Case Study: The Arizona Water Bank

Incentivizing Groundwater Recharge

Case Study #1

Working Draft

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Center for Law, Energy, and the Environment
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This case study is part of a series focusing on incentives for Managed Aquifer Recharge, and the institutional context in which MAR projects are conducted. The series is being produced as part of a larger project examining this topic. A symposium on September 10, 2019 will highlight these and other projects. More information is available at law.berkeley.edu/recharge2019.

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Contact: kiparsky@berkeley.edu

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The Arizona Water Bank

Incentivizing Groundwater Recharge - Case Study #1

Anita Milman, Rita Maguire, Kathryn Sorensen, Kathleen Miller and Michael Kiparsky

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Overview

Motivation for MAR: Store Arizona's unused Colorado river water to firm existing contracts and sub-contracts water supplies for Colorado River users; meet state obligations in settlement of Indian water rights claims; assist Nevada and California through interstate groundwater banking. Groundwater Challenges: Groundwater overdraft

MAR Challenges: Future availability of water for storage

Key Actor(s): Arizona Water Banking Authority, Arizona Department of Water Resources, Central Arizona Water Conservation District, Indian, municipal, agricultural and industrial holders of long-term subcontracts for Colorado River water in Central Arizona and mainstream communities.

Water Source: Colorado River Water, effluent[1]

Start Date: 1996

Current Status: Fully functioning

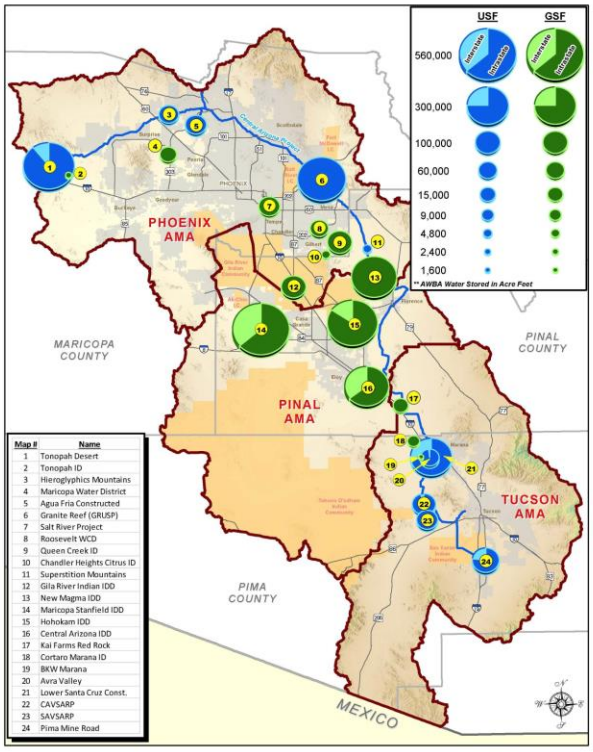

Figure 1 Map of AWBA Recharge Facilities (Source Central Arizona Project 2014)

Average Annual Yield: 172,605 AF/year average (1997-2018), 38,000 AF in the year 2018

Cost: $45 - $400/AF

1. Motivation and Goals

The Arizona Water Banking Authority (AWBA) was established in 1996 to make full use of Arizona's Colorado River entitlement. It also aims to address groundwater depletion in Central Arizona and to protect Colorado River water users in Central Arizona against future shortages and inter-annual variability in water availability.[2] Each year, the AWBA pays the costs to deliver any surplus of Arizona's entitlement to Colorado River water into central and southern Arizona and to store that water underground. The AWBA has also been used to fulfill obligations to Indian tribes incurred through settlement of water-rights claims as well as to assist both California and Nevada through interstate water banking.[3]

2. Geographic, Historical, and Regulatory Context

Arizona's dry climate, historical groundwater overdraft problem, and strategic need to limit California's Colorado River use to its 4.4 million acre-foot annual entitlement encouraged the AWBA.[4] Groundwater use in central Arizona increased in the 20th century as cotton acreage boomed and cities grew after World War II. Heavy groundwater pumping far exceeded natural recharge, creating a severe overdraft problem for central Arizona. At the same time, California was regularly exceeding its 4.4 million acre-foot annual Colorado River allocation by making use of Arizona's unused entitlement. Arizona understood that it would need to use its full 2.8 million-acre-foot annual Colorado River entitlement in order to force California to live within its annual allocation, ensuring access for Arizona in the future when demand exceeded supply.

