Case Study: H_2Oaks Aquifer Storage and Recovery

Incentivizing Groundwater Recharge

Case Study #11

Working Draft

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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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H_2Oaks Aquifer Storage and Recovery

Incentivizing Groundwater Recharge – Case Study #11

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Overview

Location: Bexar County, Texas
Motivation for MAR: Pumping restrictions on Edwards Aquifer, no carry over provision for Edwards Aquifer water, cost of imported water
Groundwater Challenges: Water quality, overuse, dependence
MAR Challenges: Distribution system challenges, movement of recharged water
Project Goals: Drought reserve
Key Actor: San Antonio Water System (SAWS)
Water Source: Edwards Aquifer water
Start Date: June 2004
Current Status: Operational
Project capacity: 30,100 AFY (current production capacity); 57,000 AFY (future production capacity after completion of Western Integration Pipeline)
Cost: $250 million for entire project

1. Motivation and Goals

San Antonio Water Systems (SAWS) developed its H_2Oaks aquifer storage and recovery (ASR) project in response to pumping restrictions set on its primary source of water supply, the Edwards Aquifer, by the Edwards Aquifer Authority. The H_2Oaks project pumps water from the Edwards Aquifer during wet years and transports it to the H_2Oaks Center, where it is injected into the Carrizo Aquifer for storage. Stored water is withdrawn to meet municipal demand during periods of extended drought when Edwards Aquifer pumping restrictions are in place and has replaced the need to develop a more traditional source of water.

2. Geographic and Historical Context

The H_2Oaks Aquifer Storage and Recovery (H_2Oaks) project is located in the southern tip of Bexar County and is the largest of the three ASR facilities in Texas.[1] It is operated by San Antonio Water System (SAWS), a public water utility that serves Bexar County as well as small parts of Comal, Medina, Atascosa, and Kendall Counties in southern Texas.[2] The region is mainly a modified humid subtropical climate, with semi-arid conditions to the west.[3] The average rainfall in the region is approximately 32 inches per year, but this amount is highly variable. The area experiences long dry periods and periods of extremely high rainfall.[4] Due to this variability in weather patterns, water supply and demand has historically been imbalanced.[5]

SAWS serves a primarily urban and suburban area with residential and commercial customers.[6] It was formed in 1992 by consolidating three existing city utilities, making it the sole agency responsible for wastewater, drinking water, stormwater, and reuse.[7, 8] The utility is headquartered in San Antonio, which houses approximately 1.4 million of its 1.9 million ratepayers.[9] Although non-residential industrial accounts make up only 6% of SAWS customer base, they account for 41% of the utility's water usage.[10] Overall water usage has trended downward in recent years due to the utility's focus on encouraging conservation.[11]

Three major aquifers in the region supply water to SAWS: Edwards, Trinity, and Carrizo-Wilcox.[12] The Edwards Aquifer provides a majority of the water supply to the utility, accounting for 66% of its total water supply in 2018.[13] In addition to groundwater, SAWS has capacity to produce 25,000 acre-feet per year (AFY) in treated recycled water, which primarily is used by commercial and industrial customers, as well as golf courses and parks.[14] Additionally, SAWS recently completed the first phase of a desalination plant at the H_2Oaks site, which can desalinate 11,200 AFY of brackish Lower Wilcox Aquifer water.[15] SAWs also has contracts to purchase supplemental water from other water suppliers that are withdrawing from the Trinity Aquifer, Carrizo-Wilcox Aquifer, Canyon Lake, Medina System and Lake Dunlap.[16] SAWS acquired additional water rights after absorbing the Bexar Metropolitan Water District (Bexar Met) in 2011. Bexar Met was struggling to meet demand, prompting Senate Bill 341 to call for the dissolution of the agency.[17] Through the merger, Bexar Met ratepayers decreased their water rates, and SAWS gained Bexar Met's 23,238 AFY of Edwards Aquifer water rights, as well as their Canyon Regional Water Authority, Medina Lake, and Trinity Aquifer water allocations.[18]

