MUNICIPAL WATER REUSE IN TUCSON, ARIZONA, USA

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Abstract:

Arizona's Groundwater Management Act limits the use of groundwater to meet growing demand for water by the municipal sector. The state's recharge and recovery program allows for water reuse through aquifer recharge and later recovery inside or out of the area of hydrologic impact. The paper discusses water reuse within the municipal sector in Arizona, with a special focus on the Tucson metropolitan area. Increased effluent utilization is playing a more prominent role in long-range planning efforts. The paper focuses on the role of reclaimed water in water management planning. It explains how the use of effluent is influenced by water quality considerations and institutional/legal arrangements.

Keywords: Effluent, recharge, management, planning, decision making.

1. INTRODUCTION

Communities in Arizona, a rapidly growing state in the semiarid southwestern United States, face significant challenges in meeting their water demands. In 1980, the Arizona Legislature enacted the Groundwater Management Act (GMA), which regulates the use of groundwater in areas of the state identified as active management areas (AMAs) [1]. AMA boundaries, shown in Figure 1, are based largely on hydrologic considerations. In the AMAs, large water users or water providers must report water use to the Arizona Department of Water Resources, the state agency charged with implementing and enforcing the GMA. A complex system of groundwater use regulations has resulted in increased reliance upon surface water to meet the growing water demands of municipalities [2]. With surface water sources nearly fully utilized, treated wastewater, also called effluent, is becoming an increasingly important component of municipal water supply portfolios [3].

It is estimated that water pumping and surface water diversions in the AMAs, where the vast majority of Arizona's population lives, totaled 3.8 million acre feet in 2003. That compares to an estimated 4 million acre feet of pumping and diversions for the rest of the state, resulting in total statewide water use of almost

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8 million acre feet of water annually [4]. An acre foot is the amount of water required to cover one acre of land by one foot of water; it equals 325,851 gallons or 1.23 million liters. Agriculture is estimated to account for approximately 70% of this demand, although precise numbers are not available outside the AMAs due to lack of measurement and/or reporting requirements. Effluent use is estimated to be about 2% statewide, with the vast majority of reuse occurring in the AMAs [5]. In 2003, effluent was the source water for supplying approximately 5% of AMA water demand, or 189,800 acre feet [6], while in the same year, estimated use of effluent outside the AMAs was estimated to be less than 1% of total water demand in these areas.

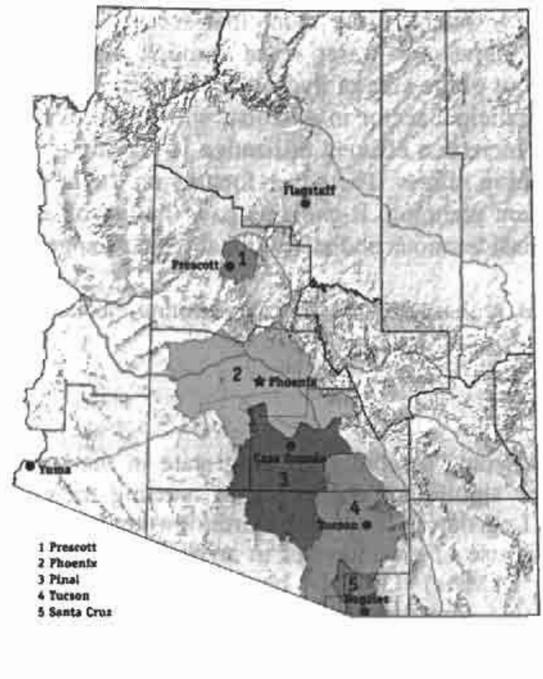

Figure 1. Arizona's Active Management Areas (Courtesy of the Arizona Department of Water Resources.)

Municipal wastewater in Arizona must be treated to certain water quality standards before it is discharged from treatment facilities. Currently, after treatment, effluent is used for golf course and turf irrigation, agricultural irrigation, and industrial uses, including power plant cooling. Some of the remainder is recharged through basin or stream bed infiltration. The Central Arizona Project (CAP) is a 336-mile canal designed to deliver 1.5 million acre feet of Colorado River water annually to Central Arizona, where the largest cities in Arizona are located. CAP water is projected to be fully utilized in the next 30 or so years. Effluent, once considered a nuisance water supply—that is, something to be disposed of—is of growing interest to municipalities searching for ways to meet future water demands. The Tucson AMA, with a population nearing one million, is no exception. However, water quality considerations, infrastructure limitations, public acceptability, and institutional constraints make it difficult to project the extent to which effluent may be used in the future to meet potable water demands.

