[SECTION 2: STRATEGIC VISION]

ARIZONA'S HISTORICAL SUCCESSES IN WATER MANAGEMENT

Water is the foundation, not only for long-term economic stability, but also for securing the success of generations of future Arizonans. Strong, forward-looking, leadership at the highest levels of State government on water issues is vital to ensure a stable future for our citizens. The Arizona Department of Water Resources (ADWR) is the logical leader in initiating this discussion and developing a comprehensive foundation to work from in this process.

Arizona has a long history of developing pro-active solutions to the challenges of developing water supplies in our arid state. The support and commitment of our current political leaders is crucial to continuing to meet those challenges *(see Appendix I – Timeline History of Arizona Water Management)*. While we reside in what some perceive as a harsh environment, those with great vision and leadership have harnessed the natural resources needed to support a thriving Arizona economy. This vision started well before statehood. Below is an overview of just a few of those achievements, which not only can serve as a guide for future planning, but will also provide a sense of the significant time and commitment required to realize the benefits of new projects. This is important to illustrate because although large-scale importation projects may not be needed until sometime in the future, the planning and politics of constructing such projects or water supply benefits of implementing management approaches can take decades to accomplish. Much of Arizona enjoys the benefit of secure water supplies today, in large part due to the vision and efforts of its past leaders. Establishing and pursuing a vision for water security for future generations of Arizonans must begin well in advance of the need to ensure orderly development, avoid economic disruption, and protect the unique environment that we all enjoy.

<u>Taming the Salt River</u>

In the late 1860's early settlers in the Phoenix area were dependent primarily upon the unregulated flow of the Salt River through diversions and canals to sustain agricultural development. The river was unpredictable - prone to both extreme flooding and droughts. Efforts to dam the river to provide more consistent and reliable supplies were impeded by the inability to finance the construction of a dam on the river (estimated at the time to cost approximately $5,000,000). A series of droughts in the 1890s and floods in the early part of the 20th century, however, highlighted the need to control the river.

With the passage of the National Reclamation Act of 1902[4], funding for projects with low-interest federal loans paved the way for the incorporation of the Salt River Valley Water Users' Association (SRP) the following year, becoming the first multipurpose project under the new Act. In 1903, over 200,000 acres of private ranching and farm lands in the association were pledged as collateral for the construction of Roosevelt Dam with a reservoir storage capacity of nearly 1.4 million acre-feet[5,6] (MAF), located approximately 76 miles northeast of Phoenix.

[4] Benjamin Fowler, an Arizona businessman, went to Washington D.C. to lobby for the federal government for this new law to find a way to finance the dam in Arizona.

[5] One acre-foot is 325,851 gallons or approximately enough water to provide for approximately two families of four living in a single-family home for one-year.

[6] From 1989 to 1996, the dam was modified by the US Bureau of Reclamation. In addition to raising the dam's height 77 feet in elevation which increased its storage capacity by 20 percent, the modification included construction of two new spillways, installation of new outlet works, and power plant modifications.

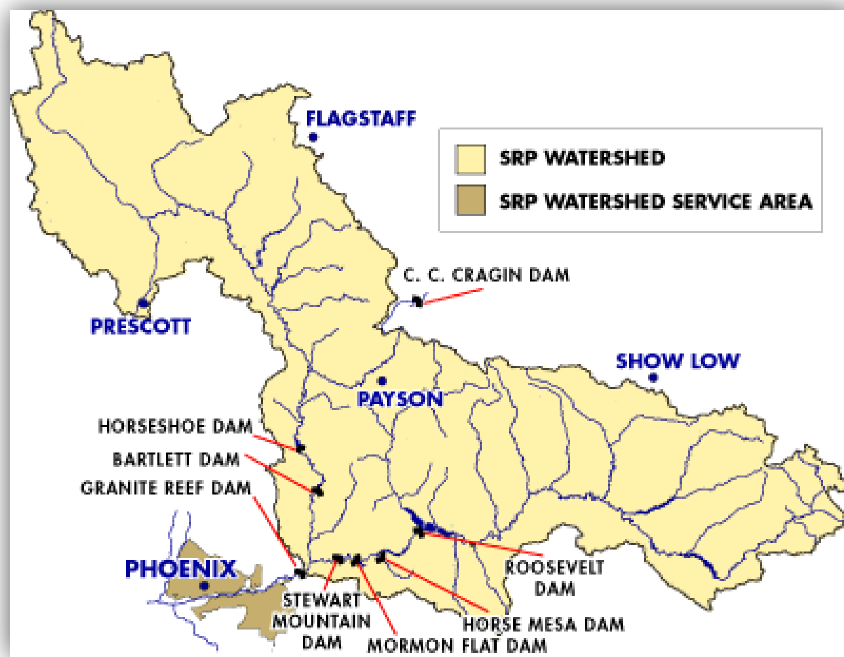

Figure 1. Salt River Project Watershed and Service Area (SRP)

Although the construction of Roosevelt Dam was SRP's most visible and costly component, an integral part of the project was also the construction and improvement of a system of canals designed to distribute the water from the Salt River among the various members living in the valley. As construction began, water rights to the Salt River in the Phoenix metropolitan area were settled in *Hurley v. Abbott (1910)*[7]. The decision, known as the Kent Decree in recognition of the presiding judge, Edward H. Kent, was a landmark in water law and still serves as an integral part of the water management structure in Arizona today. Between 1923 and 1945, five additional dams were constructed on the Salt and Verde Rivers to increase the storage capacity to greater than 2.5 MAF on the system and to generate hydropower (*see Figure 1*). Today, SRP supplies power to more than 970,000 retail customers in three Arizona counties, including most of the metropolitan Phoenix area. Integrated operation of the six reservoirs on the Salt and Verde Rivers, as well as the Granite Reef Diversion Dam and its system of canals, makes SRP an important provider of water to the Phoenix area. SRP annually delivers approximately 1 MAF of water to the Phoenix area through an extensive system of reservoirs, wells, canals and irrigation laterals and manages a 13,000-square-mile watershed. Additionally, SRP operates the C.C. Cragin Reservoir (formerly known as Blue Ridge Reservoir[8]), located on the Mogollon Rim which, in the near future, will provide renewable water supplies to the Town of Payson.

Development of the Colorado River

At the same time central Arizona was harnessing the Salt River, development of the waters of the Colorado River was also taking shape. Modern use of Colorado River water for irrigation began in the late 1800s when water was diverted for use in California's Imperial Valley. By 1901, some 100,000 acres of farmland were irrigated with Colorado River water in the Imperial Valley. As settlers and farmers in southwestern Arizona, southeastern California and the Mexicali Valley in Mexico were expanding their farming operations, rapid development in the Los Angeles basin was increasing the need for long-term water supplies. But, like the Salt River, the Colorado River was prone to highly variable and sporadic

[7] No. 4564, Decision and Decree, March 1, 1910
[8] Blue Ridge Reservoir was built by the Phelps Dodge Corporation in 1965 to provide water for its mining operations. SRP acquired the reservoir in 2005 as part of the Gila River Indian Community Water Rights Settlement approved by the 2004 Arizona Water Settlement Act to help facilitate the settlement of the Community's water rights claims.

flow regimes. From 1905 to 1907, floods impacted communities along the River, making continued reliance on its flows unpredictable.

In order to deliver Colorado River water to the Imperial Valley, water had to be diverted south of the Mexican border through an old overflow channel of the River to bypass a ridge of sand hills separating the Imperial Valley from the Colorado River. To accommodate this diversion, Mexico demanded the right to take up to one-half of the diverted water. California preferred to construct a US only canal as the solution to having to share water supplies with the Mexican farmers. Farmers in the Imperial Valley could not come up with the finances necessary for such a project and worked for years to convince Congress to construct a new aqueduct. It was not until Los Angeles got interested in augmenting its water supplies that significant progress was made. In 1920, California interests joined with Arthur Powell Davis, nephew of the famous explorer John Wesley Powell and Director of the US Interior Department's Reclamation Service (now the Bureau of Reclamation), who supported the idea of a large dam on the Lower Colorado River to help expand the west.

The year 1922 proved to be one of the most important years in the development of the Colorado River. Even before Los Angeles entered the picture, leaders in the Colorado River Basin States outside of California were becoming concerned about the rapidly expanding uses in the state that contributed the least amount of runoff to the River. In February of 1922, the US Interior Department issued the Fall-Davis Report[9], which recommended construction of an "All-American Canal", a storage reservoir "at or near Boulder Canyon," and the development of hydroelectric power to repay the cost of the dam. In April of that same year, Congressman Phil Swing from the Imperial Valley and Senator Hiram Johnson of California introduced a bill to implement the recommendations contained in the Fall-Davis Report. Then, in June of 1922, the US Supreme Court, in *Wyoming v. Colorado*, found that the doctrine of prior appropriation applied to surface water rights regardless of state lines. The doctrine of prior appropriation was the cornerstone of western water law which gave legal entitlement to the first person using water-"first in time, first in right" – and was recognized within each of the seven Colorado River Basin States as the basis for the appropriation and use of surface water[10]. Prior to this decision, it was uncertain whether the doctrine of prior appropriation applied to users in two or more states on a common river system. The outcome of this case made it clear that California, which was developing faster in both population and political power than any other area in the west, could potentially acquire rights to most of the water of the Colorado River to the detriment of the slower-growing states. As a result of the Supreme Court's decision and rapid development in California, the states in the Upper Colorado River Basin were forced to oppose all reclamation projects in the Lower Colorado River Basin until their own interests were safeguarded.

Prior to the events in 1922, Congress had already authorized the seven Basin States to negotiate a compact to divide the water between the seven states. However, representatives from each state and Secretary of Commerce Herbert Hoover, representing the federal government, were unable to reach an agreeable division between the individual states. Instead, they did reach agreement to equally divide the River [11]between the Upper and Lower Basin. The resulting 1922 Colorado River Compact (Compact) apportioned 7.5 MAF each to the Upper Basin (Colorado, New Mexico, Utah, Wyoming and a portion of

[9] The Fall-Davis Report, named for Secretary of the Interior Albert Fall and Arthur Powell Davis; who was now head of the Reclamation Bureau
[10] In 1864, the first Arizona Territorial Legislature adopted the Howell Code, which established the doctrine of prior appropriation for surface water in Arizona– "First in Time, First in Right."
[11] At this time the Colorado River was assumed to have an average annual flow of approximately 17 MAF.

Arizona) and Lower Basin (Arizona, California and Nevada) states, with a volume reserved for a future treaty with Mexico (*see Figure 2*).

While the states reached an agreement in the negotiations of the Compact, internal politics in Arizona would set the stage for years of controversy, litigation and uncertainty. The Compact faced tremendous opposition in Arizona; due in large part to the inability to secure a volumetric water supply for Arizona and political influences in Arizona who had a vision for utilization of the Colorado River which did not include sharing the River with the other states. As a result, Arizona did not adopt the Compact for 22 years. However, while Arizona sat in isolation, California continued its development of the water supplies of the Colorado River.

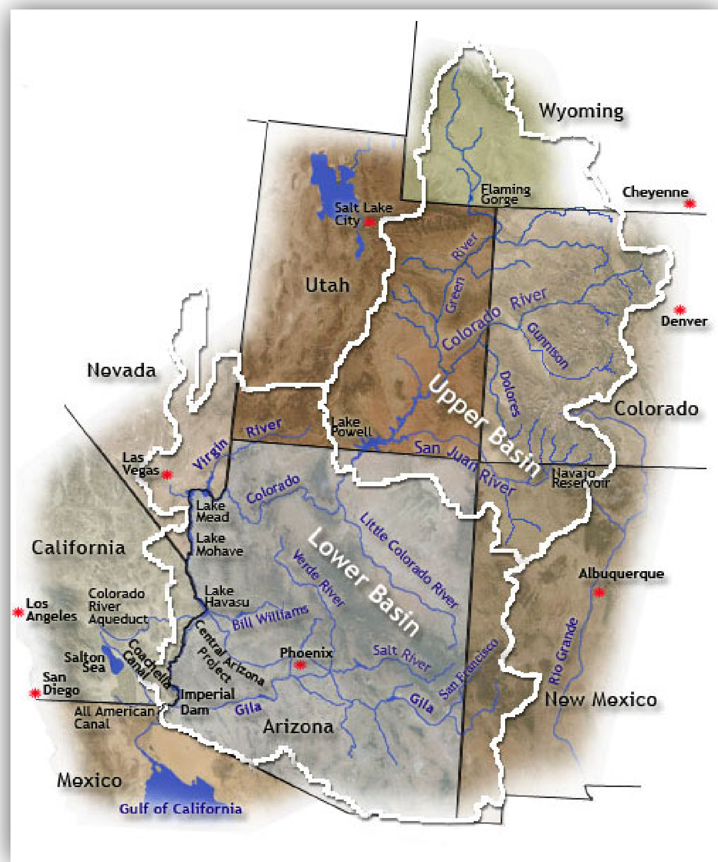

Figure 2. Colorado River Basin (Reclamation)

The Boulder Canyon Project Act was enacted in 1928 without Arizona's approval. It provided for the construction of Boulder Dam (renamed Hoover Dam after Herbert Hoover) on the Colorado River at the Arizona-Nevada border and the All-American Canal in California, paving the way for a more stable and certain future for water users in the Lower Basin.

While each state in the Colorado River Basin continued to develop their supplies, central Arizona, like Los Angeles and Denver, recognized that there was going to be a need to secure long-term water supplies from the Colorado River to ensure economic development. After years of political challenges, Arizona made application to the federal government in 1939 for a contract for the delivery of Colorado River water to secure its entitlement. This was done as Arizona realized its position was becoming increasingly tenuous as a treaty with Mexico was about to be negotiated by the US Department of State (State Department). In 1944, the US and Mexico agreed on the terms of a treaty providing 1.5 MAF of water from the Colorado River to Mexico. Arizona also promptly ratified the Colorado River Compact and signed a contract for delivery of 2.8 MAF of water allotted to the State in the Boulder Canyon Project Act of 1928.

With ratification of the Compact and execution of the delivery contract, Arizona had finally recognized the status of the Colorado River as an interstate river and the authority of the federal government to allocate its waters. These acts set the stage for development of this water supply for Central Arizona.

During this time, California was continuing to increase its use of the River and would prove to be a major hurdle to fulfillment of Arizona's vision for its future prosperity.

In 1946, the Central Arizona Project Association was formed to educate Arizonans about the need for a Central Arizona Project (CAP) and to lobby Congress to authorize its construction. Arizona Senators Ernest McFarland and Carl Hayden introduced the first bill to authorize the CAP in 1947. It would take another 21 years, including 11 years of legal battles with California, before this project would be realized. Through this entire period California continued to increase its reliance on this supply and, with its large and expanding Congressional delegation, fought the passage of a CAP bill.

Arizona filed suit in the US Supreme Court (*Arizona v. California*) in 1952 to secure its legal entitlement to Colorado River water. In the proceedings, California argued that, not only was Arizona already using its Colorado River entitlement via its tributaries, specifically the Gila River, but that because of Arizona's use of the Gila River, California was entitled to an additional 1 MAF from the mainstem of the Colorado River. After a significant shift in legal strategy, Arizona argued that its tributaries were separate from the Colorado River and the rights that Arizona had acquired to the waters of the Colorado River. Furthermore, Arizona claimed that rights to the Gila River were acquired prior to the Compact and were protected as "perfected rights"[12] under Article VIII of the Compact. Specifically, Arizona's legal argument was solidified in the language and the legislative intent of the 1928 Boulder Canyon Project Act, which recommended an allocation of 2.8 MAF of mainstem Colorado River water to Arizona *plus* the waters of the Gila River that was shared with New Mexico.

In 1963, the US Supreme Court upheld Arizona's claim[13]. The Court affirmed that the Boulder Canyon Project Act of 1928 divided the mainstem flow of the Colorado River between the Lower Basin States, with 2.8 MAF per year going to Arizona, 4.4 MAF per year going to California and 300,000 acre-feet per year going to Nevada. Further, the Court affirmed that "the tributaries are not included in the waters to be divided but remain for the exclusive use of each State[14]". This element of the decision was vital for any future CAP as there would not likely have been enough water remaining in Arizona's Colorado River apportionment to justify the construction of the project had the Court found that the use of the Gila River (approximately 1 MAF) was part of Arizona's apportionment.