As the urban population in SAWS's service area grew, it became increasingly clear that the utility needed a more stable source of water during its regular periods of drought.[19] In dry years, SAWS was spending millions purchasing supplemental water, while in wet years a portion of their Edwards Aquifer water was going unused. These factors led the utility to search for an efficient method to store water for use in dry periods. SAWS concluded that ASR would be the most feasible way to accomplish this. In September 1996, the utility was awarded $200,000 by the Texas Water Development Board to conduct a recharge feasibility study.[20, 21] The Carrizo-Wilcox Aquifer was selected as the most cost effective site for aquifer storage and recovery (ASR).[22]

In September 1999, SAWS took the first step towards developing an ASR project by purchasing a tract of farmland over the Carrizo-Wilcox Aquifer. By February 2000, the utility had a total of 3,200 acres of land – more than needed for the project.[23] By purchasing a larger amount of land than strictly needed for recharge operations, SAWS is able to afford some protection to its recharged water by preventing nearby withdrawals by other groundwater users.[24] The land is leased back to its original owners and continues to be used for agriculture and grazing.[25] In November 2001, SAWS obtained permitting from the Texas Commission on Environmental Quality to build and operate an ASR system on their purchased land.[26] Construction of the Twin Oaks ASR facility began in August of 2002 and the facility was opened in June 2004. The site is now known as the H_2Oaks Center, where the ASR project, the desalination plant, and Carrizo aquifer production wells are operated in the same location.

3. Regulatory Setting

3.1 Water Rights in Texas

Surface water in Texas is owned by the State and allocated by water right permits from the Texas Commission on Environmental Quality (TCEQ) pursuant to the 1967 Water Rights Adjudication Act. Water right applications must demonstrate beneficial use, with domestic and municipal uses having the highest preference. Water rights also follow the prior appropriations doctrine, so they have a priority date based on when the application is completed.[27] Groundwater is not owned by the state, and instead is governed by common law where landowners have the right to pump as much water as they want from beneath their property. Adopted by the Texas Supreme Court in 1904, this "rule of capture" provides no compensation to individuals whose wells go dry due to their neighbor's excessive pumping. There is no "reasonable use" provision for groundwater extraction in Texas.[28]

3.2 Edwards Aquifer Authority Act

In 1991, the Sierra Club filed a lawsuit against the United States Fish and Wildlife Service (USFWS) asserting that USFWS had violated the Endangered Species Act by failing to maintain springflows at the San Marcos and Comal Springs, which are fed by the Edwards Aquifer.[29] The court ruled in favor of the Sierra Club, requiring springflows to be maintained and ordering the creation of a regulatory system to restrict withdrawals from the Edwards Aquifer.[30] To meet this second demand, Texas State Legislature created the Edwards Aquifer Authority (EAA) in 1993 (the EAA Act).[31] After several court challenges and amendments to the Act, the EAA became operational in 1996 with the powers to manage and protect the Edwards Aquifer.[32]

The EAA manages the aquifer by issuing permits for withdrawals, with a total of approximately 572,000 AF permitted each year. Allocations were initially determined based on historical use and conservation goals. The EAA can impose restrictions during times of drought, reducing withdrawals by up to 44% of the permitted amount based on aquifer levels and springflow.[33]

The EAA assesses an aquifer management fee for all permitted users. For non-agricultural users, this annual fee is based on the amount of permitted groundwater controlled by the permit holder, whereas for agricultural users, the fee is calculated from the previous year's groundwater use. In 2019, non-agricultural fees were $84/AF and agricultural fees were $2/AF, a value determined in the EAA Act.[34] Allocations are yearly amounts, with no carry over between years allowed.[35] This restriction has led to the creation of a water market for Edwards Aquifer water in which water rights, or portions of them, can be sold or leased.

3.3 Groundwater Conservation Districts

Across Texas, a number of regions are governed by Groundwater Conservation Districts (GCDs). GCDs can be created by an act of the legislature, landowner petition, or by the TCEQ when local action is not taken within a priority groundwater management area. These districts have the authority to regulate local groundwater use by requiring all wells to be permitted and developing a management plan for their region – in essence, GCDs override the rule of capture for groundwater in Texas. GCD powers vary depending on how the district was created, but in many cases they have authority to make rules about aquifer storage and recovery. As of February 2019, about 70% of Texas counties are covered or partially covered by a GCD.[36]