In 1973, with the support of the federal government, Arizona began construction of the Central Arizona Project (CAP).[5] This aqueduct, with its 14 pumping stations, conveys a large portion of Arizona's allotment of Colorado River water to central and southern Arizona, in order to reduce dependence on groundwater in these areas.[6] Historically, the CAP conveyed more Colorado River water than demands within its service area, motivating consideration of potential storage for future use.

Legislation, including Arizona's 1986 Underground Water Storage and Recovery Act and the 1994 Underground Water Storage and Replenishment Act set the stage for storing and recovering water in the state's five Active Management Areas (AMAs).[7] These legislative acts included provisions for underground storage and set up a system for tracking and accounting for water. Long-Term Storage Credits (LTSCs) allow for the storage and recovery of water.[8] LTSCs are created when a recharging entity stores water in an aquifer. LTSCs grant a right to withdraw groundwater at a later date. LTSCs can be used by recharging entities or sold or transferred by those same entities to other water users. Until 2019, transfers of LTSCs could only be for use within the aquifer where the water was stored.[9] With passage of the Colorado Drought Contingency Plan,[10] the AWBA was authorized to exchange existing LTSCs between AMAs.

It is important to note that Arizona's system of LTSCs pre-dates creation of the AWBA. Any entity in Arizona that receives the proper permits can store water in aquifers and receive a fungible LTSC, and there is a thriving market for recharge of water and subsequent sale of LTSCs in central Arizona. However, while the AWBA can accrue, buy, sell or distribute LTSCs as part of its mission, the AWBA itself is not a market or exchange. Rather, as described below, the ABWA serves as a form of insurance set up by the state to secure supplies for the state.

3. Creation and Use of the AWBA

The AWBA was created by the Arizona Legislature to support the long-term reliability of water for Central Arizona. The AWBA was tasked with storing, on behalf of the state, Arizona's Colorado River supplies that would otherwise go unused.[11] In 1999, the Arizona legislature revised the Arizona Statutes, expanding the role of the AWBA by allowing it to perform groundwater banking services not only for the state of Arizona, but also across a broader set of

participants (including Tribes and other states). These revisions also granted the AWBA permission to store effluent if all excess CAP water had been stored.[12,13]

The AWBA stores the state's unused Colorado River entitlement in advance of shortages. That stored water is accounted for as LTSCs. During shortage conditions in the Lower Colorado River basin, Colorado River water is allocated according to priority. Because CAP water deliveries hold junior priority in the Lower Basin, shortages of Colorado River water will significantly impact CAP subcontractors,[14] as well as other junior priority Colorado River water users. When shortages in the availability of CAP water affect entities for which the AWBA has stored supplies, the AWBA will distribute LTSCs to those entities, generally free of charge. Those entities include on-river municipal long-term Colorado River contract holders, CAP municipal and industrial subcontract holders, and certain Arizona Indian Tribes with rights to Colorado River supplies. For a distribution of LTSCs to occur, the CAP must make a credit request to the AWBA detailing which delivery obligations it is unable to make. AWBA will then review the CAP's request and determine how to distribute credits.[15] Entities receiving a distribution of LTSCs from the AWBA can then exchange the LTSCs for groundwater, in essence substituting an entitlement to pump groundwater in place of surface water deliveries they will not receive as a result of decreased deliveries.[16]

In addition to supporting water users within Arizona, interstate banking allows the AWBA to serve as a key component in the management strategy of all three lower Colorado River basin states. Via the AWBA, California and Nevada can store their excess Colorado River water in Arizona, and, when they need to recover that water, they can exchange accrued LTSCs. The AWBA would then distribute LTSCs to water users in Arizona, substituting stored groundwater for surface water deliveries that instead go to California and Arizona. Currently, the AWBA has agreements to conduct water banking on behalf of both California and Nevada. Yet, as described below, only Nevada actively contracts with the AWBA for water storage. While California has not yet elected to store or use water through the AWBA, it may do so in the future.[17]

In recent years, the ABWA has also become an integral part of several Indian water settlements in central and southern Arizona. In 2004, Congress enacted the Arizona Water Settlement Act[18] (AWSA), which resulted in tribal communities in Arizona holding 46% of the state's CAP supplies, some of which are subject to shortage in drought conditions. As a result, the AWSA required the State of Arizona to 'firm' 15,000 acre-feet per year for tribal communities through the activities of the AWBA.[19] In other words, the AWBA is to annually obtain and hold LTSCs on behalf of those communities. During shortage, those LTSCs will be distributed to tribal communities, allowing them to substitute groundwater they would otherwise not be permitted to pump in place of the CAP surface water supplies they will not receive due to the shortage conditions. To date, approximately 150,000 acre-feet of LTSCs have been accrued by the AWBA on behalf of the Gila River Indian Community in central Arizona. In addition, the AWBA is required to firm up to 3,750 acre-feet per year for the benefit of the White Mountain Apache Tribe in northeastern Arizona, once the settlement becomes enforceable.

