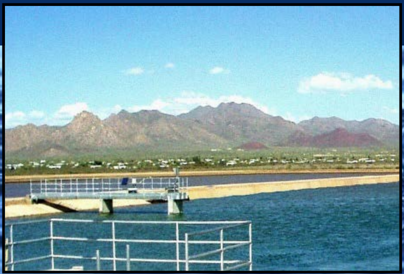
CITY OF TUCSON

TUCSON WATER

RECYCLED WATER MASTER PLAN



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Los Angeles Department of Water and Power
City of San Diego Public Utilities Department

EXECUTIVE SUMMARY

RECYCLED WATER MASTER PLAN

EXECUTIVE SUMMARY

The overall purpose of the *Recycled Water Master Plan* is to provide an integrated recycled water program that maximizes the benefits of the City's recycled water resource. This document provides information to City of Tucson decision makers, Tucson Water customers, and other stakeholders on the planned use of the City's recycled water both in its Reclaimed Water System (RWS) and through other means.

In addition, the *Recycled Water Master Plan* provides a framework for next steps and continued activities that will help ensure the timely implementation of the necessary recycled water projects and programs. These in turn will help achieve Tucson Water's objectives, ensure the long-term sustainability of the Utility's water resources, and enable it to keep its commitment to **"Water Reliability"** for its customers.

Tucson Water's Water Reliability Program includes investments and commitments to ensure our customers have a reliable water supply and system today and in the future. The Program encompasses five areas: water supply, water quality, water customers, water operations and systems, and water conservation and efficiency.

Introduction

Prior to importation of Colorado River water through the Central Arizona Project (CAP) and establishment of the Clearwater blended water program, Tucson Water had supplied groundwater to meet all potable water demands. The Arizona Groundwater Management Act of 1980 requires that groundwater usage be replaced with renewable water supplies such that "safe yield" of aquifers in portions of the State designated as Active Management Areas (AMAs), including the Tucson AMA, is achieved by 2025. In response, Tucson Water started producing and distributing reclaimed water to large turf customers in 1984 (current reclaimed water system is shown on Figure ES-1) and started importing CAP surface water in 1992 to 1994 (CAP Canal to Tucson is shown on Figure ES-2), and again after the Clearwater Program began operation in 2001. Currently, CAP water, groundwater, and reclaimed water comprise Tucson's water supplies, with groundwater still being utilized to meet peak water demands, to provide backup for emergencies and shortages on the CAP system, and to serve as a finite bridge supply until additional renewable supplies are acquired for the future.

Through the Clearwater Program, Tucson Water received its full CAP allocation for the first time in 2012. However, CAP supplies are nearly fully-allocated and the potential for additional allocations in the future are not promising. Over its three-decade history, the Reclaimed Water System (RWS) has grown to serve irrigation water to many of the golf courses, schools, and parks in metropolitan Tucson and is not anticipated to add significant additional demand in the future. This means that Tucson Water's recycled water supply that is not used in the RWS will continue to be discharged into the Santa Cruz River near the downgradient end of the Tucson Basin, where much of the resource leaves the basin without benefit to the community.

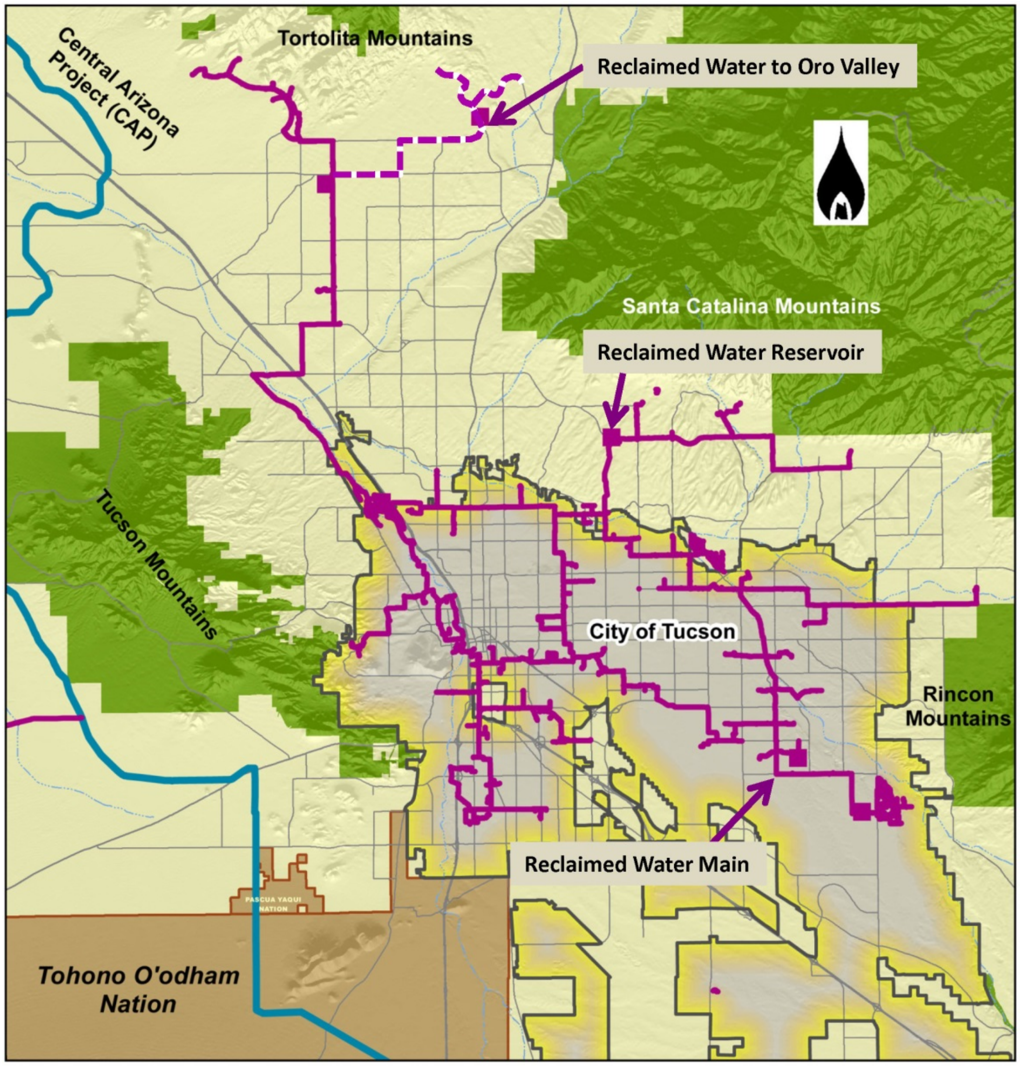

Figure ES-1. The Reclaimed Water System (RWS)

Recognizing that future impacts of sustained drought and climate change will result in shortages to the City's CAP allocation, it is necessary to fully utilize local renewable supplies to provide a reliable and sustainable supply portfolio to meet future demands. Recycled water is the only remaining additional local, renewable water resource available to Tucson. Unused treated wastewater is a valuable resource that can be used to establish additional renewable water supplies that will supplement existing supplies to meet future water demands in the Tucson Water service area.

Figure ES-2. **The Central Arizona Project (CAP)**

Community Investments in Water Resources

The metropolitan Tucson community has already made large investments and will continue to make investments to bring CAP water into the community and to manage wastewater (Figure ES-3 and Table ES-1). The Clearwater Program currently supplies the majority of Tucson's water supply, allowing for reduction of groundwater pumping in the Central Wellfield, and will continue to do so in the future. Full implementation of additional infrastructure supporting reliability of the Clearwater facilities is a primary initiative within Tucson Water's capital improvement program (CIP) planning horizon. When complete, a total of approximately $314 million will have been invested in the Clearwater Program to reliably deliver and make use of Tucson's allocation of CAP water, and $39 million will continue to be spent annually to purchase the CAP allocation and to operate and maintain the Clearwater infrastructure.

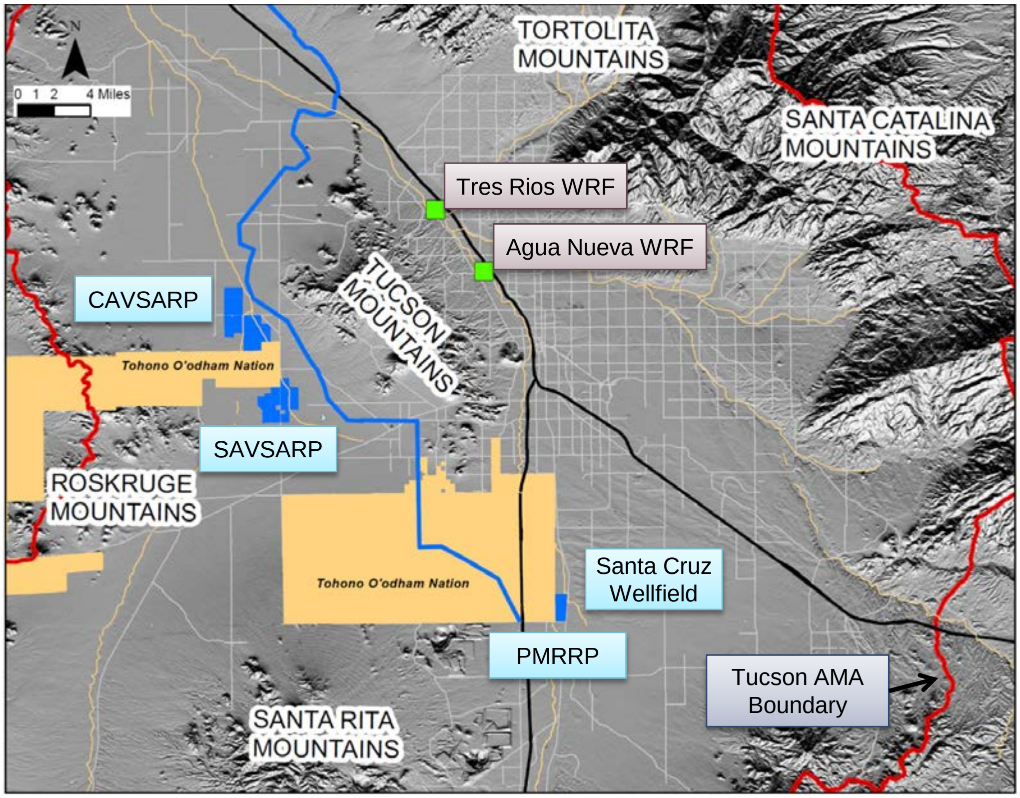

Figure ES-3. Clearwater Program Facilities

Table ES-1. Community Investments in Water Resources

Facility/Program	Capital Investments Already Made	Planned Capital Investments	Current Annual Investments
Purchase CAP allocation (144,191 AFY)	--	--	$20,800,000
Clearwater Program (Tucson Water)			
CAVSARP	$80,600,000	--	$8,300,000
SAVSARP	$47,900,000	$17,000,000	$8,600,000
PMRRP	$5,500,000	--	$200,000
Santa Cruz Wellfield	--	$6,700,000	$700,000
Reliability, Resiliency, and Redundancy Projects	--	$156,000,000	--
Subtotal Clearwater	**$134,000,000**	**$179,700,000**	**$38,600,000**
ROMP (Pima County)	$288,100,000	$372,000,000	$15,000,000
Totals	**$422,100,000**	**$551,700,000**	**$51,100,000**

The potable water used for domestic and industrial purposes is discharged to the Pima County Regional Water Reclamation Department (PCRWRD) wastewater treatment facilities. These Pima County facilities are the source for Tucson Water's recycled water supplies. The community has made a significant investment in implementing PCRWRD'S Regional Optimization Master Plan (ROMP) to replace aged treatment infrastructure, meet new environmental regulations; and, ultimately, to improve recycled water quality. The ROMP program includes upgrading and expanding the Tres Rios Wastewater Reclamation Facility (WRF), which was formerly known as the Ina Road WRF, building a new Agua Nueva WRF to replace the existing Roger Road WRF, and installing pumps and pipelines to transfer wastewater between the two plants. When complete, approximately $660 million will have been invested in ROMP, and $15 million per year will continue to be spent to treat and manage the recycled water.

Despite all of these major community investments, only a little over 50 percent of Tucson Water's recycled water is being reused or stored for future use. A new recycled water program would maximize the value of these investments by converting a valuable resource that is currently being lost from the basin into a new renewable supply to support metropolitan Tucson's water sustainability.

Preparing for Tucson's Water Future

To plan for a reliable water future, Tucson Water has produced three comprehensive, integrated long-range plans over the last 25 years: the *Tucson Water Resources Plan 1990-2100, Water Plan: 2000-2050,* and the *2008 Update to Water Plan: 2000-2050.* The *2012 Update to Water Plan: 2000-2050* is also currently being prepared and is scheduled to be complete by the end of 2013 (Figure ES-4).

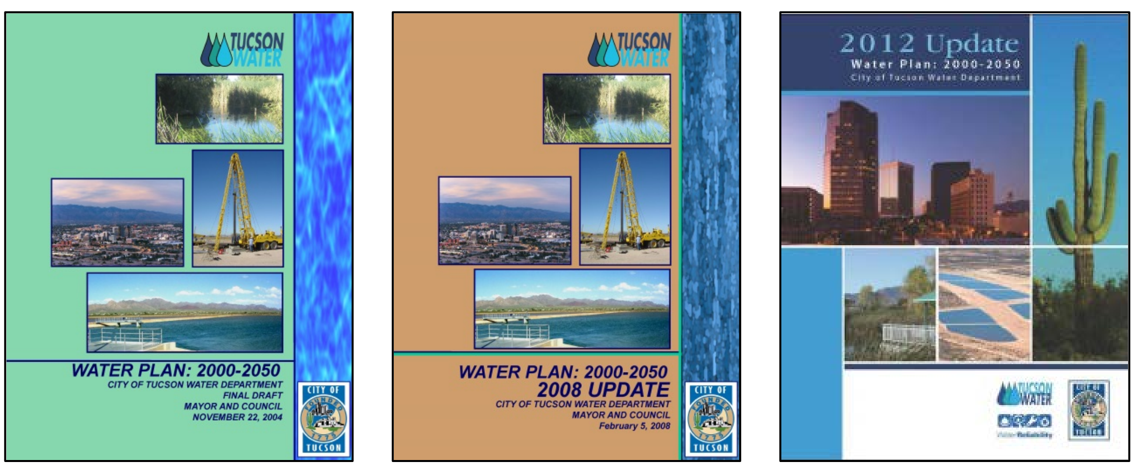

Figure ES-4. Tucson Water's Long Range Water Planning Documents

Each one of these plans recognized the importance of recycled water for both non-potable use in the RWS and for possible future potable use, thus setting the stage for the development of a *Recycled Water Master Plan*.

During the development of the 2009 City of Tucson/Pima County *Water & Wastewater Infrastructure, Supply & Planning Study,* the need for a comprehensive, long-range recycled water plan was again recognized and was included in the *2011-2015 Action Plan for Water Sustainability* (Figure ES-5).

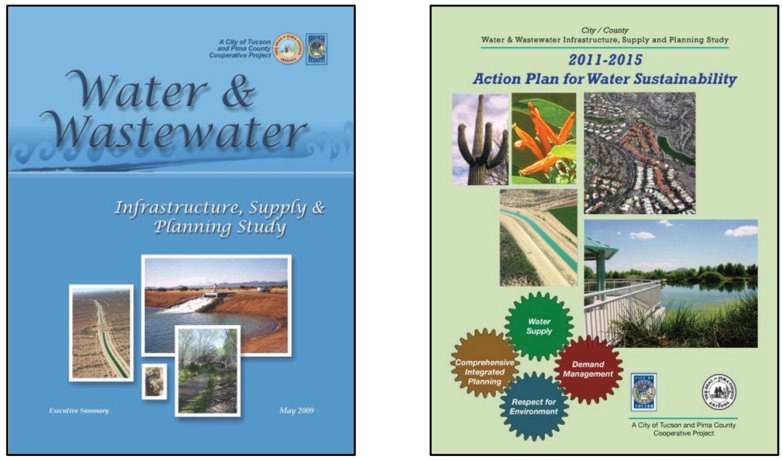

Figure ES-5. City/County Joint Long-Range Water & Wastewater Planning

Maintaining a Designation of Assured Water Supply (AWS) is vitally important for demonstrating availability of long-term, reliable water resources to support current and future water customers for communities in Arizona. Tucson Water is currently conducting an update to its long-range water planning efforts to prepare for application to extend the current Designation which expires in 2015. The *2012 Water Plan Update* projects that current CAP allocations will be sufficient for Tucson Water's "obligated service area" through approximately 2040, based on conservative assumptions of per-capita water use and occurrence of shortage on the CAP system (Figure ES-6). After 2040, the *Water Plan Update* indicates that the CAP allocations can be supplemented with a combination of Tucson Water's renewable and finite water supplies. Renewable supplies include recycled water and Central Arizona Groundwater Replenishment District (CAGRD) replenishment water. Finite supplies include Arizona Water Bank credits, long-term storage credits, and incidental recharge.

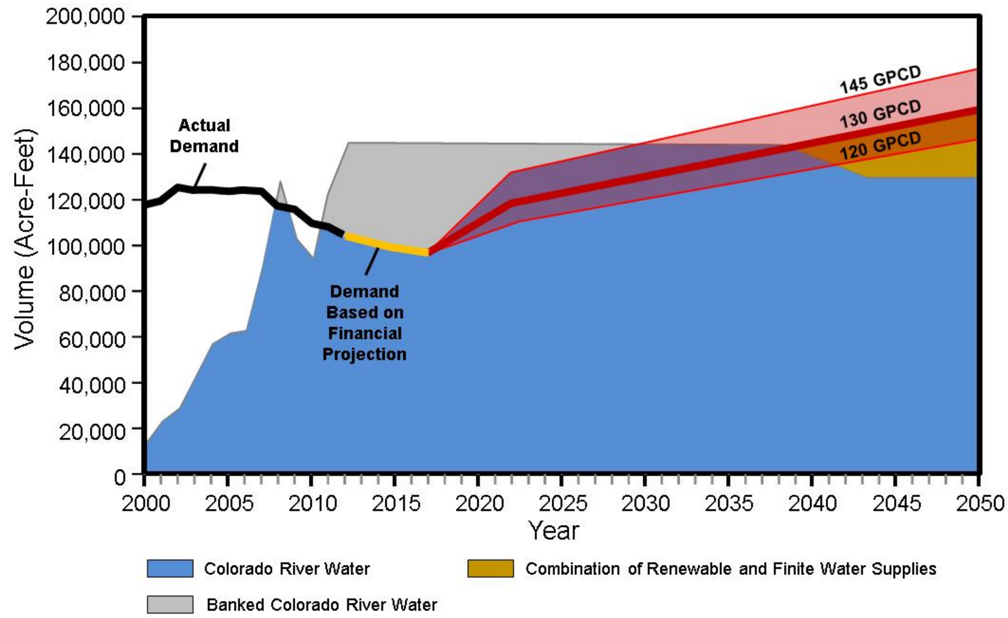

Figure ES-6. **Projected Water Demand and Supply for Tucson Water's Obligated Service Area**

Because the use of renewable supplies is more reliable and sustainable than finite supplies, it is prudent for Tucson Water to begin establishing additional renewable supplies so that it will be available for use well before potential supply shortfalls become imminent.

The *2012 Water Plan Update* concludes that Tucson Water should continue full use of its CAP allocations and complete capital programs to increase its reliability, redundancy and resiliency; continue efficiency and conservation efforts that will increase long-term reliability; and, begin outreach and demonstration of advanced treatment for recycled water.

Because there is not an immediate urgency, Tucson Water has time to carefully plan new recycled water programs. However, since planning, design, permitting, and construction for infrastructure will require significant lead time and establishment of funding, phased planning and implementation efforts should progress consistently to avert the need for urgent responses in the future.

Recycled Water Master Plan Goals

The goals and objectives of the *Recycled Water Master Plan* are consistent with the broader resource planning goals of Tucson Water's long-range water planning efforts*:*

Meet Projected Reclaimed Water Demand. The Utility's reclaimed water demand has grown since the mid-1980s, when it was first utilized. Current population projections within the Tucson Water service area indicates that reclaimed water demand will increase in the foreseeable future, albeit at a slower rate.

Utilize the Balance of the City's Recycled Water to Reinforce Vulnerable Supplies and Ensure Supply Reliability. In order for the community to be sustainable into the longer term future, Tucson Water will need to maximize its use of the projected unused portion of its recycled water. This will help strengthen currently available supplies that will be vulnerable to shortage in the future.

Continue to Meet Potable and Recycled Water Quality Targets. In addition to complying with federal, state, and local regulations, Tucson Water must also be responsive to the water quality expectations and preferences of its customers.

Manage Costs and Rate Impacts. Projects and programs to maximize the use of Tucson Water's available recycled water must be cost-effective.

Augment the City's Assured Water Supply Designation. The Assured Water Supply Program regulated and administered by the Arizona Department of Water Resources limits the amount of groundwater that utilities can legally withdraw. Expanded use of recycled water will provide Tucson Water with the ability to further reduce its reliance on groundwater for municipal supply.

For 20 years, NWRI – a science-based 501c3 non-profit located in Fountain Valley, California – has sponsored projects and programs to improve water quality, protect public health and the environment, and create safe, new sources of water.

