the AWBA to buy this water totaled more than $300 million as of 2015. Funds come from several sources: fees for groundwater pumping within the AMAs, an ad valorem property tax, and, in theory, general funds provided by the state legislature, but AWBA received its last general fund appropriation in 2001. An appropriation of $13.5 million was made available in FY 2007, but it could only



AWBA ratio of GSF to USF water storage and average cost/AF of water stored. Source: AWBA

The Market for Long Term Storage Credits

A study by WestWater Research, a private firm that advises investors on water rights issues in the Western U.S., provides a glimpse into the state of the market for LTSCs. Between 2008 and 2014, close to 400,000 acre-feet of storage credits changed hands. One of the major sellers of LTSCs is the Gila River Indian Community (GRIC), which receives more water under the terms of settlement agreements than it currently uses directly on the reservation. In a partnership with the Salt River Project, the GRIC established Gila River Water Storage (GRWS), a company that markets stored water credits primarily to developers. These credits are presented as a lower cost alternative to membership in the CAGRD or as a source of LTSCs to offset the cost of CAGRD membership, and they plan to make five million acre-feet available for sale. Other tribes have also begun to accumulate storage credits, including the Tohono O'odham Nation which has accrued over 100,000 acre-feet of storage credits since it began recharging in 2009. Whether they will seek to market some or all of the remaining credits is unknown.

Entities interested in buying credits for stored water include golf courses, developers, industrial water users, and tribes, which all negotiated agreements to acquire credits between 2008 and 2014. One of the industrial users that acquired LTSCs by both storing water and buying credits is Resolution Copper, which frames its water storage as part of a corporate sustainability strategy to reduce groundwater use. Another major buyer is CAGRD, which bought just over 100,000 acre-feet of LTSCs during this time frame. According to their most recent plan of operation, they intend to buy more storage credits in the near future. AWBA has also incorporated buying credits into its strategy as CAP water availability declines.

Intriguingly, some of the biggest players in the LTSC market have been investment firms. According to WestWater's study, investors purchased more than 250,000 acre-feet of LTSCs during the study period - more than all others combined. Vidler Water Co. was founded by Disque Deane Jr., a hedge fund manager who, as reported by ProPublica, sees water scarcity in the West as an opportunity for big returns. Though Deane later sold the company, Vidler continues to be an important player in the market for stored water in Arizona. Vidler even took the unusual step of building its own underground storage facility with a capacity of 100,000 acre-feet per year in the Harquahala Valley, just west of the Phoenix AMA. At one point, Vidler was actively purchasing excess CAP water to store at this facility, but has not done so since 2010.

Investors are betting that the value of stored water will appreciate as other water supplies become more expensive. In fact, the deals made so far show that prices tend to track closely with the price of storing CAP water at a USF, which has been steadily increasing at an average of 6 to 7 percent year-over-year in the last 15 years. When the CAGRD makes a purchase, the price is contractually tied to the cost of water from the CAP. The average price for the deals tracked by WestWater was around $140 per acre-foot - compared to a cost of $138 per acre-foot for storing CAP water at a GSF in 2014. According to a report by Pico Holdings, the parent company of Vidler, a slate of deals, not mentioned by WestWater, were made by Gila River Water Storage to sell LTSCs to Resolution Copper in 2012 and 2013. The prices all topped $300 per acre-foot. Most deals made by investors to purchase credits were made between 2008 and 2011. After 2011, many began liquidating their stored water investments under pressure from investors to recoup their investments.

be used for meeting Indian settlement obligations and the legislature later swept $12.4 million of those funds. What was left is what was used by 2010.