4. Managed Aquifer Recharge Through the AWBA

4.1. Recharge

The AWBA creates LTSCs both when water is directly recharged into an aquifer and when surface water supplies substitute for water that would have been pumped from the aquifer. This substitute, or "*in lieu*" water is either Colorado River water or effluent. Water is stored in one of 84 direct recharge and 16 *in lieu* recharge facilities that have been permitted across the state.[20,21]

Direct recharge occurs through state-permitted Underground Storage Facilities (USF)[22]. There are three recognized forms of USF's under state law: (1) *managed USFs* refers to direct recharge by percolation through a stream channel; (2) *infiltration basins* refers to recharge via percolation of water through a large manmade basin; and (3) *injection recharge* refers to recharge through an injection well into the aquifer.[23] USFs are owned and operated by municipal and third party entities. To establish a USF, entities must obtain a permit from ADWR. The USF permitting process[24] includes an initial $2,000 application fee and an application that includes a description of facility characteristics, an analysis of unreasonable harm and hydrologic feasibility, a monitoring plan, the proving of technical and financial capability, and establishment of legal access.[25] In order to store water in a permitted USF, an individual must pay an initial $1000 fee and complete a permit application.[26] This application includes information on the USF chosen for storage, a pre-decision hearing, and a site evaluation.[27]

In lieu recharge occurs through Groundwater Savings Facilities (GSF).[28] These facilities are irrigation districts that utilize Colorado River water, effluent, and other surface water instead of pumping groundwater to which they are legally entitled under the 1980 GMA.[29] Creation of a GSF requires an application, and initial $1,000 payment, and a pre-decision hearing and site visit by AWBA.[30,31] Funding for the operation of USFs and GSFs is the responsibility of their respective owners, who generally obtain that funding through the aforementioned user permits and user fees.[32]

4.2. Accounting

To ensure transparency with the storage, transfer, and withdrawal of water, groundwater stored in the state is tracked through LTSCs.[33] As described above, the LTSC system pre-dates the AWBA and includes underground storage conducted by other entities in the state for other purposes. The rules for creating and using LTSCs are uniform across all entities.

For each acre-foot of water stored via direct recharge in an USF, the user receives an equivalent LTSC minus a 5% deduction, known as "a cut to the aquifer," which is intended to represent water lost through evaporation and provide a net gain of water to the aquifer.[34,35] For each acre-foot of water stored via *in lieu* recharge, written confirmation to ADWR is needed that the recipient will reduce groundwater withdrawals by an amount equivalent to the LTSCs received.[36] ADWR then charges a $2.50 per acre-foot fee when an LTSC is used by its holder to withdraw groundwater from an USF. LTSCs are permanently retired upon recovery of the water.

Holders of LTSCs are entitled to grant, gift, sell, lease, or exchange those credits[37]and there is a thriving market for recharge of water and subsequent sale of LTSCs in Central Arizona. In order for transfer of LTSCs to occur, the seller must first complete an application to the ADWR, accompanied by a $250 fee.[38] Included within this application is pertinent information about the buyer and seller, such as LTSC account numbers and groundwater rights numbers.[39] Holders of a LTSC are entitled to sell LTSCs at any price and the cost to purchase a LTSC has fluctuated over the past ten years between $45 and $400 per acre-foot. Fluctuation of this cost is primarily due to variations in LTSC supply availability in any given year.

The AWBA obtains LTSCs through (1) purchase of a specified volume of water from a storing entity; (2) placement of water in an USF for at least one year; (3) utilization of a GSF for *in lieu* recharge; or, (4) transfer among storage and recovery entities. The AWBA will only purchase LTSCs on behalf of the state at a price that is less than or equal to the cost to the AWBA to store CAP water at the time of purchase.[40] While the AWBA can purchase LTSCs, the AWBA is not authorized to sell its LTSCs and can only distribute them in accordance with its statutory mission.

LTSCs held by the AWBA are designated for entities based on the funding source that was used to acquire them. As described below, most AWBA funding stems from an ad valorem property tax, groundwater withdrawal fees, and the state general fund. LTSCs acquired from the ad valorem property tax are designated for distribution to municipal and industrial users within the county in which the funds were acquired. LTSCs acquired using other funding sources may be used with more flexibility, and will be distributed.