In Bexar County, the Carrizo-Wilcox Aquifer is not regulated by any GCD. However, just south of Bexar County, the Evergreen Underground Water Conservation District ("Evergreen District") has jurisdiction. During the development of the H_2Oaks project, residents near the project site were concerned about the impact that it would have on their groundwater. These residents asked to be annexed into the Evergreen District, which would have subjected SAWS to pumping restrictions. The annexation vote failed, yet to address concerns about the project's impacts within Bexar County and adjacent areas, in 2002, SAWS and the Evergreen District entered into a Water Resource Protection and Management Agreement. In this agreement, SAWS agreed to limit their pumping of native Carrizo Aquifer water at the recharge site to 2 AF per acre of land, amounting to a total of 6,400 AFY that can be pumped in addition to recovered Edwards Aquifer water. The agreement restricts water that may be recharged to only Edwards Aquifer water (i.e. no reclaimed wastewater) to mitigate fears of contaminating the groundwater within the region.[37] SAWS was also required to develop a monitoring and mitigation program that would extend outside of Bexar County to limit any negative impacts of recharge and recovery operations on other groundwater users.[38]

3.4 ASR in Texas and Required Permits

Texas law recognizes aquifer storage and recovery (ASR) as a beneficial use of surface water and defines ASR as storing water underground for later beneficial use using injection wells.[39] The TCEQ administers the Underground Injection Control Program within the state, which was developed by the EPA to comply with the 1974 Safe Drinking Water Act. The program requires all injection wells to be permitted as Class V injection wells.[40] SAWS received a Class V Injection Well Permit from the TCEQ for operation of their ASR project. Other permits required for ASR projects depend on source of water and location of project. In areas covered by GCDs, the GCD may have local jurisdiction over the project.

4. Managed Aquifer Recharge Through H_2Oaks ASR

SAWS currently has an entitlement for 272,372 AF per year of Edwards Aquifer water.[41] This full quantity is needed every year, but if SAWS does not pump it, it will lose the water while still paying its yearly Edwards Aquifer fee.[42] Additionally, when SAWS does need the water during dry years, pumping restrictions on the aquifer may mean that pumping is curtailed by up to 44% of its permitted amount. To avoid paying for water it does not use and to save water for future droughts, SAWS pumps, transports and injects its unneeded Edwards Aquifer water into the Carrizo Aquifer for storage.

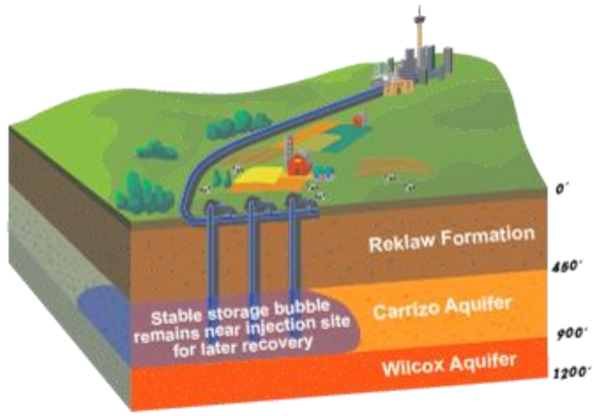

Figure 1 The H2Oaks system and aquifer formations. Source: SAWS.

4.1 Recharge

The H_2Oaks ASR project injects water pumped from the Edwards Aquifer into the Carrizo Aquifer during wet years or years with low demand.[43] A pipeline carries Edwards Aquifer water 30 plus miles from the SAWS Edwards Aquifer production wells to the H_2Oaks facility's 29 injection and recovery wells.[44] Before injection, the water is disinfected with chlorine. The water is then injected into the 400-600 foot level of the Carrizo Aquifer, where it forms a stable water bubble in the confined sand aquifer.