The *Recycled Water Master Plan* assesses the potential to improve the RWS and expand to add new customers, and evaluates how Tucson Water's unutilized recycled water supplies can be used to maximize benefits to the community.

An important element of the planning process was interaction with an Independent Advisory Panel of experts in the water reuse industry. The Independent Advisory Panel for this effort was formed and administered by the National Water Research Institute (NWRI). NWRI specializes in working with researchers across the country, such as laboratories at universities and water agencies. The Panel evaluated topics related to public health and safety, public outreach and advocacy, groundwater, advanced treatment technologies, and other topics related to recycled water reuse.

The customer outreach activities started as part of the planning process will be continued and expanded as Tucson Water implements the recycled water program

Another important element of the planning process was to begin formulating plans for outreach to Tucson Water customers. The planning process included activities to begin identifying customer outreach messages by visiting successful indirect potable reuse programs and by reviewing best practices developed by these and other successful programs. The work found that public/customer education for a recycled water program should begin early in the process and continue throughout its planning and development. Outreach should seek to engage City and Utility leadership and staff and, eventually, create community-wide support for the program.

Reclaimed Water System

The RWS is currently near full capacity with over 900 customers, including 23 golf courses, 60 schools, 49 parks, and hundreds of residential customers. The RWS has effectively done the job that was originally intended, the conversion from potable or groundwater resources used for non-potable purposes into a system that is now fully renewable for those needs. The RWS has allowed Tucson Water to retain non-renewable groundwater resources for future use or to allow those groundwater credits to be stored indefinitely. Recycled water use in the RWS will continue to be an important component of Tucson Water's Designation of AWS to demonstrate water supply reliability. For these reasons, Tucson Water is committed to continuing reliable reclaimed water service into the future. Recommendations for the RWS are presented on Table ES-2 and Figure ES-7.

It is recommended that improvements be made to the RWS to address existing system deficiencies and provide better service for existing and future Tucson Water customers, which include existing Pima County and Oro Valley Water Utility demands. The recommendations include the following:

- The **North Loop Improvements** are the highest priority improvements. The northwest area represents the highest volume of reclaimed water deliveries and provides the largest source of reclaimed water revenues. This loop would also improve service to Oro Valley and would prepare the system for future service to MDWID.
- The **Dove Mountain Area Improvements** are the second priority improvements. The primary improvement is a new storage 6 MG reservoir which will improve service in the entire northwest area. The improvements will address storage deficiencies and would improve the ability to meet contractual agreements with golf courses during peak demand periods.
- The **Northeast Loop Improvements** are the third priority improvements and would supplement booster pumping and storage at the La Paloma reservoir, and address deficiencies in nearby pipelines. The improvements, which include a new 7.3 MG reservoir, will improve reliability and the ability to meet contractual agreements with golf courses in the La Paloma area during peak demand periods.

Additional recommendations to serve future Tucson Water reclaimed water demands (including existing Pima County and Oro Valley demands) include various booster pumping expansions and upgrades.

Unutilized Recycled Water Supplies

The City of Tucson has legal rights to wastewater generated within its service area. These "effluent entitlements" are based on agreements with the federal government, Pima County, and various other local governmental entities. There are also agreements in place whereby Tucson Water can deliver reclaimed water allotted to other entitlement holders to various reuse sites through the RWS.

Conservation Effluent Pool - A Dedicated Water Supply for the Environment

As part of its commitment to enhancing the local environment, Tucson Water has undertaken an initiative, which figures prominently in determining its effluent entitlements. The City has collaborated with Pima County to allocate up to 10,000 acre-feet (AF) of effluent per year to create or enhance riparian (water-influenced) ecosystems through an agreement entitled the Conservation Effluent Pool (CEP).

Contributors to the CEP are Tucson Water, Pima County and all other water providers that have an effluent entitlement. Applications for CEP resources may be submitted by local entities that can develop restoration projects that only need supplemental water for a short establishment period (three to five years) so more projects can be completed over time. If there are no projects requesting CEP resources, then the CEP pool reverts back to the individual contributors.

Recent Effluent Entitlements

In 2012, approximately 61,400 AF of recycled water was produced by the Pima County metropolitan wastewater reclamation facilities (Table ES-3). Since none of the CEP was utilized in 2012, its allotted volume reverted back to the contributing entities. The City's entitlement was approximately 25,100 AF. In 2010, Tucson Water reused approximately 9,400 AF to meet the needs of its RWS customers and 4,000 AF was banked as long-term storage credits. A significant portion of the City's entitlement (11,700 AF) left its service area as surface flow after it was discharged to the Santa Cruz River channel without further physical or economic benefit to the City.

Projections of Effluent Entitlements

The *Recycled Water Master Pla*n developed a range of projections for Tucson Water's effluent entitlements:

- A "High" range based on the most recent "official" regional wastewater flow projections and assuming that the CEP allotment was not being utilized.
- A "Low" range based on 90 percent of the regional wastewater flow projections and assuming that the CEP allotment was being utilized by non-Tucson Water users.

Table ES-2. Recommended RWS Improvements and Cost Opinions

Project No.	Improvement	Projected Capital Costs ($1,000) [1,2,3]			
		Near-Term	Mid-Term	Long-Term	Total
IMPROVEMENTS TO ADDRESS EXISTING SYSTEM DEFICIENCIES (not in current CIP)					
North Loop Improvements (Priority 1)					
P-1	Pipe - 24-inch diameter, 57,500 LF	$20,400			$20,400
BPS-1	Booster Station - 14 MGD @ 270 ft	$2,900			$2,900
Subtotal		$23,200			$23,200
Dove Mountain Area Improvements (Priority 2)					
	Pipe				
P-2	8-inch diameter, 2,300 LF	$400			$400
P-3	12-inch diameter, 5,500 LF	$1,100			$1,100
P-4	16-inch diameter, 2,100 LF	$600			$600
T-1	Storage - 6 MG	$8,300			$8,300
Subtotal		$10,200			$10,200
Northeast Loop Improvements (Priority 3)					
	Pipe				
P-5	16-inch diameter, 10,600 LF	$1,500	$1,200		$2,700
P-6	24-inch diameter, 18,800 LF	$3,700	$3,000		$6,700
BPS-2	Booster Station - 5 MGD @ 340 ft	$1,700	$1,400		$3,100
T-2	Storage - 7.3 MG	$5,600	$4,600		$10,200
Subtotal		$12,300	$10,100		$22,400
Subtotals Existing System Deficiencies		**$45,700**	**$10,100**		**$55,800**
IMPROVEMENTS TO SERVE FUTURE TUCSON WATER DEMANDS (unless noted, not in current CIP)					
BPS-3	Tucson Reclaimed Water Plant Booster Station [4] 8 MGD @ 440 ft		$2,700		$2,700
BPS-4	Houghton Road Booster Station 1.5 MGD @ 220 ft			$900	$900
BPS-5	Thornydale Booster Station [5] 4.4 MGD @ 270 ft	$2,600			$2,600
BPS-6	Thornydale Booster Station [5] 5.4 MGD @ 270 ft			$3,200	$3,200
Subtotals Future Tucson Water Demands		**$2,600**	**$2,700**	**$4,100**	**$9,400**
GRAND TOTALS		**$48,300**	**$12,800**	**$4,100**	**$65,200**

[1] *January 2012 (ENR CCI = 9176)*
[2] *Cost opinions include engineering & administration at 25% and project contingencies at 30%*
[3] *Fiscal Year ending June 30 of the year indicated*
[4] *Project included in Tucson Water's proposed 10-year CIP*
[5] *Thornydale Booster Station upgrades necessary to serve future Oro Valley reclaimed water demands. Recommended system improvement added at request of Tucson Water staff for planning purposes (Oro Valley will be responsible for the recommended improvements).*

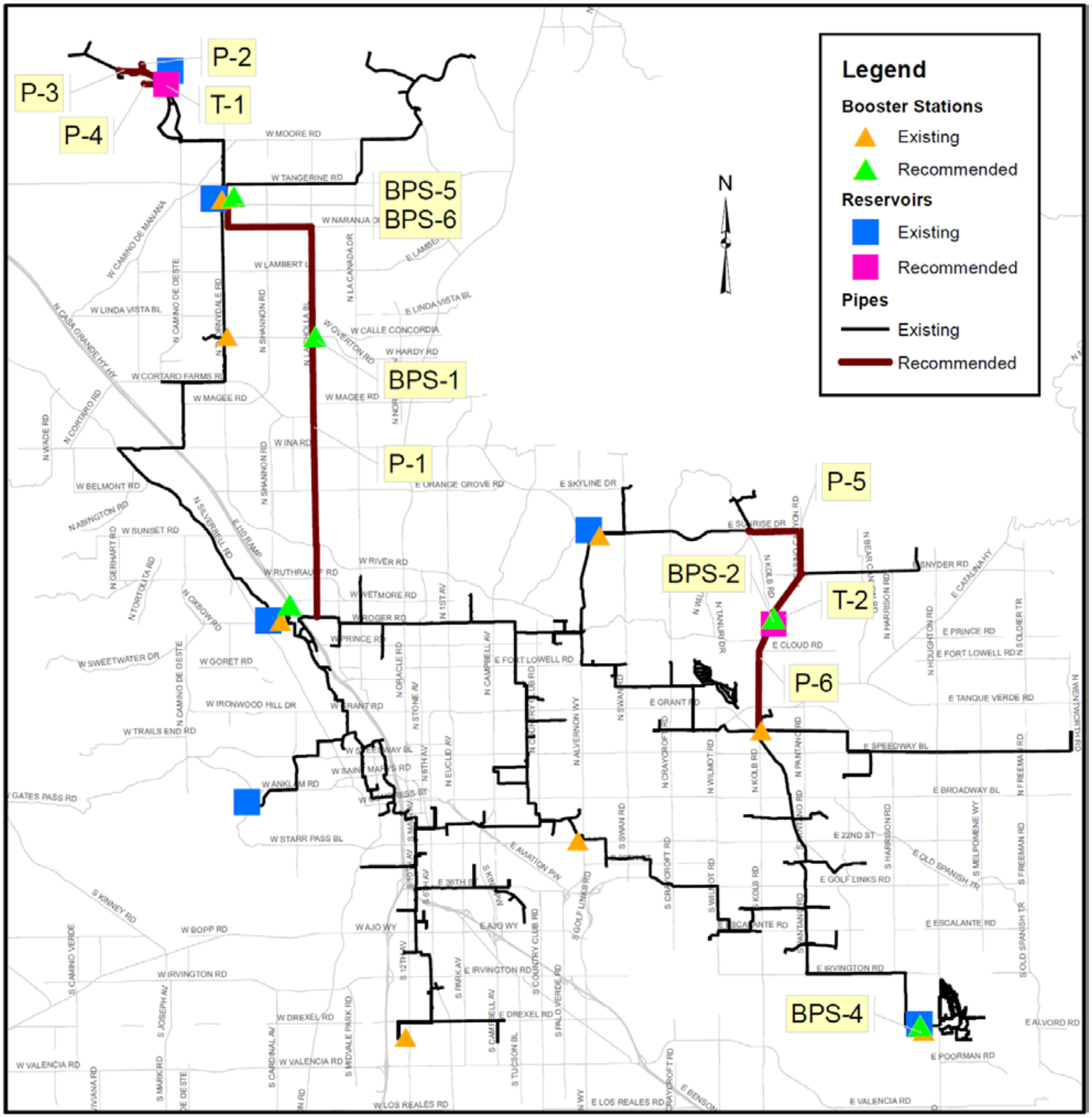

Figure ES-7. Recommended RWS Improvements

Table ES-3. Effluent Entitlements in Calendar Year 2012

Entities with Effluent Entitlements in 2012	Volume (AF)	Percent of Total
Secretary of Interior/SAWRSA	28,200	46%
City of Tucson/Tucson Water	**25,092**	**41%**
Pima County	3,319	5%
Metropolitan Domestic Water Improvement District	2,172	4%
Town of Oro Valley	1,928	3%
Flowing Wells Irrigation District	639	1%
Spanish Trail	43	>1%
Total	**61,393**	**100%**

The projections indicate that the City's annual effluent entitlement from the metropolitan area wastewater reclamation facilities could increase to as much as 46,000 AF by 2030 depending on actual wastewater flows and actual utilization of the CEP allotment (Figure ES-8).

The amount of Tucson Water's effluent entitlements (now "recycled water" after water reclamation treatment) available to be removed from river discharge and utilized for other purposes will depend on demands within the RWS and other existing non-potable uses. The projections indicate that the City's unutilized recycled water supply from the metropolitan area facilities could increase to as much as 29,000 AF by 2030 depending on actual wastewater flows and actual utilization of the CEP allotment.

Variations in Availability of Unutilized Recycled Water

The amount of unutilized recycled water will vary throughout the year due to the wide variation in RWS irrigation demands (the primary reclaimed water use) and other non-potable uses. Almost all of the recycled water is unutilized during the winter period when irrigation demands are low, and almost all of it is utilized during the summer high irrigation demand periods. This high variation in unutilized recycled water supplies figures prominently in sizing of new recycled water program facilities and infrastructure.

It is projected that in 2020, the maximum recycled water availability could vary from 19 to 32 MGD during the low reclaimed water demand period, to 0 to 8 MGD during the high demand period (Figure ES-9). In 2030, the maximum recycled water availability is projected to vary from 26 to 41 MGD during the low demand period, to 1 to 14 MGD during the high demand period (Figure ES-10).

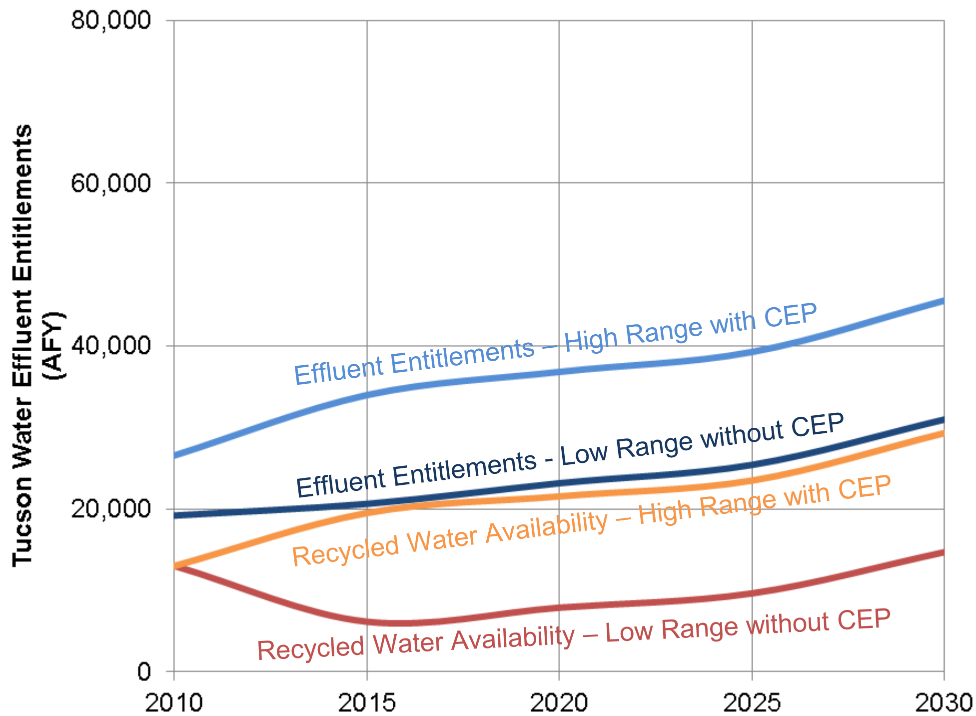

Figure ES-8. **Effluent Entitlements and Recycled Water Available For Other Programs from Metropolitan Area Reclamation Facilities**

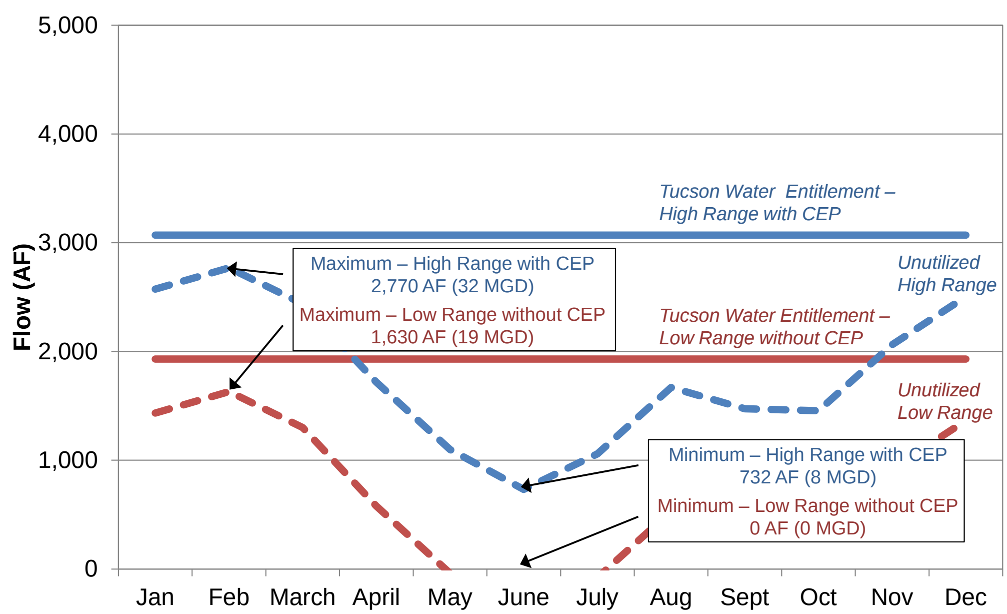

Figure ES-9. **2020 Projection of Seasonal Distribution of Recycled Water Resources from Metropolitan Area Reclamation Facilities**

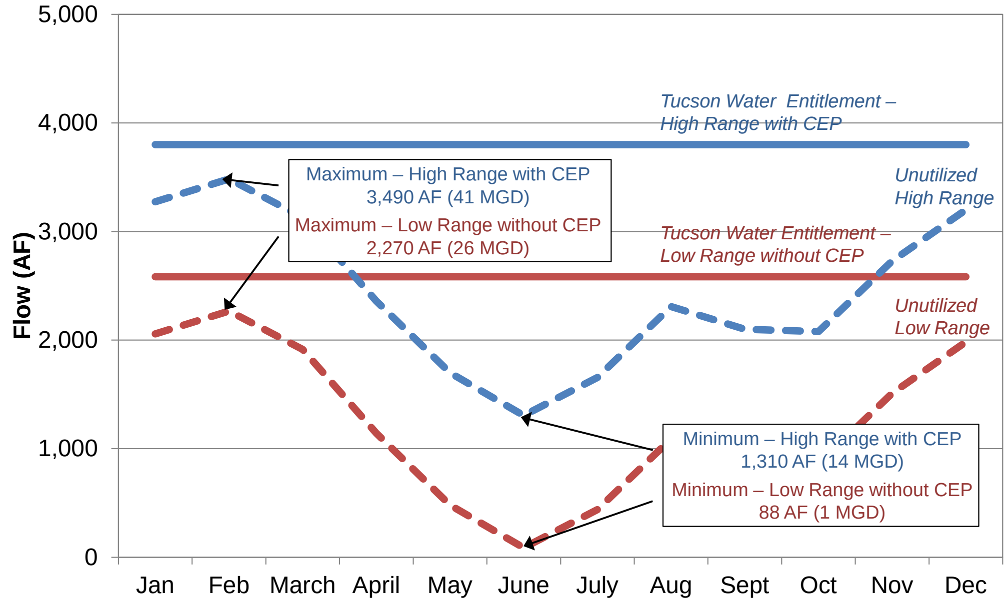

Figure ES-10. 2030 Projection of Seasonal Distribution of Recycled Water Resources from Metropolitan Area Reclamation Facilities

New Recycled Water Programs

Since limited additional demands are anticipated for the RWS, new recycled water programs will be required to put Tucson Water's unutilized recycled water resource to beneficial use. The unutilized recycled water could be used to replenish groundwater and, after additional advanced treatment, to supplement potable water supplies, a practice termed "indirect potable reuse (IPR)." This practice is now being utilized successfully by many communities in the arid southwest to supplement scarce water supplies.

Need for New Recycled Water Programs

There are several very compelling reasons for Tucson Water to establish a program to make use of the community's significant unutilized recycled water supplies:

- The impacts of sustained drought and climate change in the Southwest will result in shortages to the City's CAP allocation, and will increase the cost to purchase and deliver the water to Tucson.
- The existence of other renewable water resources that Tucson Water could access is highly uncertain at this time, including the availability, eventual costs, and legal challenges to bring other new water supplies into the area.

- Tucson Water currently has significant unutilized recycled water supplies which will increase as new customers are connected in the future.
- Recycled water is the only remaining new local, renewable water resource. It can be used to establish additional renewable water supplies and help to decrease reliance on CAP supplies and increase the reliability and sustainability of the community's water supplies.
- Tucson Water customers have made large investments and are still making investments to bring CAP water into the community and to manage its wastewater. A new recycled water program will leverage these investments and maximize utilization of the valuable recycled water resource that is currently discharged to the riverbed and leaves the basin without further benefit to Tucson Water customers.
- Recycled water programs involving IPR in the arid Southwest are being widely recognized as feasible and valuable in increasing the reliability of community water supplies.