4.3. Recovery of LTSCs

As described above, until 2019 LTSCs could only be used to withdraw water within the same Active Management Area[41] (AMA) where the water the LTSC represents was stored, and recovery must occur via a well permitted by ADWR.[42] Under the Colorado Drought Contingency Plan, the AWBA is now allowed to transfer LTSCs across AMA boundaries. Recovery can be completed as long as the groundwater table in the area of recovery has not experienced more than four feet average annual decline.[43,44] Management of LTSC accounts, and the buying and selling of LTSCs, is uniform across all entities who store groundwater and all storage facilities, regardless of whether created by direct or *in lieu* recharge.

5. Management

5.1. Institutional Structure

The AWBA is housed at ADWR, which provides administrative and technical support. ADWR performs its managerial duties in coordination with the Central Arizona Water Conservation District (CAWCD), which manages and operates the CAP. ADWR is responsible for the allocation and regulation of the use of Colorado River water. ADWR also is responsible for the permitting of USFs, GSFs and the management of LTSC accounts.[45] CAWCD serves as the chief manager and operator of the CAP, and contracts delivery of Colorado River water to AWBA storage facilities.[46] GSFs and USFs are regulated by ADWR but managed by their respective permittees;

these permittees must manage and maintain their recharge facilities in order to assure safe conditions for future usage.

The AWBA is governed by a seven member committee: five have full voting rights, and two are non-voting state legislators. The committee reviews and approves the AWBA's plan of operation, the annual budget, and operational agreements, among other tasks.[47] The ADWR director serves as committee chairman. Three members are appointed by the governor to represent: (1) a large CAP municipal and industrial subcontractor; (2) a representative of an entity holding a mainstream Colorado River contract; and, (3) a person knowledgeable in water resource management.[48] The president of CAWCD or their designee also serves as a member of the Authority.[49] The final two non-voting members of the AWBA governing committee are the President of the Arizona Senate and the Speaker of the Arizona House of Representatives, or their designees.[50] Members serve six year terms.[51]

5.2. Costs and Financing of the AWBA

Operation of the AWBA is financed through a variety of means.[52] The AWBA primarily obtains revenues through state-wide groundwater withdrawal fees of $2.50 per acre-foot of extracted groundwater and an $0.04 ad valorem property tax collected in Maricopa, Pinal, and Pima counties.[53] AWBA funding also comes from state legislative appropriations from the Annual General Fund for water banking and for groundwater replenishment purposes. Lastly, the AWBA receives monies from authorized interstate banking entities in California and Nevada,[54] including $8 Million from the Southern Nevada Water Authority and $100 Million from Nevada as part of an Interstate Water Banking Agreement, intended to develop alternative water supplies for Nevada. The AWBA has stored over 613,000 acre-feet of LTSCs on behalf of the Southern Nevada Water Authority (SNWA), at a cost to SNWA of just under $112.4 million. This storage, which included a portion of Nevada's unused Colorado River entitlement, will be recovered in Arizona allowing an equivalent amount of Arizona's and Nevada's Colorado River entitlements to be diverted from Lake Mead in the future for use in southern Nevada.

While not a core funding source, the AWBA also received $8 million in "shortage reparation" funds from SNWA pursuant to a shortage-sharing agreement between Arizona and Nevada. The purpose of these funds is to assist Arizona in offsetting impacts related to Colorado River shortages because Arizona agreed to take a greater proportion of the reductions. The AWBA has used these funds to purchase and store water.

In carrying out its operations, the AWBA can also request that its GSF partners, as recipients of *in lieu* water, pay a share of the water delivery costs.[55] For simplicity, these costs are paid directly to CAWCD. Additionally, the AWBA can collect fees from persons and Indian communities in the state that have entered into water banking services agreements with the AWBA.[56]

6. Analysis and Summary

The AWBA is a prime example of groundwater banking through MAR. Surplus surface water supplies are stored (either directly or indirectly) underground and can be recovered at a future

date. Stored water can also be transferred across water bank users, and, with constraints, locations. Through this banking scheme, Arizona is able to make full use of its Colorado River entitlement and manage future risks related to fluctuations in supply availability.

6.1. Key Elements

Several ingredients were key to implementation of the AWBA, including: strong state support and political leaders' commitment to funding; availability of surplus water for storage and the infrastructure system used to convey that water from the Colorado river to recharge sites; and the ability to serve a wide and diverse set of water users.