4.2 Accounting

SAWS tracks the amount of water in storage and is entitled to recover this amount with no loss factor.[45] The utility has measured that the aquifer has the capacity to store a total of approximately 200,000 AF. As of July 2019, 176,000 AF were stored, the equivalent of more than half the year's potable demand.[46, 47]

SAWS operates an extensive monitoring and mitigation program to address any offsite impacts of the recharge and recovery program. Thirteen monitoring wells are used to track water quality and water levels in Bexar, Wilson, and Atascosa counties. Mitigation activities have included replacing wells and lowering pumps.[48] The Carrizo Aquifer has a pH of 5.5 and contains elevated iron, manganese, and hydrogen sulfide, but has not been shown to contaminate stored Edwards Aquifer water.[49]

4.3 Recovery

Water is recovered when needed during dry periods through the same 29 wells used for injection. Two pipelines are used to recharge and receive stored water.[50] The existence of two pipelines gives SAWS the ability to inject water at the site while simultaneously distributing water to customers. The capacity of recovery is approximately 67,000 AFY.[51] Recovered Edwards Aquifer water is disinfected before distribution.[52] Native Carrizo Aquifer water, which requires full treatment as well as disinfection, is also pumped at the site through seven wells located both on and off the ASR site.[53] During the drought that occurred between 2011 and 2014, SAWS recovered over 50,000 AF of stored water to meet ratepayer demand.[54]

5. Management

5.1 Institutional Structure

SAWS is the primary decision-maker regarding the operation of the H_2Oaks project, both for day-to-day management and long-term project improvements. However, since SAWS is a public utility owned by the City of San Antonio, the San Antonio City Council has a key oversight role. The utility is governed by a Board of Trustees consisting of the Mayor of San Antonio and six members appointed by the San Antonio City Council.[55] Members of the Board serve four year terms. The Board is responsible for directing the utility by setting policy goals which are then implemented by the President/CEO.[56] The day to day operation and maintenance of the ASR facility is conducted by the Production and Treatment Group, a group of 388 employees who manage the entire SAWS wastewater and water system.[57]

Although the Edwards Aquifer Authority is not involved in the management of the ASR project, it has a large effect on how and when the project operates, due to its authority to regulate Edwards Aquifer withdrawals. Currently, the H_2Oaks facility only injects Edwards Aquifer water, making EAA permitting a vital part of the project. The EAA determines how much SAWS and other entities are allocated yearly based on the hydrologic condition of the aquifer and projected flows at the springs on the eastern edge of the Aquifer. However, SAWS can always obtain more Edwards Aquifer water by purchasing or leasing additional Edwards Aquifer water rights.

SAWS customers play an important role in supporting SAWS and the H_2Oaks project, both through funding and participation in committees and panels. Through advisory committees and panels, customers can choose to be further involved in the agency. The Capital Improvements and Advisory Committee, for example, advises and assists with implementation of fees for SAWS to recuperate the costs of offsite capital improvements. In a similar vein, the Rate Advisory Committee helps SAWS develop a rate structure that fairly balances operational needs with available financial resources. Additionally, the Citizens Advisory Panel helps SAWS management assess customer interest and support for new water supply projects, plans and policies that look to develop more sustainable and affordable water programs. SAWS also has two sustainability focused committees that generate ideas and bring local citizens and groups together to speak about conservation, water, and future planning. Such citizen committees demonstrate emphasis placed on non-monetary ratepayer support of SAWS. Not only are the customers paying for the maintenance of the project, they are also involved in determining need for new development, current projects, and in construction of rates.

5.2 Costs and Financing

The total cost of constructing the H_2Oaks ASR facility, including transmission pipelines, water treatment facilities, ASR wells, the mitigation program, land acquisition, engineering and permitting, was approximately $250 million.[58] From 2019-2023, SAWS estimates that they will spend approximately $39.5 million in capital improvements for H_2Oaks.[59]

The H_2Oaks project was the first at SAWS to be funded almost entirely by its ratepayers, who pay a Water Supply Fee to fund the development of new water sources.[60] The rate is assessed monthly on potable water usage and follows a tiered structure within each use category to encourage conservation. In the residential use category, fees start at $0.074 per 100 gallons when at least 2,992 gallons per month are used and rise to $.4809 per 100 gallons when over 20,199 gallons are used each month.[61] There are three other classes: general, wholesale, and irrigation, each with its own fee structure. SAWS also passes on EAA permit fees to customers, which come to $.03561 per 100 gallons of usage.[62] SAWS customers pay for the water they use through monthly service and volume charges, which vary based on meter size and water use.[63]

6. Analysis and Summary

The SAWS ASR project at the H_2Oaks Center is an example of a banking operation that uses injection wells to recharge groundwater with another groundwater source, making it distinct from most other recharge projects, which typically utilize excess surface water. Local restrictions on groundwater pumping during droughts led the utility to develop an underground storage program as a way to save unused portions of their Edwards Aquifer allocation for future dry periods. The program has been successful and has led to increased water security within the region.