1.1. The Framework for Water Management in the Tucson Region

The water management goal for the Tucson AMA is safe-yield. As defined by Arizona Revised Statute, safe-yield is "a groundwater management goal which attempts to achieve and thereafter maintain a long-term balance between the annual amount of groundwater withdrawn in an active management area and the annual amount of natural and artificial recharge in the active management area" [7]. Meeting the critically important goal of eliminating overdraft of the aquifers drives the water management activities of the region [8].

The main water users in the Tucson AMA are categorized as municipal, agricultural, and industrial. Of the approximately 350,000 acre feet of water demanded in 2003, 30% was used by agriculture, 15% by mining and other large industrial users, and 55% by municipalities [9]. Numerous large and small water companies, termed "municipal water providers," provide water to communities in the Tucson AMA. Tucson Water, operated by the City of Tucson, is by far the largest, serving approximately 80% of the metropolitan area's population. Although known as "municipal" water providers, these water companies may be owned and operated by cities and towns, water districts, cooperatives, or private individuals/companies. They supply water not only to residences, but also to business and commercial establishments and to turf facilities in their respective service areas. In addition, many individuals and some businesses supply their own water through individually owned and operated wells. Particularly small wells are considered legally exempt from state regulation.

2. THE ASSURED WATER SUPPLY RULES AND USE OF RENEWABLE WATER SUPPLIES

As a result of the GMA, new residential growth in AMAs with the safe-yield water management goal can no longer depend upon mined groundwater to meet community water demand. To strengthen this requirement, the set of rules known as the Assured Water Supply (AWS) Rules, was adopted in 1995. This requirement was crucial for moving the region to less reliance on groundwater in favor of alternative supplies. The rules provide significant flexibility. They do allow new growth to be served with groundwater, should a demonstration be made that 100 years' supply of groundwater is legally and physically available, but groundwater use deemed "excess" by the formulas in the rules must be replenished with water supplies that are considered renewable, such as Central Arizona Project (CAP) water or effluent [10].

A "promise" to use renewable supplies will not suffice when an Assured Water Supply (AWS) application is undergoing review. Instead, the applicant must demonstrate to the Arizona Department of Water Resources how renewable water supplies will be used. There are several ways that renewable supplies can be utilized individually or in combination:

1. A renewable water supply under long-term contract, such as CAP water, may be treated and then delivered directly to customers. This mechanism is not currently being utilized in the Tucson AMA.
2. A renewable water supply, such as CAP water or effluent, may be recharged at a permitted location within the AMA and a credit accrued for that storage. The credit may be "redeemed" when the water is recovered through a permitted recovery well. This is often considered indirect use of the renewable supply because its use is through storage and recovery rather than through a treatment plant, as in the first option. The location of the recovery of the stored water may be distant from or adjacent to the location of storage. The storage and recovery option for use of CAP water is being utilized by several water providers in the Tucson AMA. Storage and recovery activities must follow highly complex laws, regulations, and rules [11]. Reviewing staff examine the storage and recovery plans carefully to determine if the facilities to be used are in fact permitted and available for use.
3. The Central Arizona Groundwater Replenishment District (CAGRD) is an organization that assumes the responsibility to replenish groundwater use that is in excess of allowable use per the groundwater allocations established by the AWS Rules. A development or water company may sign up for replenishment services by becoming a member of the Replenishment District. The replenishment district then has an obligation to replenish the groundwater used within the AMA by its members withdrawn within three years of use. This delayed replenishment approach contrasts with the storage and recovery option above. Both options make use of Arizona recharge and recovery statutes, but in different ways. State law requires a plan to be submitted to and approved by the Department of Water Resources every ten years, but it does not require the replenishment district to demonstrate it has firm contracts to water for 100 years.
4. Extinguishment of grandfathered agricultural water rights can enable the water supplier to utilize a percentage of this water right as "mined" groundwater—that is, groundwater exempt from replenishment obligation.

The percentage becomes less generous with time, making this an increasingly limited option going forward [12].

5. The use of special sources of groundwater, such as remediated groundwater, is not considered mined groundwater.

2.1. Water Planning by Tucson Water

The most detailed long-range water plan available in the Tucson AMA is the "Water Plan: 2000–2050", released by Tucson Water in November 2004 [13]. Tucson Water is the biggest municipal water provider in Tucson and is operated by the City of Tucson. The Tucson Water Plan (TWP) identifies the important and complex issues facing the region as it attempts to accommodate the water needs of a growing population, and includes a recommended water supply strategy. Tucson has long delivered effluent water subject to tertiary treatment through its reclaimed system. Tucson's reclaimed water is sold to golf courses, schools and parks at a rate of $610 per acre foot. In 2003 Tucson delivered 13,121 acre feet directly as reclaimed water, about 40% of the total effluent produced in Tucson that year. This amount represents about 8% of Tucson's overall water demand. One of the goals of the Tucson Water Plan is to maintain this level of direct use as the area continues to grow.