The AWBA is the product of, and would not be possible without, strong state involvement and support. It was created by the state legislature for the purposes of supporting the state in making use of the state's Colorado River entitlement for the benefit of the state. The state's legal and regulatory framework also provides the backbone of its functioning. Prior to the AWBA, the state had already developed rules and regulations for underground storage and recovery of groundwater as well as a public accounting system tracking the creation of LTSCs. Further, the state created a financial structure that supports the AWBA, including appropriations from the state general fund, collection groundwater withdrawal fees and an ad valorem property tax. In addition, the state assumes the primary role of running the water bank, including both the roles of ADWR in overseeing permitting as well as the administrative role of ADWR in the day-to-day functioning of the AWBA. Lastly, the state's authority to enter into interstate agreements is key to the AWBA's ability to serve users in Nevada and California.

The availability of unused Colorado River water is central to the success of the AWBA. Without this water, the AWBA would not be possible, as there would not be a source of water for either direct or indirect recharge. Further without the CAP, construction of which was funded by the US federal government, the AWBA would be unable to transport that water to storage locations, or during recovery, from storage locations to points of delivery. As discussed below, future availability of Colorado River water is at risk and may impact long-term functioning of the Bank.

Lastly, the scale and diversity of water users benefitting from the AWBA is an important contributor to its success. The AWBA provides a statewide benefit even though its MAR activities are limited to central and southern Arizona by ensuring secure long-term water supplies for the state's major economic sectors and reducing the potential for water transfers from rural communities to larger urban communities. The connection to the Colorado River as a transboundary source allows the AWBA to provide interstate services such that Nevada and California can store surplus Colorado River water and exchange that stored water for surface water at a later date. The AWBA also supports CAP settlement Tribes through accrual of LTSCs on their behalf. Lastly and most recently, the AWBA is playing a key role in the success of the intra-state Drought Contingency Plan by facilitating the exchange of existing LTSCs between AMAs, something never before authorized.

6.2. Challenges and Future Considerations

For two and a half decades, the AWBA has functioned as a mechanism for increasing water supply reliability in the state's major population centers. Through the AWBA, the state of Arizona, water users within the state, and the state of Nevada have stored water and have exchanged LTSCs. As of 2018, the AWBA had stored more than 4 million acre-feet of unused Colorado River water in aquifers located in central and southern Arizona. [57]

The availability of unused Colorado River water has been essential to the success of AWBA. However, the volume of unused Colorado River water available to the AWBA has been decreasing since 2010. Furthermore, modeling of future hydrologic conditions performed by the U.S. Bureau of Reclamation, ADWR and CAWCD indicate that shortage conditions in the Lower Basin could occur as soon as 2021. During shortage conditions, no Colorado River water will be available to the Bank. With the continuing decrease in Colorado River supplies expected in the future, combined with increasing demands for water in central Arizona, the AWBA is faced with the need to re-examine its goals and explore new ways of securing sustainable water supplies for the state's communities.

The reduced availability of Colorado River water means future AWBA operational activities will likely shift from emphasizing storage to a greater emphasis on water management.[58,59] AWBA was specifically designed to store Colorado River water when available, with recognition that with population growth and increasing demands, surplus Colorado River water availability would decline over time.[60] As availability of water of water for storage declines, AWBA's efforts will shift to distribution of LTSCs. These shifts may create operational challenges for the AWBA. First, questions remain about water recovery. While much of the water stored in USFs and via *in lieu* recharge is located in proximity to infrastructure for recovery, 25% of water stored in USFs is located in areas where no wells or other infrastructure exist to recover or to transport recovered water.[61] Recovery of that water will either require construction of additional infrastructure or indirect recovery through exchange of LTSCs at locations closer to demands. This presents challenges related both to cost as well as to the maintenance of water levels and water quality. In some areas, recharged water was stored in aquifers that had high levels of arsenic and fluoride.[62] Water recovered from those storage facilities will require treatment prior to use.

Second, there is the issue of balancing supplies and demands. While a large quantity of water has been stored for future use, that supply is not infinite. Further, storage is not fully efficient, and there remain uncertainties regarding the full extent to which stored water is recoverable. The 5% cut to the aquifer assigned when calculating LTSCs at USFs was a negotiated number that may inadequately represent the true losses from storage. For the bank to stay "solvent" there will need to be deposits as well as withdrawals and checks to ensure "paper water" matches physical supplies. Lastly, the newly passed provision allowing transfer of LTSCs across AMA boundaries means that water can be withdrawn from aquifers other than those to which it was recharged. This presents a potential risk if demands are located in areas where recharge has not sufficiently occurred. This raises questions related to how future climate change along

with increasing demands for Colorado River water and other water will affect the operations of the AWBA.