With its victory in the US Supreme Court, the battle for the CAP went back to Congress. It would take eight more years to get a bill through Congress and, although Arizona's dream of a CAP would become a reality, it would come at a large cost in the face of California's political strength in Congress. Several issues arose in the ensuing years that influenced the framework of the authorizing legislation for the CAP, specifically:

1) California's ultimatum that their support of the project required receipt of its full 4.4 MAF apportionment during shortages, essentially giving California a priority over the CAP;
2) A study released by the Upper Basin States that showed insufficient water supplies available to justify the project; and
3) Growing opposition to the construction of two new dams proposed in the Grand Canyon to supply the power required for the project.

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[12] Meaning the use was in place prior to 1922 when the Compact was signed.
[13] *AZ v. CA.* 373 U.S. 546 (1963)
[14] Opinion in *AZ v CA*, 1963

For many years during the discussions on the CAP, the source of power to operate the project was from two proposed dams to be located in the Grand Canyon. Ultimately bowing to pressure from the environmental and recreational communities who vehemently opposed the proposed dams, Arizona agreed to energy derived from coal mined through lease agreements with the Navajo Nation and Hopi Tribe and a thermoelectric generating facility near Page, Arizona – the Navajo Generating Station (NGS).

While these issues continued to be debated in Congress, Arizona's need for the CAP increased. Beginning in the 1950's, central Arizona's dependence on groundwater supplies increased significantly, a situation that would be solved in part by the CAP (and would later become another important component in Arizona's water management history). Through the dedication and leadership of Arizona's congressional delegation, Senator Hayden, Senator Paul Fannin and Congressmen John J. Rhodes, the Colorado River Basin Project Act was signed by President Johnson on September 30, 1968.

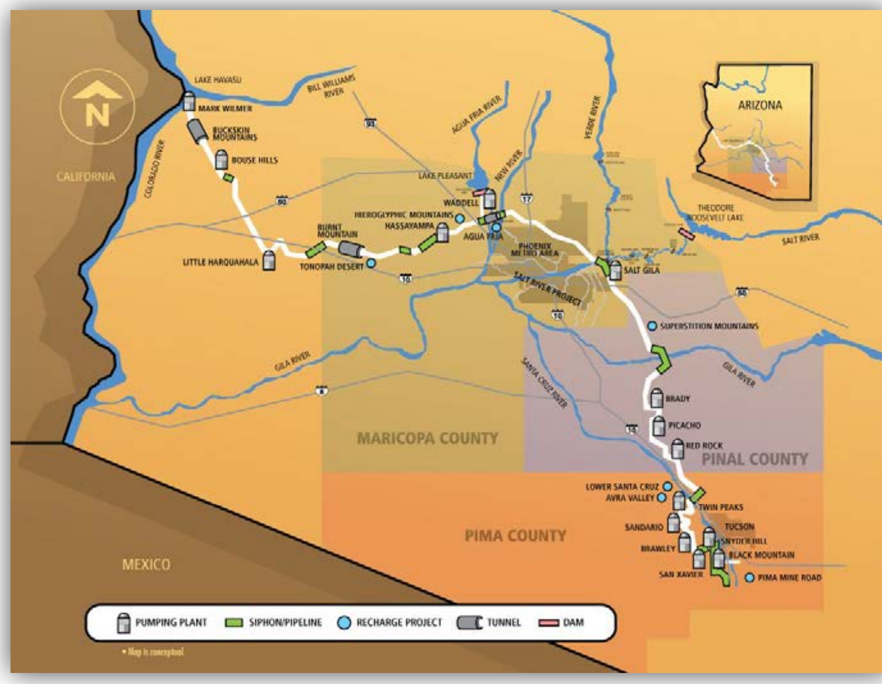

Figure 3. Central Arizona Project (CAP)

The Colorado River Basin Project Act represented a compromise for Arizona, but it did provide Arizona the project it needed to finally utilize its full Colorado River entitlement. In order to get the Act passed, Arizona agreed to a California priority of 4.4 MAF ahead of the CAP. It is important to note that this compromise on Arizona's part was with the agreement and inclusion of language in the Act that water supply augmentation would be explored by the federal government, limiting the impact of differential priority to water in the Lower Basin. To accomplish this, the Act provided for a 10-year study of water resources west of the Continental Divide in return for a 10-year moratorium on any studies aimed at bringing outside water into the Colorado River Basin (this moratorium was extended for another 10 years in 1978). The Act also identified US Bureau of Reclamation (Reclamation) as the entity to fund and construct the CAP, but authorized the Secretary of the Interior to enter into a master contract with an Arizona entity that has the power to levy assessments on real property to repay the federal government for certain costs of construction when the system was complete. In 1971, the Arizona Legislature created the Central Arizona Water Conservation District to provide a means for Arizona to repay the federal government for the reimbursable costs of construction of the CAP and to manage and operate the CAP system.

Construction began at Lake Havasu in 1973 and was completed 20 years later south of Tucson. The entire project cost over $4 billion to construct[15] (*see Figure 3*).

While presented in an extremely abbreviated fashion above, the history of the beginnings of water management on the Colorado River system is not without its controversies. The Colorado River Compact did not solve all of the issues that were to arise over the ensuing decades between the Basin States, water users, Mexico and the federal government. It has served as a platform for multiple states with very different agendas, strategies and needs coming together to solve immediate problems and is still the cornerstone of the entire "Law of the River" (*see Appendix II*), which governs the uses on the Colorado River today. Further, the history provides perhaps the most notable example of Arizonans coming together to aggressively protect and pursue their rights. The fortunes we enjoy today are directly a result of prior generations of Arizonans who envisioned bringing Colorado River water uphill into Phoenix and Tucson. The CAP was the strategic vision for Arizona from the 1940s until its completion in the early 1990s. Not without controversy, Arizona still was able to rally around the CAP, knowing that it would strengthen and bolster Arizona's future.

Private Contributions

While the development of the Salt River and Colorado River are the largest examples of Arizonan's joining efforts to develop water supplies, there are many other examples across Arizona of water users pooling their resources and expertise and developing water supplies and water storage and delivery infrastructure to the benefit of the region. A notable example is the extensive system developed by Phelps Dodge Corporation – a major mining company in Arizona (acquired by Freeport-McMoRan Copper & Gold Inc. in 2007) – to construct three large dams, reservoirs, pumping plants, pipelines and other support facilities in six different Arizona counties in cooperation with federal, state and local agencies.

With wartime efforts increasing the demand for copper in the 1940s, the need for Phelps Dodge to secure additional water supplies to increase its production was critical[16]. After extensive exploration and analysis of the water resources strategies in place at the time in Arizona, the company noted that SRP had constructed Bartlett Dam on the Verde River to regulate the flow of the Verde River in the 1930s, protecting the Phoenix area from floods and providing water for irrigation. However, the reservoir was insufficient to capture floodwaters in every year and in some years floodwaters would flow unused down the river, sometimes inundating portions of the Phoenix area. With this in mind, Phelps Dodge and SRP entered into an agreement which resulted in the construction of Horseshoe Dam in 1946 upstream from Bartlett to reduce floodflows below Bartlett and to provide SRP with additional storage for water uses in the Phoenix area. In exchange for this $2.5 million investment, Phelps Dodge secured credits for 250,000 acre-feet of water from the Black River in eastern Arizona. Intended for use at its Morenci Mine operations, the water was pumped 700 feet to the rim of Black Canyon and then gravity fed roughly six and a half miles to Willow Creek. The water was then transported another 21 miles to Eagle Creek and then another 30 miles to a diversion point near Morenci[17].

[15] http://www.cap-az.com/index.php/cap-background

[16] Prior to 1937, the company had secured rights on Eagle Creek, Chase Creek and the San Francisco River for its Morenci Mine operation.

[17] Schwantes, Charles A., *Vision & Enterprise Exploring the History of Phelps Dodge Corporation*, University of Arizona Press, 2000.

Phelps Dodge also constructed Show Low Reservoir in 1953 on the Show Low Creek tributary of the Little Colorado River, from which it delivered water 100 miles through a tributary of the Salt River, enabling a water exchange that allowed additional diversions from the Black River for the Morenci Mine. Phelps Dodge continued its water supply development efforts constructing Blue Ridge Reservoir on East Clear Creek. Water stored in Blue Ridge was pumped to the Mogollon Rim, ultimately flowing to the Verde River, where it augmented SRP supplies and allowed additional Black River diversions. These cooperative projects continue to serve as a model for advancing water resource planning and development in many portions of the Arizona.

Groundwater Management

At the same time Arizona was struggling in its efforts to develop the CAP, reliance on groundwater continued to increase. Early in Arizona's history, groundwater was identified separately from surface waters by the Courts as either flowing in underground streams or percolating through the soil beneath the land surface. Beginning as far back as 1904, the Arizona Territorial Supreme Court adopted the common law rule that percolating water was the property of the overlying land owner and not subject to appropriation as was surface water[18]. Litigation would dominate the management of groundwater in Arizona for the next 76 years.

In the 1930's, the combination of increased cotton prices, improved technology in well pumping efficiency, and the availability of inexpensive power, largely from the newly constructed hydroelectric dams on the Salt, Verde, and Colorado Rivers, led to increased groundwater pumping in central Arizona. As a result, individual well owners were experiencing declining water levels and difficulties in producing water as neighboring well owners were competing for the same groundwater supply, naturally leading to economic disruption and litigation. In response to growing concerns over increased groundwater pumping, the first commission to study groundwater was appointed by then Governor Rawghlie Clement Stanford in 1938. The sole notable accomplishment was convincing the Arizona Legislature of the need to appropriate funds to have the US Geological Survey (USGS) investigate groundwater conditions throughout the State and publish a report with regard to these investigations. The report, issued by the USGS in 1943, found that groundwater depletion would continue to increase as lands continued to be developed.

As a result of the USGS report, two bills were introduced in the 1945 regular legislative session. The first bill, originally drafted by SRP and other irrigation districts, proposed transferring groundwater from private to public ownership and requiring permits for new uses of groundwater. This would accomplish two things: 1) groundwater supplies would be quantified and appropriated amongst the existing users, setting priorities of rights, just as was done for surface water, and 2) limit or even preclude additional farming operations from locating into the State, thereby limiting competition for resources and protecting market shares for existing farmers. The second bill required the registration of all irrigation wells in the state, which would accomplish little more than identifying all well owners and their location in the State. Neither bill was approved by the Legislature.

Arizona's inability to adopt a comprehensive groundwater management strategy would not go unnoticed by the opponents to the CAP. In the first federal government salvo in moving the State towards legislative groundwater management, the US Department of Interior declared that the CAP

[18] _Howard v. Perrin_, 1904 (See Appendix I)

would not be approved until Arizona took steps to restrict groundwater irrigated agriculture. In response to this federal declaration, Governor Sydney P. Osborn reintroduced both the irrigation district bill and the well registration bill in a special session. The well registration bill, which only required the registration of all irrigation wells throughout the state, was better received than the irrigation district proposal and thus was passed by the Legislature becoming the Groundwater Code of 1945. It was immediately recognized that the 1945 Code did nothing to stop groundwater depletion and again, in 1948, the federal government threatened the future of the CAP.

A more comprehensive Groundwater Code was finally enacted in 1948. It provided for designation of ten critical areas within the State (defined as areas without sufficient groundwater to provide irrigation for cultivated lands at then current rates of withdrawal) and prohibited the expansion of groundwater irrigated agriculture within these critical areas. However, the Code did nothing to address existing pumping nor did it apportion the use of groundwater among the overlying landowners within the critical areas. The provision allowing existing groundwater pumping to continue was widely criticized, as it did nothing to stop the existing groundwater overdraft. In response, a second groundwater study commission was initiated in 1951, charged with drafting a meaningful groundwater bill. The commission introduced a bill in the 1952 legislative session that not only would have divided the State's groundwater basins into three separate management classifications, but also, and most notably, would have changed the long-held common law rule of groundwater use to a publicly-owned resource subject to appropriation. The bill was not passed by the Legislature. Instead, the Legislature passed a bill establishing yet another groundwater study commission.

In addition to the legislative efforts, these issues were being actively litigated at the time. In 1952, a case before the Arizona Supreme Court resulted in one of the most controversial decisions in the history of Arizona groundwater law. In *Bristor I*[19], the Court found that "the common-law concept that the owner of the overlying land owns the percolating waters under its surface is fallacious and that the vested rights of the users of percolating waters are more fully protected under the law of prior appropriation than under the so-called common-law rule." It was the Court's opinion that to "permit the present underground water race to continue unabated, without regulation or control, would inevitably lead to exhaustion of the underground supply and consequently to economic disaster."[20] Left unchanged, this opinion would have dramatically altered Arizona groundwater law by making the State's groundwater supplies subject to the law of prior appropriation.

The Arizona Supreme Court's opinion in *Bristor I* raised so much controversy that a rehearing was granted the following year. In 1953, the Arizona Supreme Court reversed its opinion in *Bristor I*, affirming the police power of the Legislature to regulate groundwater and reinstituting the common law rule with the addition of the doctrine of reasonable use. Under this doctrine, a landowner could pump as much water as could be put to reasonable use on the land from which it was pumped. However, no limits on the amount of water that could be reasonably used were defined, and landowners found themselves competing for the same supply. The Court's reversal in *Bristor II*[21] was seen by some as a failure to adequately allocate the State's diminishing groundwater reserves. In their dissent, Justices Phelps and Udall predicted that "the mad race to 'mine' percolating waters…will continue unabated

[19] *Bristor v. Cheatham, (Bristor I)*, 73 Ariz. 228, 240 P2d. 185 (1952)
[20] *Bristor I*
[21] *Bristor v. Cheatham, (Bristor II)*, 75 Ariz. 227, 255 P2d. 173 (1953)

until such time as these waters are declared to be public in character and suitable regulatory measures are adopted."[22]

Following the decision in *Bristor II*, the groundwater study commission introduced a bill that would: prohibit new groundwater irrigated farmland in the Salt River and Santa Cruz River Valleys; reduce groundwater use on a pro-rata basis; provide for the purchase and retirement of irrigated acreage in critical groundwater areas for municipal and industrial water supplies; and create a regulatory groundwater agency. The bill never made it out of committee. As a last ditch effort to develop meaningful groundwater legislation, Governor Howard Pyle was able to extend the commission by only one month to address what he considered the "failure… to deal effectively for more than 20 years with our continuously diminishing supplies of underground water."[23] The failure of the legislation left the resolution of groundwater issues to the courts.

Meanwhile, the State's dependence on groundwater was continuing to increase. Coupled with extended droughts on the Salt and Verde Rivers between 1942 and 1948, and again between 1953 and 1957, groundwater was legally being pumped at rates that far exceeded recharge. The concept that the water beneath the land belonged to the landowner, together with the doctrine of reasonable use, encouraged landowners to pump as much water as they needed without regard to the impact on neighboring wells. Unfortunately, natural groundwater systems act independently of legal rules and regulations. An aquifer provides a common supply for all to pump from and is not bound by land ownership or the boundaries of the critical groundwater areas. The hydrologic reality that all pumping from the common source can affect all land overlying it was still largely ignored.

Although the 1948 Code put restrictions on development of new agricultural lands (although it lacked any enforcement provisions), it was silent on obtaining water to supply new non-agricultural development. Cities and towns relied on transporting groundwater from one location to another location where the water was put to use. Although the area of pumping and the area of use were usually within the water service area of the water provider, in some instances water was being pumped from outside the service area and transported back to the urbanizing areas for domestic and industrial uses. This situation would also lead the state towards yet more complicated litigation. In fact, such transportation of groundwater was one of the issues that ultimately led to Arizona's current groundwater management structure.

In a series of decisions between 1969 and 1974, the Arizona Supreme Court tackled the issue of transportation of groundwater. In response to a lawsuit filed in 1969 (*Jarvis v ASLD I*)[24], the Court issued an injunction against the City of Tucson prohibiting the transportation of groundwater from its well fields in the Avra and Altar Valleys, which had been designated as a critical area. The Court held that the property right in percolating waters was only a right to use the water, limited by reasonable use, on overlying land, not ownership of the source. The Court ruled that a person may not transport groundwater away from the overlying land if it would cause damage to other lands. The Court found that transporting groundwater away from a critical groundwater area would inevitably damage other lands in the area.

