WATER REUSE AS A WATER MANAGEMENT STRATEGY FOR SMALL COMMUNITIES IN TEXAS

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EXECUTIVE SUMMARY

The 2007 State Water Plan of Texas (TWDB, 2007) projects that water reuse will account for 14 percent of the state's new water supply by the year 2060. The majority of this volume corresponds to water management strategies to serve large urban areas in water planning regions C, H, and K. However, the growing need for new water supplies and greater awareness of the benefits of water reuse will eventually lead smaller communities in the state to also consider water reuse management strategies.

The U.S. Environmental Protection Agency (US EPA) defines a small community as one which has a population less than 10,000 and a total wastewater flow of less than 1 million gallons per day (US EPA, 1996).

This report examines water reuse issues such as regulations, water rights, and technology as an initial step to identify key challenges that smaller communities may face in implementing water reuse strategies.

1.0 INTRODUCTION

Although the reuse of treated wastewater effluent has served as a source of water supply in Texas for decades (Hoffman, 1998), the 2002 and 2007 State Water Plans (TWDB, 2002 and 2007) project an unprecedented increase in water supply needs to be met by water reuse management strategies over the next decades.

In 2007, the state water plan estimated that water reuse strategies will generate about 1.3 million acre-feet in 2060, which accounts for 14 percent of new water supplies to be provided from all recommended water management strategies on a statewide basis. This represents a substantial increase when compared to the 2002 State Water Plan in which water reuse contributed 6 percent of new water supplies in 2050, the end of that planning period. Capital costs for the recommended water reuse management strategies are estimated to be about $4 billion in the 2007 State Water Plan, which is substantially higher than the $1.1 billion in the 2002 State Water Plan.

In the 2006 Regional Water Plans, several regional water planning groups recommended water reuse strategies to meet water supply needs for some small communities. The cities of Bowie, Ballinger, and Winters are examples of small Texas communities where water planners have recommended water reuse strategies. Appendix 1 provides a brief description of the regional water planning considerations leading to water reuse recommendations for these cities.

To help identify actions needed to support implementing water reuse strategies recommended in the regional water plans, in 2009 the Texas Water Development Board (TWDB) awarded a research study grant to assess past accomplishments and examine present needs. Although the scope of work of this study does not specifically target water reuse in small communities, the results of the study will serve to guide research and planning activities on water reuse in the state over the next biennium. The results of the study will be available by the end of 2010.

2.0 CHALLENGES COMMON TO SMALL WATER UTILITIES

In many respects, small and large utilities face the same types of challenges with regard to developing new water supply sources and replacing aging infrastructure. However, limited funds to address competing needs, limited in-house expertise, lower volumes of water available for reuse, and a reduced customer base to recover utility costs have a sharper impact on smaller communities considering water reuse than on larger cities.

For example, a survey performed by American Water Works Association's Small System Division in 2006, revealed that the issue of "aging and replacement cost" of infrastructure is the most important to small systems (Stanford, 2008). This reflects the heavy burden on elected officials deciding between addressing pressing immediate needs and initiating the necessary investments to ensure their communities' water supplies of the future.

Smaller utilities, which typically have limited staff and personnel experienced in preparing financial assistance applications, face greater difficulties in engaging financial, technical, and legal experts to secure financial assistance. Implementing a water reuse project for the first time is a complex undertaking and will likely require the service of expert consultants to assist in the planning, water rights and facility permitting, and implementing of a new project. See sections below addressing regulatory matters, including water rights considerations.

Also, many water supply systems in small communities lack licensed operators, as well as trained managers to install, repair, or operate treatment systems (Stanford, 2008). This is a challenge for water reuse projects, in particular, because these are relatively more complex projects subject to greater levels of scrutiny. Having licensed and skilled operators is essential.

Another important challenge for small communities is that of availability of reclaimed water for reuse purposes. Wastewater is generated from a variety of sources, including households, schools, offices, hospitals, and commercial and industrial facilities (Asano and others, 2007). The quantity and quality of wastewater derived from each source varies among communities depending on the population size, number and type of commercial and industrial establishments in the community, and the condition of the wastewater collection system. Due to less population and fewer commercial and industrial establishments, the potential volumes of water available for water reuse are more limited in smaller communities.