7. Analysis and Summary

Today, the Arizona Water Banking Authority is an example of a public institution with a 20-year history of using conjunctive management to maximize use of renewable water supplies. The AWBA has served as a massive insurance policy against future municipal water shortages on the Colorado River. Since its inception in 1996, at a cost of roughly $400 million through 2018, the AWBA has developed over 4 million acre-feet of LTSCs that can be tapped when Colorado River shortages in the Lower Basin materialize.

In addition to providing a firming supply to M&I users holding CAP subcontracts and providing for interstate water banking with Nevada and California, the AWBA also provides a firming supply for implementing Indian water settlements across Arizona. Further, the AWBA is authorized to use its LTSCs to meet a wide variety of water management goals within the Phoenix, Pinal and Tucson AMAs. The AWBA has thus served to secure water for a wide range of beneficiaries. The longevity of this security, and the continued effectiveness of the AWBA will depend on the how well the availability of water for storage and currently stored supplies match with future recovery needs.

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Endnotes

[1] Effluent is treated process water or waste water.

[2] Arizona Department of Water Resources. (1999). *Annual Report 1999 Arizona Water Banking Authority*. Retrieved May 24, 2019 from http://www.azwaterbank.gov/documents/1999/report99.pdf

[3] Arizona Department of Water Resources. (1999). *Annual Report 1999 Arizona Water Banking Authority*. Retrieved May 24, 2019 from http://www.azwaterbank.gov/documents/1999/report99.pdf

[4] Arizona Department of Water Resources. (no date). *Water Supply and Water Rights.* Retrieved from https://www.cap-az.com/departments/planning/colorado-river-programs/water-supply-and-water-rights

[5] Person, D. (2018). *Central Arizona Project Celebrates 50th Anniversary of the Colorado River Basin Project Act*. Retrieved March 4, 2019, from https://www.cap-az.com/public/press-releases/745-central-arizona-project-celebrates-50th-anniversary-of-the-colorado-river-basin-project-act

[6] Person, D. (2018). *Central Arizona Project Celebrates 50th Anniversary of the Colorado River Basin Project Act*. Retrieved March 4, 2019, from https://www.cap-az.com/public/press-releases/745-central-arizona-project-celebrates-50th-anniversary-of-the-colorado-river-basin-project-act

[7] Phoenix, Pinal, Tucson, Prescott and Santa Cruz Active Management Areas

[8] Silber-Coats, N., & Eden, S. (2017). Arizona Water Banking, Recharge, and Recovery. *Arroyo*. University of Arizona Water Resources Research Center. Retrieved March 15, 2019, from https://wrrc.arizona.edu/sites/wrrc.arizona.edu/files/attachment/Arroyo-2017.pdf

[9] Silber-Coats, N., & Eden, S. (2017). Arizona Water Banking, Recharge, and Recovery. *Arroyo*. University of Arizona Water Resources Research Center. Retrieved March 15, 2019, from https://wrrc.arizona.edu/sites/wrrc.arizona.edu/files/attachment/Arroyo-2017.pdf

[10] SB1227/HB2545

[11] As described in the analysis section of this manuscript, operations of the AWBA are shifting with changing conditions. Due to concerns about shortages in the Lower Basin, Arizona is now intentionally leaving water in Lake Mead as system conservation through the Drought Contingency Plan and other programs. Where once a main goal of AWBA was to ensure Arizona used its full entitlement of Colorado River water by storing it underground as a hedge against drought and shortage, Arizona is now focused on intentionally leaving portions of its Colorado River water in Lake Mead to prevent shortage conditions.

[12] Personal communication, AWBA, April 30, 2019

[13] Arizona Department of Water Resources. (1999). *Annual Report 1999 Arizona Water Banking Authority*. Retrieved May 24, 2019 from http://www.azwaterbank.gov/documents/1999/report99.pdf

[14] Under the Boulder Canyon Project Act of 1928, all users of Colorado River water in the Lower Colorado River basin are required to have a water delivery contract with the US Bureau of Reclamation (USBR). The Central Arizona Project holds a contract with the USBR for part of Arizona's entitlement to the Colorado River. Water users who receive CAP water are considered subcontractors, as they hold contracts with the CAP, which then has contract with the USBR. See https://www.usbr.gov/lc/region/g4000/wtrcontracts.html and Dishlip (2007) A Guide to Colorado River Water Supplies and Entitlements in Arizona https://new.azwater.gov/sites/default/files/Namwua_Dishlip%20report1.pdf

[15] With some exceptions, AWBA has discretion to determine when and how to distribute or distinguish LTSCs (ARS_§45-2457(D)). LTSCs obtained using funds from ad valorem taxes are required by statute to be used within the county paying the tax. Further, LTSCs obtained for interstate banking or tribal water rights settlements must be dedicated to those respective uses. See Silber-Coats, N., & Eden, S. (2017). Arizona Water Banking, Recharge, and Recovery. *Arroyo*. University of Arizona Water Resources Research Center. Retrieved March 15, 2019, from https://wrrc.arizona.edu/sites/wrrc.arizona.edu/files/attachment/Arroyo-2017.pdf

[16] Arizona Senate. (2015). *Arizona State Senate Issue Brief Arizona Water Banking Authority.*

[17] Personal communication, AWBA, April 30, 2019

[18] P.L.108-451, 108th Congress.