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[22] *Bristor II*

[23] Letter from Howard Pyle, Governor of the State of Arizona to Wesley Bolin, Secretary of State, Arizona State Archives.

[24] *Jarvis v. State Land Department (Jarvis I)*, 104 Ariz. 527, 456 P. 2d. 385 (1969).

Then, in 1970 (*Jarvis v ASLD II*)[25], the Court modified its injunction on Tucson based on the surface water statute (ARS § 45-147) for determining appropriative rights, which gives preference to municipal and domestic uses over agricultural uses. The Court allowed Tucson to purchase and retire irrigated farmlands and transport the "annual historical maximum use" of groundwater that had been applied to the irrigated acreage. This allowed the City of Tucson to annually pump the highest volume of groundwater used on the acquired farms in a single year, thus allowing more pumping than ever. In 1974 (*Jarvis v ASLD III*)[26], the Court finally modified its previous decision and limited Tucson's pumping to the average of the "annual historic maximum use."

The Arizona Supreme Court's 1976 decision in *FICO v. Bettwy*[27]is often considered the single event that prompted the passage of the 1980 Groundwater Management Act. At issue were several mining companies operating south of Tucson that were pumping groundwater in the Sahuarita-Continental Critical Groundwater Area to provide water for their mining operations located several miles away outside the critical groundwater area but within the same acquifer. Farmers Investment Company (FICO), owner of approximately 7,000 acres of farmland within the critical groundwater area, sued to enjoin the mining companies from transporting groundwater away from the area, claiming that the use of the water off "the land from which the water was taken" would damage FICO's lands and therefore violated the reasonable use doctrine established in *Bristor II*.

The mines defended their actions by asserting that the phrase "the land from which the water was taken" should be defined as the land over the common source and argued that, hydrologically, the water was being used on the same land from which it was being taken because both lands overlay the same aquifer. Further, the mines argued that the transportation of groundwater does not add to the depletion of the aquifer as long as the water is used, and eventually recharged, within the same aquifer. Adding another dimension to this dispute, the City of Tucson intervened in the case, claiming that the mines were polluting the groundwater basin from which Tucson withdrew much of its water to supply its customers (although that water was being transported away from the basin by Tucson).

In its decision in *FICO*, the Court recognized that the State had been committed to the reasonable use doctrine in an earlier case (*Bristor II*) and had operated for almost 50 years in this manner. The Court held in favor of FICO, ruling that under the doctrine of reasonable use, water may not be pumped from one area and transported to another if other wells suffer injury or damage, even if both areas overlay a common source. Additionally, counter to its earlier finding in *Jarvis II*, the Court stated that it was the Legislature's and not the Court's responsibility to establish rights based on economic interest and "…if it is the State's interest to prefer mining over farming" then the Legislature would have to decide this. The Court went further in this same opinion and limited the City of Tucson's withdrawals for transportation away from the groundwater basin to amounts consistent with what was pumped before 1972, the date of its intervention in the case. In summary, the Court held that FICO was entitled to an injunction against the mines from transporting groundwater away from the critical groundwater area, and the mines were entitled to an injunction against Tucson from transporting groundwater away from the groundwater basin.

[25] *Jarvis v. State Land Department (Jarvis II)*, 106 Ariz. 506, 479 P. 2d. 169 (1970).
[26] *Jarvis v. State Land Department (Jarvis III)*, 113 Ariz. 230, 550 P. 2d. 227 (1976).
[27] *Farmer's Investment Company v. Bettwy*, 113 Ariz. 520, 558 P. 2d. 14 (1976).

The impact of this decision was a great blow to the second and third largest water use sectors in Arizona. The mines were vital to the State's economy and needed access to groundwater to do business. Additionally, some of the largest cities were transporting groundwater long distances to supply their customers with reliable water supplies. Rather than FICO pursuing enforcement of its injunction following the decision, a negotiated settlement was reached between the parties. However, the decision and settlement did not end the legal interpretation of the phrase "the land from which the water is taken" and the issue of transportation of groundwater from the critical groundwater areas and groundwater basins remained uncertain.

After years of confusion and uncertainty, it was clear that Arizona's groundwater laws would have to be addressed by the Legislature, particularly in light of the Court's conflicting opinions. In 1976, the mines and the cities formed a complex alliance. In 1977, agricultural interests were also persuaded to join this alliance to draft amendments to the 1948 Code.

Temporary amendments to the 1948 Code were adopted in the spring of 1977 and were intended to apply only until a comprehensive plan providing for groundwater use, allocation, and distribution could be enacted. The 1977 Act established a permit system allowing for the transportation of groundwater (certain transportations were allowed without a permit) and the creation of a Groundwater Study Commission charged with developing a comprehensive groundwater code for Arizona. The Study Commission was required to produce a draft report by June 30, 1979 and a final bill by December 31, 1979. Most notable was the inclusion in the 1977 Act of the provision that the Study Commission's proposed recommendations would become law if the Legislature failed to enact groundwater legislation by September 7, 1981. This provision was included to address the long-standing inability to enact effective groundwater management regulations and was designed to force the Legislature to act once and for all.

Concurrent with the discussions on groundwater management, the federal government again weighed in on the CAP. In 1979, the Carter Administration announced that the CAP would be among the water projects cut from the federal budget. Although later removed from the "hit list", US Secretary of the Interior Cecil Andrus, warned that if Arizona failed to enact a groundwater code, the CAP would be eliminated. The events that would lead to Arizona's adoption of the 1980 Groundwater Management Act were now in place.

The Groundwater Management Act (GMA) was enacted into law in a special session of the Legislature in June of 1980. No other State has a comparable groundwater management strategy that not only protects the State's economy, but ensures its future economic stability. The GMA was developed with the assistance of the three major water using sectors: agriculture, municipal and mining. The framework is intended to protect existing users and serve new uses with non-groundwater supplies, reserving the groundwater supply as a hedge against future shortages. The GMA established a timeline for reduction and elimination of groundwater pumping in certain areas of the State - designating Active Management Areas (AMA) and Irrigation Non-Expansion Areas (INA) to facilitate this process (*see Figure 4*).

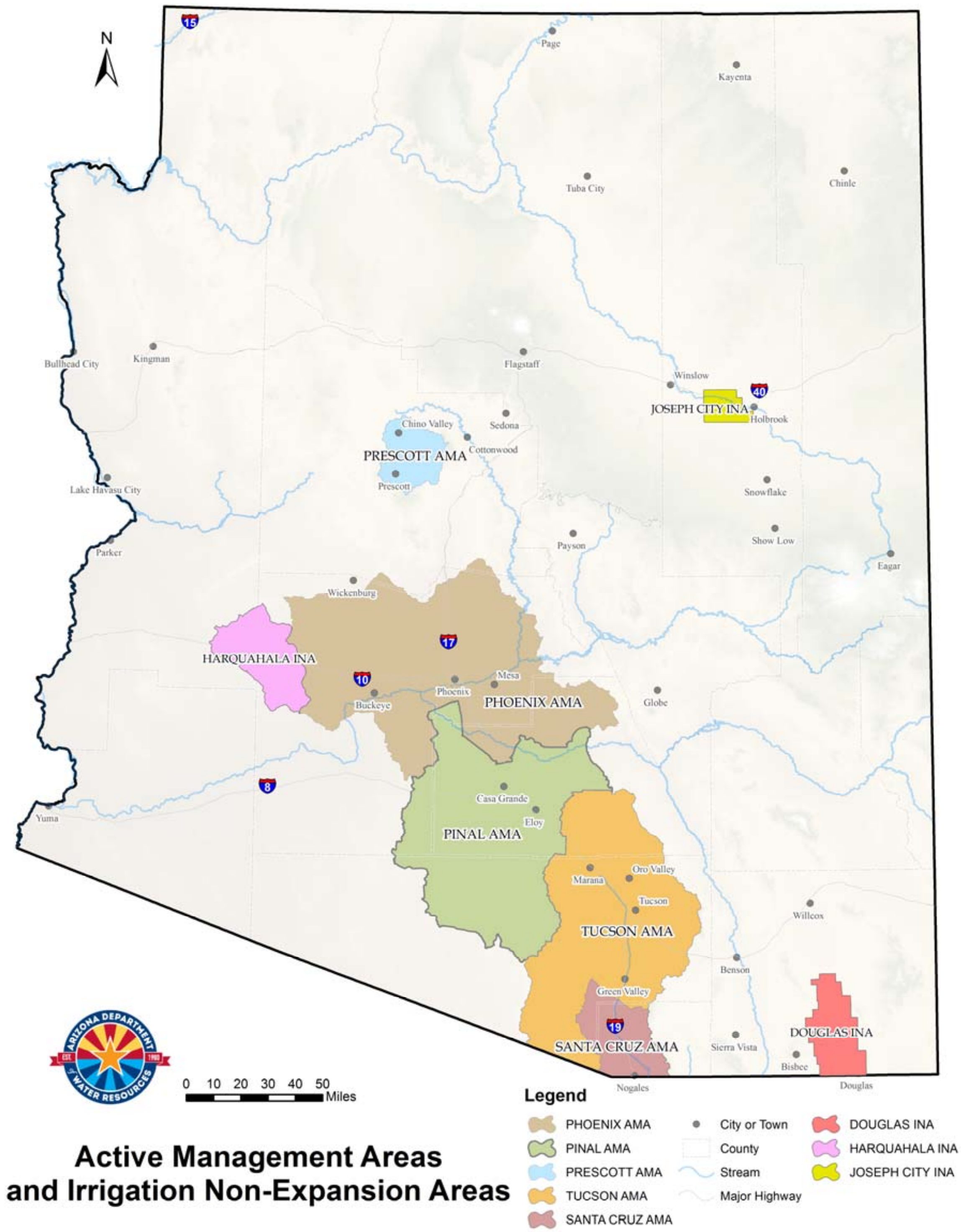

Figure 4. Active Management Areas & Irrigation Non-Expansion Areas (ADWR)

Within the AMAs, the GMA requires a "100-year Assured Water Supply" for new development and imposes mandatory water conservation requirements for agricultural, municipal and industrial groundwater users. Finally, the Act created the Arizona Department of Water Resources (ADWR) to administer and enforce Arizona's water management policies and laws for all water supplies, and to protect Arizona's Colorado River entitlement.

Subsequent significant modifications to the GMA have been enacted to: protect rural areas from groundwater transportation; encourage the use of non-groundwater supplies through the Underground Storage and Recovery Program; and allowed new subdivisions to obtain an assured water supply determination by enrolling the Central Arizona Groundwater Replenishment District (CAGRD), a district created to replenish groundwater used in excess of allowable groundwater pumping by its members. The decreasing dependence on groundwater supplies, coupled with the creation in 1996 of the Arizona Water Banking Authority (AWBA), has reduced the State's vulnerability to water supply shortages by leaving groundwater in the aquifer for use during supply shortages. The AWBA was created to store Arizona's unused Colorado River entitlement for backup water supplies and to further protect Arizona communities from water supply shortages. To date, the AWBA has stored nearly 3.5 MAF of Central Arizona Project water (CAP water) to protect against shortages, while Arizona communities and other water interests have stored an additional 5 MAF of CAP water and reclaimed water for future uses.

Resolution of Tribal Water Rights

Arizona is home to 22 Indian Reservations (*see Figure 5 - Tribal Communities in Arizona*). In 1908, the US Supreme Court held that a tribe's rights to water were established when the reservation was created and by creating the reservation, Congress implicitly reserved all the waters of the river necessary for the purposes for which the reservation was created (*Winters v. United States*)[28]. Rather than litigating these claims, water users and the State of Arizona have been working for decades to develop equitable distribution of Arizona's water supplies in cooperation with its tribal communities. The successes in this area are outlined below and include decreed rights as well as congressionally authorized water rights settlements. The remaining outstanding tribal claims are discussed in later sections.

United States Supreme Court Decreed Rights

Four Arizona Indian reservations along the Colorado River were decreed entitlements by the US Supreme Court to divert water from the Colorado River pursuant to *Arizona v. California* (1963). The reservations and their annual Colorado River entitlements are listed below:

- Cocopah – 9,707 acre-feet
- Colorado River Indian Tribes – 662,402 acre-feet
- Fort Mohave – 103,535 acre-feet
- Fort Yuma – 6,350 acre-feet

Congressionally Authorized Settlements

Ak Chin Indian Community

By Congressional action in 1978 and 1984, the Ak Chin Indian Community was provided an annual entitlement to 75,000 acre-feet of CAP water and other Colorado River water in normal and wet years (85,000 acre-feet when other surface water is available). Congress amended the 1984 Act in 1992 to

[28] 207 U.S. 564 (1908)

authorize the Community to lease any unused CAP water to off-reservation users within the Tucson, Pinal and Phoenix AMAs.

Tohono O'odham Nation

The Southern Arizona Water Rights Settlement Act (SAWRSA) was enacted by Congress in 1982 to address the water right claims of the San Xavier and Shuck Toak Districts of the Tohono O'odham Nation. SAWRSA provided the districts an annual entitlement to 37,800 acre-feet of CAP water and 28,200 acre-feet of settlement water to be delivered by the US Secretary of the Interior to the two districts. The districts may also collectively pump annually up to 13,200 acre-feet of groundwater from non-exempt wells. In addition to state and local financial contributions, the City of Tucson contributed 28,200 acre-feet annually of reclaimed water to be used by the Secretary to facilitate deliveries to the districts (through sale or exchange).

Figure 5. Tribal Communities in Arizona (ADWR)

In December 2004, the Arizona Water Settlements Act amended the 1982 SAWRSA and provided a mechanism to implement the Settlement. The amendment identified Non-Indian Agricultural (NIA) Priority CAP water as the water source of the Settlement. The Nation may lease its CAP water within the CAP service area. State law was amended to provide additional protection to groundwater resources on the San Xavier Reservation, and allow the Nation to store its CAP water at a groundwater savings facility (GSF). The Nation's water right claims will not be completely satisfied until the claims of the Sif Oidak District in Pinal County, commonly known as Chui Chu, are addressed. While that district currently holds a contract for 8,000 acre-feet of CAP water, it has stated a need of an additional amount of almost 20,000 acre-feet.

Salt River-Pima Maricopa Indian Community

The Salt River-Pima Maricopa Indian Community Water Rights Settlement Act of 1988 was enacted by Congress approving an agreement providing the Community an annual entitlement to 122,400 acre-feet of water plus storage rights behind Bartlett and modified Roosevelt Dams. Sources of water for the Community under the settlement include the Salt and Verde Rivers, groundwater and CAP water. The Community is allowed to pump groundwater, but must achieve safe-yield[29] when the East Salt River Valley Sub-basin in the Phoenix AMA Groundwater Basin does so. The Community has leased its 13,300 acre-foot CAP water allocation to municipalities in the Phoenix metropolitan area.

Fort McDowell Yavapai Nation *(formerly Ft. Mc Dowell Indian Community)*
In 1990, Congress ratified an agreement between the Fort McDowell Indian Community and federal and State parties, including: SRP; Roosevelt Water Conservation District; the cities of Chandler, Mesa, Phoenix, Glendale, Scottsdale, and Tempe; the Town of Gilbert; CAP the United States; and the State of Arizona. Under that agreement, the Fort McDowell Indian Community is provided an annual entitlement to 35,223 acre-feet of water from the Verde River and CAP. The 18,233 acre-feet of CAP water in the Fort McDowell water budget may be leased for up to 100 years off-reservation within Pima, Pinal, and Maricopa counties. Currently, 4,300 acre-feet is being leased to the City of Phoenix. This settlement also provides for a minimum stream flow of 100 cubic feet per second (CFS) on the Lower Verde River.