Potential Benefits of New Recycled Water Programs

New recycled water programs through indirect potable reuse would enhance Tucson Water's renewable water resources portfolio and support the utility's Water Reliability efforts by providing the following community benefits:

- **Increase the reliability of Tucson Water's future water supplies.** The imported CAP water supplies are susceptible to drought, which is anticipated to become more problematic due to climate change. Recycled water is a renewable water supply that is not significantly affected by drought and its increased use will strengthen the resistance of the community's water supply to drought and water emergencies.
- **Increase the sustainability of local groundwater resources.** Groundwater replenishment with recycled water will further protect the basin from subsidence and resulting reductions in water storage capacities.
- **Support economic development.** A reliable water supply will attract more industry and businesses to the community which will increase the revenue and tax base, and ultimately contribute to community enhancements and sustain a high standard of living.
- **Increase local control and management of water resources.** The community will become less dependent on the decisions and actions of other agencies and entities that may have different objectives for the State's renewable water resources.
- **Avoid the costs and environmental impacts of importing additional water supplies.** New water supplies will be costly and may be located at great distances from the community and require significant pumping energy to deliver the water.

- **Expand and diversify the water supply portfolio.** Recycled water, as an additional renewable water supply, will increase water supply reliability, reduce the risks of relying on finite supply sources, and increase flexibility for water supply management.
- **Provide the opportunity to start improving the region's groundwater quality through salinity control.** By including membrane treatment processes as part of the advanced water treatment process, a side benefit is that minerals contributing to salinity would be removed from the urban water cycle. It is estimated that advanced water treatment can remove between 4,000 and 7,500 tons per year of salt from the water supply (for 2020 and 2030 recycled flows, respectively).
- **Support environmental stewardship.** Additional use of recycled water resources will support and promote the community's desire for sustainability, increasing efficient use of water, and protecting its water resources.

Advanced Water Treatment

An Independent Advisory Panel established with the assistance of the National Water Research Institute (NWRI) reviewed the work to identify recycled water program alternatives and helped to shortlist advanced treatment process options for detailed evaluations.

To secure support and investment for new recycled water projects, Tucson Water will need to build trust with respect to multiple issues, but especially water quality. This clearly applies to water treatment recommendations and decisions regarding IPR. Although advanced water treatment is not technically necessary to meet safe drinking water standards, it is a prudent approach to reducing public health risks. Advanced water treatment processes can be employed to provide multiple barriers for removal of pathogens and diverse barriers for removal of trace organic contaminants in recycled water projects.

The *Recycled Water Master Plan* identified and prioritized advanced water treatment processes for consideration in new recycled water program alternatives (example process shown in Figure ES-11). Advanced water treatment was considered both before recharge (pre-recharge) and after recovery (post-recovery). Pre-recharge treatment is more costly and energy intensive, as the treatment facilities must be sized to accommodate the significant variations in unutilized recycled water during the year. Post-recovery treatment is efficient for inland IPR applications (where there is no ocean to accept brine from the treatment steps) and provides the opportunity for soil aquifer treatment (SAT) as a natural treatment process for removing many wastewater constituents remaining after treatment at the Pima County water reclamation facilities. SAT also provides natural pre-treatment that replaces processes, such as filtration prior to membrane treatment. Therefore, post-recovery treatment has the potential to be more cost-effective because 1) the aquifer provides storage to buffer the seasonal variations in unutilized recycled water, resulting in smaller treatment facilities that can be operated at uniform flows year-round, and 2) the natural treatment provided by SAT reduces advanced treatment process needs.

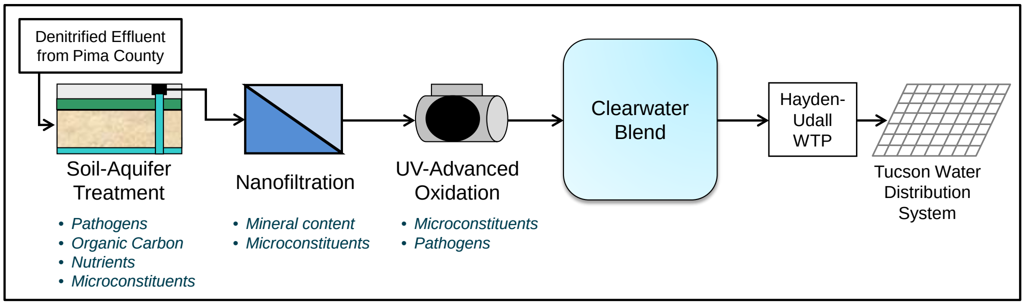

Figure ES-11. Example Advanced Water Treatment Schematic

New Recycled Water Program Alternatives

The *Recycled Water Master Plan* also identified and evaluated new recycled water program alternatives employing IPR. The alternatives evaluated represent the range of program possibilities given the current uncertainties that will influence the development of any new recycled water program. The alternatives included water conveyance, pumping, recharge and recovery, advanced water treatment, and finished water transmission facilities. The advanced water treatment for the alternatives consisted of the highest priority treatment process trains (Table ES-4).

Table ES-4. New Recycled Water Program Alternatives

Alternative	Pre-Recharge Treatment	Natural Treatment & Storage	Post-Recovery Treatment	Concentrate Treatment
North CAVSARP-1	MF + NF + UV-AOP	Recharge	Disinfection	O_3 + BAC + IX + EDR
North CAVSARP-3	-	Recharge/SAT	SAT + NF + UV-AOP + GAC (for H_2O_2 quenching) + Disinfection[1]	EDR
North CAVSARP-4	-	Recharge/SAT	SAT + NF + Disinfection[1]	EDR + GAC

CAVSARP - Central Avra Valley Storage and Recovery Project, SAVSARP - Southern Avra Valley Storage and Recovery Project, SE Tucson - Southeast Tucson, MF - Microfiltration, NF - Nanofiltration, UV-AOP - Ultraviolet/Hydrogen Peroxide Advanced Oxidation Process, O3 - Ozone, BAC - Biologically Activated Carbon, IX - Ion Exchange, EDR - Electrodialysis Reversal, SAT - Soil Aquifer Treatment, GAC - Granular Activated Carbon

The estimated conceptual unit costs for new recycled water program alternatives employing IPR are presented on Table ES-5. The recycled water source for all alternatives is the future Water Reclamation Campus. The recycled water conveyance route from the Water Reclamation Campus to the North CAVSARP location is approximately 25 miles, with a total pumping lift of approximately 100 feet. The recycled

Table ES-5. Estimated Conceptual Costs for New Recycled Water Program Alternatives

Item	North CAVSARP-1		North CAVSARP-3		North CAVSARP-4	
Mainstream Treatment Train	MF + NF + UV-AOP + Recharge		Recharge/SAT + NF + UV-AOP + GAC (for H_2O_2 quenching)		Recharge/SAT + NF	
Flow Basis (Year)	2020	2030	2020	2030	2020	2030
Capital Costs	$329	$406	$203	$266	$198	$258
Annualized Capital Costs[1]	$19.0	$23.5	$11.7	$15.4	$11.5	$15.9
Annual O&M Costs	$6.7	$11.1	$3.4	$6.1	$3.5	$6.4
Total Annual Costs	$25.7	$34.6	$15.1	$21.5	$15.0	$21.3
Annual Water Supply	7 MGD (7840 AFY)	13 MGD (14,560 AFY)	7 MGD (7840 AFY)	13 MGD (14,560 AFY)	7 MGD (7840 AFY)	13 MGD (14,560 AFY)
Unit Cost ($/AF)[2]	**$3,300**	**$2,400**	**$2,000**	**$1,500**	**$2,000**	**$1,500**

[1] Based on an interest rate of 4% and term of 30 years.

[2] Unit cost based on Annual Water Supply.

water conveyance route for the SE Tucson location is approximately 35 miles long and would require three booster stations with a total pumping lift of 1,200 feet.

New recycled water programs will come at a significant cost, due primarily to the need to move large volumes of water over long distances. Other Arizona cities, as well as other large cities in the arid Southwest, are conducting long range planning to assure water supply reliability. Because much of the existing water supplies have been allocated, many projects being contemplated involve moving water supplies over long distances and utilizing waters with impaired quality (brackish water, seawater, recycled water, etc.). A comparison of the estimated costs of recently implemented and proposed Southwest water supply projects indicates that the potential costs for a Tucson Water new recycled water program is generally comparable with other Southwest water supply projects, particularly at higher new water supplies provided (Figure ES-12).

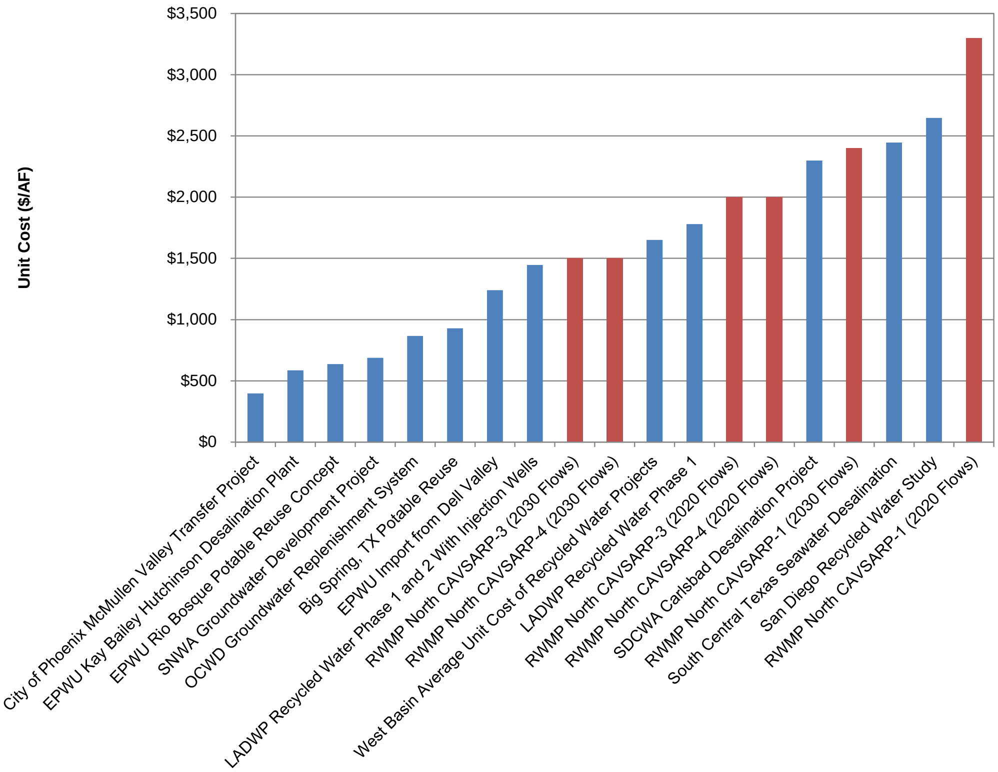

Figure ES-12. Comparison of Southwest Water Supply Projects

Recommendations for New Recycled Water Programs

Because of the impelling business case, it is recommended that Tucson Water continue with an implementation program to put its future unutilized recycled water supplies to beneficial use. Recycled water is a local renewable water supply that can be used to increase the reliability of the City's water supplies. A new recycled water program will maximize utilization of the valuable recycled water resource that the community has invested heavily in and that currently leaves the basin without further physical or economic benefit to Tucson Water customers. Finally, a new recycled water program will provide a range of other benefits to the community, including increasing the sustainability of local groundwater resources, supporting economic development, providing an opportunity to begin salinity management for local groundwater resources, and supporting the community's desire for sustainability and protection of water resources.

It is recommended that Tucson Water prepare a phased multi-year implementation plan that identifies near- and long-term activities and capital improvement program requirements to support sustained progress toward realization of this renewable water supply. The implementation plan should be structured around addressing the following key uncertainties that have been identified in this *Recycled Water Master Plan*:

- **Conveyance Pipeline to Avra Valley:** Additional investigations should be conducted to acquire the necessary rights-of-way in advance of additional development that may occur along the alignment. The investigations should include a study to identify the most feasible pipe alignment, refine cost estimates, identify potential additional regional contributors, and identify any reclaimed water source issues (physical and institutional) that can be addressed to reduce costs.
- **Facility Planning at North CAVSARP Site:** Additional investigations should be conducted to refine the North CAVSARP site concepts and to develop a preliminary site design that identifies and locates all recharge, treatment, recovery and conveyance facilities.
- **Hydrogeologic Investigations**: Investigations should be conducted of the North CAVSARP site to refine the recharge and recovery concepts, define the water retention times in the ground before recovery, assess the ability to segregate the recycled water recharge and recovery operations from the CAVSARP operations, and provide information for permitting.
- **Role of SHARP in Future Recycled Water Programs:** Additional work should be conducted to clearly define the role of SHARP in a new recycled water program. This work should include determination of the ability to reliably deliver recycled water to the SHARP site, the site's potential for a demonstration project, groundwater quality impacts, and the ability to manage recharged water at the site for demonstration testing, recharge and recovery for the RWS, and/or for long-term underground storage.
- **Cost and Effectiveness of Advanced Treatment and Concentrate Management:** The preferred treatment and concentration management processes should be investigated and refined through additional research, bench- and pilot-scale testing, and demonstration efforts. A literature review should be conducted to monitor evolving trends in recycled water treatment and concentrate management and to assist in the design of bench- and pilot-scale testing and demonstration project opportunities. All testing and demonstration efforts should be carefully planned to provide information for implementation, including refinement of facility layouts, treatment evaluations, impact of blending advanced treated water with other Clearwater blend water, sustainability analysis, and cost estimates. The program should also develop sufficient information for permitting of the program facilities and operations. Opportunities for collaboration with key entities such as the University of Arizona and Pima County in these investigations should be explored.
- **Public Outreach:** Public outreach efforts should be developed to engage local and regional stakeholders. The efforts should leverage lessons learned from similar programs that have been particularly successful, engage experts in the recycled water industry (including those that have planned and implemented outreach programs for similar projects), and provide public information on best management

practices developed for groundwater replenishment and IPR. The program should also leverage an advanced treatment demonstration program to educate the public through activities such as site tours, expert presentations, and treated water tasting.

- **Financial Plan for Implementation:** The estimated costs for a new recycled water program are significant. A financial plan should be developed for the program that considers a range of funding alternatives, impacts to water rates, and sensitivities to different implementation horizons.

Due to increasing water demands, continued droughts, and dwindling water supplies, the drinking water and water reuse industry is now moving towards direct potable reuse (DPR), which involves introduction of recycled water directly into potable water treatment facilities without an intermediate natural or engineered buffer, such as an aquifer or reservoir. Although DPR may become a valid consideration at some point in the future, this Recycled Water Master Plan focuses on IPR since the momentum for such projects in the Southwest is well established. Tucson Water should, however, monitor developments in the DPR regulatory and technological advances, and should continue to revisit the goals and objectives of the program, given the advances, during further implementation of a new recycled water program

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LIST OF ACRONYMS

AACE	Association for the Advancement of Cost Engineering
ADD	Acquisition, Development, and Delivery
ADEQ	Arizona Department of Environmental Quality
ADWR	Arizona Department of Water Resources
AF	acre-feet
AFY	acre-feet per year
AMAs	Active Management Areas
AWBA	Arizona Water Banking Authority
AWS	Assured Water Supply
AZPDES	Arizona Pollutant Discharge Elimination System
BAC	Biologically Activated Carbon
C2E	Conserve to Enhance
CAP	Central Arizona Project
CAVSARP	Central Avra Valley Recharge and Recovery Project
CAWCD	Central Arizona Water Conservation District
CCL3	Contaminant Candidate List 3
CEP	Conservation Effluent Pool
CIP	capital improvement program
CWA	Clean Water Act
CWAC	Citizens' Water Advisory Committee
EDCs	endocrine-disrupting compounds
EDR	Electrodialysis Reversal
ENRCCI	Engineering News Record Construction Cost Indices
EPA	Environmental Protection Agency
ESA	Endangered Species Act
FWID	Flowing Wells Irrigation District
GAC	Granular Activated Carbon
GFRs	grandfathered groundwater rights
GMA	Groundwater Management Act
IGA	Intergovernmental Agreement
IPR	indirect potable reuse
IX	Ion Exchange
LEED	Leadership in Energy and Environmental Design
LRV	log reduction value
LT2	Long Term 2 Enhanced Surface Water Treatment Rule
MCL	Maximum Contaminant Level

MDWID	Metropolitan Domestic Water Improvement District
MF	Microfiltration
MG	million gallons
mg/L	milligram per liter
MGD	million gallons per day
NF	Nanofiltration
ng/L	nanogram per liter
NTU	Nephelometric Turbidity Units
NWRI	National Water Research Institute
O&M	operations and maintenance
O3	Ozone
OCWD	Orange County Water District
PCRWRD	Pima County Regional Wastewater Reclamation Department
PMRRP	Pima Mine Road Recharge Project
PPCPs	pharmaceuticals and personal care products
RO	Reverse Osmosis
ROMP	Regional Optimization Master Plan
RWS	Reclaimed Water System
RWTP	Reclaimed Water Treatment Plant
SAT	soil aquifer treatment
SAVSARP	Southern Avra Valley Storage and Recovery Project
SAWRSA	Southern Arizona Water Rights Settlement Act
SDWA	Safe Drinking Water Act
SE	Southeast
SHARP	Southeast Houghton Area Recharge Project
TDS	total dissolved solids
TOC	total organic carbon
US&R	underground storage and recovery
UV-AOP	Ultraviolet/Hydrogen Peroxide Advanced Oxidation Process
WISP	Water and Wastewater Infrastructure, Supply and Planning Study
WRDC	Water Resources Development Commission
WRF	Wastewater Reclamation Facility

PREFACE

This document presents the *Recycled Water Master Plan* developed by Malcolm Pirnie, the Water Division of ARCADIS, the project consultant, with the assistance and guidance of Tucson Water. It identifies a program for maximizing the use of the City of Tucson's recycled water, a renewable water resource that is locally-controlled and increases in volume over time. The program includes two major components required to maximize recycled water use:

1. Serving existing and future non-potable water demands through Tucson's Reclaimed Water System.
2. Replenishing Tucson's water supplies with recycled water that remains available after meeting non-potable demands.

Water supply replenishment with recycled water could occur through groundwater recharge, water purification, and blending using an approach termed "indirect potable reuse" that is currently practiced in other communities in the arid Southwest.

"We forget that the water cycle and the life cycle are one."

Jacques Yves Cousteau

The *Recycled Water Master Plan* is an integral part of Tucson Water's comprehensive water resources planning program, a key component of "Water Reliability." This planning program strives to ensure that Tucson Water has the strategic flexibility and adaptive capacity required to meet the resource challenges that lie ahead, and can maintain a reliable water supply and system into the future. The *Plan* reflects Tucson Water's priorities and commitments to its customers:

- Providing safe, high-quality water to our customers.
- Planning and investing to ensure our customers continue to receive reliable water supplies, with an emphasis on use of renewable water resources.
- Ensuring high quality water service based on sound financial management.
- Effectively communicating with customers about important water issues.
- Protecting and enhancing the natural environment.

Throughout this document, the water resource that comprises the City of Tucson's treated wastewater is termed "effluent entitlements" when referring to inter-governmental agreements and other legal documents that govern how the entitlements are apportioned to Tucson Water, Pima County, and other local governmental entities and water agencies. The water resource is then referred to as "recycled water" after water reclamation treatment. The portion of that recycled water treated for non-potable use in the Reclaimed Water System will continue to be called "reclaimed water."

Chapter 1 • SETTING THE STAGE

RECYCLED WATER MASTER PLAN

Chapter 1. SETTING THE STAGE

Purpose

The overall purpose of the *Recycled Water Master Plan* is to provide an integrated recycled water program that maximizes the benefits of the City's recycled water resource. This document provides information to City of Tucson decision makers, Tucson Water customers, and other stakeholders on the planned use of the City's effluent entitlement both in its Reclaimed Water System (RWS) and through other means.

The *Master Plan* assesses how projected population and potable water demand within Tucson Water's service area will annually produce wastewater which, as part of the urban water cycle, will become part of the Utility's renewable water resources portfolio. Modeling of the RWS is incorporated into the planning process to evaluate how to upgrade and expand existing systems and to identify the projects and programs that should be implemented over time to ensure strategic flexibility and future water supply reliability.

In addition, the *Recycled Water Master Plan* provides a framework for next steps and continued activities that will help ensure the timely implementation of the necessary recycled water projects and programs. These in turn will help achieve Tucson Water's objectives, ensure the long-term sustainability of the Utility's water resources, and enable it to keep its commitment to "Water Reliability" for its customers.

Tucson Water's Water Reliability Program includes investments and commitments to ensure our customers have a reliable water supply and system today and in the future. The Program encompasses five areas: water supply, water quality, water customers, water operations and systems, and water conservation and efficiency.

WaterReliability

Background

During the past 20 years, Tucson Water has produced three comprehensive, integrated long-range plans, the *Tucson Water Resources Plan 1990-2100, Water Plan: 2000-2050,* and the *2008 Update to Water Plan: 2000-2050*. The *2012 Update to Water Plan: 2000-2050* is also currently being prepared and is scheduled to be complete by the end of 2013. These plans address the availability and use of water supplies to serve the utility's current and future customers. Each one of these plans also recognized the importance of recycled water for both non-potable use in the RWS and for possible future potable use, thus setting the stage for the development of a recycled water master plan.