[19] Generally, "firm yield" refers to the amount of water that can be expected in most circumstances, including drought conditions.

[20] Arizona Department of Water Resources. (2019). *Active Groundwater Savings Facilities*. Retrieved April 8, 2019, from http://www.azwater.gov/querycenter/query.aspx?qrysessionid=4C8820B502DD32F9E0534C00000A01DC

[21] Arizona Department of Water Resources. (2019). *Active USF's* (Rep.). Retrieved March 4, 2019, from http://www.azwater.gov/querycenter/query.aspx?qrysessionid=4BF6C620A82B9838E0534C00000A47B1

[22] For complete information on all active USF's, see the ADWR's website at http://www.azwater.gov/querycenter/query.aspx?qrysessionid=4BF6C620A82B9838E0534C00000A47B1.

[23] Arizona Water Banking Authority. (no date). *Water Storage.* Retrieved March 4, 2019, from http://www.azwaterbank.gov/Water_Storage/Recharge_and_Facilities.htm#Facilities

[24] For more information on the permitting process of an USF, the application checklist for USF permitting can be found on the ADWR website, under 'apply for an underground storage facility permit'.

[25] Arizona Department of Water Resources. (2017) *Underground Storage Facility Application Checklist* Retrieved March 1, 2019, from https://new.azwater.gov/sites/default/files/media/USF Checklist for Website (Final Version 10-3-2017)_0.pdf

[26] For more information on the permitting process to store water in an USF, the application to do so can be found on the ADWR website under 'apply for a water storage permit' See https://new.azwater.gov/recharge/applications

[27] Arizona Department of Water Resources. (2018). *Application for Groundwater Savings Facility Permit* Retrieved May 24, 2019 from https://new.azwater.gov/recharge/applications

[28] For complete information on all active GSF's, see the ADWR's website at http://www.azwater.gov/querycenter/query.aspx?qrysessionid=4C8820B502DD32F9E0534C00000A01DC

[29] Arizona Department of Water Resources. (2019). *Active Groundwater Savings Facilities*. Retrieved April 8, 2019, from http://www.azwater.gov/querycenter/query.aspx?qrysessionid=4C8820B502DD32F9E0534C00000A01DC