Small utilities are also challenged by their limited customer base. It costs small utilities more per unit volume of production to operate their systems, which, in turn, increases the production cost of water. Coupled with smaller customer bases, these costs result in higher utility rates for customers (Stanford, 2008). Therefore, when considering water reuse projects, small utilities need to consider costs more closely than larger utilities. Small communities share with larger cities the concerns and need for educating their customers and citizenry on issues related to public and environmental health and social acceptance of water reuse.

3.0 REGULATIONS FOR WATER REUSE IN TEXAS

In Texas, the application of reused water for beneficial purposes is regulated by the Texas Commission on Environmental Quality as prescribed in Title 30, Chapter 210 of the Texas Administrative Code (30 TAC Ch. 210). These regulations apply regardless of the size of system. Based on the likelihood that the water would come in contact with humans, Chapter 210 defines two types of reused water; Type I and Type II. Type I reused water can be used in instances where incidental contact with humans is likely to occur; Type II reused water can be used in instances where incidental contact with humans is not likely to occur (Alan Plummer Associates Inc., 2005). Table 1 shows Type I and Type II uses of reused water.

4.0 WATER REUSE APPLICATIONS

There are two types of water reuse: direct and indirect reuse. Direct reuse is the use of effluent from that is piped directly from a wastewater treatment plant to the place where it is used. Indirect reuse (also called “bed and banks”) is the use of treated wastewater effluent that is discharged into a water body (lake, river, or stream) and then diverted further downstream to be used again (TWDB, 2007).

Direct reuse is usually implemented for non-potable purposes, which include garden irrigation, toilet flushing, home air conditioning, car washing, golf course watering, and agricultural irrigation.

Currently, direct reuse is not permitted for potable purposes by state or federal regulations in the United States (Black and Veatch, 2009). Several major issues, including public perceptions, health risk concerns, and cost considerations prohibit the implementation of reused water for potable purposes in the United States.

Table 1: Type I and Type II Reused Water Uses

Item	Type I Uses	Type II Uses
Definition	Reused water can be implemented where contact with humans is likely	Reused water can be implemented where contact with humans is unlikely
Uses	Irrigation or other uses in areas where public may be present	Irrigation or other uses in areas where public is not present
Examples of uses	• Residential irrigation • Unrestricted urban irrigation, including parks, school yards, and athletic fields • Fire protection systems • Direct irrigation of food crops that will be peeled, skinned, cooked, or thermally processed • Irrigation of pastures for milking animals • Maintenance of unrestricted recreational impoundments • Toilet or urinal flush water • Other similar activities in which the potential for unintentional human exposure may occur	• Site not used by public when irrigating golf courses, cemeteries, and landscaped areas • Irrigation of food crops without contact with edible part or with pasteurization • Irrigation of animal feed crops • Maintenance of impoundments/water bodies where direct human contact is unlikely • Soil compaction or dust control
Quality standards (TAC)[1]	BOD_5[2] or $CBOD_5$[3]: 5mg/L Turbidity: 3 NTU[4] Fecal coliform: 20 CFU[5]/100 ml (geometric mean) Fecal coliform: 75 CFU/100 ml (single grab sample)	BOD_5: 20 mg/L or $CBOD_5$: 15mg/L (for a system other than a pond system) BOD_5: 30 mg/L (for a pond system) Fecal coliform: 200 CFU/100 ml (geometric mean) Fecal coliform: 800 CFU/100 ml (single grab sample)
Sampling and analysis (TAC)	Twice per week	Once per week

NOTE:

1	TAC	30 Texas Administrative Code, Chapter 210
2	BOD_5	Five-day biochemical oxygen demand
3	$CBOD_5$	Carbonaceous biochemical oxygen demand
4	NTU	Nephelometric turbidity unit
5	CFU	Colony forming unit

Indirect reuse programs include recharging aquifers and augmenting surface water reservoirs with reused water. In groundwater recharge projects, reused water can be spread or injected into aquifers to augment groundwater supplies and to prevent salt water intrusion in coastal areas. For example, since 1976, the Water Factory 21 Direct Injection Project located in Orange County, California, has been injecting highly treated reused water into the aquifer to prevent salt water intrusion and augment the potable groundwater supply. Although numerous successful groundwater recharge projects have been operated for many years, planned augmentation of surface water reservoirs has been less common.