During the development of the 2009 City of Tucson/Pima County *Water & Wastewater Infrastructure, Supply & Planning Study* the need for a comprehensive, long-range recycled water plan was recognized by City and County staff as well as by the project's Oversight Committee, and was included in the *2011-2015 Action Plan for Water Sustainability* (2010).

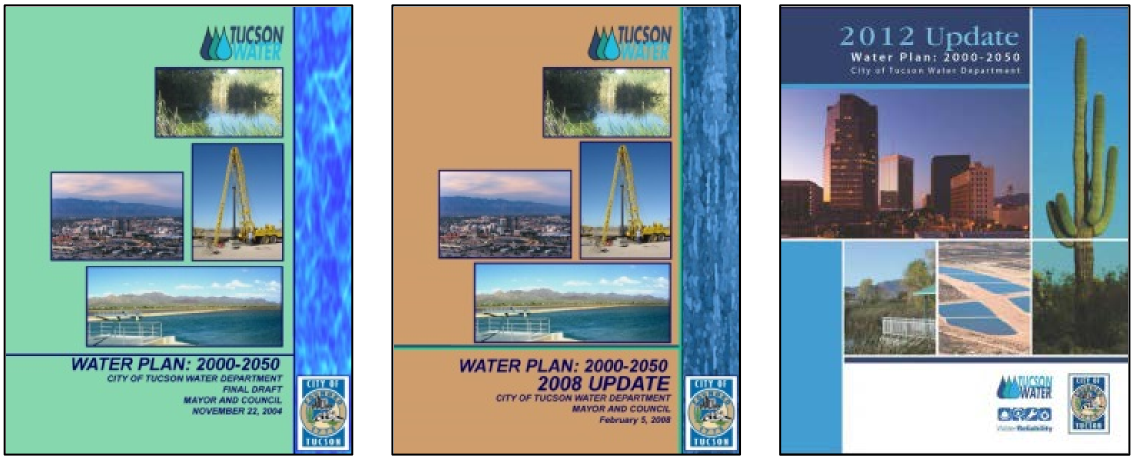

Figure 1-1. Tucson Water Long-Range Water Planning

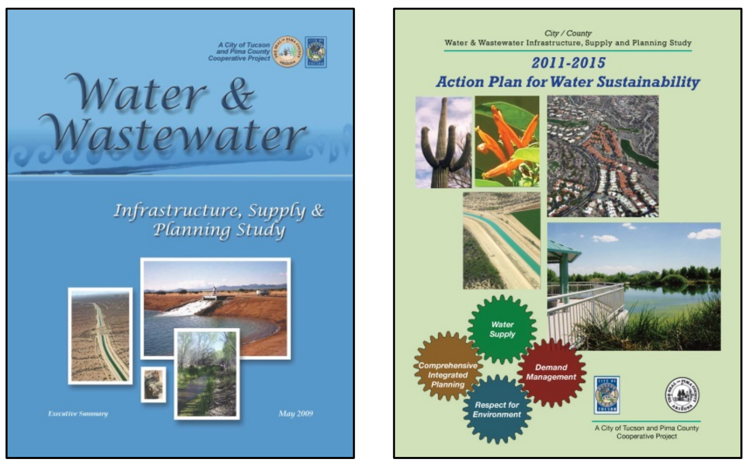

Figure 1-2. City/County Final Report and Action Plan

The importance of recycled water was also recognized statewide when the Governor's Blue Ribbon Panel on Water Sustainability (2010) focused on advancing water sustainability by recommending increased water recycling to meet the needs of non-potable reclaimed water reuse and for indirect potable reuse.

The development of a master plan for the City's recycled water was initiated in 2010, as part of Phase IIB of the "Water Quality Assessment and Implementation Program," which the Mayor and Council approved in 2005. This *Recycled Water Master Plan* documents the results of that master planning process.

Recycled Water Master Plan Goals

The goals and objectives of the *Recycled Water Master Plan* are consistent with the broader resource planning goals summarized in *Water Plan: 2000-2050* and its *2008 Update*:

Meet Projected Reclaimed Water Demand. The Utility's reclaimed water demand has grown since the mid-1980s, when it was first utilized. Current population projections within the Tucson Water service area indicates that reclaimed water demand will increase in the foreseeable future, albeit at a slower rate.

Utilize the Balance of the City's Recycled Water to Reinforce Vulnerable Supplies and Ensure Supply Reliability. In order for the community to be sustainable into the longer term future, Tucson Water will need to maximize its use of the projected unused portion of its recycled water. This will help strengthen currently available supplies that will be vulnerable to shortage in the future.

Continue to Meet Potable and Recycled Water Quality Targets. In addition to complying with federal, state, and local regulations, Tucson Water must also be responsive to the water quality expectations and preferences of its customers.

Manage Costs and Rate Impacts. Projects and programs to maximize the use of Tucson Water's available recycled water must be cost-effective.

Augment the City's Assured Water Supply Designation. The Assured Water Supply Program regulated and administered by the Arizona Department of Water Resources limits the amount of groundwater that utilities can legally withdraw. Expanded use of recycled water will provide Tucson Water with the ability to further reduce its reliance on groundwater for municipal supply.

Geographic Setting

The City of Tucson is located in the northern semi-arid reaches of the Sonoran Desert in eastern Pima County, Arizona. As shown on Figure 1-3, the Tucson Water obligated service area is situated in the north-central part of the Tucson basin which is a broad desert valley surrounded by mountain ranges.

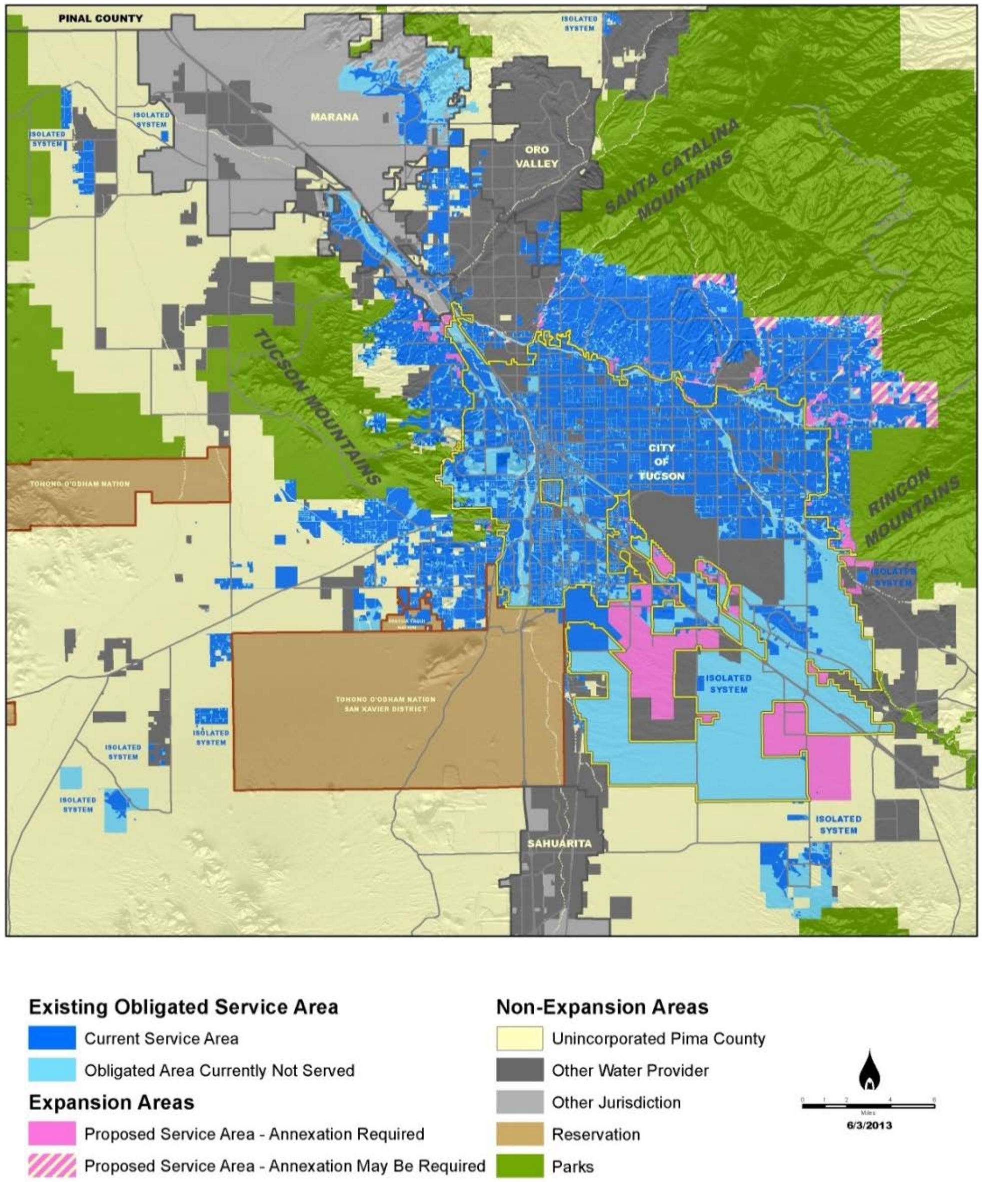

Figure 1-3. Tucson Water Service Area

The *Recycled Water Master Plan* focuses on the Tucson Water obligated service area as adopted by the City of Tucson Mayor and Council on August 4, 2010 in Resolution No. 21602.

Tucson Water is a municipal water provider owned and operated by the City of Tucson. The Utility is subject to the authority of the City of Tucson Mayor and Council, and the Director of Tucson Water is subject to the authority of the City Manager. Tucson Water is self-supporting and relies totally on revenues generated from water fees and sales. Actual cost of service is used to determine water rates; in other words, customers are charged in direct proportion to the cost of developing supplies and delivering the water. The Utility operates a dual water system that serves potable (drinking) water and reclaimed water for irrigation and other non-potable uses. Tucson Water's RWS is shown in Figure 1-4.

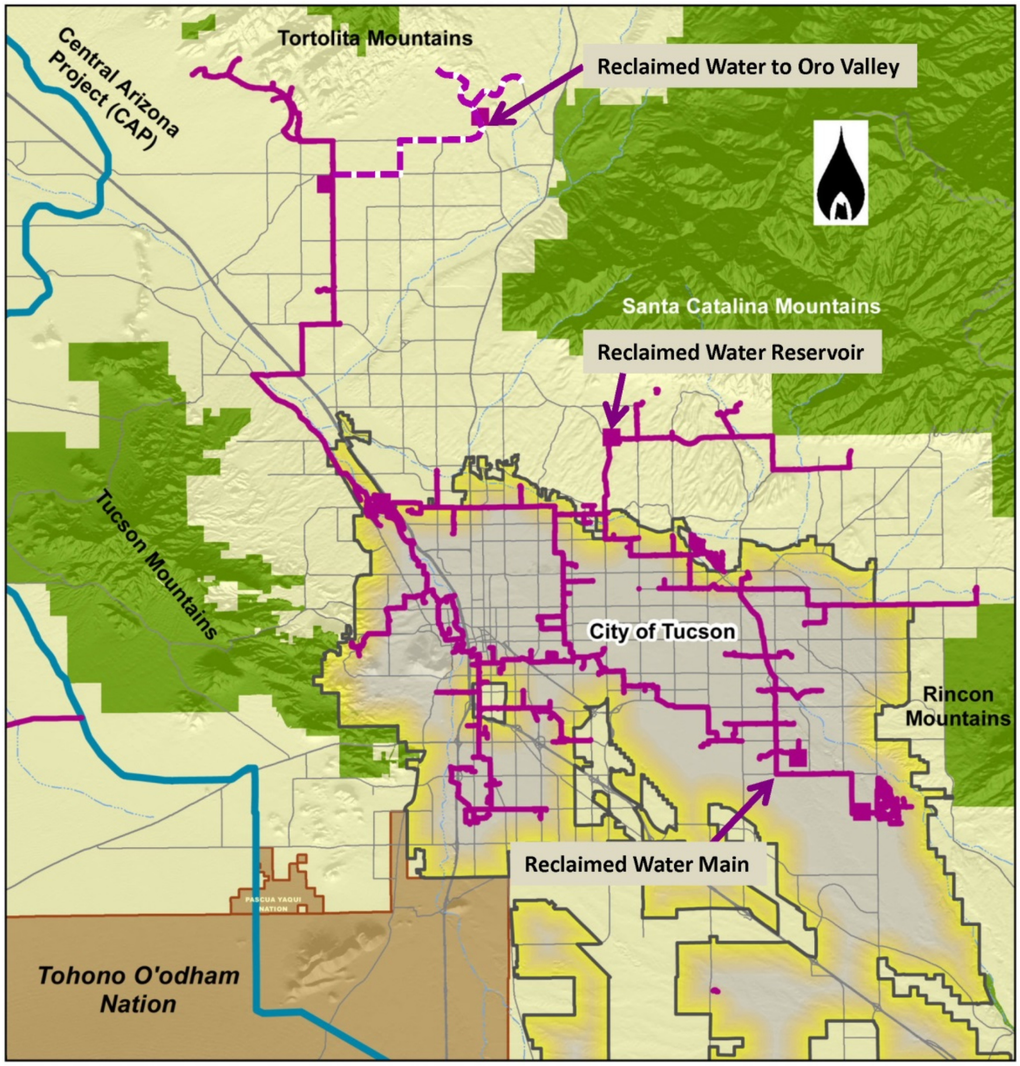

Figure 1-4. Map of Reclaimed Water System

That portion of the City's recycled water supply not currently diverted into the RWS is either delivered to non-reclaimed customers or discharged to the Santa Cruz River where it flows out of Tucson Water's service area. The *Recycled Water Master Plan* identifies Tucson Water's current reclaimed water customers and assesses the potential to expand the RWS and add future customers. The *Recycled Water Master Plan* also addresses that portion of the City's recycled water supply which is discharged to the Santa Cruz River and how that resource could be used by Tucson Water to maximize benefits to the community it serves.

The Master Planning Process

The *Recycled Water Master Plan* was developed, in part, by revisiting the Utility's scenario planning assumptions and uncertainties for recycled water reuse developed in *Water Plan: 2000-2050*. Tucson Water utilized the best available information and planning assumptions to address many possible views of the future related to water reuse. The recommended plan was developed to maintain the Utility's flexibility so that it can more readily adapt to future uncertainties. Figure 1-5 shows the planning process used to develop the *Recycled Water Master Plan*.

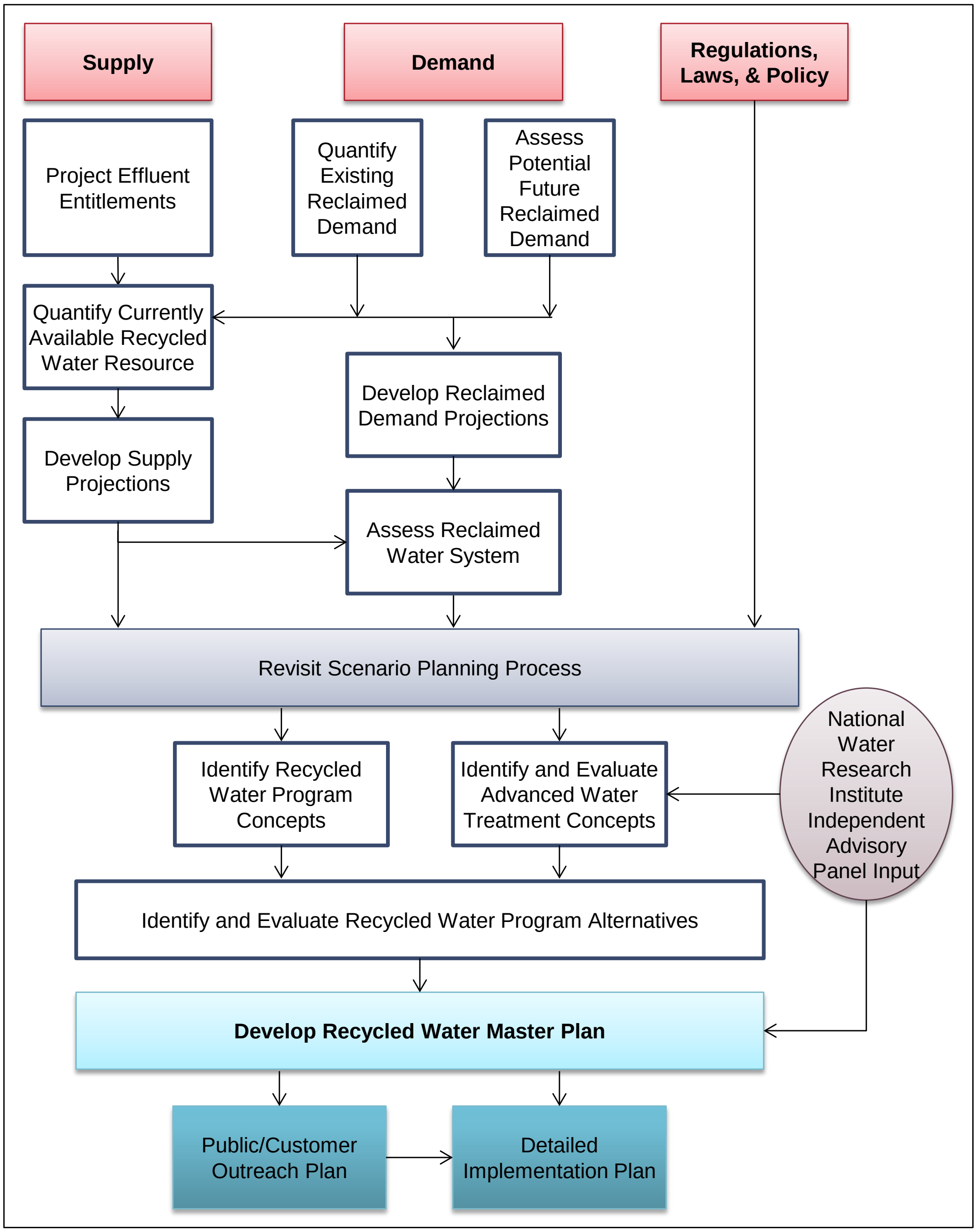

Figure 1-5. Recycled Water Master Plan Development Sequence

Planning assumptions will be revisited periodically to ensure Tucson Water's commitments and planning goals will continue to be met. The *Recycled Water Master Plan* will be revised over time in order to respond to changing conditions and new opportunities. The Utility, in conjunction with the Citizens' Water Advisory Committee (CWAC), the official advisory body to the Mayor and Council on water issues, will determine when a comprehensive revision should be initiated. The *Recycled Water Master Plan,* as well as subsequent updates will be submitted to Mayor and Council for consideration and possible adoption.

Independent Advisory Panel Input

An important element of the planning process was interaction with an Independent Advisory Panel of experts in the water reuse industry. The Independent Advisory Panel for this effort was formed and administered by the National Water Research Institute (NWRI). NWRI specializes in working with researchers across the country, such as laboratories at universities and water agencies, and are guided by a Research Advisory Board (representing national expertise in water, wastewater, and water reuse) and a six-member Board of Directors (representing water and wastewater agencies in Southern California).

For 20 years, NWRI – a science-based 501c3 non-profit located in Fountain Valley, California – has sponsored projects and programs to improve water quality, protect public health and the environment, and create safe, new sources of water.

Through its research program, NWRI supports multi-disciplinary research projects with partners and collaborators that pertain to treatment and monitoring, water quality assessment, knowledge management, and exploratory research. NWRI also provides third-party expertise and scientific advice in reviewing projects or policies for local and state agencies through their Independent Advisory Panel Program.

In the review of the *Recycled Water Master Plan*, the Panel evaluated topics related to: public health and safety; public outreach and advocacy; groundwater; advanced treatment technologies (such as use of advanced treatment technologies to reduce mineral content, attenuate contaminants of emerging concern, etc.); and, other topics related to indirect potable reuse. The Panel members for this effort were selected to represent a broad range of disciplines and experience relevant to potable reuse (e.g., engineering, water reuse criteria, groundwater hydrology, chemistry, and risk assessment), and included the following:

- Panel Chair: Shane Snyder, Ph.D., University of Arizona (Tucson, AZ)
- Jörg E. Drewes, Dr.-Ing., Colorado School of Mines (Golden, CO)
- Ian Pepper, Ph.D., University of Arizona (Tucson, AZ)
- Anne Browning-Aiken, University of Arizona, Udall Center for Studies in Public Policy (Tucson, AZ)
- Michele Robertson, P.G., Montgomery & Associates (Scottsdale, AZ)
- Robert Hultquist, California Department of Public Health (El Cerrito, CA)
- Ron Wildermuth, West Basin Municipal Water District (Carson, CA)

Public/Customer Outreach

Another important element of the planning process was to begin formulating plans for outreach to Tucson Water customers. Very successful indirect potable reuse programs have been instituted in other areas around the country. The lessons learned from these programs, and the knowledge of the experts involved in the programs, can be included in customer outreach activities for a Tucson Water recycled water program. However, Tucson is a unique region with special understanding and unique experience when it comes to customer water use and water knowledge. Therefore, while much of what has been done successfully and accomplished with great results in other communities will be valuable, the Tucson Water effort must be fine-tuned to match the needs of its customers, the City's leadership, and the Utility's staff.

The planning process included activities to begin identifying best practices and public outreach messages by visiting successful indirect potable reuse programs, and by reviewing best practices touted by these programs and others in the water reuse literature. The work found that public/customer education for the recycled water program should begin early in the process and continue throughout its planning and development.