San Carlos Apache Tribe
The water rights claims of the San Carlos Apache Tribe to the portion of the reservation within the Salt River Watershed were settled through Congressional enactment of the San Carlos Apache Tribe Settlement Act of 1992. The Tribe was awarded an annual entitlement of up to 71,445 acre-feet of CAP water and water from the Salt, Gila and Black Rivers. The Tribe is authorized to lease its allocation of 64,135 acre-feet of CAP water off-reservation within Pima, Maricopa, Pinal, Gila, Graham, and Greenlee counties. Groundwater may also be pumped on the reservation. The agreement also includes a 100-year lease with the City of Scottsdale for a portion of the Tribe's CAP water. The water right claims of the San Carlos Apache Tribe to the portion of the reservation within the Upper Gila River Watershed will be the subject of separate negotiations or litigation.

Yavapai-Prescott Indian Tribe
Congress enacted the Yavapai-Prescott Indian Tribe Water Settlement Act in 1994. The Act settled the Tribe's water rights claims by: 1) confirming the Tribe's right to pump groundwater within the boundaries of the reservation; 2) providing for relinquishment of the Tribe's CAP water contract, the proceeds to be used to fund a water service contract with the City of Prescott; and 3) providing that the Tribe may divert a portion of the water from Granite Creek that, at the time, was diverted by the Chino Valley Irrigation District. The Act also provided authorization to the Tribe and the City of Prescott to market their CAP water to the City of Scottsdale, which has been completed (500 acre-feet from the Tribe and 7,127 acre-feet from Prescott, respectively).

Zuni Indian Tribe
President George W. Bush signed P.L. 108-34, the Zuni Indian Tribe Water Rights Settlement Act, into law in June, 2003. The Act awards the tribe a right to annually use 5,500 acre-feet of surface water from the Little Colorado River and up to 1,500 acre-feet of underground water, both for wetland restoration

[29] Safe yield is the condition where water pumped out of the aquifer is in balance with water entering the aquifer, whether naturally or artificially.

at the Zuni Heaven Reservation. It also grandfathers existing surface and groundwater uses in the area, restricts future wells near the reservation and facilitates local environmental programs.

Gila River Indian Community

President George W. Bush signed P.L. 108-451, the Arizona Water Settlements Act, into law in December, 2004. Title II of the Act provided approval of the Gila River Indian Water Settlement Agreement. The Settlement provided the Community an annual entitlement to an average of 653,500 acre-feet of water from various sources including: CAP water, reclaimed water (through CAP water exchanges), groundwater, and surface water from the Gila, Verde and Salt Rivers. It also gave leasing authority to the Community for its CAP water as long as the water is leased within Arizona. In partial fulfillment of its obligations under the Settlement Agreement, the State enacted legislation to provide protection to certain water resources of the Community.

White Mountain Apache Tribe

Federal legislation authorizing the White Mountain Apache Tribe Water Rights Quantification Agreement became law in December 2010. The parties executed a revised settlement agreement in 2013 to conform the Agreement to the federal legislation. Other actions are required for the settlement to become final, including approval of the settlement agreement by the adjudication courts. Under the settlement agreement, the White Mountain Apache Tribe is entitled to an annual depletion totaling 27,000 acre-feet of surface water and groundwater from the Salt and Little Colorado River watersheds and 25,000 acre-feet of CAP water (23,782 of which is NIA Priority CAP water previously set aside for future Indian tribal settlements). The Tribe will lease its CAP water to several Phoenix area cities and CAP.

Water Conservation & Reuse

Water conservation is the foundation of Arizona's water management strategy and is an area where the State of Arizona and its citizens have achieved unparalleled water supply improvements that serve as a model for water managers throughout the world. The GMA created the Phoenix, Pinal, Prescott, and Tucson, and later the Santa Cruz, AMAs. A major component of the GMA is the requirement for statutorily-mandated water conservation by municipal, industrial and agricultural water users located in those areas. In addition, the programs enacted by the State's policy leaders have also spurred adoption of many voluntary conservation programs throughout the State.

The majority of Arizona's total water use, 86 percent of the state's total municipal water use and 61 percent of the state's total industrial water use, occurs in the AMAs and is subject to mandatory water conservation programs. While 39 percent of the state's agricultural water use occurs in the AMAs (and is subject to statutorily-mandated water conservation requirements), nearly 50 percent of the State's total agricultural water use is in the Yuma area where agricultural water users have voluntarily employed state-of-the-art agricultural water conservation measures to stretch the water supplies vital to that area's economy.

In addition to the statutorily-mandated water conservation requirements for AMAs in the GMA, Arizona's policy leaders went even further in 2005 with the passage of Arizona House Bill 2277[30]. Under the provisions of this bill, codified in law at A.R.S. §45-341, et. seq., water systems in Arizona that serve

[30] Arizona Revised Statutes Title 45, Chapter 1, Article 14

at least 15 connections used by year-round residents, or that regularly serves at least 25 year-round residents, must submit a water use report every year, and a system water plan every five years that contains the following:

1) A Water Supply Plan that describes the service area, transmission facilities, monthly system production data, historic water demands for the past five years, and projected water demands for the next 5, 10 and 20 years; and
2) A Drought Preparedness Plan that includes drought and emergency response strategies, a plan of action to respond to water shortage conditions, and provisions to educate and inform the public; and
3) For those communities located outside of the AMAs, a Water Conservation Plan that addresses measures to control system leaks and lost water, considers water rate structures that encourage efficient use of water, and plans for public information and education programs on water conservation.

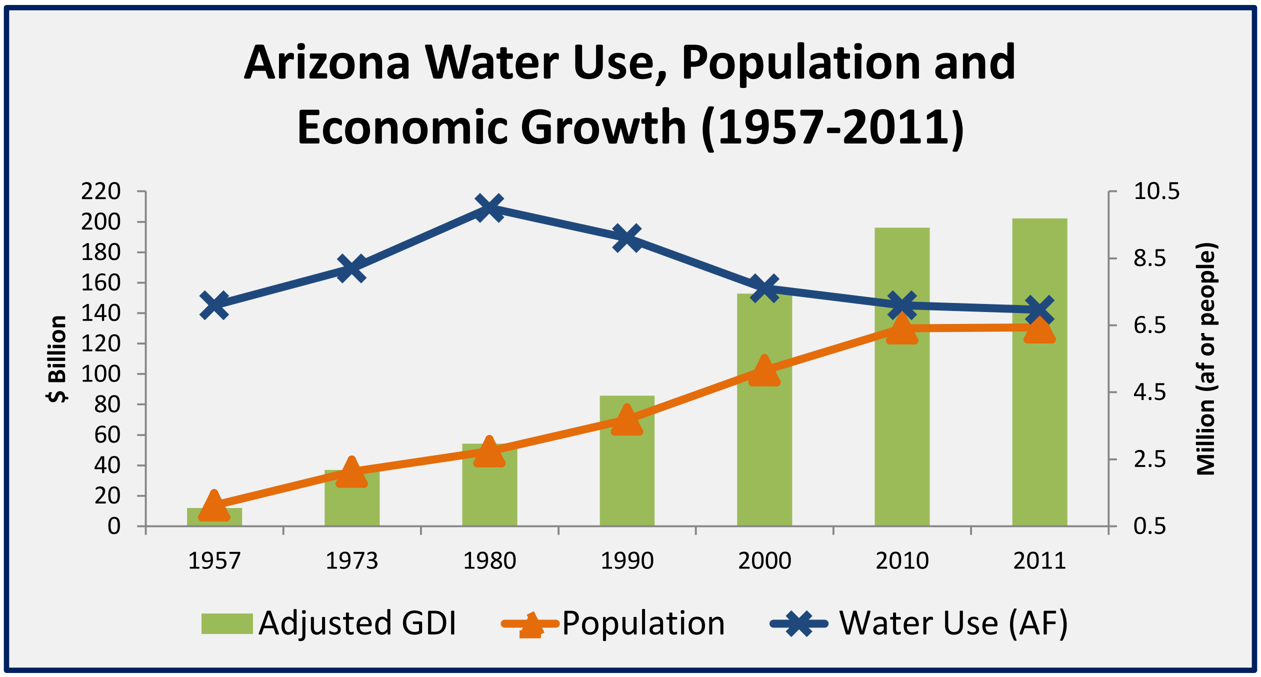

Figure 6. Arizona Water Use, Population and Economic Growth 1957 – 2011 (ADWR, 2013)

While there will continue to be potential for additional water conservation in Arizona, our past successes cannot be discounted. The GMA, along with both the passage of HB 2277 and the voluntary implementation of some very strong conservation measures across Arizona, has already resulted in significant water supply savings (*see Figure 6 - Arizona Water Use, Population and Economic Growth 1957 - 2011*). Most Arizona communities already understand the benefits of water conservation as a less expensive alternative to water supply augmentation and have taken steps to implement conservation measures.

A significant portion of the reclaimed water produced in Arizona is reused for landscape and golf course irrigation, agricultural irrigation, power generation, irrigation of parks and schools and artificial recharge into groundwater aquifers. A portion of the reclaimed water is also discharged into the beds of rivers and streams, benefiting the environment by providing habitat for wildlife and adding aesthetic and economic value to Arizona's landscape. While these benefits are important locally and notable, there may be additional opportunities to further leverage these locally available supplies to replace existing uses of limited groundwater and surface water supplies, while maintaining or enhancing our natural ecosystems. A 1989 Arizona Supreme Court Decision, *Arizona Public Service Company v. Long*[31] held that reclaimed water is owned by the entity that produces it. The Court ruled that until reclaimed water is returned to the system as surface water or groundwater, it has the legal character of neither surface water nor groundwater and, therefore, a treatment plant operator that produces reclaimed water is free to use it without regard to the laws governing surface water and groundwater. This ruling creates a strong incentive for reuse by allowing those who generate reclaimed water to maintain the right to reuse or market that water.

Currently, Arizona, along with California, Florida, and Texas, leads the nation in utilization of reclaimed water[32]. Increased utilization of reclaimed water is not without challenges. For example, although the Arizona Department of Environmental Quality (ADEQ) administers a comprehensive regulatory program governing the safe use of reclaimed water, public perception of water quality limitations still remains a significant obstacle for water managers. Developing a strong recycled water program must appropriately address public health and safety concerns and the significant capital and operating costs associated with reuse infrastructure. Increased utilization of this supply is anticipated to be one of the least-cost alternatives available to Arizona to meet local water supply imbalances. Full utilization of this locally available supply has the potential to reduce future water supply imbalances by more than 50 percent in the year 2110. In order to provide a long-term sustainable water supply for the citizens throughout the State, water managers must address the challenge of long-held public perceptions and, while protecting public health and welfare, remove regulatory barriers to ensure Arizona's continued economic and environmental viability into the future.

Summary

Arizona's water management history not only highlights the motivation and vision that our past leaders have exhibited, but also the time, effort, steadfastness and political will it took to develop the water management programs and water supply projects that are the foundation of our vibrant economy and quality of life. It took nearly 50 years to secure Arizona's Colorado River entitlement and achieve deliveries of CAP water to Central Arizona. It took over 70 years of sometimes confusing and inconsistent court rulings before the Arizona Legislature proactively and meaningfully addressed groundwater management for the benefit of Arizonans and passed the Groundwater Management Act in 1980.

However, and more importantly, this history underscores Arizona's standing as a State that aggressively secures, delivers, protects and manages its water supplies, creating a viable and economically stable environment in which to live and do business. Arizona's future as an economic leader in the Southwestern US will depend on this same determination, tenacity and the willingness to do what it takes to protect and develop its water supplies for its current and future citizens.

[31] 160 Ariz. 429, 773 P.2d 988 (1989)
[32] Water and Wastes Digest @ http://www.wwdmag.com/EPA-Releases-Updated-Version-of-Guidelines-fo-Water-Reuse-article6636

ARIZONA'S FUTURE WATER SUPPLY & DEMANDS

The current challenge facing Arizona is that, although the State has an existing solid water management foundation, water demands driven by future economic development are anticipated to outstrip existing supplies. Water resources planning efforts are instrumental in the identification and evaluation of these challenges. Arizona has been actively evaluating future water supply and demand conditions for decades.

Every ten years, consistent with State statute, ADWR evaluates water supply and demand conditions in each of the State's AMAs – primarily to evaluate the ability to achieve the management goals identified by the Legislature for each AMA under the GMA. Management Plans have been developed in 1985, 1990 and 2000. In 2009 and 2010, in anticipation of the next Management Plan, ADWR developed a demand and supply assessment for each of the five AMAs to: (1) evaluate the AMAs current status and ability to achieve the management goals and (2) to frame the discussions for alternative management strategies needed to meet and maintain those goals. Additionally, ADWR also produced the *Arizona Water Atlas* in 2010 to provide water-related information on a local, regional and statewide level to frame and support water planning and development efforts. The development of the Atlas also has spurred the development of a statewide water resources data repository housed at ADWR, which is continuously updated as water use information is reported and collected. These are on-going efforts that are either aimed at specific regions of the State or provide past and present water use information.

Since 1980, Arizona has also developed, or partnered in, comprehensive and prospective statewide (see Appendix III) and multi-state planning efforts. More recently, the Water Resources Development Commission (WRDC) was an Arizona-only effort aimed at projected future statewide water demands and available water supplies for the next 25, 50 and 100 years. *The Colorado River Basin Water Supply and Demand Study* (Bain Study) was developed by Reclamation in cooperation with the seven Basin States (Arizona, California, Colorado, New Mexico, Nevada, Utah and Wyoming) to define current and future imbalances in water supply and demand in the Colorado River Basin and the adjacent areas that receive water from the Colorado River, through 2060. The findings of these large-scale prospective efforts are discussed below.

Colorado River Basin Water Supply and Demand Study

Although the Basin Study was completed after the WRDC, it will be discussed first since it only addresses a certain portion of Arizona's total water supply and only examines those areas where that supply is currently being utilized. However, some assumptions were also analyzed for the utilization of this supply to meet future growth in other areas of Arizona in excess of its 2.8 MAF entitlement to address expanded growth within Arizona, though this does not mean Arizona is seeking an increase in its entitlement.

The Colorado River system spans seven western states. It serves the municipal uses of nearly 40 million people and supplies water to irrigate nearly 5.5 million acres of land. The Colorado River is also an important resource for wildlife and recreation, and hydroelectric generation from water stored at dam sites along the Colorado River totals about 12 billion kilowatt-hours per year. The power is shared among several western states[33]. The Colorado River also flows into Mexico where it is a vital resource

[33] http://www.waterencyclopedia.com/Ce-Cr/Colorado-River-Basin.html

for agricultural and municipal water users. Reservoirs have been developed on the River to store almost four years of the natural flow of the River (60 MAF) and, while the West has been in the grips of the worst 14-year drought in the last century, the needs of these users have been fully met by this system. With the continued uncertainty of the magnitude and duration of the drought gripping the Colorado River Basin, and the need to meet the increasing demands that are anticipated in the Western States, Reclamation, in cooperation with the seven Basin States, conducted a study to determine the current and future imbalances in the Basin through 2060. The study area included the Colorado River Basin and adjacent areas dependent on this resource (*see Figure 7 - Colorado River Basin Study Area*)[34]. The Basin Study was released in December of 2012.

This extensive study estimated that population within the study area is projected to increase from about 40 million people in 2015 to between 49.4 million and 76.5 million people by under the slow growth and a rapid growth scenario, respectively. As a result of this increased population, and factoring in Mexico's 1.5 MAF 1944 Treaty allotment and losses due to evaporation and system operations, projected demands in the Basin may range between 18.1 MAF (slow growth scenario) and 20.4 MAF (rapid growth scenario) by 2060. Over the past 10 years, the Colorado River's yield has averaged about 15.3 MAF annually. Comparing the median water demand projections to the median water supply projections, the long-term projected Basin-wide imbalance is estimated to be 3.2 MAF by 2060. However, the actual imbalance may be much larger, or could be slightly smaller, depending on the availability of water and actual growth in the region.