Indirect reuse ultimately reduces the amount of flow in the watercourse that is available for use by other water rights holders and the environment. This effect, of course, is most evident downstream of the point where the indirect reuse occurs (TWDB, 2007). A few examples of direct and indirect water reuse programs are shown in the following table.

Table 2: Examples of Direct and Indirect Reuse of Water

Type	Use	Opportunities	Limitation
Direct Reuse	**Irrigation**	Reused water can be implemented for the production of agricultural crops.	Soil, plant, groundwater, and local environment should be protected from contamination. The cross-connection between reused water and potable water should be avoided.
	Residential uses	Reused water can be implemented in garden irrigation, toilet flushing, home air conditioning, and car washing.	Quality of water should be ensured. The cross-connection between reused water and potable water should be avoided.
	Urban and recreational use	Reused water can be implemented in street cleaning, firefighting, ornamental impoundments, and decorative fountains.	Reused water should be free from contamination.
	Aquaculture	Reused water can be implemented for the cultivation of aquatic plants and animals.	Aquatic environment should be protected from adverse effects of toxic substances.
Indirect Reuse	**Aquifer recharge**	Reused water can be implemented for recharging aquifers and augmenting surface water reservoirs.	Indirect reuse reduces flow in the downstream watercourse.

5.0 WATER RIGHTS CONSIDERATIONS

A water right allows water to be diverted at one or more particular points and a portion of the water to be used for one or more particular purposes. Water rights are an especially important issue since the rights allocated by the state can either promote reuse measures, or they can pose an obstacle. In other words, state law can either promote or constrain reuse projects depending on how the state's system of water rights regards the use and return of reused water (US EPA, 2004). In Texas, water rights apply to both direct reuse and indirect reuse.

In Texas, it is undisputed that a surface water right holder may directly reuse and fully consume effluent, subject only to limitations contained in the underlying water right from which the effluent was derived. Where contracts or other laws have clearly transferred ownership of that effluent to another, such as a wastewater treatment provider, the direct reuse may lie with the owner of the effluent. Obtaining authorization for direct reuse under today's regulatory scheme is fairly streamlined. Typically, only certain water quality authorizations must be obtained from the Texas Commission on Environmental Quality for this kind of reuse (30 TAC, Chapter 210).

In contrast to the clear authority to engage in direct reuse without water rights permitting implications, the ability to engage in indirect reuse is less clear. There are currently pending before Texas Commission on Environmental Quality a large number of water rights applications seeking indirect reuse authorization, nearly all of which have been protested (TWDB, 2007).

6.0 PLANNING FOR WATER REUSE PROJECTS

Planning and management of water reuse projects in small communities will vary from one community to the other depending on the water needs, available supplies, permit requirements, stakeholders' acceptance, and costs associated with meeting the water needs of these individual communities (Black & Veatch, 2009).

Effective planning of water reuse projects includes detailed considerations about identifying reused water availability, screening for potential users, developing financial plans, and implementing timing and investment cycles (WateReuse Association, 2009). To ensure the quality and quantity of reused water, institutional and organizational coordination needs to be implemented between different stakeholders of the project and the end users.

6.1 Identification of the Reuse Water Availability

The first step of developing a water reuse plan is to identify demands and production capacity of the community's reused water (Water Reuse Association, 2009). As reused water is an alternative water source, its competitiveness to conventional water resources must be clearly demonstrated and the demand risks analysis proven to be at an appropriate level.

6.2 Screening for Potential Users

All existing users in the community need to be screened and evaluated to establish potential users for reused water (US EPA, 2004). After identifying the potential users for reused water, all users need to be contacted to determine if they will oppose the substitution of reused water for domestic water.

6.3 Financial Planning

Feasibility of using reused water in a community depends on the availability and cost of fresh water, transportation and treatment costs, water quality standards, and the reclamation potential of the wastewater (Asano and others, 2007). Sometimes water recycling is more expensive than treating and discharging wastewater and relying on non-recycled sources to meet water demand. Communities with an abundance of water resources that exceed their needs often do not need to recycle, primarily because the cost of building and operating the treatment and distribution systems required to supply reused water are not cost effective.

6.4 Technology Selection

Once a community has determined potential users and completed its financial planning, appropriate treatment technologies need to be selected in light of the characteristics of the specific source water, the proposed use of the discharge water body, and applicable federal and state regulations.