Each acre-foot of water stored is designated to a specific purpose. AWBA estimates that 2.7 million acre-feet are needed to firm municipal supplies for the next 100 years. Its latest annual report (2015) shows 85 and 89 percent progress toward meeting M&I firming goals for the Phoenix and Pinal AMAs respectively, but only 52 percent for Tucson. Tucson's property tax revenues are smaller relative to its firming goal as compared to Maricopa County and under the law, property taxes must be used for the benefit of the county in which the tax was collected. The AWBA goal of storing 420,000 acre-feet for communities along the Colorado River is 96 percent complete. Lastly, current estimates indicate the AWBA will need approximately 550,000 acre-feet of water to meet its Indian settlement responsibilities, including 350,000 acre-feet for the Gila River Indian Community (GRIC) and 200,000 acre-feet for future settlements. About 35 percent of the firming goal for the GRIC has been met and represents water stored directly on Community lands. While no water has been stored specifically for future settlements, the AWBA has over 700,000 acre-feet of credits that can be tapped for water management purposes, including both Indian and CAP M&I firming purposes when needed. For interstate banking, the AWBA has stored just over 600,000 acre-feet of water in Arizona on behalf of the Southern Nevada Water Authority. The dwindling availability of excess CAP water is driving a major shift in AWBA's role. The water available for storage has been declining since 2010. The 10-year plan for 2016-2025 anticipated for the first time that no excess water will be available, while the plan for 2017-2026 anticipates excess water will likely to be available only in 2017. In this context, AWBA is expanding its approach from buying and storing water to buying LTSCs for water stored previously by others. The AWBA has already agreed to buy up to 45,000 acre-feet of credits from the City of Tucson. The latest (2015) 10-year plan calls for accruing an additional 470,000 acre-feet of credits. If after 2017 excess CAP water supplies are unavailable, AWBA proposes to develop credits to meet this goal through LTSC purchases and use of other supplies. Moreover, the prospect of an end to excess CAP water and a deeper shortage affecting other users, raises the possibility that AWBA will shift its focus from storing water to distributing credits for recovery.

Recovery – Getting the Water Back

The logic of recovery is fairly simple: Anyone who stores water underground, or who acquires storage credits from someone who has them, should be able to take it back out. The ADWR maintains an account of storage credits for all entities that hold LTSCs. This account is meant to function like a positive balance in a bank account. Recovery may occur in the same calendar year as storage, Annual Storage and Recovery, or in later years, recovery of LTSCs.

Water can be recovered only within the AMA or groundwater basin in which it was stored and must be recovered through a "recovery well" permitted by ADWR. Recovery wells are no different from other extraction wells but are authorized to recover LTSCs that retain the legal characteristic of the water that was stored (e.g., CAP water or effluent); these withdrawals are not considered to be groundwater. This legal classification allows storers to comply with ADWR regulations meant to advance AMA groundwater management goals.

Since recovery can take place anywhere within the same AMA, the recovered water is not necessarily in the recharge project's "area of hydrologic impact". With certain exceptions, when issuing a permit for recovery, ADWR considers whether pumping water will occur in areas where there are local declines in the water table. If the rate of decline in the aquifer exceeds the limit set forth in ADWR's well spacing rules, ADWR will not issue a permit. Also, a recovery well may not be located in an area experiencing an average annual rate of decline that is four feet or more per year.

For most entities, the recovery process runs fairly smoothly. For recovery of the LTSCs held by AWBA, however, recovery raises a host of complex issues.

Recovering AWBA Water

This section draws primarily from the 2014 "Joint Recovery Plan" completed by the AWBA, CAWCD, and, ADWR, with input from the Bureau of Reclamation and other stakeholders. The plan was a collaborative effort between these agencies because of the legally established relationships among them. The AWBA, while responsible for storing water to meet its goals, does not have the authority to undertake recovery directly. That responsibility lies with the CAWCD. The CAWCD, which operates the CAP, does not actually own the canal - the Bureau of Reclamation does. The ADWR, as the agency responsible for regulating and overseeing storage and recovery, also has an important role to play in formulating recovery plans.

The Joint Recovery Plan makes plain that there are numerous uncertainties facing recovery of water stored by AWBA. Some of the most salient questions are: when will recovery need to take place and at what magnitude? How, and by whom will recovery be accomplished? Where will recovery take place? These questions touch on cross-cutting issues of how much recovery will cost, who will pay, and the implications for sustainable groundwater management.

When will recovery take place and how much will be recovered?

While the need to recover water may be triggered by a number of factors, such as interstate storage and recovery obligations to Nevada and extraordinary disruptions in CAP operations, the major trigger of concern is a declared shortage on the Colorado River.