Effluent not directly utilized through the reclaimed water system (the other 60% of the effluent supply) is currently discharged into the Santa Cruz River. The second goal outlined in 2030 the TWP aims to increase utilization of effluent through recharge and recovery. Effluent will be stored underground through basin infiltration at specially constructed recharge basins or through stream bed infiltration and then recovered. Tucson Water will have difficulty meeting water demands beyond 2030 unless it uses effluent in this manner or finds other water supplies to meet projected demands.

The increased use of effluent indirectly through recharge has received much attention both locally and nationally. This has brought widespread recognition of effluent as a water supply of growing importance [14]. Effluent utilization plays an important part in the preferred long-range planning option. Nevertheless, whether Tucson Water will be able to use effluent to meet potable water demands to the extent projected remains to be seen. The determinants of future effluent use, as discussed below, are often regional in nature.

2.2. Future Use of Effluent in the Tucson Region

Several issues affect the extent to which the Tucson region incorporates effluent utilization into its water supply portfolio. They are discussed in turn.

3. INSTITUTIONAL COMPLEXITIES

Control of effluent is divided among multiple jurisdictions, making unified planning for its use difficult. The institutional context for wastewater treatment is unusual in Tucson. In the late 1970s, through an intergovernmental agreement, the City of Tucson took over responsibility for the bulk of community water provision, while Pima County, the county in which Tucson is located, became the regional wastewater provider. As a result, Tucson claimed ownership of 90% of the effluent produced, with the remaining 10% going to Pima County. This is unlike most other large cities in Arizona, where water and wastewater responsibilities reside with the city. In addition, there is a significant commitment of the effluent (28,200 acre feet per year) from the two large metropolitan treatment plans to the United States Secretary of the Interior for use in settlement of water rights claims of the Tohono O'odhäm Indian Nation.

At one time, Tucson Water was expected to serve as the regional water provider, but those plans did not materialize due to inter-jurisdictional conflicts and difficulties Tucson Water experienced with delivery of treated CAP water in the early 1990s. Subsequent to the 1979 agreement, Tucson Water has transferred ownership of a portion of its 90% share to other jurisdictions. These jurisdictions sometimes have conflicting goals regarding its utilization. For example, for several years, Pima County criticized the city for underutilization of the effluent. Currently, unutilized effluent is discharged into the otherwise dry Santa Cruz River (see Figures 2 and 3), and the Town of Marana, through which the Santa Cruz River runs, is concerned about future withdrawal of a significant portion of the effluent by the City of Tucson. In addition, stakeholders concerned about degradation of the riparian areas in the effluent-dominated portion of the Santa Cruz River have concerns about future removal of the effluent in the future for municipal use. A multijurisdictional, large-scale planning effort for the Santa Cruz River is underway but is not yet complete.

Figures 2 and 3 show the significance of the wastewater flows to riparian growth. Figure 2 shows the dryness of the Santa Cruz River bed upstream of the discharge point of the Roger Road Wastewater Treatment Plant. Figure 3 shows riparian growth in Marana, downstream of the Roger Road plant and a second, larger treatment plant. Future deliberations are likely to determine how much effluent water is removed from the Santa Cruz River for use.

3.1. Indirect Use of Effluent

Unknowns related to effluent water quality make it difficult to plan for its utilization. Effluent or reclaimed water has long been accepted as a source of water for municipal turf irrigation. However, the current supply of effluent easily exceeds projections of future demands for municipal turf irrigation [15]. Agriculture is unlikely to be a future user of effluent in the Tucson area. In the Tucson AMA, agriculture is giving way to residential and commercial development, a trend that is expected to continue. Although there had been some use of effluent by agriculture in the past, there is currently no agricultural use of effluent in the Tucson AMA.

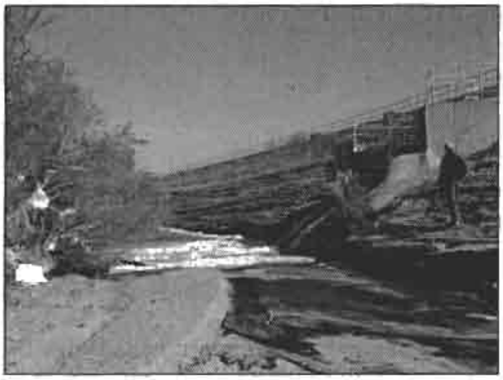

Figure 2. Outfall of regional wastewater treatment facility (Courtesy of Pima County Regional Flood Control District.)