6.5 Distribution Layout

The water taps, piping, and plumbing fittings for the reused water need to be labeled properly to prevent the water from being used for drinking purpose. Backflow prevention devices are also required on potable services to prevent contamination from cross-connections. Rechlorination facilities need to be provided at each storage reservoir for chlorine residual maintenance.

6.6 Operation and Maintenance

A thorough routine maintenance should be performed when implementing a water reuse program for the community. The operation and control of the onsite system should prevent direct human consumption of reused water. Proper training for operators, installers, and other industry professionals should be conducted to maintain the system, and site-specific operating and control measures need to be developed for minimizing discharge onto areas not under the control of the user. Additionally, different demonstration projects of water reuse should be developed to educate the end users.

A flow chart of planning and managing a water reuse program for a small community is presented in the following figure.

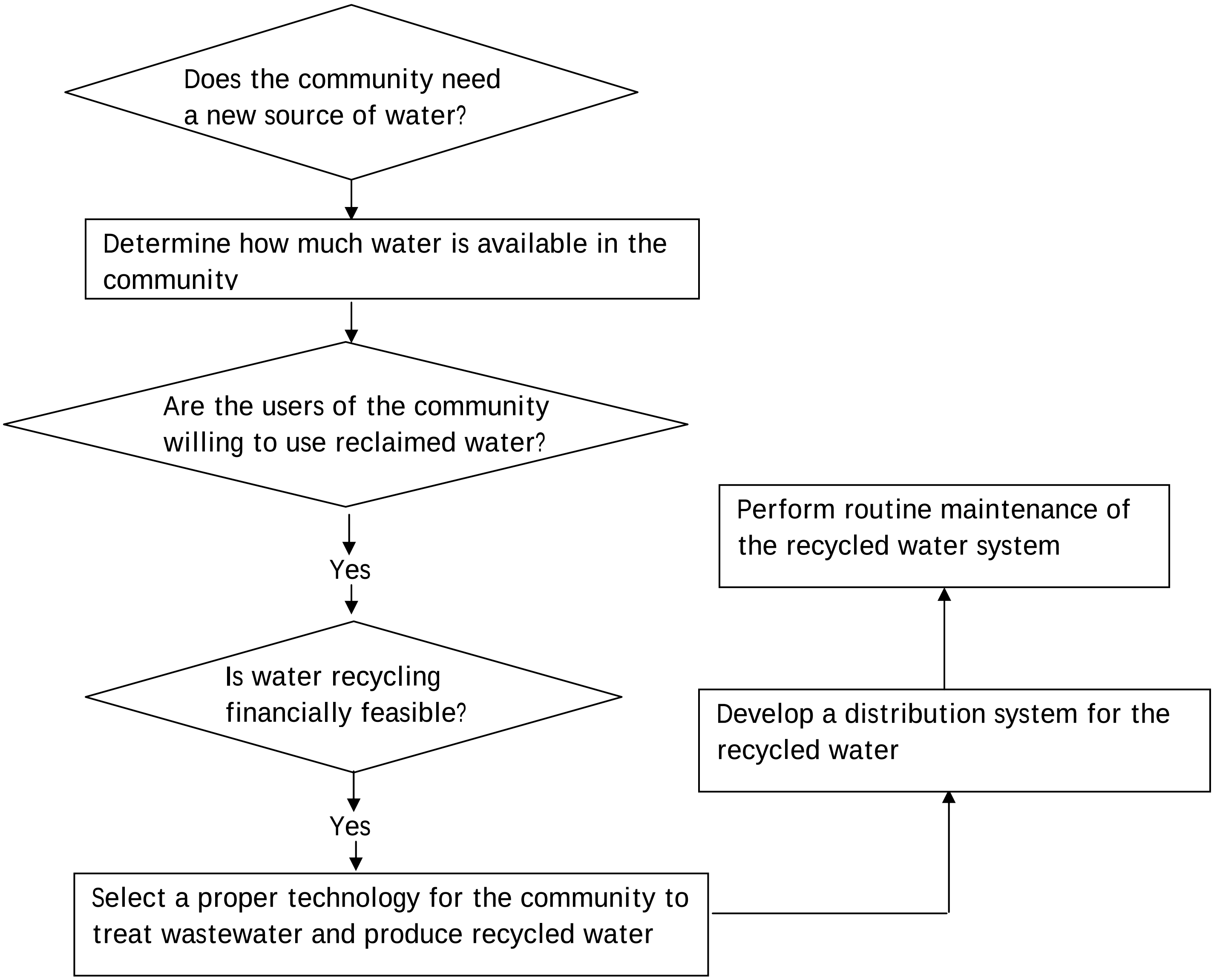

Figure 1: Planning for Water Reuse Projects

7.0 TREATMENT TECHNOLOGIES FOR WATER REUSE

Several technologies are used to produce reused water. Most widely used treatment technologies of water reuse programs are shown in the following table.