In the event of a shortage declaration, there would be a reduction in Arizona's share of the Colorado River, including a reduction in water delivered through the CAP system. In order to predict when and how much AWBA water will need to be recovered, water managers have to gauge when a shortage on the Colorado could be declared and at what level. There are three tiers of shortage triggered as Lake Mead levels fall to 1075, 1050, and finally 1025 feet above sea level. A tier-1 shortage would reduce Arizona's allocation by 320,000 acre-feet, and CAP has indicated that they will bear the shortage. A tier-1 shortage would eliminate AWBA storage of excess CAP water but would have little effect on recovery. Tier-2 (400,000 AF) and tier-3 shortages (480,000 AF) would mean greater volumes of water would need to be recovered. The AWBA has estimates based on modeling of how much may need to be recovered in the coming decade based on projections for shortage levels. These shortage levels were part of an agreement in place since 2007 on shortage sharing. An agreement being negotiated among Arizona, California, and Nevada, however, could both increase the amount and accelerate the timeline for Arizona's reductions.

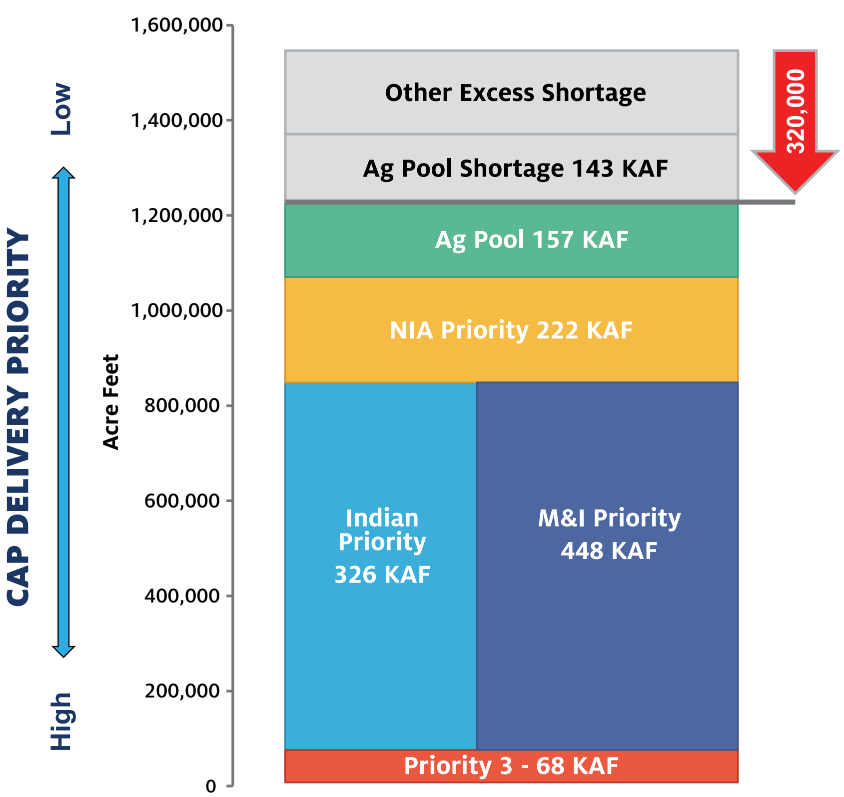
Based on modeling done by CAP, impact estimates for CAP's water supply indicate that cuts at each tier will affect users according to CAP priority categories. Of the four long-term contract priorities, the highest (excluding a small quantity of higher priority water allocated to the Ak-Chin and Phoenix Valley cities that originated

Lower Basin Shortage Reductions.*				
Lake Mead Elevation	**Arizona**	**California**	**Nevada**	**Mexico**
1075’	320,000 AF	0 AF	13,000 AF	50,000 AF
1050’	400,000 AF	0 AF	17,000 AF	70,000 AF
1025’	480,000 AF	0 AF	20,000 AF	125,000 AF

***Reductions taken according to 2007 shortage sharing guidelines (Colorado River Interim Guidelines for Lower Basin Shortages and Coordinated Operations for Lake Powell and Lake Mead). Source: CAP**

from Wellton-Mohawk and Yuma-Mesa Irrigation and Drainage Districts) is shared by contracts with Indian tribes and M&I users. This category will not see cuts at the first two tiers. The first cuts will mainly affect recharge and agricultural water users that rely on excess CAP water. Second priority water uses could see small cuts. These include users of water from the Non-Indian Agriculture Priority pool (one of the most confusing terms in Arizona water policy, as much of this water has been reallocated to Indian tribes under the terms of settlements but retains the NIA label, or even more confusingly is referred to as “Indian NIA”).