Figure 3. Effluent-dependent riparian segment of the Santa Cruz River, flowing through Marana, AZ (Courtesy of the Town of Marana.)

The potential for increased utilization rests with the potable system. Yet, water quality considerations associated with reuse of effluent for potable use are significant. Any discussion of the use of effluent in this manner is almost immediately connected by the media and others with the moniker "toilet to tap", a proposition that is unappealing to the general public [16].

The public has become aware that hormones and other pharmaceuticals have been found in water discharged from wastewater treatment plants, including those in the Tucson AMA [17]. In the near to intermediate term, no Tucson area water provider is considering treating effluent through membrane facilities for direct delivery through the potable water system. Arizona's recharge and recovery program provides an attractive alternative for future use [18].

3.2. Use of Effluent through Recharge

The water storage and recovery program, discussed in Section 2.1, provides the statutory framework for a multifaceted system of recharge of aquifers. This program has proven to be invaluable in assisting water providers and the state in meeting water policy objectives. Due to cost considerations, indirect utilization of effluent through recharge and recovery is likely to be the mechanism of choice for water providers.

The recharge program allows accrual of storage credits, with the credit holder entitled to withdraw water at a future time. Recovery requires the permitting of a well or wells, and must be in the AMA where the storage occurred, but not necessarily in the area of hydrologic impact of the recharge. Recovery within the area of hydrologic impact is beneficial from a water management standpoint in that the aquifer that has benefited from storage is the location of the recovery activity. However, that also means that the water recovered is likely to resemble effluent water, after the tertiary treatment associated with soil aquifer treatment. Nitrates and total dissolved solids are higher in effluent water than in situ groundwater. Water quality considerations are likely to be less of an issue if the recovery occurs at a site that is remote from the storage. Yet, that means water is withdrawn from a location that has not benefited from the increase in aquifer storage. There are tradeoffs associated with each approach. Clearly, water quality considerations suggest that the water suppliers should take advantage of the flexibility in the storage and the recovery program and recover outside the area of hydrologic impact. Aquifer storage considerations, on the other hand, suggest that recovery ought to occur within the area of hydrologic impact.

To date, the storage of effluent for storage credits in the Tucson AMA has been somewhat limited. That is because it took considerable effort for the jurisdictions with ownership of effluent to come together and apply to have the Santa Cruz river, where most of the effluent is discharged, permitted as a storage facility. Moreover, storage of effluent passively through stream bed recharge, as opposed to constructed basins (Figure 4), results credit accrual for only 50% of the water stored rather than 100%, as is allowed at constructed basins (Figure 4). Some contest this provision, stating that it provides owners of the effluent with an incentive to remove the effluent from the river, thereby reducing water available for the environment.

Figure 4. Effluent recharge basins at the Sweetwater Wetlands reclamation facility (Courtesy of Deirdre Brosnihan.)

3.3. Use of Effluent by the CAGRD

As discussed in Section 2.1, one of the means of complying with the AWS Rules requirement that renewable water supplies be utilized is through enrollment in the CAGRD. CAGRD is required to replenish groundwater that is used to meet municipal demands, pursuant to calculations established by the AWS Rules and at this time does not have contracts for firm or long-term renewable water supplies. Since its inception in the mid-1990s, it has been using CAP water that would otherwise be unused to meet its replenishment obligations. At the same time that its replenishment obligations grow, availability of excess CAP water will diminish, and this agency will be required to find other supplies of water to meet its replenishment obligations. In the Tucson AMA, the effluent has been considered a possible source of water for replenishment. The US Department of the Interior is one of the participants in the recharge of effluent in the Santa Cruz River. Over time, the US Department of the Interior may enter into a long-term financial arrangement with the Tucson AMA. There could well be competition for this effluent in the future.

3.4. Environmental Considerations

In an effort to increase the amount of water available for environmental interests, the City of Tucson and Pima County modified their intergovernmental agreement governing effluent in 2001. A key provision was the establishment of an environmental pool of effluent water. Ten thousand acre feet could potentially be used for environmental purposes, subject to certain conditions. Although none of this pool has been allocated to the environment, this represents an important source of water to satisfy some environmental demands in the future.

4. CONCLUSION

The GMA provides the regulatory framework for groundwater management in the Tucson AMA. However, effluent is not a regulated source of water. Its use is related to groundwater regulations because it is a growing, alternative water supply. Therefore, its importance as part of the water supply portfolio for municipalities throughout Arizona is expected to grow. Water management is a very decentralized activity in Arizona; although there is regulation at the state level, decisions regarding how to meet the regulations are made at the local level. Key decisions will be made by local elected officials, only after considerable gathering of information and public input.

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