Table 3: Treatment Technologies for Water Reuse Projects

Technology	Description	Advantages	Disadvantages
Pretreatment Technologies	Pretreatment technologies may include the use of gross pollutant traps, such as racks, screens, baskets, pits, grinders, grit chambers, oil/water separators, etc., to remove large debris, coarse sediment, floating matter, and oil and grease.	• These methods reduce downstream maintenance requirements. • These methods do not require large land areas.	• There are potential odor problems associated with litter. • These methods are not suitable for the removal of dissolved pollutants. • These methods require regular maintenance.
Detention Basins	Detention basins are operated by detaining water runoff for a short period and then releasing it.	• Detention basins mitigate the effects of isolated pollution events in the drainage area. • These basins act as aquifer storage and recovery systems. • These basins provide recreational and open space opportunities.	• Detention ponds require large land areas. • These basins require periodic sediment removal. • These basins may not be suitable with high groundwater levels, as a permanent pool may occur.
Retention Ponds	Retention ponds have a similar design to detention ponds but maintain a permanent pool of water (US EPA, 1993).	• Retention ponds mitigate the effects of isolated pollution events in the drainage area. • These ponds act as aquifer storage and recovery systems. • These ponds provide recreational, aesthetic, and open space opportunities. • These ponds provide wildlife and aquatic habitat.	• Retention ponds require dry-weather base flow to maintain the permanent pool. • These ponds require periodic sediment removal. • These ponds require large land areas. • There may be potential problems associated with litter, scum, algal blooms, nuisance odors, and mosquito breeding.

Technology	Description	Advantages	Disadvantages
Constructed Wetlands	Constructed wetlands are artificial wetlands, designed to utilize natural aquatic plants and organisms to improve water quality, retain water for flood control during heavy rain events, and provide wildlife habitat.	• Constructed wetlands reduce downstream scour and loss of aquatic habitat. • They mitigate the effects of isolated pollution events in the drainage area. • They act as aquifer storage and recovery systems. • They provide recreational, aesthetic, and open space opportunities.	• Constructed wetlands require near-zero land slope. • They require dry-weather base flow to maintain the permanent pool. • Constructed wetlands require large land areas. • High water infiltration rates may make it difficult to maintain a permanent pool.
Sand Filters	Sand filters consist of a filter bed with a gravel and perforated pipe under-drain system (US EPA, 1999).	• Sand filters are applicable in areas with high evaporation rates or in areas where soils are too pervious for the use of constructed wetlands. • They are applicable for treating runoff from highly impervious drainage areas.	• Sand filters may get clogged. • They require periodic replacement of filter media. • They require flat surface areas. • They may have high head losses and low unit flow rates.
Bioretention Systems	Bioretention systems use planted soil beds to remove water pollutants (US EPA, 1999). Runoff enters the bioretention area, ponds over the surface, and infiltrates into the soil bed.	• Bioretention systems may contribute to groundwater recharge. • When properly maintained, they can be aesthetically pleasing. • Layout of a bioretention system can be flexible, and a wide variety of landscape designs are possible.	• Bioretention systems may contaminate groundwater. • Bioretention systems are not applicable to areas where the groundwater table is within 6 feet of the ground surface. • They are not applicable to areas with slopes greater than 20%.

Technology	Description	Advantages	Disadvantages
Advanced Technologies	Advanced water treatment technologies are physical, chemical, and/or biological processes commonly used in water and wastewater treatment. Possible treatment methods include dissolved air flotation, lime softening, biological nutrient removal, granular media filtration, granular activated carbon, ion exchange, microfiltration, ultrafiltration, and reverse-osmosis membrane treatment.	• Advanced technologies require less land area. • These technologies may produce better water quality.	• Advanced technologies are more expensive and more complex to operate. • These technologies may produce residuals that require treatment or create disposal challenges, such as brine.