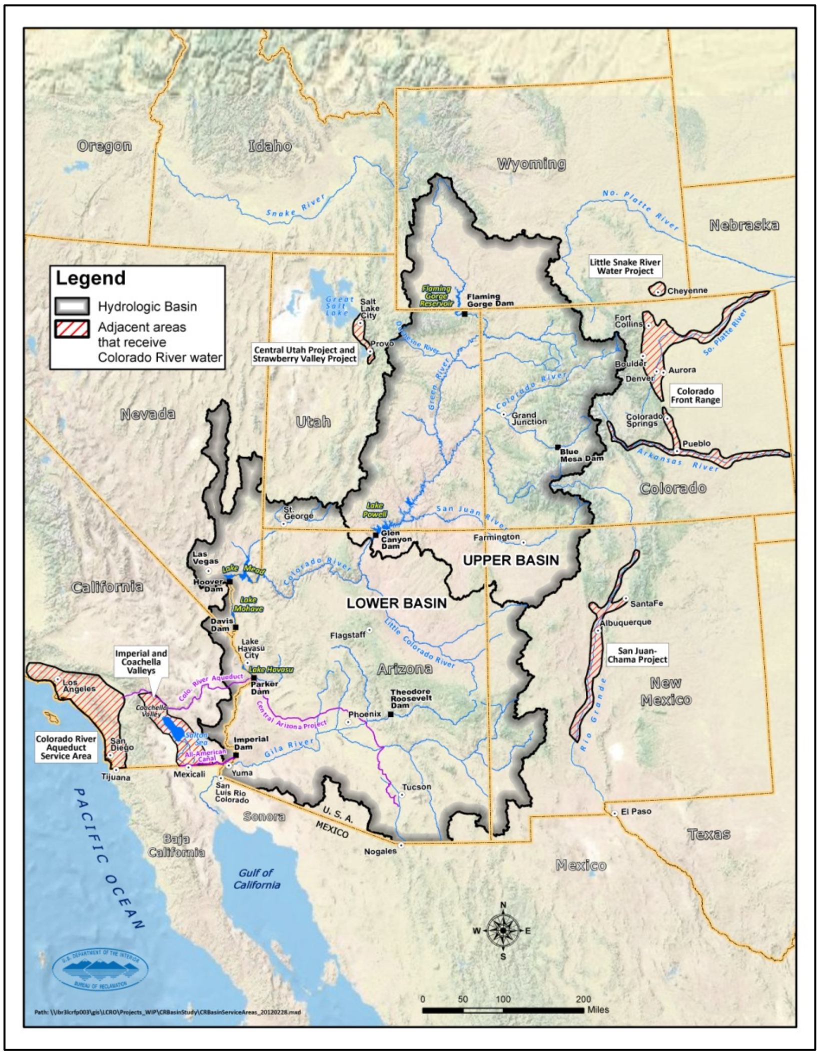

Figure 7. Colorado River Basin Study Area (Reclamation, 2012)

[34] Source: US Bureau of Reclamation

The Basin Study process incorporated a broad range of input from the Study participants, interested stakeholders and the general public to identify possible options to address the supply and demand imbalances. These options were not extensively evaluated during the study due to time and resource constraints, however, over 150 options were submitted and were organized into four groupings:

1) Increase Supply – Options that increase Basin water supply;
2) Reduce Demand - Options that reduce Basin water demand;
3) Modify Operations – Options that focus on modifying how the River is operated; and
4) Governance and Implementation – Options that mainly focus on Basin governance and mechanisms to facilitate optional implementation.

The specific options were identified in the Basin Study, setting the framework for the next step discussions currently underway between the Basin States attempting to address these future imbalances[35]. This Strategic Vision will be a tool that will help guide ADWR in our deliberations in these discussions.

Water Resources Development Commission

Recognizing that water is essential to Arizona's prosperity, the Legislature passed House Bill 2661 in 2010 establishing the WRDC. The WRDC was tasked with assessing Arizona's water demands and available supplies to meet those demands for the next 25, 50 and 100 years. Seventeen Commission members, representing various Arizona industries and water users from a regional and geographic cross-section of the state, were selected for their knowledge about various water resources and water management issues in Arizona. Additionally, nine ex officio members representing state and federal agencies and the Governor's office participated on the Commission.

The findings of the WRDC were based on the combined work of many individuals in developing forecasted water demands for municipal, industrial, agricultural and tribal uses and current and projected water supplies to meet those demands. Additionally, the WRDC prepared an inventory of Arizona's water-dependent natural resources, providing future planning efforts valuable information on the State's water supplies and the environmental resources they support. Work was also done on identifying possible mechanisms to finance the development of additional water supplies and the associated infrastructure needed to deliver those supplies.

The WRDC found that Arizona has grown from a population of 2.7 million people with an economy of approximately $30 billion in 1980 to nearly 6.6 million people with an economy of $260 billion by 2009. Estimates for population growth in Arizona were developed for 2035, 2060 and 2110. The population estimates for these years are 10.5, 13.3 and 18.3 million people, respectively. Annual water demand is expected to grow from current levels of 6.9 MAF to between 8.2 and 8.6 MAF in 2035; between 8.6 and 9.1 MAF in 2060 and between 9.9 and 10.5 million acre-feet in 2110.

The WRDC also analyzed the availability of currently developed supplies. Baseline water supplies were catalogued within each groundwater basin in the State. These supply sources included: existing developed groundwater resources; in-state surface water diversions; existing developed reclaimed

[35] Colorado River Basin Supply and Demand Study – Executive Summary, December 2012 – Table 2: Summary of Representative Options Including Cost, Timing, Potential Yield, and Inclusion in Portfolios, p. 13

water supplies; mainstem Colorado River water; and CAP water. The total water supply that is currently developed or readily available to meet existing demands is approximately 7.7 MAF. Additional groundwater and reclaimed water supplies are also available to meet future demands. However, the availability of these water supplies may be constrained to specific water right holders, specific places of use within the State and, in the case of in-state surface water, Colorado River water and CAP water, subject to possible shortages due to drought.

OPPORTUNITIES AND CHALLENGES FOR ARIZONA

The studies described above identify the potential imbalance between available water supplies and projected demands which could limit Arizona's future economic growth if no actions are taken. Consequently, the economic future of this State, and the region, is dependent on a resource for which legal and physical complexities need to be taken into consideration and addressed.

Complexities Affecting Long-Term Water Use and Planning

Arizona is characterized by widely diverse geographic regions, ranging from forested mountain areas to arid deserts. These areas have dissimilar climates and precipitation regimes, resulting in variability in, and accessibility to, surface water supplies. Arizona is also geologically complex, which impacts the availability, quality and accessibility of groundwater supplies. Areas of water demand are also unevenly distributed across the state. Central Arizona exhibits the highest concentration of urban/municipal uses and growth. Much of this use is located on retired irrigated farmlands. Agricultural irrigation is still significant, and is the most prevalent water use sector in the State. It continues to provide a significant benefit to Arizona's economy and serves as the foundation of the local economies in many regions of the State. Important industrial sectors, such as copper mining remain regionally significant water users and economic engines in isolated portions of the State. Portions of the State also remain popular winter-time destinations and golf courses are a prevalent and important economic use throughout the State.

Land Ownership

Arizona is also unique in its land ownership patterns. Less than 18 percent of the land within the State is under private ownership. State Trust Land comprises almost 13 percent of the land, with the remaining 69 percent in either federal or Indian ownership. This variability in land ownership adds additional complexity to the water supply challenges that must be met. These challenges range from the need to appropriately involve tribal entities to ensure that Indian water supplies, demands and water right claims are accurately understood and addressed, and ensuring that the mandates of federal lands are fulfilled. This ownership is also often fragmented, with federal, state, and private land holdings assembled in a "checkerboard" fashion that further complicates the development and execution of comprehensive land and water management strategies.

Additionally, there are possible limitations on the ability to construct and develop water transmission lines across federal and tribal lands. Because 69 percent of the land in Arizona is federally controlled, there is a strong likelihood that a federal nexus will exist, and the requirement for environmental compliance under the National Environmental Policy Act (NEPA) will be triggered. As water supplies are developed and water treatment and delivery infrastructure is designed, it will be important to consider the potential financial impacts of federal environmental compliance requirements. Those impacts could also result in a longer planning horizon to provide time to secure permits or other federal approvals. In most cases, environmental compliance processes include formal public input and the opportunity for third party legal action challenging the final decision of the federal agency issuing the permit or approval. This can increase the lead time for planning and constructing projects and may introduce additional levels of uncertainty in the outcome.

Experience with the planning, design, construction and operation of existing water projects shows that complying with federal requirements can add anywhere from several months to several years to a project. Some compliance programs that may be encountered whenever there is a federal nexus associated with a project include:

1) The National Environmental Policy Act of 1969 (NEPA). NEPA became effective on January 1, 1970. In simple terms, it requires that the federal government consider all environmental factors when making a decision on a major federal action. NEPA can result in projects incorporating mitigation measures that avoid, minimize or compensate for potential adverse environmental impacts. The federal agency taking the action is responsible for administering the Act.

2) The Endangered Species Act of 1973 (ESA). The ESA became law on December 28, 1973. Generally, the Act protects species from becoming extinct, by prohibiting the take of endangered or threatened species and adverse modification of a species critical habitat. Projects and actions that fall under the umbrella of the ESA may be required to minimize and mitigate negative impacts to species and their habitat to the maximum extent practicable. The ESA is administered by the US Fish and Wildlife Service and the National Oceanic and Atmospheric Administration.

3) Section 404 of the Clean Water Act (CWA). Section 404 of the CWA regulates the dredge and fill of materials into waters of the United States. The program to administer it was established in 1972. It is intended to protect aquatic resources and to avoid or lessen degradation of waters of the United States. The permitting process encourages avoidance of impacts and may require minimizing and mitigating impacts to the environment. The program is primarily administered by the US Army Corps of Engineers with additional oversight by the US Environmental Protection Agency.

Arizona Water Law

Another factor in the complexity of developing water supplies is the Arizona water law system under which groundwater and surface water are largely regulated under separate statutes and rules. While the groundwater management system primarily applies inside designated AMAs and INAs, the surface water system (except for Colorado River supplies) is administered statewide. Colorado River supplies are managed in cooperation with the State, but contracts for Colorado River water are initiated through the US Secretary of the Interior and administered by Reclamation. Reclaimed water use is managed under a completely different set of regulations and policies and was significantly influenced by case law[36]. This legal complexity adds to the challenge of ensuring that adequate supplies exist to meet the demands across the state.

General Stream Adjudication

Adding to the legal complexities within the State are the on-going general stream adjudications of the Gila and Little Colorado river systems. General stream adjudications are judicial proceedings to determine or establish the extent and priority of water rights. Thousands of claimants and water users are joined in these judicial proceedings that will result in the Superior Court issuing a comprehensive

[36] *Arizona Public. Service Co. v. Long*, discussed earlier

final decree of water rights for both river systems[37]. The Gila River adjudication was initiated in 1974 when SRP filed a petition with Arizona State land Department (ASLD[38]), before the creation of ADWR, for the adjudication of the Upper Salt River. Thereafter, SRP, Phelps Dodge Corporation (Phelps Dodge), ASARCO and the Buckeye Irrigation Company filed petitions to adjudicate other watersheds within the Gila River Basin. The Gila River Adjudication includes much of the southern half of the state and covers the following seven watersheds: Upper Salt River, Upper and Lower Gila River, Verde River, Agua Fria River, Upper Santa Cruz River, and the San Pedro River.

The Little Colorado River Adjudication began in 1978 when Phelps Dodge filed a petition with the ASLD for the adjudication of water rights within the Little Colorado River system and source. The Little Colorado River Adjudication includes the northeastern part of the state and covers the following three watersheds: Silver Creek and the Upper and Lower Little Colorado River.

The general stream adjudications are comprehensive proceedings, evaluating water uses and claims by both State and federal entities. The State parties include municipalities, mines, utility companies, private water providers, water users' associations, conservation districts, irrigation districts, state agencies and individual water users that rely on water diverted from streams, lakes, springs, stored in reservoirs or stockponds, and withdrawn from wells. Within these proceedings, water rights are also being adjudicated for water uses on Indian reservations and federal lands including military installations, conservation areas, parks and forests, monuments, memorials, and wilderness areas. These water uses may include both surface (non-Colorado River) water and groundwater in certain instances. It is critical that the adjudication move forward in the near future to provide certainty regarding future water supply availability to the various water users throughout these watersheds, particularly during times of drought.

Outstanding Indian Water Rights Claims

While progress on the adjudication process has been complicated by the diversity of water users and the need to resolve preliminary legal issues, the State has made significant progress in reducing uncertainty through execution of Indian Settlements[39]. However, there are still Indian claims that have yet to be addressed and completion of these settlements is essential to not only provide a secure water supply for tribal communities, but also to provide long-term certainty for all water users in Arizona (*see Table 1*).

[37] As of July 2013, there are 83,244 claims in the Gila River Adjudication and 14,522 claims in the Little Colorado River Adjudication.
[38] Upon its creation in 1980, ADWR assumed the role of administering surface water rights throughout the State. ASLD performed this function prior to ADWR's establishment.
[39] Discussed above in Section II Part III: Arizona's Historical Successes in Water Management, Resolution of Tribal Water Rights.

Table 1. Outstanding Indian Water Rights Claims

Tribe	Potentially Affected Planning Area(s) ***See Section 3***
Havasupai Tribe	*Bill Williams, Verde, Western Plateau and Central Plateau*
Hualapai Tribe	*Bill Williams, Verde, Western Plateau and Central Plateau*
Hopi Tribe	*Navajo/Hopi, East Plateau, Central Plateau, Basin & Range AMAs, Colorado Mainstem – North, and Colorado Mainstem – South*
Kaibab Paiute Tribe	*Arizona Strip*
Navajo Nation	*Navajo/Hopi, East Plateau, Central Plateau, Basin & Range AMAs, Colorado Mainstem – North, and Colorado Mainstem – South*
Pasqua Yaqui Tribe	*Basin and Range AMAs*
San Carlos Apache Tribe (On-Reservation Gila River tributary claims)	*Basin & Range AMAs*
San Juan Southern Paiute	*Navajo-Hopi*
Tohono O'odham	*Basin & Range AMAs*
Tonto Apache Tribe	*Roosevelt and Basin & Range AMAs*
Yavapai Apache Nation	*Verde and Basin & Range AMAs*

Land Subsidence

Land subsidence occurs when groundwater has been withdrawn from certain types of aquifers, such as those containing fine-grained sediments, in excess of rates of replenishment. When groundwater is withdrawn from the open pore spaces between the soil particles, the sediments can collapse – causing a lowering of the land surface. In some systems, when large amounts of water are pumped, this can result in a permanent reduction in storage capacity of the local aquifer system. Uneven compaction of the soils overlying aquifer systems can lead to the formation of earth fissures (large cracks). Earth fissures typically form underground and can express themselves on the surface. The impacts of land subsidence include: damage to linear utilities and flood conveyance infrastructure; differential settling of building foundations; earth fissuring; and loss of aquifer storage capacity through compaction. The rate and magnitude of land subsidence is highly variable across the basins in the planning areas and are dependent upon geologic conditions and historical volumes of groundwater withdrawals.

Summary

The diversity, variability and complexity that are unique to Arizona make developing water supply strategies difficult. In some areas, water users have access only to surface water from rivers and streams. In others, they rely solely on groundwater. Other regions have access to both groundwater and surface water, which can be conjunctively managed to provide renewable and redundant supplies for the benefit of local water users. Some areas may have elaborate and far reaching water storage, transmission and delivery systems, while others have limited infrastructure and rely entirely on local wells. Some areas may have already experienced rapid growth and others have not. Some areas of the state have available water supplies in excess of projected demands. In others, the currently developed supplies may not be sufficient to meet projected future demands, although there may be locally available supplies that can be developed in volumes adequate to meet those needs. Absent development of supply acquisition and importation projects, some portions of this arid State will struggle to meet projected water demands with locally available supplies.

Water Supply Development Opportunities

Over the next 20 to 100 years, Arizona will need to identify and develop an additional 900,000 to 3.2 MAF of water supplies to meet its projected demands. While there may be local water supplies that have not yet been developed, water supply acquisition and/or augmentation will be required for some areas of the State to realize their growth potential. Examples of these potential supplies are:

1) Non-Indian Agricultural Priority CAP water;
2) Reclaimed water/water reuse for which there is not yet delivery or storage infrastructure constructed to put it to direct or indirect use;
3) Groundwater in storage;
4) Water supplies developed from revised watershed management practices;
5) Water supplies developed through weather modification;
6) Water supplies developed from large-scale or macro rainwater harvesting/stormwater capture; and
7) Direct importation or exchange of new water supplies developed outside of Arizona (e.g., ocean desalination).