The customer outreach activities started as part of the planning process will be continued and expanded as Tucson Water implements the recycled water program

Based on the work completed, Tucson Water will continue developing a customer outreach plan that focuses on the Water Reliability objectives. The information shared with customers will include key messages from that program about water supply (including the value of wastewater currently unused), water quality (including salinity issues), and water efficiency. The customer outreach plan will be developed, refined and executed during subsequent implementation steps and will include, community-wide education on recycled water; development of a speakers bureau to meet with local social, professional, and trade organizations; and, more informal meetings with individuals and smaller groups requesting additional information. The plan will also include development of printed educational information, social media, and video. Finally, the plan will include an advanced treatment demonstration program to educate customers through site tours, expert presentations, and treated water tasting to eventually create community-wide support for the program.

Contents of the Report

This report consists of eight chapters and seven supporting appendices.

Chapter 1. Setting the Stage. Provides an overview of the purpose and background of the Recycled Water Master Plan, as well as describes the geographic setting and master planning process.

Chapter 2. The Value of Reuse: Recycled Water as a Community Resource. Provides an overview of recycled water as a community resource.

Chapter 3. Laws, Regulations and Policies. Summary of the laws, regulations, and policies that govern the use of recycled water in Arizona.

Chapter 4. Recycled Water - a Reliable Local Resource. Presents projections of Tucson Water's effluent entitlements after apportionment of available effluent to the various local entities.

Chapter 5. Recycled Water Supply and Demand. Presents variability of Tucson Water's projected recycled water supply available for new recycled water programs.

Chapter 6. Reclaimed Water System Evaluation. Presents results of the RWS analysis.

Chapter 7. New Recycled Water Program Evaluation. Presents results of the new recycled water program analysis.

Chapter 8. Conclusions and Recommendations. Provides an overview of the conclusions and recommendations of the Recycled Water Master Plan.

Appendices A-G. Detailed information used to develop the Recycled Water Master Plan.

Chapter 2 • THE VALUE OF REUSE: RECYCLED WATER AS A COMMUNITY RESOURCE

RECYCLED WATER MASTER PLAN

Chapter 2. THE VALUE OF REUSE: RECYCLED WATER AS A COMMUNITY RESOURCE

The City of Tucson is not unique in its need for water. Many water resources around the globe are under greater stresses today than they have ever been in human history. With rising population rates, demand for food, and industrialization of the world economy, developing water resources to meet the needs of tomorrow is one of the greatest challenges that engineers, scientists, planners, and managers who work in the water industry are currently facing. Here in Tucson, the same is true.

Too Valuable to Waste: Tucson's History of Water Reuse

Environmental Impacts of Historic Water Use

Dry Santa Cruz Riverbed

In the early 1980s, Tucson Water officials understood the necessity for renewable water resources to enter the local water portfolio. A century of groundwater withdrawals from the Tucson Aquifer had already left an environmental mark within the community. The first evidence of the unsustainable use of groundwater occurred as the Santa Cruz River ceased to be an intermittent flowing river. The river, sometime during the 1920s, developed into an ephemeral waterway and remains so today as aquifer levels ceased being able to provide perennial flow.

The next environmental issue was the risk of land subsidence. Land subsidence is a condition where unconsolidated sediments, once devoid of water, are restructured by gravity and compressed under their own weight (Figure 2-1). An unconsolidated aquifer, like the Tucson Aquifer, that has been dewatered to the extent that it had in the 20th century increases its risk of falling unto itself, thus lowering the land surface elevation. Elevation studies during the later part of the century were showing the occurrence of land subsidence within the Tucson Basin.

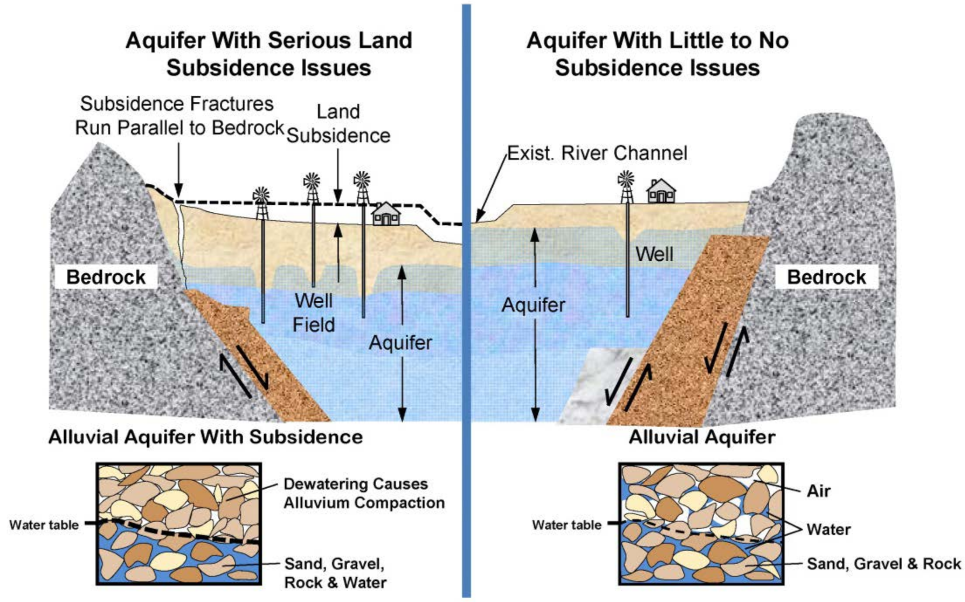

Figure 2-1. Land Subsidence

The RWS: the First Step to Offset Groundwater Usage

In the early 1980s, City leaders decided it was time to start using wastewater effluent to offset the historic usage of groundwater. This, in part, was a reaction to the landmark Arizona Groundwater Management Act of 1980 (further discussed in Chapter 3). At this time, the project of choice was to plan and construct a RWS that would be accessible for public and private interests. In the 1970s, the City of Tucson had once delivered reclaimed water from a small wastewater treatment plant located near the center of the community (22nd Street and Alvernon Boulevard) to the golf assets associated with the Randolph Park facility. The first experience with reclaimed water for irrigation use was deemed successful. The early 1980s was the time to think on a larger, community-wide scale.

The ideal location for reclaimed water facilities was near where the wastewater effluent was generated. The RWS would take secondary effluent from the Roger Road Wastewater Reclamation Facility (WRF) and deliver it to a City of Tucson facility located on Sweetwater Drive (the name of this facility was recently changed by Pima County Regional Wastewater Reclamation Department to Agua Nueva WRF). Here, the secondary effluent could be tertiary-treated through pressure filtration and disinfected a second time in preparation for its use as a non-potable supply.

In the 1980s, when one would look for non-potable demands for water in the Tucson Basin, the largest candidate was the destination golf resort industry. Though many other sites were considered to be part of the reclaimed system, the golf courses in the community were consistent in their high water use and location. Golf courses were located throughout the Tucson community, but many newer courses at the time were being planned and built along the periphery of the community. Courses like La Paloma and The Raven (now known as Arizona National) were located along the foothills area. The City of Tucson also had several courses located around the Tucson area and discussions about the future included plans for golf courses in the northwest (Dove Mountain), southwest, and southeast parts of the city. Due to these many possible customers, recharging the aquifer with wastewater effluent would be needed to store large amounts of water so recovery of the water in a timely fashion would be available to meet the fluctuating demands of irrigation.

La Paloma Golf Course

Using Recharge and Recovery to Address Irrigation Demand Variations

The Sweetwater Recharge Facilities were originally created on the west side of the Santa Cruz River directly across from the Roger Road WRF (now called Agua Nueva WRF). Between 1984 and 1989, the Demonstration Phase of recharge and recovery began for Tucson Water (Kmiec and Thomure, 2006). During this period, small basins were constructed to test the recharge viability as well as to study the changes in water quality as the water moved through the earth and into the aquifer. During these first few years, potable water was used as the test water for the recharge efforts. A recovery well network was also constructed to return the water from the recharged aquifer back to the reclaimed water treatment plant (RWTP) where it could be blended with the tertiary treated water for delivery to the customer base.

After the success of the test basins in 1989, Tucson Water began to develop four large recharge basins in the test area to be used as a full-scale recharge project. Tucson Water acquired an Arizona Underground Storage Facility permit as well as an Aquifer Protection Permit which allowed for the recharge of secondary effluent into the aquifer. This system of recharge and recovery served the Tucson Water Reclaimed Water program for the next eight years.

In 1997, with the success and continued expansion of the RWS not only to local golf courses, but several Tucson Unified Schools, the University of Arizona, and the City and County Park systems, the recharge and recovery system needed to expand further. This last phase of expansion, the Full Scale Phase, was constructed. This phase included adding four more recharge basins on the east side of the Santa Cruz River and a treatment wetlands feature for the treatment of backwash water that was being generated at the City's pressure filtration plant. The wetlands, referred to as the Sweetwater Wetlands, were designed as a treatment stage and a community amenity for nature enthusiasts and bird watchers. It was anticipated that this creation of habitat would attract wildlife from around the area as well as migrating birds as they travel along their North American migration pathways.

Sweetwater Wetlands and Recharge Facilities

RWS Commitment

The Tucson Water RWS has remained relatively unchanged since 1997. The addition of extraction wells EW-007 and EW-008, the drilling of two more wells, and future expansion of recharge capacity on the north side of the reclaimed treatment plant are all currently in the works. As the demand for reclaimed water remains present, Tucson Water will continue to serve.

Locally Made, Locally Used: Regional Stories

There are several other agencies throughout the world and particularly throughout the Western United States where the use of recycled water is necessary for the long-term sustainability of the communities for which they serve. The following information addresses some of those communities that are similar to Tucson in their desire to utilize renewable resources for the advancement of their community's long term water interest. Appendix A provides additional details of the review of these community recycled water programs.

Orange County Water District

The Orange County Water District (OCWD) is located on the Pacific coast in southern California between the counties of Los Angeles and San Diego. The OCWD was created in the 1930s to meet the growing population surge in this southern California area. The majority of the District is served by the Santa Ana River Basin Aquifer.

Due to over-pumping of their aquifer, concerns arose from the community and local agricultural interests in the area that the Pacific Ocean was starting to fill the depleted aquifer with saline waters. In the 1970s, the creation of the OCWD Groundwater Replenishment System was established. The main objective at the time was to divert wastewater that was otherwise sent to the ocean, treat it with advanced treatment processes, and recharge the aquifer with the water to create a seawater intrusion barrier to protect the freshwater aquifer.

More recently, the OCWD has expanded their Groundwater Replenishment System to include larger volumes of water that are not only used as a seawater barrier, but a system of recharge locations within the central part of the aquifer where purified water can be recharged for future direct use as a potable supply. The new Groundwater Replenishment System can store up to 70 million gallons per day (MGD) of highly purified water that would otherwise be wasted to the ocean. This is enough water to serve approximately 600,000 people annually.

West Basin Municipal Water District

The West Basin Municipal Water District is located in Los Angeles County, California. The District was formed in 1947 to help the Los Angeles area acquire imported water resources for its quickly expanding population.

Historically, the District received most of its water supply through large scale aqueduct projects throughout California. The two major imported water projects either bring water down from northern California from the Sacramento River-San Joaquin Bay Delta or the Colorado River from eastern California. Each of these imported resources are supplying water from areas of the state that are increasing not only in the energy necessary to move the water to Los Angeles, but also each of the areas are under greater stresses from an environmental standpoint. This means their reliability as a future, consistent water supply is less certain. To combat these uncertainties, the District has embarked on a large recycled water campaign called “Water Reliability 2020.” The Water Reliability 2020 program goals are to diminish the dependence of the community on imported water supplies and switch to a water scheme to increase recycled water use. This goal is being addressed by integrating a number of smaller programs including conservation efforts, expansion of the recycled water program for non-potable and groundwater replenishment, advancement and expansion of education programs, and ocean desalination. The recycled water program alone is expected to increase the District’s use of recycled waters to 22 percent of total water demand by 2020.

City of San Diego

The City of San Diego has been reliant on water importation for many years. In some years, as much as 90 percent of the San Diego water supply has been imported either from the Colorado River or from water resources in Northern California. Because of the changing demands in the San Diego area, coupled with risks to the reliability of the imported water supply, San Diego is moving forward with a Reservoir Augmentation program utilizing local water resource supplies.

The San Vicente Reservoir, a primary surface water reservoir in the San Diego area, will be the storage location for future potable water supplies for San Diego. A currently active project, the Water Purification Demonstration Project, will be taking tertiary treated water that is currently in use for their non-potable reuse system and applying advanced water treatment techniques to the water. Monitoring of the water quality to determine the effectiveness of the treatment will also take place. The Demonstration Project looks to treat and analyze up to 1 MGD. During this demonstration phase, the water would be returned to the non-potable recycled water system, not the San Vicente Reservoir that is currently used for drinking water. If the tests and demonstration phase prove to be successful, the next steps for the City of San Diego would be to build the infrastructure necessary to treat and deliver highly treated wastewater to the San Vicente Reservoir to be available for use by the potable water system.

The Value of Tucson Water's Recycled Water Resource

Currently, the Tucson Water RWS is near full capacity. There are over 900 customers including 18 Golf courses, five more with the Town of Oro Valley, 60 schools, 49 parks, and hundreds of residential customers. The Tucson Water RWS has effectively done the job that was intended many years ago, the conversion from potable or groundwater resources used for non-potable purposes into a system that is now fully renewable for those needs. The value of the Tucson Water RWS to help meet the needs of renewable supplies has allowed Tucson Water to retain its non-renewable groundwater resources for future use or to allow those groundwater credits to be stored indefinitely.

There is a significant portion of recycled water that is currently under-utilized by the City of Tucson. An examination of potential future uses will be presented in this *Recycled Water Master Plan* that may assist the City of Tucson in preparing for the effective and efficient use of all those recycled water supplies. Until the full utilization of recycled water supplies is achieved, the City of Tucson will continue to allow a part of its recycled supplies to go to the river and be utilized by other jurisdictions in the Tucson Active Management Area or outside the County.

Chapter 3 • LAWS, REGULATIONS AND POLICIES

RECYCLED WATER MASTER PLAN

Chapter 3. LAWS, REGULATIONS AND POLICIES

Federal, state, and local regulations and policies play an important role when making water service and long-range water resource planning decisions. Water resource planning requires an understanding of water-related regulations that present opportunities and challenges to managing available water supplies. This chapter summarizes the most pertinent federal, state, and local regulations and policies which must be taken into account when planning for the use of Tucson Water's recycled water supplies.

Federal Regulations

Federal regulations apply to a wide range of water-related activities including water resource utilization, compliance with water quality standards, and environmental protection.

Federal Water Resource Regulations

There are many federal water resource obligations that can influence Tucson Water's operations and planning activities. Two of the most important include regulation of the Colorado River, including Arizona's Colorado River water rights, and Native American water rights.

Law of the Colorado River

The Colorado River Compact of 1922 is the foundation of the "Law of the River." The Compact apportioned 7.5 million acre-feet (AF) of surface water annually to each of the Upper and Lower Colorado River Basins. A small part of Arizona is in the Upper Basin, but its primary water interests are in the Lower Basin, which also includes California and Nevada. The Compact did not become effective until passage of the Boulder Canyon Project Act of 1928 which was ratified in 1929 by six of the seven Upper and Lower Basin States; Arizona refused to ratify the Compact. The Boulder Canyon Project Act authorized construction of Hoover Dam and the All-American Canal which diverts Colorado River water to California. The Act also specified annual allocations of waters apportioned among the Lower Basin States: 2.8 million acre-feet per year (AFY) to Arizona, 4.4 million AFY to California, and 300,000 AFY to Nevada. Each of the Lower Basin States was also allocated percentages of any annual surplus that might occur in a given year. Arizona eventually ratified the Compact in 1944.

The Colorado River Basin Project Act of 1968 authorized construction of the Central Arizona Project (CAP) as well as five Upper Basin projects. The CAP has rights to 1.5 million AF of Arizona's 2.8 million AFY apportionment. The Act provides that the 1963 Decree in Arizona vs. California, which further reinforced Arizona's rights, will be administered so that in shortage years, diversions for the CAP will be junior to the annual apportionments of Arizona, California and Nevada.

The Secretary of the Interior administers Colorado River water allocations for the Lower Basin States. The Central Arizona Water Conservation District (CAWCD), formed in 1971, contracts with the Secretary for delivering a portion of Arizona's apportioned share of Colorado River water and, in turn, subcontracts with relevant entities within Arizona to formalize CAP apportionments. CAWCD also operates and maintains the CAP delivery system. CAWCD is authorized to levy a property tax in Pima, Pinal, and Maricopa Counties to repay construction and operation and maintenance costs of the CAP.

The City of Tucson adopted a subcontract with CAWCD in 1988 to obtain a CAP allocation. The City's current CAP allocation is 144,191 AFY. In addition, as State trust land is sold and developed in Tucson Water's projected service area, portions of the State's allocation could be transferred to the City.

Shortage on the Colorado River

As the Utility utilizes its CAP allocation to meet demand, close monitoring of drought conditions on the Colorado River watershed are needed because a severe drought on the watershed could result in the Secretary of the Interior declaring a shortage on the river. Section 301 (b) of the Colorado River Basin Project Act of 1968 provides for Arizona to curtail use of its CAP entitlement to assure water availability to satisfying uses in California and water rights in Arizona and Nevada, which are higher priority than the CAP, if Colorado River water supplies are below normal.

The Secretary of the Interior annually (usually in October) determines the condition of the Colorado River for the coming "water year" as surplus, normal, or shortage. A declaration of shortage, meaning the river does not have sufficient capacity to fully meet all of the allocations to states with contractual rights to the water, could impact delivery of Tucson's CAP water.

In surplus or normal water years, reliable potable water supplies are available through the City's Colorado River water allocation delivered through the CAP, and its backup groundwater resources. However, if the Secretary declares a shortage on the Colorado River and CAP deliveries are reduced, groundwater resources may need to be used for drought mitigation.

In 2007 the Secretary of the Interior signed the *Record of Decision*, *Colorado River Interim Guidelines for Lower Basin Shortages and the Coordinated Operations of Lake Powell and Lake Mead*. These guidelines supersede the previous shortage operations which would have eliminated all CAP deliveries once a shortage was declared on the Colorado River. The guidelines determine the amount of shortage out of the 7.5 million AF annually for the Lower Basin States to be shared based on lake level elevations in Lake Mead. For Arizona, this means the CAP canal would be shorted by 320,000 AF at elevation 1075 feet, 400,000 AF at elevation 1050 feet and 480,000 AF at elevation 1025 feet. These shortages, however, would not reduce deliveries to municipal and Indian allocations which are the highest priority on the CAP canal. Agriculture will take the vast majority of shortage of water deliveries. If levels in Lake Mead go below elevation of 1025 feet, the Secretary would initiate consultations with the Lower Basin States on additional shortage volumes necessary. These shortage volumes would probably affect municipal and Indian CAP allocations.

In anticipation of droughts on the Colorado River, the Arizona Water Banking Authority (AWBA) has been “firming” CAP allocations, or adding water supply reliability, for municipal users by storing (recharging) excess Colorado River water in underground facilities such as Tucson Water’s Central Avra Valley Recharge and Recovery Project (CAVSARP) and Southern Avra Valley Recharge and Recovery Project (SAVSARP). If there were reductions in delivery of the City’s CAP allocation due to drought on the Colorado River, this “firmed” water could be made available (pumped) to help meet demand.

Native American Tribes

The greater Tucson region is home to the Tohono O’odham Nation and the Pasqua Yaqui Tribe.

<u>Tohono O’odham Nation</u>

The Tohono O’odham Nation is located on approximately 2.8 million acres in south-central Arizona. The Nation’s total population in 2000 was approximately 24,000 people (Inter Tribal Council of Arizona, 2003). The largest community is Sells and the second largest is the San Xavier District, located on 72,000 acres south of Tucson.

In 1975, the United States, on behalf of the Tohono O’odham Nation, filed suit against the City of Tucson and other major water users in the area seeking to protect the water resources of the Nation’s San Xavier District. The City and the other water users negotiated a settlement which Congress ratified as the Southern Arizona Water Rights Settlement Act of 1982 (SAWRSA). The San Xavier and Eastern Schuk Toak Districts of the Nation have a contract with the United States for 66,000 AFY of CAP water. The Secretary of the Interior also is obligated under SAWRSA to provide an annual total of 28,200 AF of “effluent” to the Nation.

The City of Tucson entered into an agreement with the Secretary of the Interior to implement SAWRSA the following year. The City agreed to annually deliver 28,200 AF of effluent for the Secretary’s use in support of the settlement. The agreement will terminate if the lawsuit is not dismissed. Motions for dismissal are still pending subject to another act of Congress that would package SAWRSA amendments with other Native American water claims and CAP-related settlements. The Secretary is obligated under SAWRSA to annually provide 23,000 AF of water suitable for agricultural use to the

Tohono O'odham Nation at the San Xavier District, and 5,200 AF of such water to the Eastern Schuk Toak District.