When cuts to CAP result in shortages to entities for whom the AWBA has a firming obligation, recovery is triggered. A tier-1 shortage does not cut into water the AWBA is responsible for firming, but as the cuts get deeper, AWBA’s recovery obligations increase substantially. Even so, AWBA scenario analyses predict that no less than 75 percent of the AWBA’s credits will remain in underground storage in 2045.



2007 projected tier 1 shortage impact. Source: CAP

Along with uncertainty about future water supply, there is also uncertainty about demand. Arizona’s share of the Colorado is split between on-river users and the CAP. “M&I firming” applies to both CAP service area firming and “on-river” firming for municipalities along the Colorado River. In 2014, when the Joint Recovery Plan was completed, on-river municipalities were not claiming their full entitlement, leaving about 50,000 acre-feet unused. Demand for this water is expected to increase, however, as communities along the Colorado River continue to grow. This increased demand increases the AWBA’s firming responsibility, and therefore creates a greater need for recovery during shortage.

Another question related to demand has to do with the water stored for Nevada. The roughly 600,000 acre-feet that Nevada has stored must be recovered by 2063, but Nevada has not indicated exactly when it will ask for this water. Nevada will take delivery of the water by diverting part of Arizona’s entitlement from Lake Mead. CAP would take less water from the Colorado River and CAWCD would have to recover banked water to make up the difference. Nevada has agreed to create a 10-year plan, updated annually, to forecast the amount of water they will request from Arizona. Their first such plan indicates that they do not anticipate requesting this water in the near future.

Given these various uncertainties, a Joint Recovery Plan, developed by AWBA, CAWCD, and ADWR, includes modeling results for various recovery scenarios that show the likelihood of recovering a given amount of water in each year from 2014 to 2045. These scenarios vary significantly depending on the timing and level of a shortage, demand by on-river cities, and requests from Nevada. Overall, however, the model shows that more water will need to be recovered as time goes on.

How and by whom will recovery be done?

Three basic mechanisms are planned for recovering water stored by the AWBA. For direct recovery, water is pumped from a permitted recovery well into the CAP canal for delivery through the system. Although possibly the simplest option to understand, it most likely requires building new infrastructure (e.g. well fields and treatment facilities) and therefore significant investment, may have long lag times between planning and completion, and would require energy to recover stored water.

The second method is indirect recovery. A "recovery partner", an existing CAP customer, agrees to receive storage credits instead of their regular delivery of CAP water. They would then recover those credits through their own recovery wells.

Similarly, a "credit exchange" allows storage credits to be recovered and exchanged for CAP water that would otherwise be delivered. The distinction is that credit exchanges apply to entities that would normally use the water for storage in a USF. For example, utilities that practice Annual Storage and Recovery could agree to recover credits from AWBA in lieu of CAP water and continue pumping the same amount through their existing recovery wells. This method could also be used with CAGRD replenishment. CAGRD could accept AWBA credits to meet its replenishment obligations instead of water it buys from the CAP for replenishment. In either case, this frees up water that would have been sent to a recharge facility to be delivered to someone else for immediate use.

Where will recovery take place?

Restrictions are placed on the use of AWBA credits based on the funding source used to acquire them. Credits acquired using the ad valorem property tax must be used for the benefit of the same county where funds were raised. For instance, storage credits acquired with property tax funds in Maricopa County cannot be used to firm supplies for cities on the Colorado River. Credits acquired with funds from groundwater withdrawal fees and from the general fund, on the other hand, may be used more flexibly, with the caveat the withdrawal fees must be used for the benefit of the AMA in which the funds were collected.

The model created for the Joint Recovery Plan suggests that the supplies that will need to be firmed over the next two decades are those related to Indian settlements and on-river users, and for interstate banking. While there are credits located in all three of the AMAs for these purposes, the majority of these credits are stored in the Pinal AMA. For this reason, the Joint Recovery Plan suggests that the Pinal AMA will be the main focus of recovery efforts in the near term. Recovery for cities in the Phoenix and Tucson AMAs becomes more likely toward the end of the planning horizon.