1) Non-Indian Agricultural Priority CAP Water

The Arizona Water Settlements Act[40] (Settlements Act) was enacted on December 10, 2004. The Settlements Act ratified the Arizona Water Settlement Agreement (Agreement) between the United States, ADWR, and CAP and provided for the reallocation of 96,295 acre-feet of Non-Indian Agricultural Priority CAP water (NIA Priority CAP water) for municipal and industrial uses in the State of Arizona.

Both the Settlements Act and the Agreement required the US Secretary of the Interior (Secretary) to reallocate the 96,295 acre-feet of NIA Priority CAP water to ADWR "to be held under contract in trust for further allocation."[41] Both the Settlements Act and the Agreement also specified that the Director of ADWR shall submit a recommendation for reallocation to the Secretary, and that the Secretary shall carry out all necessary reviews of the proposed reallocation in accordance with applicable federal law[42]. The Agreement further provided that ADWR develop eligibility criteria and make the water available for reallocation "at periodic intervals, starting in 2010[43]." On August 22, 2006, the Secretary reallocated the 96,295 acre-feet of NIA Priority CAP water to ADWR acknowledging that "before the water may be further allocated the Director of ADWR shall submit to the Secretary of the Interior a recommendation for reallocation[44]."

The NIA Priority CAP water has a lower priority than Indian or Municipal and Industrial (M&I) Priority CAP water and is expected to have reduced availability, especially during times when Arizona's supplies are affected by shortage operations on the Colorado River. ADWR's analysis of the average availability of this 96,295 acre-feet of NIA Priority CAP water estimates that an average of about 64,000 acre-feet per year will be available over the next 100 years, assuming a moderate development schedule on the mainstem of the Colorado River. This availability is expected to reduce to an average of about 58,000

[40] Public Law 108-451
[41] Settlements Act § 104(a)(2)(A); see also Agreement Paragraphs 3.1 and 9.3.1.
[42] Settlements Act § 104(a)(2)(C); see also Agreement Paragraph 9.3.4. The Department has traditionally provided recommendations of allocations of CAP water to the Secretary, consistent with its authority in A.R.S. § 45-107.
[43] Agreement Paragraph 9.3.4.
[44] *Notice of Modification to the Secretary of the Interior's Record of Decision, Publication of a Final Decision of CAP Water Reallocation*, 71 Fed. Reg. 50449, 50451 (Aug. 25, 2006).

acre-feet per year over the 100-year period after 2030 due to projected increases in use for all Colorado River water users. This means that over the next 100 years in some years this NIA water supply will be fully available, some years it will be partially available, and some years it will not be available at all. Recipients of this water will need alternate water supplies and the necessary infrastructure to use those alternate water supplies in order to meet future firm demands in years of reduced or no availability of this NIA Priority CAP water.

ADWR has divided the full reallocation volume of 96,295 acre-feet into three pools and the water will be reallocated in a tiered process, with phases starting in 2013, 2021 and, if there is any remaining water, in 2030. ADWR has initiated the reallocation process for the first pool, in the amount of 46,629 acre-feet of NIA Priority CAP water, within the three-county CAP service area (Maricopa, Pinal and Pima counties). The Director of ADWR will submit a recommendation for allocation of this volume to the Secretary by December 31, 2013. The second pool of NIA Priority CAP water (17,333 acre-feet) will be offered to water users inside of the three county CAP service area in 2021. The third pool of NIA Priority CAP water (17,333 acre-feet) will be offered to water users located outside of the three county CAP service area, also beginning in 2021.

2) Reclaimed Water/Water Reuse

Substantial volumes of reclaimed water are utilized today through underground storage and recovery and through direct use to non-potable uses such as landscaping and turf irrigation. ADWR has projected additional volumes of reclaimed water that can be generated by future populations[45]. Along the Colorado River, water users can receive return flow credits for discharge of reclaimed water back to the River, allowing them to divert above their entitlement by the volume of return flows. The current volume of reclaimed water supplies available to meet demands is over 500,000 acre-feet. In 2035, the estimated volume of reclaimed water that can be generated is approximately 745,000 acre-feet. In 2060, the volume is estimated at approximately 935,000 acre-feet and in the year 2110 the volume is estimated to be approximately 1.3 MAF.

Reclaimed water supplies are potentially available to partially offset the projected imbalances throughout the State. Significant investments will need to be made to put this water to use and to overcome the public perception associated with direct potable reuse of this supply. By using this supply more effectively, the future imbalances can be reduced by nearly 50 percent to 155,000 acre-feet in 2035 and 1.9 MAF in 2110. In addition to reducing a community's possible water supply imbalance, expanding a community's sewer collection and treatment system to customers who are dependent on septic systems can also protect local water quality.

The volumes stated above are based on production from municipal wastewater systems. Other sources of water reuse include: 1) in home grey water reuse systems, which recycle water from uses such as washing machines and dishwashers for outdoor landscape watering or toilet flushing and 2) industrial wastewater.

[45] These projections were conservatively derived by holding the current percentage of the population that is connected to a sewer system in each groundwater basin constant and applying a constant reclaimed water generation factor to the projected population.

3) Groundwater

ADWR estimates that the groundwater currently in aquifer storage within the State to a depth of 1,000 to 1,200 feet below land surface (or bedrock, whichever is higher) is just over 1.2 billion acre-feet[46]. If this groundwater were fully accessible and was utilized through 2110, without regard to the negative impacts of pumping that supply to those depths, the 100-year annual volume available would be 12.5 MAF. While at face value this would solve the water supply challenges facing Arizona, the available groundwater is not always located in the areas that have the greatest projected demands and depletion of this resource is not in the best interest of the State. For example, the adjusted estimated groundwater in aquifer storage in the Little Colorado Plateau Groundwater Basin is over 760 MAF (7.6 MAF annually for 100 years) while the projected demand in that basin in the year 2110 ranges from 300,000 to 400,000 acre-feet. Additionally, much of the groundwater basin underlays Indian reservation lands and is not likely available for off-Reservation uses.

In some areas of the State (e.g., Buckeye and Yuma), successful agricultural practices require leaching of salts from the soil profile and drainage of shallow groundwater to depths below crop root zones. This is accomplished through an extensive gravity drainage system and operation of dewatering wells, which discharge or dispose of this "brackish groundwater," typically to nearby rivers. Capture, treatment and direct use of this locally available resource can serve to augment local water supplies reducing demands on other groundwater supplies or can be transported to other areas as needed. Highly saline brine will be a by-product of the treatment required to reuse this supply. Development of a cost-effective brine disposal method will greatly enhance the viability of this supply augmentation alternative.

The potential for negative consequences associated with groundwater mining (withdrawing water from groundwater storage in excess of the rate of replenishment) is the primary reason for not relying on groundwater to meet all future water needs. These may include but are not limited to:

- Declining groundwater tables;
- Dewatering of certain areas of the basin;
- Declining well yields;
- Increased pumping depths and cost;
- Land subsidence and earth fissuring;
- Diminished water availability to water dependent natural resources; and
- Deterioration of water quality and the costs associated with treating that water.

Developing a regional analysis of the sustainable or optimal yield from Arizona's groundwater basins would provide water managers with information necessary to determine the long-term security associated with local reliance on groundwater supplies to meet current and projected water demands.

4) Watershed Management

Increasing water yields through vegetation management may be a viable option for water management for on-site or off-site uses. Vegetation management does not have to occur through extreme measures, such as clear-cutting (either wholesale clearing or type conversion), but can include strategies to decrease interception and evapotranspiration in upland areas outside of the riparian zone by reducing the numbers of trees and shrubs and replacing those species with plants that use less water, such as

[46] Arizona Department of Water Resources

native grasses. Existing soils, topography, precipitation and vegetation types are important elements in the effectiveness of this practice and will affect the timing and magnitude of potential water yields and required management practices essential to maintaining the benefits. Cost also must be weighed in determining whether to initiate and maintain such a program. The value of the water yield has to be compared to the other societal uses of the land. However, finding projects that have mutual benefits compatible with other natural resource objectives, such as increased livestock forage, recreational opportunities and reduced risks and costs of associated with wildfires may offset these costs.

Table 2. Compilation of Water Yield Data From Experiments in Arizona

(*Source: Water Yield Improvement by Vegetation Management, Ffolliott and Thorud, 1977 & Arizona Forest Resource Assessment- Arizona State Forestry Division, 2013*)

Vegetative Zone	Experimental Location	Water Yield Increase	Acreage of Traditional Forest Types in AZ	Studied Management Practice
Mixed Conifer Forests	Workman Creek – North Fork	No Change	450,221acres	Removal of riparian vegetation
	Workman Creek – North Fork	0.10 ac-ft/ac/yr		Conversion of 1/3rd of watershed, specifically moist-site vegetation immediately adjacent to stream channel
	Workman Creek – North Fork	0.45 ac-ft/ac/yr		Conversion of 1/3rd of water watershed, specifically the dry-site vegetation immed.adjacent to the moist-site conversion.
	Workman Creek – South Fork	No Change		Individual tree selection cut
	Workman Creek – South Fork	0.50 ac-ft/ac/yr		Subsequent uniform thinning of areas dominated by Ponderosa pine, and after areas dominated by Douglas-fir and White fir were cleared
Ponderosa Pine Forests	West Fork of Castle Creek	0.05ac-ft/ac/yr	4,043,854 acres	Clearing 1/6th of the overstory, with the remaining 5/6^{ths} subject to thinning treatment
	Beaver Creek	0.20 ac-ft/ac/yr		Clearing 1/3rd of the forest overstory in uniform strips on Watershed 9 and irregular strips on Watershed 12
	Beaver Creek	0.15 ac-ft/ac/yr		Thinning of forestry overstory by group selection on Watershed 17
Pinyon-Juniper Woodlands	Beaver Creek	0.04ac-ft/ac/yr	13,420,572 acres	Aerial application of herbicides on Watershed 3
		Minimal increases		Mechanical conversion

Watershed management strategies have been explored and used in Arizona and across the West for decades to increase yields in localized settings. At a larger scale, Arizona's forests are an integral part of the watershed management strategy in this State. The Tonto National Forest, which owes its existence to the construction of Roosevelt Dam, was created in 1905 to protect the watersheds of the Salt and

Verde Rivers and, according to its web site, continues to be a central focus of the Forest[47]. Additionally, the Apache-Sitgreaves National Forests[48] include the health and restoration of the watersheds as one of their management concerns, and the Prescott National Forest[49] manages its watershed for the purpose of protecting the Agua Fria and Verde Rivers.

In the early 1960s, the Arizona Watershed Program was initiated to research integrated watershed management techniques for the purpose of increasing water yield. The program was a joint effort of the ASLD, working with the USDA Forest Service and other government agencies and cooperators. This effort was instrumental in many of the historic experimental research projects in Arizona, some exhibiting potentially promising results. The results of many of these projects were summarized in a report, *Water Yield Improvement by Vegetation Management* (Ffolliott and Thorud, 1977). The report presented the available information from experiments conducted in Arizona on water yield improvement for eight different vegetative zones. Those results are summarized above in Table 2.

ADWR recognizes that these studies are dated. New information is being developed through private and governmental organizations and should be part of the on-going analysis within Arizona to identify possible areas of focus. Combining efforts with other management initiatives (such as the Four Forest Restoration Initiative) may be a cost-effective way to advance this option and provide multiple benefits. The Four Forest Restoration Initiative (4FRI) is a collaborative effort to restore forest ecosystems on portions of four National Forests - Coconino, Kaibab, Apache-Sitgreaves, and Tonto - along the Mogollon Rim in northern Arizona. The vision of 4FRI is restored forest ecosystems that support natural fire regimes, functioning populations of native plants and animals, and forests that pose little threat of destructive wildfire to thriving forest communities, as well as support sustainable forest industries that strengthen local economies while conserving natural resources and aesthetic values[50]. Future plans, through the 4FRI effort, for landscape scale restoration activities in Arizona's national forests have the potential to increase water yield and overall forest health.

Another area that may have promise for increasing water yields is Tamarisk removal[51]. Tamarisk, commonly known as salt cedar, is a non-native shrub or tree that was introduced into the US in the 19th Century. During the Great Depression in the 1930s, tamarisk was used as a tool to fight soil erosion in the Great Plains. Tamarisks are very prolific and displace native vegetation and animals, alter soil salinity, and increase fire frequency[52]. Tamarisk is an aggressive competitor for water supplies and often develops into monoculture stands, which can negatively impact native vegetative communities. In Arizona, Tamarisk has colonized into dense stands along many water courses, altering flow regimes and reducing downstream flows. Measures to control the growth of, or eradicate, tamarisk have been attempted for the purpose of reducing vegetative water consumption, improving habitat conditions, and improving river system function. Maintaining the benefits of these measures has proven difficult, but may have promise in selection regions of the State.

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[47] http://www.fs.usda.gov/tonto
[48] http://www.fs.usda.gov/asnf
[49] http://www.fs.usda.gov/prescott
[50] http://www.4fri.org/
[51] Other areas vegetation manipulation should also be explored, such as mesquite encroachment, but we are focusing on tamarisk in this report.
[52] http://www.nps.gov/grca/naturescience/exotic-tamarisk.htm

The ability to employ watershed management practices is becoming significantly more constrained due, in part, to environmental concerns. Areas that appear to have potential for water yield improvement will also need to be evaluated not only for the vegetative, physiographic and climate potential but also social, institutional and economic factors.

5) Weather Modification

Weather modification (cloud seeding) is the application of scientific technology that can enhance a cloud's ability to produce precipitation. The technique was developed in the 1940's using small particles of dry ice and converting water droplets existing at temperatures lower than freezing (supercooled) to ice crystals. There are two types of projects that are being conducted today in parts of the US: 1) projects that increase snowpack (cold rain) and 2) projects that increase localized precipitation for range and croplands (warm rain).

The process is based on enhancing the natural formation of precipitation in the atmosphere. As wind pushes moist air over rising terrain, the rising air cools and water droplets are then formed through condensation, resulting in the formation of orographic clouds. The clouds consist of small droplets that, despite below-freezing temperatures, remain liquid. The water's purity and the lack of foreign particles in the atmosphere prevent the droplets from freezing, forming supercooled clouds. As temperatures decrease further, the droplets form ice crystals around small atmospheric particles such as dust (known as "condensation nuclei").

Cloud seeding introduces additional particles or nuclei into the atmosphere, causing more ice crystals to form. Silver iodide compounds and dry ice are the most common cloud seeding agents. Aircraft or ground-based generators are used to introduce the agents into the atmosphere. As the ice particles grow, they attract nearby water vapor and droplets, growing larger and heavier. These enlarged ice particles eventually fall as snow.

Cloud seeding experiments originally were focused largely on cumulus clouds, the most common, widely distributed cloud form, and the world's most important precipitation source. The short life span and instability of cumulus clouds complicated seeding operations. Orographic clouds, which form as air masses are forced over mountainous areas, are preferable for seeding as they typically last longer and are more predictable, allowing for more easily controlled weather modification experiments. Orographic clouds are the source of both rain and snow. In the mid-latitudes, nearly all precipitation begins as snow but, if it is much warmer than freezing below the cloud base, the snow melts and reaches the ground as rain. Freezing temperatures are required for crystallization to occur with the seeding material or agent. As a result, snow is the expected product of cloud seeding.

The West provides favorable conditions for weather modification as the mountainous terrain is generally favorable to the forming of orographic clouds. Additionally, it is an area of water scarcity, with the dependable flows of its natural streams typically fully appropriated. Therefore, the natural conditions and water supply needs suggest suitability for weather modification activities. With a large proportion of its area arid or semiarid, Arizona can be expected to benefit by weather modification, certainly to a greater extent than less arid states in the Nation.

SRP conducted some of the earliest cloud seeding operations in Arizona. During the 1950s, a time of drought in Arizona, SRP set up a series of ground-based seeders on its 13,000-square-mile watershed.

The operations relied on air masses to lift propane-burned silver iodide for seeding. SRP also contracted for aerial seeding during the 1950s and 1960s. These early efforts were suspended when drought conditions eased.