6.1 Key Elements

As a large regional utility, SAWS possesses the financial budget and institutional capacity to take on a project of this scale. Critical to the project's success was the ability to purchase land over the Carrizo Aquifer, which was naturally suited for water storage. SAWS avoided potential backlash against the project by leasing land to agricultural users, preventing the land from being taken out of production.

The H_2Oaks site currently has 176,000 AF in storage and available for use by SAWS. This successful build-up of supply is in part due to fortuitous timing of the project. Several wet years occurred after the project came on line in 2004, allowing SAWS to build up an impressive drought reserve. Further negotiations with surrounding groundwater districts allows SAWS to recognize a 1:1 recharge to recovery factor, with no loss factor included. Since the H_2Oaks site is located in an area without a groundwater conservation district, SAWS can withdraw as much stored water as needed without facing local groundwater pumping restrictions.

6.2 Incentives and Benefits

The SAWS ASR project benefits SAWS and its ratepayers by providing an additional water source in times of drought. Originally, proposed EAA pumping restrictions, which would have reduced water available to SAWS from the Edward Aquifer, directly incentivized the creation of the H_2Oaks program. SAWS initially envisioned using the project regularly, by storing excess water in wet years to meet peak demand year-round. However, the pumping restrictions put in place by EAA ended up not being as severe as expected, and SAWS transitioned the project to storing water for drought. EAA regulations have also incentivized SAWS to diversify their water resources, leading to additional conservation efforts and other projects, such as the desalination plant, to improve the sustainability of SAWS and water security in San Antonio.

While the H_2Oaks project's most obvious benefit is supplementing municipal water supplies, it also benefits endangered species in the Edwards Aquifer system. In 2007, the Edwards Aquifer Recovery Implementation Program was established. This program was the result of an amendment to the EAA Act, which directed the EAA to create a habitat conservation plan (HCP) in order to comply with the Endangered Species Act.[64] The HCP was developed by the EAA, SAWS, the City of San Marcos, the City of New Braunfels, and Texas State University. Following the development of the HCP, US Fish and Wildlife Service issued an Incidental Take Permit in 2013 to the entities above, protecting them from future environmental lawsuits and regulation of the aquifer.[65] A major component of the HCP involves using water banked in SAWS's H_2Oaks facility to prevent streamflow depletion during drought periods that would harm endangered or threatened species. Per an agreement between SAWS and the EAA, the EAA banks Edwards Aquifer water in the SAWS H_2Oaks project to mitigate additional drought restrictions placed on SAWS during specified severe drought conditions.[66] This provides a benefit to endangered species in the Edwards Aquifer system by helping to protect stream flows to critical habitat.

6.3 Challenges and Future Considerations

While the H_2Oaks project is largely successful, SAWS continues to make infrastructural updates to its facilities to improve capacity and distribution. SAWS recently completed the first phase of a western integration pipeline to add a second avenue for distributing water in and out of the H_2Oaks site. This second integration pipeline has created flexibility in the operation of the site by providing SAWS with the ability to integrate greater quantities of stored water back into its distribution system.

With greater ability to integrate more water in shorter time periods and larger volumes of water stored at the site, new challenges may occur. Challenges include how SAWS will operate H_2Oaks site once it reaches its planned storage capacity. If storage capacity at the site fills up, SAWS may need to change operations to consistently withdraw water from the site while depositing additional sources, maintaining a targeted total stored volume of water without giving up any unused supply. Other questions facing the site is whether the current well field configuration provides the most efficient approach to managing the larger storage volume, or whether additional wells will be needed to maintain control of the stored volume. Finally, SAWS continues to research the mixing zones of the stored Edwards and Carrizo waters to determine whether additional treatment capacity is needed if greater mixing occurs between the two sources when production exceeds the current treatment of 30 MGD.

The SAWS H_2Oaks project has helped to spur the question of water sustainability and security throughout Texas. State officials have encouraged the construction of new ASR in other districts in the state, analyzing Twin Oaks as an effective method of drought management due to minimal water loss from evaporation and sustainability.

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