Pasqua Yaqui Tribe

The Pasqua Yaqui are descendants of the ancient Toltecs who once ranged from northwestern Mexico, southern Colorado, and California. Pasqua Yaqui tribal lands are located on 222 acres about 15 miles southwest of Tucson. Tribal population in 2000 was approximately 9,000 people (Inter Tribal Council of Arizona, 2003). The Pasqua Yaqui have a CAP allocation of 500 AFY. In 2011 the Tucson Mayor and Council approved three agreements between the Tribe and the City pertaining to the delivery of potable water to the Tribe. The agreements provide for:

- Wheeling (delivering) the Tribe's 500 AF CAP allocation through City CAP storage facilities and back to the Tribe;
- Storing the Tribe's CAP allocation and other water in City underground storage facilities; and,
- Additional terms regarding the Tribe's payment to Tucson Water for 5,000 AF of long-term storage credits.

This 2011 agreement protects the City from water rights claims filed on behalf of the Tribe, as long as the City provides water to the Tribe through recharge and recovery of renewable water supplies.

Federal Water Quality Regulations

Water quality regulations often originate from federal legislation. Two major federal laws that govern potable water supply delivery are the Clean Water Act and the Safe Drinking Water Act.

Clean Water Act

Congress established the Environmental Protection Agency (EPA) in 1970 in response to growing public demand for cleaner water, air, and land. The intent of the Clean Water Act (CWA), formerly the Federal Water Pollution Control Act of 1972, was to restore the chemical, physical, and biological integrity of the nation's water supplies. The CWA's primary regulatory mechanism is a permit that governs the discharge of pollutants to "waters of the United States." In practice, the waters of the United States include the Santa Cruz and Rillito River channels and the washes in the Tucson area that drain the Santa Cruz and Rillito watersheds.

Section 404 of the CWA outlines wetlands regulations and requires the United States Army Corps of Engineers, with the concurrence of the EPA, to issue permits for activities that disturb the waters of the United States. For the purposes of Section 404, waters of the United States include most Arizona streams, stream channels and wetlands. Section 404 is intended to prevent the unlawful filling of wetlands and would apply to any channel modification Tucson Water would implement to support in-channel underground storage facilities.

The 2009 Clean Water Restoration Act amended the Federal Water Pollution Control Act (commonly known as the CWA). Updates such as these underline the importance of Tucson Water staff keeping apprised of changes that could impact project development or administration. The 2009 amendment replaced the term "navigable waters" with the term "waters of the United States," defined to mean all waters subject to the ebb and flow of the tide, the territorial seas, and all interstate and intrastate waters and their tributaries, including lakes, rivers, streams (including intermittent streams), mudflats, sandflats, wetlands, wet meadows, and natural ponds. It also maintains the authority of the Secretary of the Army (U.S. Army Corps of Engineers) or the Administrator of the EPA under the provisions of the CWA related to discharges.

Safe Drinking Water Act

The Safe Drinking Water Act (SDWA) was enacted in 1974 and authorizes the EPA to set national health-based standards for potable water. SDWA rules are based on identifying and regulating contaminants that pose potentially serious public health risks. The Act requires the EPA to determine if a contaminant has an adverse effect on public health and that regulation of this contaminant presents a meaningful opportunity for health risk reduction before a drinking water regulation is established. This process includes setting a “Maximum Contaminant Level” (MCL) and a MCL “goal.” A MCL is the highest level of a contaminant that is allowed in drinking water. A MCL goal is the level of a contaminant in drinking water below which there is no known or expected health risk. Tucson Water’s water quality are either identical to EPA’s MCLs or are more restrictive.

Other Federal Regulations

Tucson Water is also subject to regulations administered by agencies whose missions include protection of plant and animal species. The most important of these is the Endangered Species Act.

The Endangered Species Act (ESA) was enacted in 1973 to address concerns that many of the nation’s plants and animals were in danger of becoming extinct. The ESA consists of several sections, many of which can apply to public works projects. Section 10 of the ESA provides a process for landowners to develop and implement an approved “habitat conservation plan” while Section 7 allows for individual projects to proceed based on case-by-case consultations. These processes enable development of land inhabited by endangered species. Entities with proposed development projects that are approved by the U.S. Fish and Wildlife Service receive an “incidental take” permit that allows project implementation to proceed. The City of Tucson has begun work on a habitat conservation plan that will provide a pre-determined path which project planners can use to mitigate harm caused to an endangered species. However, the ability of such plans to provide mitigation against species declared as endangered in future years is currently in question. Such plans may only provide the City of Tucson and Tucson Water with limited certainty and assurance when adding expensive capital improvements to its water supply infrastructure.

State Regulations

Enforcement of federal regulations is often delegated to states. The State of Arizona plays an important role in the implementation of federal legislation. State regulations apply to a wide range of water-related activities including groundwater and surface water utilization, and compliance with water quality standards. The State also has several ongoing proceedings and activities that may impact future Utility water management responsibilities.

State Water Resource Regulations

The State of Arizona has numerous regulations that govern groundwater management and utilization, water recharge and recovery, water transfers, provision of assured water supplies, and water banking.

Arizona Groundwater Management Act of 1980

The Groundwater Management Act (GMA) was passed by the Arizona Legislature in 1980. The GMA established the Arizona Department of Water Resources (ADWR) and created four Active Management Areas (AMAs) within the State where more stringent water resource regulations apply. A fifth AMA was established in 1994. Boundaries of the AMAs are primarily based on locations of groundwater basins but also take into account water use patterns. The groundwater management program established for AMAs limits groundwater withdrawals, prohibits development of new irrigated farmland, requires new subdivisions to have long-term dependable water supplies, and requires groundwater withdrawals to be measured and reported. The five AMAs currently account for about 75 percent of the groundwater pumping in Arizona and contain over 80 percent of the State's population.

Each AMA is authorized to have a Groundwater Users Advisory Council (GUAC), which consists of five members who are appointed by the Governor. The members of the council represent the users of groundwater in the AMA. The roles and responsibilities of the GUAC are to advise the area director for the AMA, make recommendations on AMA groundwater management programs and policies, provide comment on the management plans before they are promulgated by the director, and provide comment to the AWBA.

The Tucson AMA is one of the original AMAs designated for regulation by ADWR. The Tucson AMA includes eastern Pima County and parts of Pinal and Santa Cruz counties. The Tucson AMA was established because of groundwater depletion within the Upper Santa Cruz and the Altar-Avra Valley subbasins.

The GMA specified that ADWR establish management plans for each AMA to achieve AMA goals, established a statutory system of groundwater rights within AMAs to be administered by ADWR, and changed the rules for permitting and operating new wells within AMAs.

Tucson AMA Management Plans

The GMA established five management periods between 1980 and 2025 to achieve the management goals of the AMAs. For the Tucson AMA, management plans are developed prior to each management period by the Tucson AMA director and ADWR staff. The main components of each management plan are water supply augmentation, water quality, and water conservation plans for agricultural, municipal, and industrial users and providers in the Tucson AMA. For water providers, the conservation plans specify per-capita water use targets. Only potable water is included in calculating per-capita use and recycled water is not included in the calculation in order to provide an incentive for its use. Failure to comply with ADWR target use rates could result in fines or other punitive actions.

The management plans give ADWR and AMA water users the chance to analyze the effectiveness of previous water management efforts and address water management issues in the AMA. The First Management Plan was the first step toward a comprehensive water management program with a focus on water conservation programming. The Second Management Plan expanded on the First's conservation programs and integrated water augmentation into the AMA management strategy.

The Third Management Plan establishes a water management strategy that uses water conservation, augmentation, recharge, and water quality management by the agricultural, municipal, and industrial sectors to help achieve the 'safe yield' (groundwater withdrawals are no more than what can be naturally augmented) goal by 2025 in the Tucson AMA. This is to be achieved by implementing water conservation by all water users, utilizing renewable water resources such as Colorado River water and recycled water, retiring agriculture with advancing urbanization, and by purchasing and extinguishing grandfathered groundwater rights (GFRs).

The Third Management Period constitutes the midpoint in the state's effort to achieve its groundwater management goals. This period ended in 2010 and only 15 years remain to achieve the safe yield goal. This goal and the means to achieve it will likely be even more strongly emphasized during the Fourth Management Period from 2010-2020; although major budget and staffing shortfalls at ADWR have delayed development of the Fourth Management Plan.

Rights to Withdraw Groundwater in the Tucson AMA

Tucson Water primarily withdraws groundwater pursuant to non-irrigation GFRs and its service area right. These groundwater rights can be used to bridge the supply gap while plans and programs for the use of recycled water are being put into place.

Grandfathered Rights

On the date that an AMA is established, all existing non-municipal uses of groundwater are capped and are accorded GFRs. This is a marked departure from the reasonable use doctrine which still applies to groundwater users outside AMAs. A provider can also withdraw groundwater outside of its service area pursuant to GFRs. With few exceptions, GFRs cannot be restricted by ADWR to achieve safe yield.

The Type I non-irrigation GFRs apply to farmland retired from irrigation after January 1, 1965 in anticipation of eventually using those rights for municipal supply. A Type I right allows a right-holder to pump three AF of groundwater per acre of land retired from irrigation. Type I rights are tied to the land and cannot be transferred to another location. Tucson Water has Type I rights totaling 47,116 AFY as a result of the Avra Valley agricultural land retirement program.

Type II non-irrigation GFRs apply to non-irrigation withdrawals of groundwater in existence as of June 12, 1980. Type II rights are not tied to specific lands and hence may be transferred from one location to another. Tucson Water has 9,203 AF of Type II rights.

Service Area Right

Under its service area right, Tucson Water may withdraw and transport as much groundwater from within its service area as may be required to serve customers within that area, subject to applicable ADWR water conservation and also Assured Water Supply requirements (defined later in this chapter). The GMA defines the service area of a city, town, or private water company as the area of land served by a water provider and any additional areas that contain an operating distribution system owned by the provider that is used primarily for the delivery of non-irrigation water. Tucson Water has established its service area in accordance with ADWR regulations and annually submits maps to the agency that show service area extensions.

Underground Water Storage, Savings, and Replenishment Act

The State's Underground Water Storage, Savings, and Replenishment Act of 1994 expanded the recharge program established by the Groundwater Recharge and Underground Storage Act of 1986. Recharge, storage, and recovery of all classes of water including non-potable water are regulated. The Act integrated the various underground water storage programs adopted since 1986 into a single, unified program. This more streamlined process was intended to facilitate development of recharge projects. Its intent also was to improve the recharge permitting system and address the assignment of long-term storage credits. Tucson Water has recognized the potential for using artificial recharge to help achieve its water management goals and has instituted water recharge programs to accomplish those goals. Tucson Water must have a recovery well permit issued by ADWR to recover storage credits. Recovery must not harm other land and water users as described in ADWR's recovery well spacing and impact rules.

Arizona Groundwater Transfers Bill

The Arizona Groundwater Transfers Bill (Senate Bill 1055) was passed and formally became ARS § 45-463 in 1991 and was established to regulate Type I non-irrigation GFRs associated with retired irrigated land. The bill added provisions for certain non-irrigation GFRs to be included in the calculation of Assured Water Supply for a city. Credits were granted to the City of Tucson in recognition of the water savings gained from purchase and retirement of irrigated land in the Avra Valley. A total of 9,570 acres were being irrigated when the City of Tucson purchased them, thereby obtaining a 1984 Certificate of Grandfathered Rights for 28,710 AFY. This right can be exchanged for the maximum allowable 2 million AF of groundwater credits.

Assured Water Supply (AWS) Rules

The ADWR AWS Rules were established as a component of the 1980 GMA; however, the rules under which the program is currently governed did not become effective until 1995. The rules tighten the conditions under which groundwater can be pumped by municipal providers in AMAs.

Under the current AWS Designation extension issued in 2007 (the original designation was obtained in 1998), the City of Tucson's 100-year supply of water that meets all of the AWS criteria is 185,688 AFY. However, ADWR has capped the City's designation at 183,956 AF (or by January 1, 2014, whichever is earlier -- this is because this amount was the projected demand volume for 2015 at the time the City applied for its extension). The City's current water supply is based on its physically available groundwater, Colorado River water, and recycled water. The current designation contains water resources to meet projected growth through 2016. To maintain the designation without interruption, Tucson Water will need to re-apply to extend the designation order at least two years before this demand is reached.

Arizona Water Banking Authority

The Arizona legislature established the AWBA in 1996 to coordinate the off-stream delivery, storage, and transfer of storage credits relating to Arizona's 2.8 million AF apportionment of Colorado River water. The AWBA is staffed by ADWR employees and is tasked with increasing the State's utilization of its annual allocation to firm Arizona water users against future Colorado River water supply shortages. The AWBA also can enter into storage contracts with California and Nevada to store unused Colorado River water in Arizona to help meet the future water supply needs of these states. Other potential benefits cited at the time of its establishment include drought protection, enhanced water management through replenishment, and a possible means to settle Native American water rights settlements. The majority of funding for the AWBA comes from a $0.04 property tax levied by CAWCD in Maricopa, Pinal, and Pima counties to pay for the storage of Colorado River water to firm deliveries to CAP municipal and industrial (M&I) subcontractors during shortages. The Water Bank is authorized to obtain tax funds through 2017.

Tucson benefits from recharging AWBA water at CAVSARP and SAVSARP, where that water can be recovered in times of drought. Other local facilities storing water for the AWBA (such as the Lower Santa Cruz Underground Storage Facility) do not include recovery. The AWBA's goal for storage in the Tucson AMA is 864,000 AF. Through 2011, it has stored approximately 481,000 AF or 56 percent of that goal. Through 2012, Tucson Water will have delivered over 180,000 AF of water for the AWBA to the CAVSARP and SAVSARP facilities. Plans for 2013 are to deliver an additional 11,901 AF to SAVSARP for the AWBA.

State Water Quality Regulations

State water quality standards have been established for groundwater, surface water, and reclaimed water. These standards are enforced by the Arizona Department of Environmental Quality (ADEQ) through the Environmental Quality Act of 1986. The Act established ADEQ to regulate water quality, air quality, hazardous waste, and solid waste. State water quality regulations for groundwater match the MCLs established by the EPA. Surface water quality standards have been developed for various uses including full-body contact, partial-body contact, fish consumption, agricultural irrigation, and livestock watering. The EPA has also delegated to the State the responsibility of issuing Arizona Pollutant Discharge Elimination System (AZPDES) permits that regulate water discharges from primarily municipal and industrial water users under the CWA.

Recent and Ongoing State Proceedings

There are several ongoing State-wide and regional proceedings and activities that may impact Tucson Water's water management practices.

Gila River Adjudication

The Gila River Adjudication is a comprehensive, ongoing court proceeding in Maricopa County Superior Court to determine the nature, extent and priority of surface water rights in the Gila River system. Initiated in 1974, the proceedings involve seven major watersheds (including the Santa Cruz River) and 16 Native American reservations. The appropriative allocations at stake are among the most coveted in Arizona. Any person or entity that uses water or has made a claim to use water, on property within the Gila River system or within the Little Colorado River system, may potentially be affected. The Legislature has charged the Arizona Superior Court with determining, quantifying, and prioritizing water rights claimed in these watersheds. The final decrees will establish the existence and ownership of claimed water rights as well as important attributes of the water rights including location of diversions, water uses, quantity of water used, and date of priority of water rights. Historically, Tucson Water has relied on groundwater as its sole source for municipal supply. The outcome of the Gila River Adjudication may bring some water that was formerly considered groundwater within the purview of the Adjudication Court. This could hinder the ability to withdraw water from certain well fields in order to protect water users with senior appropriative rights, and Tucson Water staff are carefully monitoring the adjudication's progress.

Blue Ribbon Panel on Water Sustainability

The Blue Ribbon Panel on Water Sustainability was formed by Arizona Governor Jan Brewer in 2009. The Panel (40 members of diverse water interests and including Tucson Water staff) was charged with making recommendations to water statutes, rules, or policy that could be implemented between now and 2020.

The Panel's report was published in 2010. Key recommendations include:

- Increase the volume of recycled water reused for beneficial purposes in place of raw or potable water;
- Advance water conservation, increase the efficiency of water use by existing users, and increase the use of recycled water by the M&I and agricultural sectors;
- Reduce the amount of water required to produce and provide energy by Arizona power generators; and
- Increase public awareness and acceptance of recycled water uses and the need to work toward water sustainability.

Water Resources Development Commission

The Water Resources Development Commission (WRDC) was established by the Arizona Legislature in 2010 to analyze Arizona's water needs for the next 100 years, as well as evaluate the issues associated with meeting those needs. The WRDC consisted of 17 commission members and 9 ex officio members representing Arizona water industries and state and federal agencies. The commission issued a final report in fall 2011 which will be used as a foundation for future water management planning. The group also requested it be given until September 30, 2012 to continue the development, evaluation, and prioritization of potential solutions or legislative proposals.

Local Agreements or Policies

Agreements with other entities and locally-generated policies play a key role in Tucson Water's day-to-day operations. A few of the more critical agreements and policies are described below.

City-County Effluent Intergovernmental Agreements

On June 25, 1979, the City of Tucson entered into an Intergovernmental Agreement (IGA) Relating to Effluent with Pima County. The IGA transferred ownership of the City's sewage treatment plants and conveyance system to Pima County. The City retained the right to use 90 percent of the "effluent" (after the Secretary of the Interior's proportionate share under the SAWRSA) treated at the metropolitan treatment facilities. The County quitclaimed all rights to effluent from the metropolitan treatment plants but is entitled to use up to 10 percent of the effluent treated in these facilities (after the Secretary's share). Under the terms of the IGA, Pima County is required to treat metropolitan effluent to state and federal water quality standards for discharge whether or not the water is actually discharged. The City of Tucson retained unilateral control of all effluent discharged from Pima County treatment plants outside the metropolitan area.

The City of Tucson and Pima County entered into a Supplemental IGA in early 2000 to resolve issues related to recharging effluent in the Santa Cruz River. The Supplemental IGA contained numerous agreements including:

- The City of Tucson and Pima County agreed to establish a Conservation Effluent Pool for use on riparian projects;
- The City and Pima County agreed to cooperatively plan and establish recharge projects to store effluent;
- Effluent from Tres Rios WRF (formerly known as the Ina Road WRF) would be divided among the parties in the region with contractual rights to effluent;
- The City would no longer control effluent from existing non-metropolitan plants; and
- The County could use its allocation of effluent for any public use.

The landmark 2000 Supplemental IGA also established the principle that the City would grant to other local water providers ownership of that portion of metropolitan effluent that was derived from the other water providers' delivery of potable water to its customers. The amounts of effluent owned by the entities vary, depending on how much potable water is delivered in any given year. The agreements are subject to the provisions of the effluent IGAs between the City of Tucson and Pima County. In addition, pursuant to recommendations of the 2009 City/County *Water & Wastewater Infrastructure, Supply & Planning Study*, Tucson Water staff have worked collaboratively with these other jurisdictions to develop agreements in which the City would "wheel" (convey) the water supply of other jurisdictions and/or water providers through Tucson Water infrastructure.

A Dedicated Water Supply for the Environment

As southeastern Arizona's largest municipal water provider, Tucson Water's obligation to provide an adequate, high quality water supply to its customers is understood. What may be less apparent is its commitment to provide water in an environmentally responsible manner. The following paragraphs describe initiatives that Tucson Water has undertaken to assure water supplies to enhance the local environment.

Conservation Effluent Pool

The City has collaborated with Pima County to allocate up to 10,000 AF of effluent per year to create or enhance riparian (water-influenced) ecosystems through an IGA entitled the Conservation Effluent Pool (CEP). The framework for the CEP was established in the City/County 2000 Supplemental Agreement, and finalized with implementation criteria in a separate IGA approved by County supervisors in December 2010 and City council members in January 2011.

City and County staff have long recognized that rapid development and the resulting increased groundwater pumping had resulted in environmental degradation. The need to address these and other regional water issues resulted in staff embarking on the *Water and Wastewater Infrastructure, Supply and Planning Study (WISP).* WISP started in 2008 with an appointed oversight committee and City and County staff researching, analyzing, and publicly deliberating a range of water issues that were captured in reports published in May and December 2009. The effort resulted in multiple action items (including completion of the CEP agreement) to be completed by City and County staff based on four guiding principles: respect for the environment, comprehensive integrated planning, water supply, and demand management. An Action Plan was subsequently prepared that lists programming for each of the principles to be completed between 2011 and 2015.

Riparian ecosystems provide many benefits to the environment and society. River systems with well vegetated floodplains reduce flooding. The community's drinking water supply is pumped from groundwater aquifers that are recharged/replenished by streambed infiltration. Riparian areas provide wildlife habitat essential for residential and migratory bird populations, supporting the growing and state-lucrative wildlife watching industry. Water from the CEP could provide a source to help recover some of this natural habitat.

With exception to the water bill 'checkbox' program described below, the CEP is the only existing commitment of water to be used for environmental purposes. Applications for CEP resources may be submitted by local jurisdictions and water providers who have an effluent allocation that contributes to the CEP. Contributors include the City of Tucson, Pima County, the town of Oro Valley, the Metropolitan Domestic Water Improvement District, Flowing Wells Irrigation District, and the Spanish Trail Water Company. By developing restoration projects that only need supplemental water for a short establishment period (three to five years) more projects can be completed over time. In so doing, the CEP would be used like an 'investment pool' to support a myriad of restoration opportunities instead of a few.