8.0 WATER REUSE PLANNING RESOURCES

Many water reuse resources are available to guide planning of water reuse projects.

8.1 U.S. Bureau of Reclamation

The U.S. Bureau of Reclamation (Reclamation) is authorized to conduct appraisal and feasibility studies on water reclamation and reuse projects. It also provides general authority for research and demonstration programs to test water reclamation and reuse technologies. Reclamation also participates in constructing reuse projects after congress has authorized the project.

A legally organized nonfederal entity, such as an irrigation district, or an organization within a municipality, such as the water department, is eligible to apply for loans or grants from Reclamation. The applicant must be able to furnish the nonfederal cost share and assume the operation and maintenance of the project upon completing construction. A feasibility report must be completed, either solely by the nonfederal sponsor or with assistance from the federal government. A statement of financial capability by the nonfederal sponsor must be provided to Reclamation. This statement demonstrates the capability of the sponsor to fund its portion of the feasibility report, its share of construction costs, and the ability to fund and assume responsibility for the operation and maintenance of the completed project. A cost-share agreement must be completed with Reclamation before funds can be requested for appropriation for construction.

8.2 WateReuse Foundation

The WateReuse Foundation (Foundation) is an educational, nonprofit public benefit corporation that conducts applied research on behalf of the water and wastewater community to advance the science of water reuse, recycling, reclamation, and desalination. The Foundation's research covers a broad spectrum of issues, including chemical contaminants, microbiological agents, treatment technologies, salinity management, public perception, economics, and marketing. The Foundation's research supports communities across the United States and abroad in their efforts to create new sources of high-quality water while protecting public health and the environment.

Primary sources of funding for the Foundation are its subscribers and funding partners, which include the U.S. Bureau of Reclamation, the California State Water Resources Control Board, the California Department of Water Resources, and the Southwest Florida Water Management District. The Foundation's subscribers include water and wastewater agencies, consulting engineering firms, and other interested organizations.

8.3 Water Research Foundation

The Water Research Foundation (Foundation) coordinates multiple research programs to collectively address issues of its subscribers and the drinking water community as a whole. Proactive planning processes are used to develop a balanced, well-rounded research agenda. Management and oversight are applied at each stage of research, including peer review. The common thread in all research projects is value and benefit to subscribers.

Funding for the Foundation research programs is provided primarily from subscribing members. Additional sources include funding awarded through various federal governmental agencies, partnerships with other research organizations, and contributions made by supporters. Through the Small System Initiative program, the Foundation provides funds to address issues of particular importance to small water systems.

8.4 Texas Water Development Board

TWDB assists with regional planning and preparing the state water plan for developing, managing, and conserving Texas' water resources, as well as administering cost-effective financial programs for constructing water supply, water infrastructure, wastewater treatment, flood control, and agricultural water conservation projects.

9.0 CONCLUSIONS

Water reuse is a proven and expanding technology, as well as a cost-competitive option for meeting the increasing water demands for small communities of Texas. This paper provided a brief overview of key issues that need to be considered when planning water reuse projects for small systems.

Many small water and wastewater utilities continue to struggle to achieve financial stability, managerial excellence, and technical proficiency. Although addressing these complex and novel issues will be challenging for most small communities; improving communication with state, and local agencies, developing useful tools for management, and implementing effective practices, policies, procedures, regulations and standards will assist small utilities to develop successful water reuse programs.

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Appendix 1- EXAMPLES OF WATER REUSE STRATEGIES FOR SMALL COMMUNITIES IN TEXAS (2006 REGIONAL WATER PLANS)

City of Bowie (Region B Regional Water Plan, population 5,219)

The City of Bowie is projected to have a total water need of 134 acre-feet per year in 2060. The regional water planning group considered two options for the City to meet the projected water need: develop groundwater supplies and water reuse. After evaluating both options, the regional water planning group recommended that the City consider water reuse as a potential water management strategy to meet the water need of 134 acre-feet per year by 2060.

Currently the city discharges approximately 672 acre-feet per year of treated wastewater from its existing plant. With enhanced treatment and approximately 5,280 feet of conveyance pipe, this water could be reused by the city to meet current and future water demands. The capital cost for additional water from water reuse is $895,000 with an annual cost of $122,000.

The water reuse option would have a low-to-moderate impact on the receiving stream of the plant because a portion of the effluent would be diverted. Additionally, there could be an issue with public acceptance of a water reuse system because of perceived health and safety concerns from using wastewater.