Reclamation released a study in 1974 that described the potential of weather modification to increase water resources in the region. The study estimated the average annual water augmentation potential in the Upper Colorado Basin to be about 1.4 MAF, with 300,000 acre-feet in the Lower Basin and 500,000 in adjacent basins. Most of the 300,000 acre-foot Lower-Basin yield would come from Arizona watersheds. The study found that an additional 300,000 acre-feet could be delivered to Arizona via the Central Arizona Project. The study estimated the cost of generating this new runoff to be about $2 to $5 per acre foot (1974 dollars- $9.50 to $23.75, adjusted to 2013 with CPI).

The Mogollon Rim, in central Arizona, has been identified as offering the greatest potential for in-state weather modification efforts[53]. Stretching from northwest to southeast, the Rim forms a physical barrier that forces flowing air upward to cool, a situation favorable to orographic cloud development. According to the Arizona Water Resources Research Center, about 40 percent of the water for central and northern Arizona falls as winter precipitation over this area and drains north into the Little Colorado River and south to the Verde and Salt River systems. Thus, according to the Research Center, it provides an ideal opportunity for weather modification experimentation and research.

While studies continue, weather modification still remains somewhat scientifically uncertain and raises legal and public policy concerns in need of resolution, such as:

- How is it determined that precipitation was in fact the result of weather modification?
- How is the amount of new water to be quantified for credit and distribution?
- On what basis is the new water induced by weather modification to be allocated among water users?
- How can those who pay for the weather modification be assured that they will in fact receive their share of the new water?

Also not to be neglected are the possible unintended consequences resulting from weather modification (storm damage and flooding liability). Environmental studies would also be required to determine the effects of cloud seeding. Computer modeling is capable of contributing to this effort.

Weather modification may have potential to increase water supplies in Arizona. However, studies are needed to identify areas with potential, and practical public policies must be developed to address the legal and public policy concerns to benefit and protect Arizona water users and landowners.

6) Water Transfers

There are established laws, policies and procedures for transfers of groundwater, Colorado River water and in-state surface water. They are designed to protect local interests and other water users and water right holders in the system. These protections make water transfers difficult to execute and would likely limit their utility in addressing future water supply imbalances. In other

[53] https://wrrc.arizona.edu/publications/arroyo-newsletter/weather-modification-water-resource-strategy-be-researched-tested-tri

words, transfers that are possible *under existing law* may be a helpful limited tool to enhance water supplies under the right cooperative conditions, but it is clear this is not the mechanism for dealing with more comprehensive enhancement needs around the state.

Moving water from one area of Arizona to another has the potential to create controversies, especially if the area from which the water is being transferred has existing water uses and economies built on that water supply. However, such transfers have already been accomplished in limited cases and are subject to regulation aimed at protecting local economies and water users.

The Arizona State Legislature passed the Groundwater Transportation Act in 1991, prohibiting most transfers of groundwater. The law was passed in response to some of the larger cities in Maricopa and Pima counties purchasing large farms in other areas of the State to augment their water supplies. The restrictions imposed by the Transportation Act are intended to protect hydrologically distinct groundwater supplies and the economies in rural areas by ensuring the groundwater is not depleted in one groundwater basin to benefit another. The law does, however, recognize pre-existing investments in water transfers and allows for the following limited, exceptions to these restrictions, under specific statutory conditions that are unique to each exception:

1) Butler Valley Groundwater Basin to an initial AMA;
2) Harquahala Irrigation Non-Expansion Area to an initial AMA;
3) McMullen Valley Groundwater Basin to an adjacent initial AMA;
4) Big Chino Sub-Basin of the Verde River Groundwater Basin to an adjacent initial AMA;
5) Yuma Groundwater Basin;
6) Little Colorado River Plateau Groundwater Basin (under very limited conditions); and
7) Parker Groundwater Basin (under very limited conditions).

A transfer of a Colorado River water entitlement or allocation must be approved by the Secretary. State statute authorizes the Director of ADWR to consult, advise and cooperate with the Secretary in contracting for the delivery of water from the Colorado River[54]. State statute also requires that a person proposing to transfer a Colorado River entitlement or allocation cooperate and obtain the advice of the Director of ADWR[55]. ADWR has adopted a substantive policy statement that establishes the procedures that must be followed and criteria that must be met for the Director to recommend approval of a proposed Colorado River water transfer. Importantly, this process requires the input of stakeholders who may be impacted by these transfers. This input is designed to ensure that all impacts are evaluated prior to removing these water supplies from the region of origin and is an integral component of ADWR's Transfer Policy and, if conditions are met, its recommendation to the Secretary[56].

Transfers of in-state surface water (non-Colorado River water) are also allowed under specific conditions set forth in State statute[57]. Generally, these types of transfers are limited to the same river system and do not involve trans-basin transfers. State law allows water to be transferred to another location on the river system but, depending on the type of use and location, the transferred supply may not retain the same water right priority date, which can limit its viability as a source for large-scale transfers.

[54] *A.R.S. §45-107(A)*
[55] *A.R.S. §45-107(D)*
[56] http://www.azwater.gov/azdwr/Legal/LawsRulesPolicies/documents/CR7.pdf
[57] *A.R.S. §45-172*

The role of water transfers for long-term water management strategies must be evaluated on a case-by-case basis. While certain transfers may have minimal impacts, others may not only impact local economies, but also operations of nearby and downstream irrigation districts, environmental and recreational needs, the operation of intra-state rivers for hydroelectric power, water quality, and international treaty obligations. Depending on the source of water, using transfers for long-term water supplies must take into account the long-term availability of the water supply that is subject to the transfer request, the reliance of the local area on that water supply, and the impacts to other water users in that system. In areas where the availability of the water to be transferred is limited, short-term and/or dry year options may be more suitable and beneficial to the communities.

There are established laws, policies and procedures for transfers of groundwater, Colorado River water and interstate surface water. They are designed to protect local interests and other water users and water right holders in the system. These protections make water right transfers difficult to execute and may limit their utility in addressing future water supply imbalances.

7) Large-Scale(Macro) Rainwater Harvesting/Stormwater Capture

The practice of rainwater harvesting dates back to the earliest days of civilization and refers to the technology for capturing, storing and using rainwater. This can be accomplished on a small-scale at a single residence, intercepting the precipitation that falls on impervious areas around the home or from rooftops and diverting it to cisterns or barrels for on-site uses such as landscape watering. In Arizona, rainwater harvesting is encouraged at the residential level as a water conservation best management practice and is a common, voluntarily employed, practice across the State. Some Arizona water providers offer incentives for their customers to invest in and utilize this technique. For example, Tucson Water has a program that will rebate qualifying residential rainwater harvesting systems costs up to a maximum of $2,000[58].

Larger-scale techniques for the capture of rainwater or stormwater can be used for residential subdivisions, commercial developments, industrial sites, parking lots, roads and highways. While these types of projects can utilize commercially available equipment, they can also be accomplished through design of facilities and grading land surfaces to slow down flows and enhance infiltration into the aquifer, thereby creating the potential to enhance natural aquifer recharge. Large-scale stormwater capture and recharge is managed through ADEQ's Arizona Pollution Discharge Elimination System (AzPDES) permitting process and supports compliance with ADEQ's best management practices for stormwater management.

While, stormwater capture and infiltration enhancement projects exist in Arizona, proposals to obtain underground storage credits through ADWR's Underground Storage and Recovery Program have added a new dimension to this activity. Typically, rainwater or stormwater either infiltrates into the ground, ultimately replenishing local aquifers, or flows over the land surface to rivers, streams or other surface water management systems or impoundments. Water that infiltrates into the aquifer is considered a benefit to the aquifer, the environment, and all users in that system. Allowing individual entities to accrue underground storage credits for this water would require significant monitoring of localized storm events, accounting and administration. Additionally, there are concerns from some water rights

[58] For more information see http://cms3.tucsonaz.gov/water/rwh-rebate.

holders that inhibiting flows that otherwise would have entered the surface water system may reduce their water availability. To address these issues, the Arizona Legislature passed House Bill 2363 in 2012 establishing a Joint Legislative Study Committee on Macro-Harvested Water to evaluate the issues arising from the collection and recovery of large-scale harvested water. The process to evaluate these projects will be important in determining whether or not the projects can result in significantly enhancing water supplies beyond what is currently available for future uses, and whether those local benefits can be earmarked for specific parties. Pilot projects are currently being developed to analyze this activity in the Upper San Pedro Basin in Cochise County.

8) Importation of New Water Supplies

While Arizona has local options available to meet its near-term water supply challenges, there still may be a need to explore and acquire water supplies from outside of the State. Water supply augmentation from outside Arizona will be challenging and, most likely, more costly than the in-State options. In the public discussions following the release of the Basin Study, options for importation of water supplies were generally dismissed as less desirable than local conservation and reuse.

Unfortunately for Arizona, the significant strides that have already been made in the area of conservation and reuse have been ignored by external parties perhaps due to lack of understanding of the magnitude of Arizona's efforts. While Arizona has significant potential to reduce the future imbalances using reclaimed water, and to some extent the other options described above, there may remain an imbalance between future demands and available supplies that needs to be addressed. Given the long lead time that will be required, addressing this need cannot be pushed off into the future. Acquiring and developing imported water supplies could be an exponentially more difficult task than it was to bring Colorado River water to Central Arizona through authorization of the CAP, as the supplies will likely be derived from outside the State. Several other states are in the same, or nearly the same, position as Arizona, but do not share the challenge of having a significant portion of its entitlement as the junior priority on the Colorado River. If we take a wait-and-see approach to pursuing these options, we will certainly be at a disadvantage, as other states and municipal water suppliers are actively exploring similar options. If we are choosing to pursue economic expansion, for the future of Arizona, we must begin today to actively explore opportunities to expand our water supplies to meet those needs.

The pursuit of similar opportunities by entities outside of Arizona presents both potential competition and opportunities for cooperation. Arizona has and shall maintain its stalwart protection of our Colorado River supplies. We have been able to do that while maintaining a spirit of cooperation and collaboration with our fellow Basin States and representatives of Mexico. We continue to work to solidify those relationships and can expand on those relationships to explore importation opportunities from outside the State.

Options for importation of water supplies are limited because of the distance from the supplies and in some cases, the local demands on those supplies in the area of origin. Additionally, the cost-effectiveness of developing these options (acquiring, transmission, energy and maintenance) further limits the practical application of utilizing such supplies. Some of the importation alternatives identified in the Basin Study include trans-basin importation of Mississippi River water to the Lower Basin; importation of Missouri River water to the Upper Basin; and ocean desalination. Of all the options identified in the Basin Study, seawater desalination may be the most cost-effective and politically viable importation option available to Arizona. Desalination refers to any of several processes that remove some amount of salt and other minerals from saline water to produce fresh water suitable for human consumption or irrigation.

The cost of desalinating sea water (including the infrastructure, energy and maintenance) is generally higher than obtaining fresh water from rivers or aquifers, reusing reclaimed water, or employing water conservation practices. Options for acquiring and delivering this supply vary based on the anticipated location of delivery within the State and the ability to develop agreements with neighboring states or Mexico. Table 3, below, identifies several desalinating options identified in the Basin Study. Obviously, among the Basin States, the state of California has access to the nearest US supply of ocean water. California is a partner in the Colorado River Basin and has significant needs for dependable water supplies into the future. Arizona can explore options for exchanging California's Colorado River water entitlement for use in Arizona for the construction and operation of desalination plants on the Pacific coast of California. This option is only likely to be possible if a mutually beneficial arrangement can be struck between Arizona and California. California already has access to large volumes of seawater and currently has no incentive to share its Colorado River entitlement. Thus, while monetary incentive may present an option, it is still uncertain if California would be a willing cooperator. Exploration of this option would require significant time and effort but, if viable, could provide a mechanism to address Arizona and Nevada's needs.

Table 3. Desalination Options Identified in the Colorado River Basin Supply and Demand Study

Option Type	Option Category	Representative Option	Estimated Cost ($/AF)	Years Before Available	Potential Yield by 2035 (AFY)	Potential Yield by 2060 (AFY)
Increase Supply	Desalination	Gulf of California	2,100	20 - 30	200,000	1,200,000
		Pacific Ocean in California	1,850 – 2,100	20 -25	200,000	600,000
		Pacific Ocean in Mexico	1,500	15	56,000	56,000
		Salton Sea Drainwater	1,000	15 – 25	200,000	500,000
		Groundwater in Southern California	750	10	20,000	20,000
		Groundwater near Yuma, AZ	600	10	100,000	100,000
		Subtotal			**776,000**	**2,476,000**

Source: Reclamation, 2012

Mexico is at the end of the Colorado River system and has an annual entitlement of 1.5 MAF. Two options are available for entering into an agreement for desalination with Mexico, but would require significant capital investment and negotiations through the State Department. First, capital investment in Mexico to construct a desalination plant for Mexico on either the Sea of Cortez or the Pacific Ocean could provide Arizona with an opportunity to exchange Mexico's Colorado River entitlement for desalinated ocean water. Depending on the volume and location of delivery, this option would also require additional transmission capacity from the Colorado River to the location of use if the volume exchanged exceeds the current CAP canal capacity, as well as a source of energy to desalinate and deliver that supply to areas in Mexico. Secondly, cooperating with Mexico on the construction of a facility on the Sea of Cortez and directly transporting that water into Arizona (and along the pipeline route in Mexico) for use would provide water to an area of need. Both of these options would require significant capital investment for construction, energy development and transmission.

To provide a general sense of the cost for a desalination project, the San Diego County Water Authority has proposed construction of the 54 million gallons per day (MGD) Carlsbad Desalination Facility (approximately 60,000 acre-feet per year) and 10 miles of 54-inch transmission line. Capital costs for the project are approximately $700 million. The annual operating costs for the facility are estimated at approximately $50 million, with 50 percent of that cost for the energy production needed to operate the facility to produce and deliver drinking water. The cost to the ratepayers is (including capital repayment, operation and maintenance) is about $2,329/acre-foot ($7.14/1,000 gals)[59].

A more local study analyzed a desalination plant located on the Sea of Cortez, just northeast of the central part of Puerto Peñasco and delivery of the water above Imperial Dam, north of Yuma, Arizona[60]. The study assumed that desalinated water conveyed to Imperial Dam could then be used to displace Colorado River water and exchanged to users in Arizona, and possibly other partnering states, which would then divert the additional Colorado River water through their existing, expanded, or new infrastructure (possibly requiring additional costs). A regional scenario that included a 1.07 Billion Gallon per Day (1.2 MAF) treatment facility and a 143-mile open canal conveyance structure was estimated to cost approximately $1,183/acre-foot ($3.63/1,000gallons), not including 500 MW energy production capacity requirement for this scenario. Replacing the open canal conveyance structure with a closed pipe system could provide more supply security but could also add as much as $4.47/1000 gallons to the overall cost. In comparison, the current rate for M&I water delivered to Phoenix through the CAP canal is approximately $0.45/1,000 gallons before treatment and approximately $5.00/1,000 gallons after treatment, depending on location and treatment technology. It is interesting to note that the cost of that same volume of water from commercial bottled water is approximately $12,736/1,000 gallons.

It is also important to note that an entity proposing a project in Mexico would need to consider supplying security to protect the project from possible terrorism, and would also need to consider environmental impacts, including disposal of the by-products of the desalination project, both of which could add to the cost.

[59] http://www.sdcwa.org/sites/default/files/files/board/2012_presentations/presentations_2012_06_14.pdf
[60] Investigation of Binational Desalination for the Benefit of Arizona, United States, and Sonora, Mexico – Final Report, June 5, 2009, HDR Engineering

GOING FORWARD:
CREATING AN ARIZONA STRATEGIC VISION FOR WATER SUPPLY SUSTAINABILITY

Based on the most recent study conducted by the water community in Arizona, the legislatively formed WRDC, Arizona could be facing a water supply imbalance between projected demands and water supply availability in the next 25 to 50 years of approximately 900,000 acre-feet. In many portions of the State, this short term imbalance can likely be solved with locally available water supplies. However, there is still a need for financing the infrastructure necessary to accomplish this.