Water Bill 'Checkbox' for Riparian and Open Space Contributions

One goal from the WISP effort, as part of the respect for the environment guiding principle, is linking water conservation to environmental preservation/restoration. Tucson Water has partnered with the Watershed Management Group, University of Arizona Water Resources Center and the Sonoran Institute to offer the Conserve to Enhance (C2E) Program. C2E enables Tucson Water customers to contribute funds that will protect and enhance riparian areas and open space by making an "Open space and Riparian Contribution" donation by delineating it on a checkbox on utility bills. Contributions are currently helping to support the Atturbury Wash Restoration Project on Tucson's east side.

Sweetwater Wetlands: Water Management and Riparian Enhancement in One Project

In the not-so-distant past, water resource development and environmental enhancement efforts often had conflicting goals. The WISP is a present-day example of increased regional collaboration to produce projects with more of a mutually-beneficial approach.

The Sweetwater Wetlands is a water treatment facility, an urban wildlife habitat, and an outdoor classroom. Effluent that has undergone secondary treatment at the County's wastewater facility and filter backwash water from Tucson Water's tertiary filtration plant are further treated at the site's artificial wetlands and then infiltrates in constructed basins next to the wetlands. Extraction wells recover this recycled water from the basins during periods of high water demand to irrigate parks, schools, golf courses and other large turf areas. Sweetwater also is urban wildlife habitat to birds (including many migratory populations), insects, and small mammals such as raccoons and bobcats. Local schools use the site as an outdoor classroom to learn about local ecology and water resource management. Tucson Water also supports the educational mission through funding for youth education programs focused on the Sweetwater Wetlands, and through provision of public tours.

Metropolitan Domestic Water Improvement District IGA

The Metropolitan Domestic Water Improvement District (MDWID) Board of Directors approved the terms of an effluent agreement with the City on May 14, 2001. Significant provisions of the agreement are as follows:

- The City assignment of effluent rights to MDWID is subject to the provisions of the 1979 IGA and 2000 Supplemental IGA with Pima County;
- MDWID will contribute proportionally to the SAWRSA effluent, the CEP, and the County's 10 percent share;
- Unless otherwise agreed to, MDWID will share proportionally in any higher quality effluent produced from the Tres Rios WRF or any other future metropolitan area plant; with appropriate agreements, including payment of treatment and delivery costs,
- MDWID may receive its effluent as reclaimed water from the City RWS on an "Interruptible as Available" basis;
- Neither party shall oppose the other's effluent storage projects unless such projects cause material harm to the protesting party; and
- MDWID may participate in the City's effluent recharge and recovery projects.

In 2011, the City and MDWID amended the 2001 IGA to further establish specific responsibilities of the parties to construct the required RWS connection infrastructure, and to operate the system after it is built. In addition, the amendment specifically allows the City to interrupt flow to MDWID for long periods of time as may be necessary to serve the City's higher priority customers from its northern Thornydale reclaimed water pipeline.

The amendment will also allow MDWID to serve reclaimed water as a component of the water use for the Tucson National Golf Course. Tucson National is the most prominent local golf course that does not yet use reclaimed water. MDWID will deliver approximately 300 AF of reclaimed water per year to the golf course and nearby Pima County parks.

Oro Valley IGA

On November 5, 2001, an effluent sharing agreement was approved with the Town of Oro Valley. Reclaimed water agreements were also adopted at the same time and established that the City would provide reclaimed water production and delivery service to Oro Valley. The effluent sharing and reclaimed water agreements anticipated that one or more follow-up agreements would be adopted that would implement the direction in the 2001 agreements. Subsequently, on October 27, 2003, the City adopted Addendum 1 to the 2001 agreements. The 2003 Addendum established the following:

- Tucson agreed to treat Oro Valley's reclaimed water and deliver it to the Town at the City's Thornydale Reclaimed Reservoir. Oro Valley agreed to pay for the design and construction of a booster and interconnect at the Thornydale site, and to construct the additional infrastructure required for the Town to deliver the reclaimed water to golf courses and other turf facilities within its service area. The required construction was completed as provided in the Addendum, and the Town of Oro Valley began taking reclaimed water from the Thornydale Reservoir in October 2005.
- The Addendum defined the initial 5-year time frame in which the City would charge Oro Valley the interruptible rate for reclaimed water: it would begin no later than October 31, 2005 (thus, this period ended on October 31, 2010). During this five-year term, the City guaranteed the availability, under normal operating conditions, of a peak flow of 3.75 MGD of reclaimed water to Oro Valley.
- After this initial five-year period, the 2003 Addendum established that the City would not guarantee delivery of reclaimed water to the Town unless both parties had entered into a subsequent agreement for delivery of reclaimed water to Oro Valley on a non-interruptible basis. If no subsequent agreement was entered into, the Town could elect to continue receiving reclaimed water at the interruptible rate, but the City would not guarantee the amount of delivery capacity available to the Town at the interruptible rate. In such case, Oro Valley would be at risk that the City would

obtain new reclaimed customers along this portion of the reclaimed system who would pay non-interruptible rates. Such new customers could use up some or all of the 3.75 MGD desired by Oro Valley.

Flowing Wells Irrigation District and Spanish Trail Water Company IGAs

Similar to the MDWID and Oro Valley agreements, the City entered into IGAs with Flowing Wells Irrigation District (FWID) and Spanish Trail Water Company for entitlement and wheeling of effluent in 2009. FWID has an estimated 3,000 customer connections and Spanish Trail has 700 connections. Significant provisions of the agreements are as follows:

- The volume of effluent allocation assigned to FWID and Spanish Trail is based on their wastewater return flows from potable water deliveries;
- The City assignment of effluent rights is subject to the provisions of the 1979 IGA and the 2000 Supplemental IGA with Pima County;
- FWID and Spanish Trail will contribute proportionally to the SAWRSA effluent, the CEP, and the County's 10 percent share;
- Unless otherwise agreed to, FWID and Spanish Trail will share proportionally in any higher quality effluent produced from the Tres Rios WRF or any other future metropolitan area plant;
- With appropriate agreements, including payment of treatment and delivery costs, FWID and Spanish Trail may receive their effluent as reclaimed water from the City on an "Interruptible as Available" basis;
- Neither party shall oppose the other's effluent storage projects unless such projects cause material harm to the protesting party; and
- FWID and Spanish Trail may participate in the City's effluent recharge and recovery projects.

The important components of calculating each entity’s entitlements are the volume of potable water delivered for non- turf purposes, the percentage of that potable water that enters the sewer system and arrives at a treatment plant as wastewater, the volume of effluent produced from that wastewater, and finally, how that volume of resulting effluent is distributed for different purposes. The amount of wastewater generated within FWID and Spanish Trail (and for other parties with effluent agreements) is agreed to be a specific percentage (62%) of the potable, non-turf water delivered. The amount of FWID and Spanish Trail wastewater consumed by the treatment process is estimated from comparing historical plant inflows and outflows. The volume of remaining FWID and Spanish Trail-related effluent is then reduced in proportional amounts for FWID's and Spanish Trail's share of the City's commitments to SAWRSA, CEP and the County.

Mayor and Council Water Policies

Tucson Water is a municipal water provider owned and operated by the City of Tucson. The Mayor and Council determine the overarching policies which govern the Utility and set the potable and reclaimed water rates. The Mayor and Council have adopted Water Policies that cover a broad range of issues, including water rates, water supply, recharge, conservation, water quality, effluent use, and reclaimed water use. These policies are reviewed periodically by the CWAC, a 15-member group of local residents appointed by the City Manager and Mayor and Council.

The City's Reclaimed Water Program is guided by the adopted water policies (presented in Appendix B) of the Mayor and Council. The main policies relating to the use of reclaimed water are summarized below:

- Priority shall be given to the development of treatment capacity and delivery systems for non-potable water.
- Whenever possible, the use of non-potable water in place of potable water shall be required for landscape irrigation and industrial uses.
- Tucson Water shall work actively with new and existing large users, including golf courses, parks, schools, cemeteries, industrial, and multi-family complexes so that the RWS can provide practical and economic service.
- New turf facilities and golf course development shall use effluent or reclaimed water for irrigation purposes.
- The substitution of effluent and reclaimed water for potable source waters is an important element in achieving safe yield in the Tucson Basin. Rate setting for effluent shall be in accordance with the following precepts:
  - Charges for effluent and reclaimed water shall be based on the cost of service whenever possible, and
  - To the extent that charges for effluent and reclaimed water that are based on cost of service do not provide an adequate price incentive, the price of reclaimed water shall be based on a market value which encourages its use.

Chapter 4 • RECYCLED WATER – A RELIABLE LOCAL RESOURCE

Chapter 4. Recycled Water – A Reliable Local Resource

This chapter focuses on the physical availability of Tucson Water's recycled water resource. In addition to local groundwater and imported Colorado River water, locally-generated recycled water is the third source of supply available to the Utility. The City's recycled water supplies will become an increasingly important component of Tucson Water's resource portfolio since it will help ensure future supply reliability

Groundwater as a Future Resource

Tucson Water has historically relied on four well fields to provide groundwater supply: the Avra Valley Well Field, the Central Well Field, the Southside Well Field, and the Santa Cruz Well Field. These four well fields are shown on Figure 4-1.

Tucson Water will continue to rely on local groundwater resources well beyond 2030. Local groundwater will remain an important supply source for the following reasons:

- To meet peak water demand during the hottest months;
- To provide emergency backup supply should there be a disruption in Colorado River water supply due to operational problems with CAP or Tucson Water infrastructure;
- To provide backup potable supply should a temporary shortage be declared on the Colorado River;
- To provide longer-term backup supply to help offset potential climate change impacts on Colorado River water availability; and
- To serve as a finite bridge supply until additional, renewable and more reliable supplies are acquired to maintain sustainability and any future growth.

In order for local groundwater to remain a viable resource for future use, Tucson Water is in the process of largely shifting to Colorado River water, which is conveyed to the Tucson region via the CAP Canal. Locally-mined groundwater is considered a finite resource and future supply reliability will ultimately depend on fully utilizing all available renewable supplies, increasing water conservation, and acquiring additional supplies to help off-set future CAP shortages and to provide for potential growth. In addition, substantial quantities of imported groundwater could potentially be conveyed to central Arizona and hence to Tucson via the CAP.

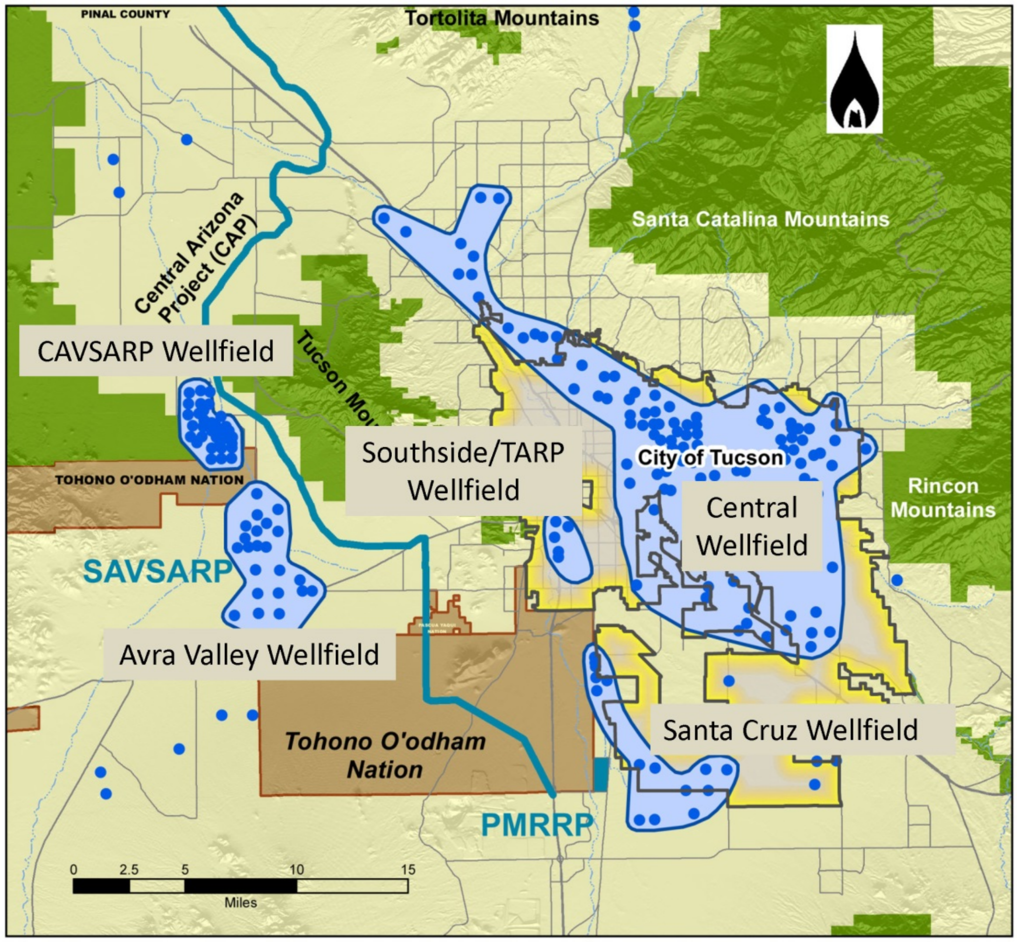

Figure 4-1. Tucson Water's Well-Fields

Central Arizona Project Water – an Imported Supply

The City of Tucson has rights to the largest annual M&I allocation of CAP water in the State—currently 144,191 AF. CAP water is, for the most part, Colorado River water that is conveyed to the Tucson area via the CAP as shown on Figure 4-2.

Tucson Water currently has sufficient capacity to recharge its entire CAP allocation each year, and purchased its full allocation for the first time in 2012. Tucson Water currently relies on CAP water for over 95 percent of its potable supply and this will increase over time as additional recovery and conveyance infrastructure is put into operation.

Figure 4-2. CAP Alignment to Tucson

The primary uncertainty related to Tucson's use of Colorado River water is the future impacts of potential shortage conditions. There are several factors that could individually or in combination result in a declaration of shortage on the Colorado River:

- Annual allocations of Colorado River water exceed the actual long-term average yield of the Colorado River;
- Effects of extended drought conditions on M&I CAP water availability; and
- Effects of long-term climate change on M&I CAP water availability.

Water users in the Colorado River basin have experienced extended drought on many occasions; paleoclimate tree ring data indicate that some of these droughts lasted decades. Because of the current severity of drought conditions within the Colorado River watershed, the first shortage declaration on the Colorado River may occur as soon as 2016 or 2017; however, the first delivery reductions for M&I CAP water subcontractors like the City of Tucson will likely occur sometime after 2040. The probability of shortage in the longer term may increase based on current climate change projections for the Southwest. These projections generally agree that a gradual long-term regional warming trend and a decrease in average annual precipitation are likely. The effects of climate change could be significant with regard to the long-term yield of the Colorado River.

Tucson Water continues to prepare for periods of time when access to Colorado River water will be reduced. In order to prepare for eventual shortages, the Utility has taken several proactive steps with regards to both supply and demand. It has participated in state-wide planning efforts to protect Arizona's renewable water resources, cooperated with the AWBA to store excess CAP water for eventual recovery during times of shortage, and developed operationally-flexible infrastructure that will remain viable when the supply of Colorado River water becomes more variable from year to year. In addition, Tucson Water will seek to acquire and develop additional, higher priority sources of renewable water supply such as main stem (non-CAP) Colorado River water as well as locally-generated recycled water to help ensure future supply reliability. The availability of the City's recycled water supplies for reuse, both in the present and the future, will become an increasingly important issue.

City's Current Effluent Entitlement

Municipally-generated recycled water is a renewable water supply that steadily grows along with the population. The City of Tucson has legal rights to its "effluent entitlements" based on agreements with the federal government (SAWRSA) and various local governmental entities as discussed in Chapter 3. There are also wheeling agreements being put in place whereby Tucson Water can deliver reclaimed water allotted to other entitlement holders to various reuse sites through the RWS.

The recycled water that is delivered through Tucson Water's dedicated non-potable water system is called reclaimed water and provides a sustainable alternative to mining groundwater to satisfy urban irrigation demand.

Recycled water that is not used for reclaimed water may potentially be used to replenish local aquifers and later recovered to ensure water supply reliability in times of need.

In 2012, approximately 61,400 AF of recycled water was produced by the Pima County metropolitan area wastewater reclamation facilities. The metropolitan area facilities include the Randolph Park WRF, the Agua Nueva WRF (formerly the Wastewater Reclamation Campus at Roger Road) and the Tres Rios WRF (formerly the Ina Road WRF). Since none of the CEP was utilized in 2012, it reverted back to the contributing entities. As shown on Table 4-1, the City of Tucson had entitlement to approximately 25,100 AF (about 41 percent) of this locally-generated resource. In 2012, Tucson Water directly reused approximately 9,400 AF to meet the needs of its reclaimed water customers and 4,000 AF was banked as long-term storage credits. A significant portion of the City's entitlement (11,700 AF) left its service area as surface flow after it was discharged to the Santa Cruz River channel. In contrast, all of the effluent annually allotted to the Secretary of the Interior (28,200 AF) was discharged to the channel and it constitutes the majority of the perennial recycled water flow observed in the Santa Cruz River downstream from the existing metropolitan WRFs.

Table 4-1. Effluent Entitlements in Calendar Year 2012 From Metropolitan Area Wastewater Reclamation Facilities

Entities with Effluent Entitlements	Volume (AF)	Percent of Total
Secretary of Interior/SAWRSA	28,200	46%
City of Tucson/Tucson Water	**25,092**	**41%**
Pima County	3,319	5%
Metropolitan Domestic Water Improvement District	2,172	4%
Town of Oro Valley	1,928	3%
Flowing Wells Irrigation District	639	1%
Spanish Trail	43	>1%
Total	**61,393**	**100%**

Since such a large volume of the City's effluent entitlement physically flows outside its service area, only a portion of the City's annual entitlement is available to Tucson Water as an actual water supply resource. One of the goals of the Recycled Water Master Plan is to develop a program that will maximize the water resource benefit of the City's entitlement for Tucson Water's customers.

City's Projected Effluent Entitlements

In Chapter 3, the principal agreements between Tucson Water, Pima County, and several other local communities were described that form the basis for water and wastewater management in the Tucson area for the next thirty years. The agreements, or series of IGAs, specify how the wastewater that is generated within the Tucson Water service area would be apportioned into effluent entitlements for each entity. The entitlements that remain after each entity has received their allocations, and after Tucson Water has satisfied its reclaimed water demands, are currently discharged to the Santa Cruz River.

Projections of wastewater generation through 2030 (and extrapolated to 2050) were compiled in consultation with the Pima County Regional Wastewater Reclamation Department (PCRWRD). The most recent "official" projections, completed by Pima County in 2006 and 2008, were based on population growth projections and assumptions of per-capita potable water usage, sewer return flow rates, septic tank usage, and other factors. The details of future effluent volumes and entitlement projections are presented in Appendix C.

The initial projections of effluent entitlements in Appendix C were completed in October 2011. Since actual wastewater flow data was available through 2010 at that time, Appendix C only discusses flow comparisons for 2010. The discussion to the right has been updated with actual flow data through 2012.

Actual wastewater flows to the metropolitan area facilities were compared to the official projections and showed that actual flows have generally followed projected flows until about 2007 when they flattened and even decreased. The decrease, which is generally attributed to the national economic crisis (slowdown in development, vacancies, etc.), continues through 2012. The actual flows in 2010, 2011 and 2012 were approximately 92 percent, 90 percent, and 87 percent of the projected flows, respectively. As the economy recovers and growth picks back up, it is anticipated that wastewater flows will recover and again start increasing. Exactly when the flow increases will begin and how fast they will recover to previous projections, if at all, is uncertain at this time. For the purpose of long-range planning, however, it is prudent to assume that the flows will recover and approach previous official projections.

Based on the comparison of actual to projected flows, a range of projections for Tucson Water's effluent entitlements was developed:

- A "High" range based on the most recent "official" regional wastewater flow projections.
- A "Low" range based on 90 percent of the regional wastewater flow projections to acknowledge the flow decreases and the potential for slow recovery.

The High and Low range projections were also determined for two cases: 1) the CEP is not being utilized (the CEP would revert back to the contributing entities) and 2) the CEP is being utilized by non-Tucson Water users.

Figure 4-3 presents the projection of Tucson Water's total effluent entitlements from all metropolitan area and non-metropolitan area facilities, and Figure 4-4 presents the effluent entitlement projections for just the metropolitan area facilities. Figure 4-4 also shows the actual effluent entitlements from the metropolitan area facilities for 2010 through 2012 which have also been decreasing. As shown on the figure, the Low range projections have bracketed the actual entitlements since 2010. .

As the population increases and as all other available potable water supplies become fully utilized, the need for a renewable supply like recycled water (derived from the City's effluent entitlements) will also grow. Recycled water will also likely serve as a locally-generated, renewable resource that can help bolster the Utility's CAP water supply which will be vulnerable to shortage due to extended drought and/or climate change in future years. The recycled water will most likely be banked in local aquifers through a sequenced program of enhanced treatment and aquifer recharge. Tucson Water considers recycled water to be a vital renewable water resource that will ensure supply sustainability and drought resistance in the long term.