City of Ballinger (Region F Regional Water Plan, population 3,724)

The City of Ballinger is projected to have a total water need of 1,329 acre-feet per year in 2060. The regional water plan identified seven strategies to meet the water need for the City: subordination of downstream senior water rights, voluntary redistribution from Hords Creek reservoir, voluntary redistribution from a proposed regional system from Lake Brownwood, voluntary redistribution from the Colorado River Municipal Water District system, voluntary redistribution and desalination from the proposed San Angelo desalination project, water reuse, and water conservation. After evaluating the feasibility of each of these strategies, the regional water plan recommended four strategies for the City. The recommended strategies are: subordination of downstream water rights, voluntary redistribution of water from Ivie Reservoir, water reuse, and water conservation.

The 2006 Regional Water Plan estimated that reuse could provide as much as 220 acre-feet per year by 2060, which is 16.5 percent of the total need. The city currently holds a wastewater discharge permit for 0.48 million gallons per day (538 acre-feet per year). This strategy assumes that a portion of the wastewater stream will be sent through advanced treatment (membrane filtration and reverse osmosis), which will then be blended with raw water prior to treatment at the city's existing water treatment plant. The capital cost for water reuse is $1,980,000 with an annual cost of $219,845.

Implementing a water reuse program in the City of Ballinger may reduce the volumes of water discharged by the city. Therefore, an analysis of the impacts on the receiving stream will be required in the permitting process. However, because of the relatively small amount of reduced flow associated with this reuse project, the impact is not expected to be significant.
The City of Ballinger supplies a large portion of the drinking water for rural Runnels County. Since the proposed project will make the city's water supply more reliable, it should have a positive impact on rural and agricultural interests in the area.

The City of Ballinger is a rural community; therefore, the cost of this strategy may have an adverse impact on the community's limited financial resources and the surrounding rural area.

City of Winters (Region F Regional Water Plan, population 2,569)

The Region F planning group projected that water needs for the city will be 670 acre-feet per year by 2060 and identified six strategies to meet those needs: subordination of downstream senior water rights, voluntary redistribution from a proposed regional system from Lake Brownwood, voluntary redistribution and desalination from the proposed San Angelo desalination project, water reuse, water conservation, and drought management. After evaluating the feasibility of each of these strategies, the regional water plan recommended that the City consider reuse and water conservation as long-term alternatives to increase the reliability of the city's water supply.

Reuse could provide as much as an estimated 110 acre-feet per year by 2060, which is 16.4 percent of the total need. The city currently holds a wastewater discharge permit for 0.49 million gallons per day (549 acre-feet per year). Treated effluent is also authorized for irrigation. This strategy assumes that a portion of the wastewater will be treated (reverse osmosis) and then blended with raw water prior to treatment at the city's existing water treatment plant. The capital cost for water reuse is $1,660,000 with an annual cost of $198,000.

Reuse may make less water available for irrigation by diverting part of the treated effluent currently use for irrigation. The cost of this strategy may have an adverse impact on the community's limited financial resources and the surrounding rural area.

Table A-1 provides projected water need (in 2060), recommended reuse (in 2060), and the cost estimates for the production of reused water for these three communities.

Table A-1: Water Reuse Strategies for three small communities in Texas

Water User Group	Population	Projected Water Need in 2060 (Ac-ft/Year)	Wastewater Discharge in 2006 (Ac-ft/Yr)[1]	Recommended Water Reuse Strategy in 2060 (Ac-ft/Yr)	% of Total Need Met By Reuse in 2060	Capital Cost [2] ($) or Reuse Program	Annual Cost ($)for Reuse Program	Unit Cost for Reuse Program ($/Ac-ft)[3]
City of Bowie	5,219	134	672	134	100%	$895,000	$122,000	$911 (before amortization) $328 (after amortization)
City of Ballinger	3,724	1,329	538	220	16.5%	$1,980,000	$219,845	$999 (before amortization) $345 (after amortization)
City of Winters	2,569	670	549	110	16.4%	$1,660,000	$198,000	$1800 (before amortization) $482 (after amortization)

NOTE:

1 Ac-ft/Year: Acre-feet per year
2 Cost is based on the estimate of 2002
3 Debt was amortized on a 20-year 6-percent interest basis