Recommendations for the Pinal AMA must address unique issues. The AWBA's storage in Pinal is entirely at GSFs. The Joint Recovery Plan suggests that a large portion of the AWBA's requirements can be met through indirect recovery in partnership with irrigation districts. These districts, which already have some infrastructure in place to pump groundwater, would have their wells permitted for recovery. Instead of receiving CAP water, they would agree to receive AWBA storage credits and recover those credits by pumping more from their wells. While technically the water is being recovered within the same AMA in which it was originally stored, the CAP supplies that the Pinal AMA partners forego can be used anywhere else in the system; they may be taken by Nevada out of Lake Mead, diverted to supply cities on the Colorado River, or sent to tribes either in or outside of the AMA. This method will only be possible in the short term, however, as the irrigation districts in Pinal rely on a low-priority pool of CAP water (known as the "Ag Pool") that is scheduled to be reduced to zero by 2030, even without shortages.

The Joint Recovery Plan also suggests direct recovery as a possibility, with the same caveats about cost and timing as apply elsewhere. Since there are no USFs for storing CAP water in the Pinal AMA, the Joint Recovery Plan also recommends building some to accumulate more stored water and create the possibility for credit exchanges in the future. Arizona Water Company, a private utility that supplies customers throughout central

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Arizona and accounts for 70 percent of the municipal CAP water use in the Pinal AMA, is moving forward with plans to build a USF with an annual capacity of nearly 11,000 AF.

Arizona Water Company also offered the most substantial comments on the Joint Recovery Plan for the Pinal AMA. The company suggested that it could be a potential recovery partner in the AMA. At the same time, it voiced concerns about making up for shortages outside of the AMA with CAP water that otherwise would have gone to Pinal and the negative impact of increased pumping on groundwater supplies. Drawdown of aquifers once CAP water is no longer available, however, is a predictable outcome from the substantial use of GSF storage in the Pinal AMA.

In the Phoenix AMA, the Joint Recovery Plan emphasizes credit exchanges and indirect recovery as the best options. Regarding credit exchanges, CAGRD and many local utilities that direct CAP water to underground storage could agree to accept storage credits in lieu of this water. Large regional water suppliers like the Salt River Project are identified as potential partners for indirect recovery, since their systems already include permitted recovery wells. An option for direct recovery is also included: the Tonopah USF would seem to be an ideal site for a new recovery well field. The plan stresses, however, that this option would be a major financial undertaking and should not be seen as a high priority due to its cost.

Glendale and Peoria, cities in the Phoenix metropolitan area, both provided detailed comments on these plans. Glendale's comments point out that the recommendation for credit exchanges with utilities that use Annual Storage and Recovery could create an incentive for others to adopt this approach, causing them to build additional USFs and recovery wells and incur costs that are not factored into the Joint Recovery Plan's calculations. Noting that recovery of water from Tonopah seems an unlikely outcome, Glendale also encouraged shifting storage away from this facility. Peoria, on the other hand, expressed skepticism about the indirect recovery and credit exchange methods and promoted direct recovery at Tonopah as the best option. Peoria argued that the indirect recovery and credit exchange methods assume the city can seamlessly transition to recovery wells for their water supply. In fact, due to the underlying geology of the aquifer, Peoria does not have access to enough stored water to meet current demand, and their system relies on direct use of CAP supplies.

The Plan's proposals for the Tucson AMA emphasize credit exchanges with utilities using Annual Storage and Recovery, including Tucson Water and Metro Water, although there is over 200,000 acre-feet of AWBA water in a Tucson Water facility, which will be recovered directly.

Tonopah Desert Recharge Project in relation to Phoenix area cities. Source: WRRC

There is a possibility of developing well fields for direct recovery near the farms that are storing water as GSFs, but this is again presented as a less desirable option due to its high cost. Comments related to the Tucson AMA are less contentious than those in the Phoenix AMA, but suggestions include considering a direct recovery facility near the Lower Santa Cruz Recharge Project, where a large volume of AWBA credits have been stored.