[30] For more information on the permitting process of a GSF, the application for a GSF permit can be found on the ADWR website, under 'apply for a groundwater savings facility permit'.
[31] Arizona Department of Water Resources. (2018). *Application for Groundwater Savings Facility Permit* Retrieved May 24, 2019 from https://new.azwater.gov/recharge/applications
[32] Arizona Department of Water Resources. (no date). *Assured and Adequate Water Supply.* Retrieved March 15, 2019, from https://new.azwater.gov/aaws
[33] Buschastzke. T. (2017). *Annual Report 2016* Arizona Water Banking Authority. Phoenix, AZ.
[34] There is not a detailed modeling analysis that calculates potential loss from movement within the aquifer.
[35] Silber-Coats, N., & Eden, S. (2017). Arizona Water Banking, Recharge, and Recovery. *Arroyo*. University of Arizona Water Resources Research Center. Retrieved March 15, 2019, from https://wrrc.arizona.edu/sites/wrrc.arizona.edu/files/attachment/Arroyo-2017.pdf
[36] Arizona Department of Water Resources. (2018). *Application for Water Storage Permit* Retrieved May 24, 2019 from https://new.azwater.gov/recharge/applications
[37] Arizona Department of Water Resources. (no date). *Underground Water Storage, Savings, and Recovery*. Retrieved March 1, 2019, from https://new.azwater.gov/recharge/accounting
[38] For more information on the permitting process to transfer LTSC's among entities, the application to do so can be found on the ADWR website under 'transfer long term storage credits'.
[39] Arizona Department of Water Resources. (2018). *Long Term Storage Credit Transfer Form* Retrieved May 24, 2019 from https://new.azwater.gov/sites/default/files/LTSC%20Transfer%20Form_6-1-2016.pdf
[40] Personal communication, AWBA, April 30, 2019
[41] Under Arizona's Groundwater Management Act, five regions of the state are designated as Active Management Areas. These regions, which encompass the major urban and agricultural centers of the state, are governed by groundwater management plans and are subject to more stringent groundwater regulations than other portions of the state (See Megdal, S., Smith, Z., & Lien, A. (2008). *Evolution and Evaluation of the Active Management Area Management Plans*. Arizona Water Institute)
[42] Silber-Coats, N., & Eden, S. (2017). Arizona Water Banking, Recharge, and Recovery. *Arroyo*. University of Arizona Water Resources Research Center. Retrieved March 15, 2019, from https://wrrc.arizona.edu/sites/wrrc.arizona.edu/files/attachment/Arroyo-2017.pdf
[43] Silber-Coats, N., & Eden, S. (2017). Arizona Water Banking, Recharge, and Recovery. *Arroyo*. University of Arizona Water Resources Research Center. Retrieved March 15, 2019, from https://wrrc.arizona.edu/sites/wrrc.arizona.edu/files/attachment/Arroyo-2017.pdf
[44] This constraint means that withdrawals of groundwater are allowed even while a notable level of drawdown is occurring. The basis for selecting 4' average decline as the threshold at which withdraws would be prohibited is not known, and personnel at AWBA commented that this was likely a negotiated number, and not based on a technical assessment of recharge or recovery potential (Personal communication, AWBA, April 30, 2019).
[45] Megdal, S. B. (2012). *Arizona Groundwater Management*. Retrieved March 5, 2019, from https://wrrc.arizona.edu/sites/wrrc.arizona.edu/files/AZgroundwater-management.pdf
[46] Cite to the AWBA website
[47] Buschastzke. T. (2017). *Annual Report 2016* Arizona Water Banking Authority. Phoenix, AZ.
[48] A.R.S. §45-2421(A).
[49] A.R.S. §45-2421(A).
[50] (A.R.S. §45-2421(F).
[51] (A.R.S. §45-2421(C).
[52] See http://www.azwaterbank.gov/Background/Funding.htm.
[53] (A.R.S. §45-2425(B)); Arizona Water Banking Authority. (n.d). *Funding*. Retrieved March 4, 2019, from http://www.azwaterbank.gov/Background/Funding.htm
[54] (A.R.S. §45-2425(B)). Approximately 600,000 acre-feet has been stored in Arizona's aquifers for future use in southern Nevada.
[55] (A.R.S. §45-2455(C)).
[56] (A.R.S. §45-2458).
[57] Barchfield,V. and Davis, T. (2018) *Arizona Has Been Banking CAP Water But Doesn't Have a Clear Plan to Withdraw It.* Arizona Public Media Retrieved May 24, 2019 from

https://news.azpm.org/p/lastdrop/2018/8/20/135331-arizona-has-been-banking-cap-water-but-doesnt-have-a-clear-plan-to-withdraw-it/

[58] Buschastzke. T. (2017). *Annual Report 2016* Arizona Water Banking Authority. Phoenix, AZ. and Buschastzke. T. (2018). *Annual Report 2017* Arizona Water Banking Authority. Phoenix, AZ.

[59] When the AWBA was established in 1996, it was anticipated that the state's unused Colorado River supplies would diminish over time. In fact, the enabling legislation only authorized the AWBA to acquire Colorado River water through 2016. This provision has since been repealed and the duties of the AWBA expanded.

[60] O'Connell, V., & Rossi, T. S. (2017). *2016 Annual Report and Ten Year Plan* Presentation for the Arizona Water Banking Authority quarterly meeting). Phoenix, AZ: Arizona Water Banking Authority. Retrieved May 24, 2019 from http://www.azwaterbank.gov/Meetings/documents/09-2016AnnualReportandTenYearPlanPresentation06.27.17.pdf

[61] Barchfield,V. and Davis, T. (2018) *Arizona Has Been Banking CAP Water But Doesn't Have a Clear Plan to Withdraw It.* Arizona Public Media Retrieved May 24, 2019 from https://news.azpm.org/p/lastdrop/2018/8/20/135331-arizona-has-been-banking-cap-water-but-doesnt-have-a-clear-plan-to-withdraw-it/

[62] Barchfield,V. and Davis, T. (2018) *Arizona Has Been Banking CAP Water But Doesn't Have a Clear Plan to Withdraw It.* Arizona Public Media Retrieved May 24, 2019 from https://news.azpm.org/p/lastdrop/2018/8/20/135331-arizona-has-been-banking-cap-water-but-doesnt-have-a-clear-plan-to-withdraw-it/