The imbalance is projected to increase by an additional 2.3 MAF by the year 2110. The availability of local water supplies to meet these needs will vary based on the intensity of the demands within each region of the State. Local water supplies may not be sufficient to address these needs and more options must be explored and evaluated, including importation and transportation of desalinated seawater. Pursuit of such options will require sustained investment and commitment by Arizona's policy and business leaders. In order to avoid economic disruption, these efforts must begin immediately to ensure that long-term solutions are in place in advance of the need.

Regional Strategies

There is no single strategy that can address projected water supply imbalances across the State. Instead a portfolio of strategies needs to be implemented dependent on the needs of each area of the State. It is very important to recognize the uniqueness of the various regions throughout the State and the varying challenges facing those regions. A more thorough regional overview and evaluation of the water supply needs for each delineated "Planning Area" within Arizona is included in Section 3 of this report. These Planning Areas have been identified based on possible short-term and long-term strategies available to meet the projected water supply imbalances (*see Figure 8*). Additionally, Table 4 highlights the portfolio of strategies that have been identified and the applicability to each of the Planning Areas, as discussed in more detail in Section 3.

Statewide Strategies

In analyzing all the strategies on a regional basis it became clear that there were specific issues that have widespread potential benefit to all Arizonans. Strategic priorities are identified below which ADWR believes will move Arizona forward through its next century. Additionally, action items have been identified for the first 10 years following the submittal of this report including a requirement for the continued review and update of this report every 10 years.

Figure 8. Strategic Vision Planning Areas

Table 4. Planning Area Strategies

Strategy	Applicable Planning Area(s)*	Supply Limitation	Drought Resiliency	Implementation Challenge	Timeline**
Reclaimed Water Reuse	**1, 3, 5, 6, 9, 14, 15, 17, 18, 19, 20** *10, 16*	Derivative Supply Increases w/Growth	Yes	Low to Moderate Cost Perception of Direct Use	C/EEP to Short
Conservation	**ALL Planning Areas**	Potential Limited by Existing Programs	Yes	Low	C/EEP to Short
Weather Modification	**3, 5, 9, 16, 17,19**	Limited	Limited	High NEPA Limited Local Data	Med
Watershed/Forest Management	**1, 3, 5, 9, 14, 16, 17, 18, 19**	Limited	Some	High NEPA	Med
Expanded Monitoring & Reporting of Water Use	**ALL Planning Areas**	N/A Assists in Managing Existing Supplies	N/A	Moderate Consent of Unregulated Parties Required	Short
Resolution of Indian and Non-Indian Water Rights Claims/Settlement Implementation	**1, 3, 4, 9, 10, 12, 13, 14, 16, 17, 18, 19, 22** *5, 6*	N/A Reduces Supply Uncertainty	Supply Dependent	High Uncertain Federal Funding Consensus among Tribal Parties	Med to Long
Increased Access to Locally Available Groundwater (Potable & Brackish) & Enhanced Recharge	**1, 3, 5, 9, 14, 15, 18, 19** *4, 10*	Moderate Need Additional Studies to confirm	Yes Short Term Drought	Moderate Securing Supplies & ROW Access	Short to Med
Local Water Supply Study – Groundwater System Analysis/Modeling	**1, 2, 4, 6, 9, 10, 11, 14, 15, 17, 20, 22** *3, 5,19*	N/A Assists in Managing Existing Supplies	Gain Local Knowledge of GW/SW Link	Low - Moderate But Resources and Data Collection Needed	Short to Med
Local Water Supply Management	**6,19**	N/A	Supply Dependent	High Need Local Support	Med
Firming of Low Priority Colorado River Supplies	**3, 7, 20**	Limited by Available Resources	Yes	Low - Moderate Existing Authority But Resources Limited	C/EEP to Short
Importation – Instate SW or GW	**3, 5, 16, 19**	Limited by Available Resources	Supply Dependent	Moderate – High Some GW already avail. Public Opposition Likely	Med to Long
Importation – Desal Exchange	**3, 18, 19** *5*	Limited by Exchange Opportunities and Infrastructure	Exchange Supplies Limited	High Securing Supplies & ROW NEPA	Long
Importation – Desal Direct Use	**3, 18, 19** *5*	Supply Unlimited Economics will drive capacity	Yes	High Securing Supplies & ROW NEPA	Long

Planning Area Key

ID	Name
1	Apache
2	Arizona Strip
3	Basin & Range AMAs
4	Bill Williams
5	Central Plateau
6	Cochise
7	Colorado River Mainstem – North
8	Colorado River Mainstem – South
9	East Plateau
10	Gila Bend
11	Hassayampa/Agua Fria
12	Lower Gila
13	Lower San Pedro
14	Navajo/Hopi
15	Northwest Basins
16	Roosevelt
17	Upper Gila
18	Upper San Pedro
19	Verde
20	West Basins
21	West Borderlands
22	Western Plateau

Recommended Implementation Schedule:
C/ EEP = Continuation/Expansion of Existing Programs
Short = Short-Term (1-5 yrs)
Med = Medium- Term (5 – 15 yrs)
Long = Long-Term (> 15 yrs)

* Applicable Planning Area – **BOLD** are areas where strategy is recommended – *Italicized* are areas where strategy could be utilized but not a primary option.

Strategic Priorities

7) Resolution of Indian and Non-Indian Water Rights Claims

Arizona has been successful in resolving, either in whole or in part, 13 of 22 Indian water rights claims, providing substantial benefits to both Indian and non-Indian water users. However, the general stream adjudications, which began in the 1970s, remain incomplete. As of July 2013, there are 83,244 claims in the Gila River Adjudication and 14,522 claims in the Little Colorado River Adjudication by both federal and non-federal parties. These legal proceedings involve complicated technical analysis and legal issues that can often be litigated for years. Completion of a general stream adjudication will result in the Superior Court issuing a comprehensive final decree of water rights. Until that process is complete, uncertainty regarding the nature, extent and priority of water rights will make it difficult to identify all the strategies necessary for meeting projected water demands. ADWR believes that options need to be developed by the State to accelerate this process. Creation of a Study Committee to develop options in a short time frame could help provide guidance to ADWR so adequate funding can be identified and obtained to complete the necessary technical work to support completion of this process. Development of options could initially focus on conceptualization of water rights administration in a post-adjudicated Arizona. This will streamline the Court and ADWR's effort to collecting and evaluating only that information what will assist in administering the final water rights decrees.

8) Continued Commitment to Conservation and Expand Reuse of Reclaimed Water

Arizona leads the nation in water conservation. However, we cannot be complacent with these successes. Conservation is the foundation of sustainable water management in our arid State. A continued commitment to using all water supplies as efficiently as possible is necessary to stretch our existing water supplies and delay the need to acquire other, more expensive, supplies.

Arizona is also a leader in the reuse of reclaimed water. Reclaimed water is continually produced from residential and industrial water users and is a secure source of water, but Arizona is only taking advantage of a fraction of its potential reuse opportunities. Many non-potable uses are being met by reclaimed water including: landscape irrigation of parks and golf courses; agricultural irrigation; and streamflow augmentation benefitting ecosystems. Reclaimed water is produced consistently throughout the year, with limited seasonal fluctuation. But irrigation demands, which are the most common use for reclaimed water, fluctuate seasonally, with high demands during the summer months and lower demands in the winter. Underground storage of unused reclaimed water during times of excess supplies and recovery of those supplies during higher demand seasons is a way to ensure renewable reclaimed water is available to meet demands. Using reclaimed water limits use of potable water for non-potable purposes and saves potable water for drinking water supplies. However, as demands increase and water supplies become more stretched, the need to explore and invest in direct potable reuse for drinking water supplies will become necessary. Using this supply that is readily available also reduces or delays the need to find alternative, more expensive, water supplies. Addressing legal hurdles and ensuring the public that this is a safe source of water needs to start now to ensure that direct potable reuse of reclaimed water will be available when it is needed.

9) Expanded Monitoring and Reporting of Water Use

Monitoring of water use outside of the AMAs and INAs is limited to (1) the Community Water System Reports submitted by municipal water providers and (2) Colorado River accounting reports submitted to Reclamation. Metering and reporting across the State would serve to support and enhance analysis of current hydrologic conditions. Data collection is a crucial element of the development of groundwater models, which have proven to be invaluable tools throughout the State in developing more thorough understandings of hydrologic systems and evaluating future conditions and potential impacts of new uses and/or alternative water management strategies. Additionally, expanded exploration drilling and testing of wells throughout the State will increase knowledge of local groundwater systems in addition to potentially mitigating local pumping impacts.

10) Identifying the Role of In-State Water Transfers

A source of significant controversy across the State, water transfers have been the focus of much debate throughout Arizona's history. So much so that the 1991 Groundwater Transportation Act was adopted prohibiting (with a few exceptions) the transportation of groundwater to the AMAs in order to protect rural Arizona water supplies. However, no such statutory prohibitions exist for the transfer of Colorado River supplies and in-state surface water. The absence of a statutory prohibition on moving these supplies does not mean that transportation is easily achieved. The conflicts that have arisen result from the perception that all transfers will be harmful to local communities and economies. A comprehensive analysis of water transfer is needed in Arizona. Evaluation of long-term versus short-term transfers may actually provide insight into how water transfers can be developed to protect or even benefit local communities. Lessons from other western states that have adopted more market-based water right transfer models may be worthy of review as part of this analysis.

Assuming, upon comprehensive vetting and study, such transfers could be effected in a manner that is satisfactory to at-risk constituencies with respect to local protection and benefit, another issue in this category is the physical transportation of water throughout the state. Typical mechanisms would be through construction of water pipes or canals. The ability to move water throughout Arizona is significantly inhibited by the amount of and dispersal of federal lands. Some land management agencies are amenable to allowing water transmission works to cross their lands while others are not. Because Arizona's highway system has already been constructed, using the rights-of way of existing highways provides an opportunity for colocation of water utility infrastructure and reduces the impact to surrounding lands and ecological resources. However, because of ADOT policy, the ability to utilize these existing corridors is extremely limited. Without this access utilities may have to acquire potentially costly lands and wait for lengthy federal processes to develop much needed infrastructure. Accordingly, in terms of finding some contributing value toward dealing with supply imbalances in the vein of possible mutually desired transfers, finding a compromise to right-of-way access for infrastructure development would assist in hastening the necessary development of water supplies for many communities.

11) Supply Importation - Desalination

Importation of water from outside of Arizona will likely be required to allow the State to continue its economic development without water supply limitations. Supplies derived from ocean or sea water desalination can be imported directly into Arizona to meet the water needs of municipal and industrial water users, while at the same time providing aesthetic, recreational and ecological benefits. Alternatively, desalination can be done in partnership with other Colorado River water users in exchange for water from Lake Mead. Potential partners for seawater desalination include higher priority Colorado River entitlement holders in Arizona, the State of California, and the State of Nevada. Additionally, advancing Governor Brewer's initiative to work cooperatively with Mexico through the Arizona Mexico

Commission, developing much need water supplies for both Arizona and Mexico through desalination on the Sea of Cortez could prove most effective. Projects of this magnitude are expensive and energy intensive, although unit capital and operating costs have significantly reduced as technology has improved and are comparable to water rates in other parts of the country. More importantly, because of the need to identify partners and develop agreements, these projects will require a significant investment of time – up to 20 years to bring to fruition. Because of the time it takes to develop these projects, and the more pressing need for water supplies in certain parts of the State, exploration of this strategy should begin immediately.

12) Develop Financing Mechanism to Support Water Supply Resiliency

The proverbial elephant in the room is cost. The strategies identified above, both statewide and regional, will require capital investment. For many years, the water community has attempted to develop options for funding water supply acquisition and infrastructure development. These conversations and analyses have largely been conducted in the absence of substantial financial expertise and have achieved limited success. It is time to elevate this conversation and address Arizona's future water supply needs, and only Arizona's community, political, and business leaders are capable of garnering the financial resources and mechanisms necessary to meet these needs. Historically, large water supply projects were funded by the Federal government. These Federal options may no longer be available and, if they are, will likely come at a financial premium to Arizona as the Federal land agencies seek to leverage their missions in exchange for approval and access to project financing. A dialogue is needed, perhaps modeled off the development of the Arizona Commerce Authority, to address Arizona's future water supply needs. Evaluation of the potential role of private capital in funding water treatment and delivery infrastructure will be required as a fundamental element of this planning process.

Some areas of the State need immediate assistance in developing water projects, specifically portions of rural Arizona. Unfortunately, these are areas where limited populations cannot finance the required water infrastructure. The Water Resources Development Revolving Fund was created by the Arizona State Legislature to provide financial backing for these communities, but has not been funded to date. Seed money for this revolving fund will be very important to meet the near-term needs of rural communities and provide long-term water supply security for many Arizonans.

Other areas of the State can develop smaller projects for now and may have sufficient population to financially sustain these smaller-scale water projects. But ultimately, large-scale water projects will need to be developed to meet the needs of Arizona's growing economy. While the water supply needs may not be immediate, addressing the financing of future large-scale water projects needs to begin as soon as possible to ensure Arizona's citizens and industries have secure water supplies into the future.

10-Year Action Plan Outline

- Legislate Strategic Vision update every 10 years (Year 1)
- Begin Discussions on Ocean Desalination (Year 1)
  - Exchange Options
    - California
    - Mexico
  - Direct Options
    - Mexico
- Resolve ADOT Right-of-Way Issues for utilities (Year 1)
- Establish Adjudication Study Committee (Year 1)
- Begin Discussions on Water Development Financing (Year 2)
  - Immediate Needs for Water Resources Development Revolving Fund for rural Arizona
  - Long-Term Needs for Large-Scale water importation projects
- Remove current statutory limitation (*A.R.S. § 45-801.01(22)*) on the ability to receive long-term storage credits for recharging reclaimed water beyond 2024 (Year 2)
- Review Legal and Institutional Barriers to Direct Potable Reuse of Reclaimed water – develop and implement plan for resolution (Year 3)
- Review and implementation of Adjudication Study Committee Findings (Year 3)
- Develop and Begin Implementation of Direct Potable Reuse of Reclaimed Water Public Perception Campaign (Year 4)
- Begin discussions with New Mexico on an interstate cooperative program for watershed management/weather modification in the Upper Gila watershed (Year 4)
- Resolve Remaining Indian Settlements (Year 1 - 10)
- Resolve General stream Adjudication (Year 5 - 10)

CONCLUSION

Just as Arizona's greatest past successes have been directly linked to water, Arizona's future success is tethered to how well we continue to manage our water resources and develop new water supplies and infrastructure. Previous achievements in water management and water supply development such as the Salt River Project, the Central Arizona Project, the Groundwater Management Act, and the Arizona Water Banking Authority have contributed to Arizona's phenomenal growth, its robust economy, an attractive way of life, and protection of much of its natural resources. Arizona has been more proactive in water management than its neighbors; thus, creating of culture of investment in water supplies and giving Arizona residents and businesses a secure foundation.

Yet, our present success cannot sustain Arizona's economic development forever and we must continue to plan and invest in our water resources. The recent work of the State's WRDC and the Basin Study both concluded that between 2030 and 2060, Arizona will begin to have a growing statewide imbalance between its water supplies and demand. While there are local areas that require more immediate action, the State as a whole has the good fortune of not facing an immediate water crisis. Now is the time to begin addressing this challenge by developing a strategic vision for Arizona's water future. **The lack of an immediate problem increases the potential for inaction, running the risk of procrastinating and not motivating ourselves to plan and invest in our future.**

Arizona needs a Strategic Vision for Water Supply Sustainability to guide its economic stability through the next century. The water professionals of this State recognize that if planning and investing in our next water resources does not start now, Arizona's foundation and advantageous position in the West will erode. Unlike the most notable successes in our past, the SRP and CAP, the Strategic Vision for our future will not have a single solution or region to unite around. Rather this Strategic Vision will encompass the entire State and identify potential water resource development and infrastructure needs for various regions and water users in Arizona. This is critical since all areas of the State are becoming more and more linked and our future success will be based more and more on the sum of the whole. This Strategic Vision provides a foundation for how Arizona can continue to plan and invest in its water resources and is just as important to Arizona as the Central Arizona Project was in the 1940s.