Much of the debate surrounding the Joint Recovery Plan has to do with the question of costs. The plan emphasizes the high costs of direct recovery, which would be passed on as fees to CAP subcontractors. Some of these subcontractors, though, raise concerns about hidden costs associated with the indirect recovery and credit exchange methods. These costs are associated with questions of potential local groundwater depletion. The case of the Tonopah USF illustrates this well: although a great deal of water has been stored there, raising the water table locally, focusing recovery efforts there is costly and controversial. Other options that would tap aquifers outside Tonopah's area of impact have been recommended instead.

Beyond the Joint Recovery Plan

Plans for AWBA recovery touch on an issue that the CAP has faced since before the CAP canal was even fully completed: Can the CAP transport water that did not come directly from the Colorado River (called "non-project water")? Recovering stored groundwater though the various methods described here points to the need for a number and variety of "wheeling" agreements to move non-project water through the system. In light of this, the CAP undertook a process to establish a "system use" agreement that lays the groundwork for various exchanges of water. The CAP System Use Agreement, signed on February 2, 2017 by CAP and the U.S. Bureau of Reclamation resolves a myriad of legal, financial, and operational issues related to the manner in which CAP would carry non-project water and paves the way for federal approval of projects to firm project water during shortages as well as expand the capacity of the system to wheel new supplies of non-project water through the canal.

One part of the CAP System Use Agreement sets up a framework for exchanges, including across AMA lines. If the CAP water in the exchange is delivered to a "downstream" location, it will have a lower priority for access to canal capacity than normal contract deliveries. This and other provisions of the CAP System Use Agreement will further facilitate innovative water partnerships such as the agreement between the city of Phoenix, Tucson Water, and Metro Water (another Tucson area utility), for an inter-AMA exchange. Phoenix has extra CAP water but nowhere to store it, while the Tucson utilities have extra room in their storage facilities. Phoenix would send the water down the CAP canal for storage in Tucson. When Phoenix needs the water, Tucson would request delivery of a portion of its CAP allocation to Phoenix's water treatment plants. In exchange, Tucson would use its wells to recover an equal amount of storage credits for Phoenix under Phoenix's recovery permits. Tucson Water has recovery capacity at its USFs of over 130,000 acre-feet per year.

CAWCD has also moved forward with several options for recovery. Preliminary studies are underway for a well-field at the Tonopah USF, with initial estimates suggesting it could cost $200 million. These initial studies have suggested that water quality issues are more salient than anticipated. Because the water pumped at Tonopah may have elevated levels of arsenic and other contaminants, CAWCD is concerned that introducing this water into the canal without treatment could trigger greater oversight from the Environmental Protection Agency. In order to avoid this, potential plans now include a water treatment plant on the site.

Conclusion

Arizona has an innovative groundwater storage program, made possible by the abundance of large sand and gravel aquifers thousands of feet deep that provide storage space for millions of acre-feet of water. The availability of unused CAP water and favorable legal and regulatory conditions facilitated enormous growth in groundwater storage since the 1990s. What began as a means of saving unused CAP water has expanded into a multipurpose tool that simultaneously addresses a number of water supply issues. These include:

- securing future supplies (e.g. AWBA and water utilities)
- making up for unsustainable water use (e.g. CAGRD replenishment)
- increasing efficiency (e.g. effluent recharge)
- facilitating exchanges between water haves and have-nots

Yet, for all its flexibility and innovation, the water banking, recharge, and recovery program is not a panacea. In some cases, it postpones rather than resolves issues relating to groundwater, such as in the Pinal AMA where drawdown has abated but now is likely to ramp up again. Furthermore, the disconnect between location of storage and location of recovery invites a return to groundwater mining in places. In addition, the prospect of a Colorado River shortage after years of excess brings questions of recovery to the forefront where differences in perspectives on equity have already surfaced.

Much more discussion, negotiation, and planning is needed as water banking, recharge, and recovery pivot from storing excess water to recovering stored water during shortage. Hard choices, avoided in the past, will have to be addressed and new mechanisms for insuring that water is available where it is needed will have to be adopted. These larger issues will require input from an informed public with a clear picture of how water resource management choices will affect their lives. Understanding these important activities can illuminate important questions related to the sustainability of water in Arizona.

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