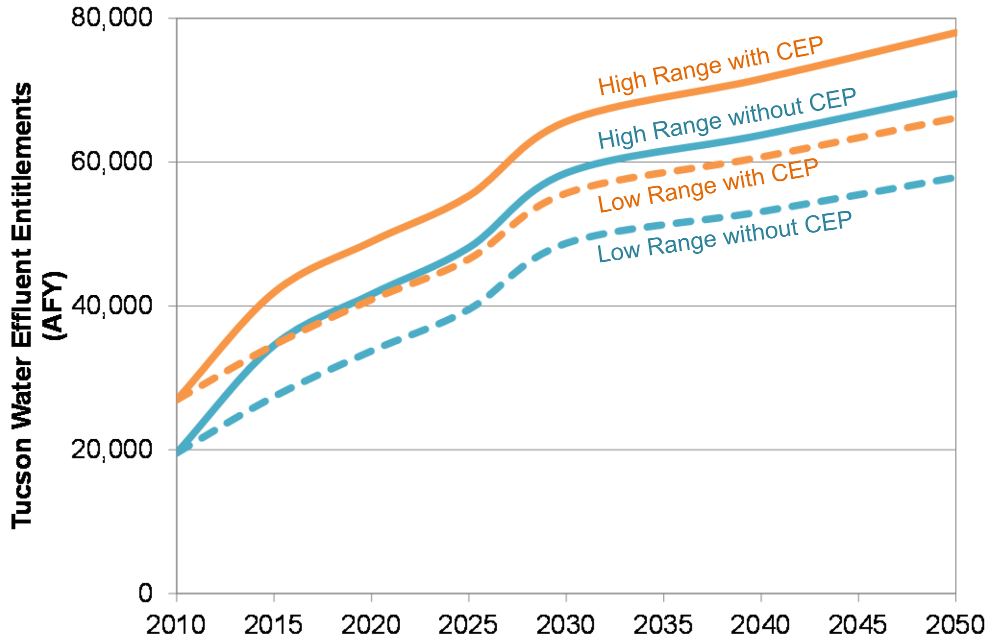

Figure 4-3. Projection of the City's Total Effluent Entitlements

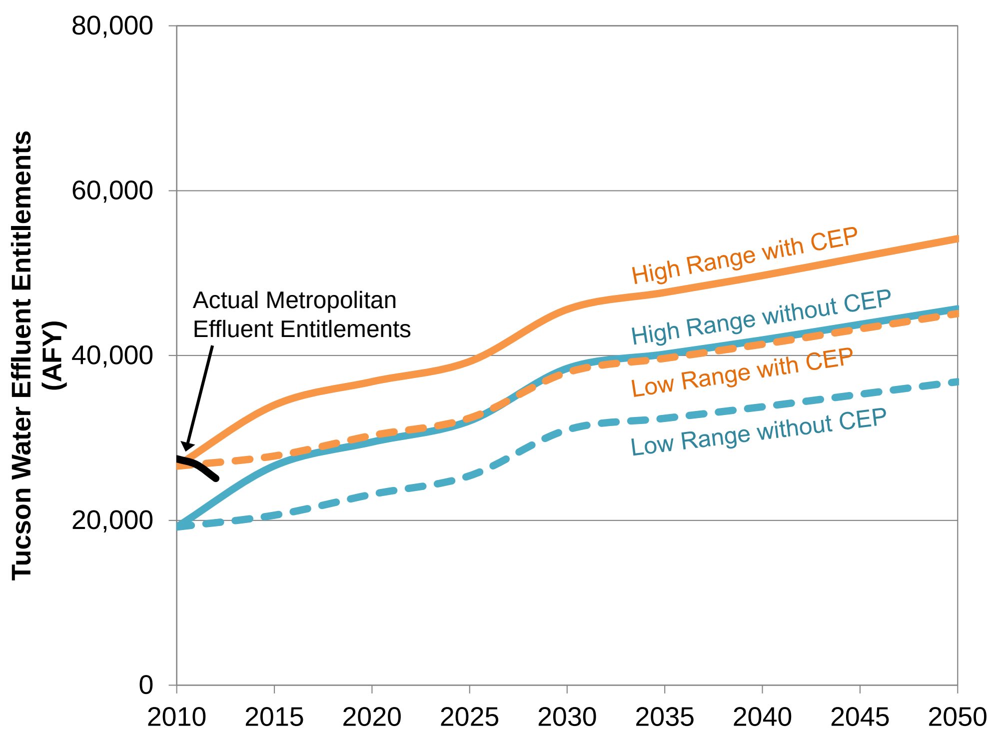

Figure 4-4. Projection of the City's Metropolitan Effluent Entitlements

Chapter 5 • RECYCLED WATER SUPPLY AND DEMAND

Chapter 5. RECYCLED WATER SUPPLY AND DEMAND

The previous chapter presented projections of Tucson Water's effluent entitlements after apportionment of available entitlements to the various local entities. The amount of Tucson Water's recycled water (derived from its effluent entitlements) available to be removed from river discharge and utilized for other purposes, such as groundwater replenishment, will depend on demands within the RWS and other existing non-potable uses. The available recycled water will vary throughout the year due to the wide variation in irrigation demand (the primary reclaimed water use). This chapter summarizes the variability of Tucson Water's projected recycled water supplies available to potentially replenish the local aquifers and to supplement future water supplies. Appendix C contains the details of the projections and analysis of potential seasonal recycled water availability.

Existing Seasonal Reclaimed Water Usage

Tucson Water's existing uses of reclaimed water include serving demands within the RWS and several other consumptive non-potable uses, including filter backwash water sent to the Sweetwater Wetlands (approximately 750 AFY), recharge flow required to maintain the groundwater mound below the Sweetwater Underground Storage and Recovery (US&R) facility (approximately 300 AFY), and irrigation at the City's Silverbell Golf Course (approximately 152 AFY). Tucson Water indicates that the consumptive uses are fairly constant throughout the year, and that the uses can be assumed to stay at current levels throughout the planning horizon.

Consumptive Uses of Reclaimed Water

Figure 5-1 shows the 2010 distribution of recycled water resources, including Tucson Water's effluent entitlement, total reclaimed water deliveries, and other consumptive uses. Tucson Water's effluent entitlement is assumed to remain constant throughout the year because wastewater generation remains fairly constant through the year. Also shown on Figure 5-1 is the recycled water that remains after the reclaimed water uses. This recycled water is currently discharged to the river, but could be available for new recycled water programs. The figure shows that, currently, almost all of the recycled water supply is unutilized during the winter period when irrigation demands are low, and almost all of it is utilized during the summer high irrigation demand periods.

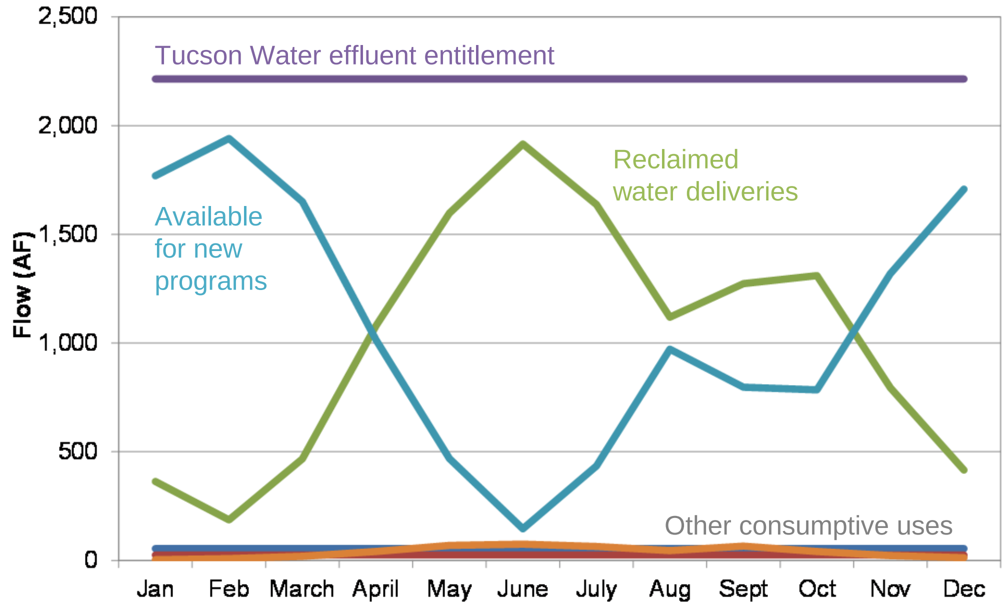

Figure 5-1. 2010 Seasonal Distribution of Recycled Water Resources

The shape of the seasonal demand curve for the RWS has historically remained similar to the curve shown in Figure 5-1. Thus, the shape of the 2010 seasonal demand curve was used to project the seasonal availability of Tucson Water's unutilized recycled water supplies.

Tucson Water Projected Reclaimed Water Demands

Potential New RWS Customers

In 27 years of operating the RWS, Tucson Water has been successful in converting golf courses, parks and schools with high irrigation water needs from potable supplies to reclaimed water. There still remain a number of sites that have high irrigation or industrial water needs but may not likely convert to reclaimed water in the near future for a variety of reasons including:

- The potential customer is currently using groundwater, which is being pumped under grandfathered water rights at less than half the cost of reclaimed water;
- The reclaimed water is not of the appropriate quality for use without additional treatment, especially for most cooling towers;
- The volume of reclaimed water used by the potential customer is insufficient to generate the savings needed to pay back the customer's cost to extend a reclaimed water main and undertake the required site modifications to comply with the City's regulations for use within a reasonable time;
- The potential customer is not within a reasonable distance of a reclaimed water main, generally no more than ½-mile from an existing main is considered feasible.

While there is potential for expansion of the RWS, growth will likely occur more slowly than in the past. Most of the future customers are expected to be either existing or new parks or schools. Changes in State law and/or financial incentives may be needed to bring current groundwater users onto the system.

Potential New Uses of Reclaimed Water

In 2010, irrigation accounted for almost all of the reclaimed water use. Non-irrigation uses of reclaimed water included toilet flushing at three City parks, one middle school and a Sun Tran Bus Facility; private fire hydrants at a private country club (Skyline Country Club); and, construction water for dust suppression.

In the future, it is anticipated that most of the reclaimed water use will continue to be for irrigation. The Leadership in Energy and Environmental Design (LEED) building certification program and community acceptance may increase the use of reclaimed water for toilet flushing in non-residential buildings if they are located near a reclaimed water line for this to be cost-effective. It is not anticipated that the City will amend its adopted version of the Uniform Plumbing Code to allow toilet flushing in residential buildings in the near future.

When Pima County begins producing an improved quality of recycled water under its Regional Optimization Master Plan (ROMP) program in 2014 (at Tres Rios WRF) and 2015 (at Agua Nueva WRF), there may be a possibility of some cooling towers being converted to reclaimed water. At that time, if the RWS is permitted as having Class A+ quality water, reclaimed water might also be more widely used for fire and dust suppression. Otherwise, Tucson Water is assuming that most of the growth in the RWS demand will continue to come from irrigation customers.

Projected Tucson Water RWS Demands

Projected additional demands in the RWS were compiled by Tucson Water staff, based on historic new connections to the RWS, for the purposes of this *Recycled Water Master Plan*:

- A demand increase of 560 AFY by 2016.
- Between 2016 and 2020, an additional demand increase of 800 AFY.
- Beyond 2020, additional demand increases of 500 AFY every five years.

Projection of Unutilized Recycled Water Resources

Projections of Tucson Water's effluent entitlements were presented in Chapter 4. A range of effluent entitlements were presented:

- A "High" range based on the most recent "official" regional wastewater flow projections.
- A "Low" range based on 90 percent of the regional wastewater flow projections to acknowledge the recent wastewater flow decreases.

The High and Low range projections were also determined for two cases: 1) the CEP is not being utilized (the CEP would revert back to the contributing entities) and 2) the CEP is being utilized by non-Tucson Water users.

The reclaimed water demand projections discussed previously were applied to the projected effluent entitlements from the metropolitan area wastewater reclamation facilities to project the unutilized recycled water resources that may become available for other programs. Figure 5-2 presents the projections for a "High High" scenario (High range plus CEP not being utilized) and a "Low Low" scenario (Low range plus CEP being fully utilized by non-Tucson Water users). The figure provides the full range of projected recycled water availability and illustrates how conservative the cost evaluations of recycled water program alternatives are in Chapter 8 of the *Recycled Water Master Plan,* the cost evaluations are based on the Low Low recycled water volumes.

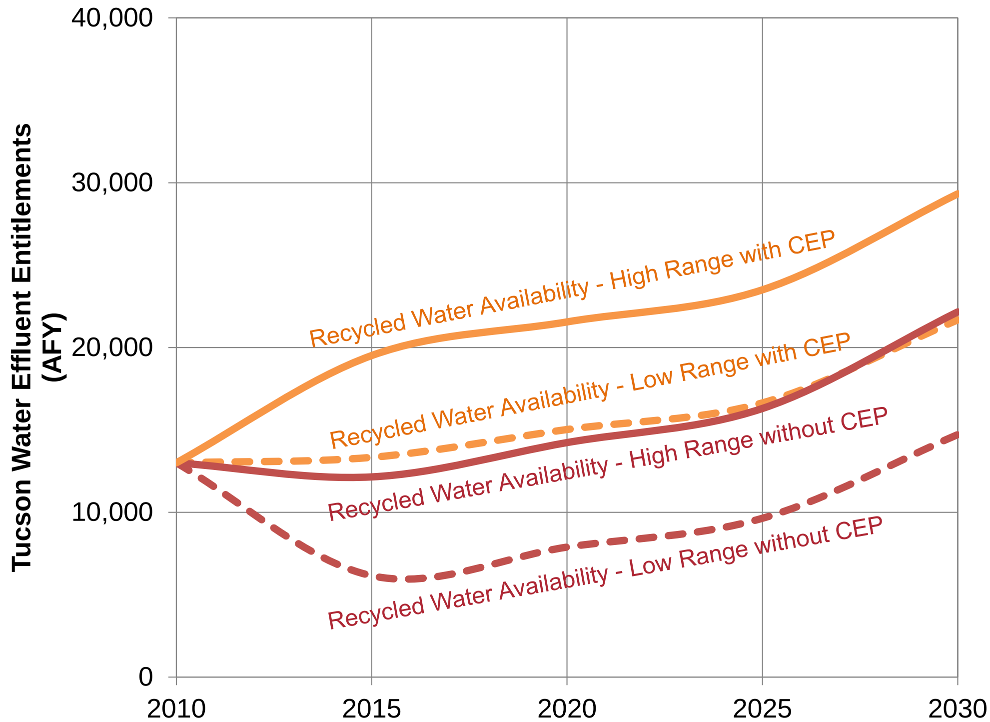

Figure 5-2. Projection of Unutilized Recycled Water Resources from Metropolitan Area WRFs

Projected Seasonal Distribution of Recycled Water for New Recycled Water Programs

The seasonal distribution of recycled water resources also discussed previously were applied to the projections of unutilized recycled water resources to determine the projected seasonal distribution of available recycled water supplies. Figure 5-3 (2020) and Figure 5-4 (2030) illustrate that the availability of recycled water for other programs in 2020 is projected to range from 7,900 to 21,600 AF on an annual basis, between zero to 730 AF per month during the summer, and between 1,600 to 2,800 AF per month during the winter. By 2030, the availability of recycled water is projected to increase to 14,700 to 29,300 AF on an annual basis, between 400 to 1,900 AF per month during the summer, and between 2,700 to 4,200 AF per month during the winter.

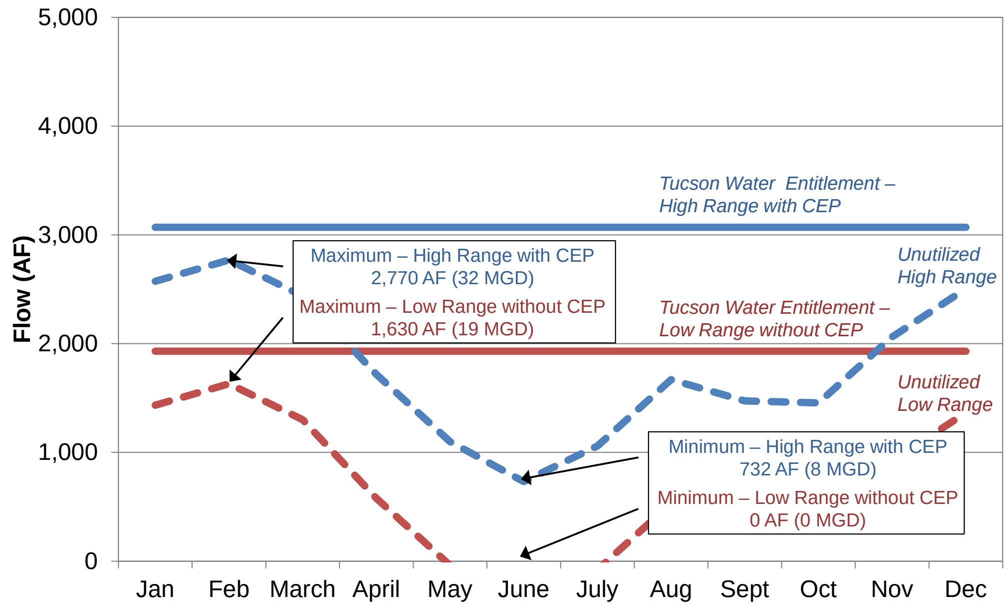

Figure 5-3. 2020 Seasonal Distribution of Unutilized Recycled Water Supplies

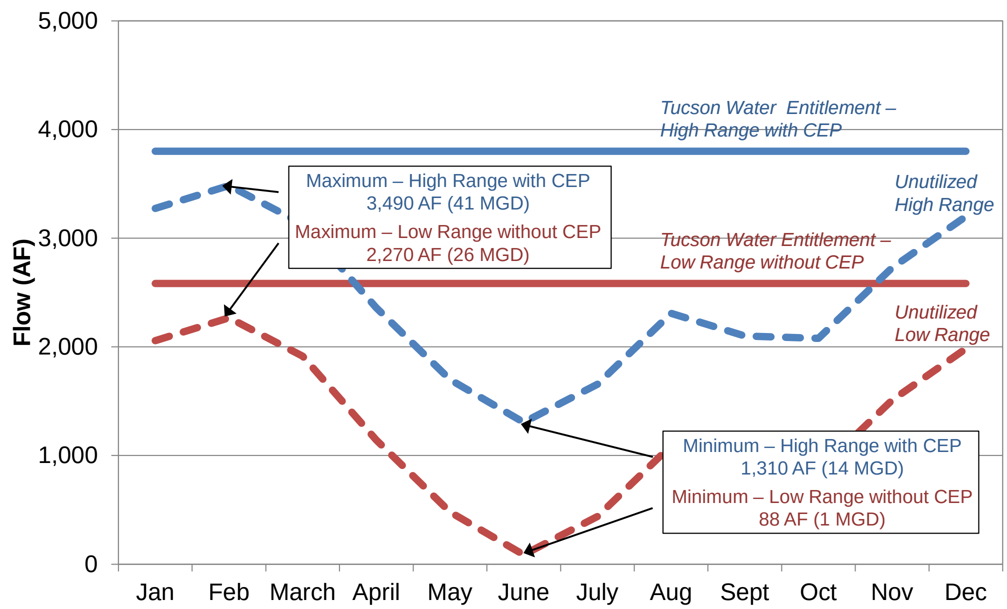

Figure 5-4. 2030 Seasonal Distribution of Unutilized Recycled Water Supplies

Chapter 6 • RECLAIMED WATER SYSTEM EVALUATION

RECYCLED WATER MASTER PLAN

Chapter 6. Reclaimed Water System Evaluation

The purpose of the RWS analysis was to identify system improvements that will provide reliable reclaimed water service, both in the near-term and in the long-term. The analysis was conducted by utilizing Tucson Water's existing hydraulic model of the RWS to assess system performance under current and future reclaimed water demand conditions. Various system improvement options were identified and evaluated to address existing system deficiencies and to meet future Tucson Water customer demands, which include existing Pima County and Oro Valley Water Utility demands. Once a recommended schedule of improvements and costs were identified for Tucson Water demands, additional analyses were completed to determine the impacts of potential future demands of first, other water providers, including the Town of Oro Valley (Oro Valley), MDWID, FWID, and Spanish Trail Water Company; and second, Pima County. This chapter summarizes the RWS analysis. The details of the analyses are provided in Appendix D.

Existing Reclaimed Water System

Reclaimed water has been used extensively in the Tucson metropolitan area since 1984. The RWS includes production facilities, distribution pipelines, storage, and booster pumping facilities. Figure 6-1 shows the configuration of the existing RWS.

Service Area

Tucson Water delivers reclaimed water to customers within its potable water service area (see Figure 1-3) and to the service areas of the University of Arizona, Davis-Monthan Air Force Base, Town of Marana, and FWID. These service areas are located within the governmental jurisdictions of the City of Tucson, Town of South Tucson, Town of Marana, and in unincorporated Pima County. Tucson Water also treats and delivers reclaimed water from the effluent entitlements of Pima County, MDWID and Oro Valley through the RWS. MDWID and FWID are in various stages of developing their own reclaimed water systems.

Treatment and Production Facilities

The City's reclaimed water production facilities include a tertiary filtration plant, an US&R facility, and a wetlands treatment system. Pima County's Randolph Park WRF also provides reclaimed water to the system. Secondary effluent produced at the Agua Nueva WRF is piped to the City's RWTP for filtration. The filtered effluent is disinfected with chlorine to ADEQ standards for Class A reuse prior to distribution. The RWTP is designed to treat 10 MGD of secondary effluent from the

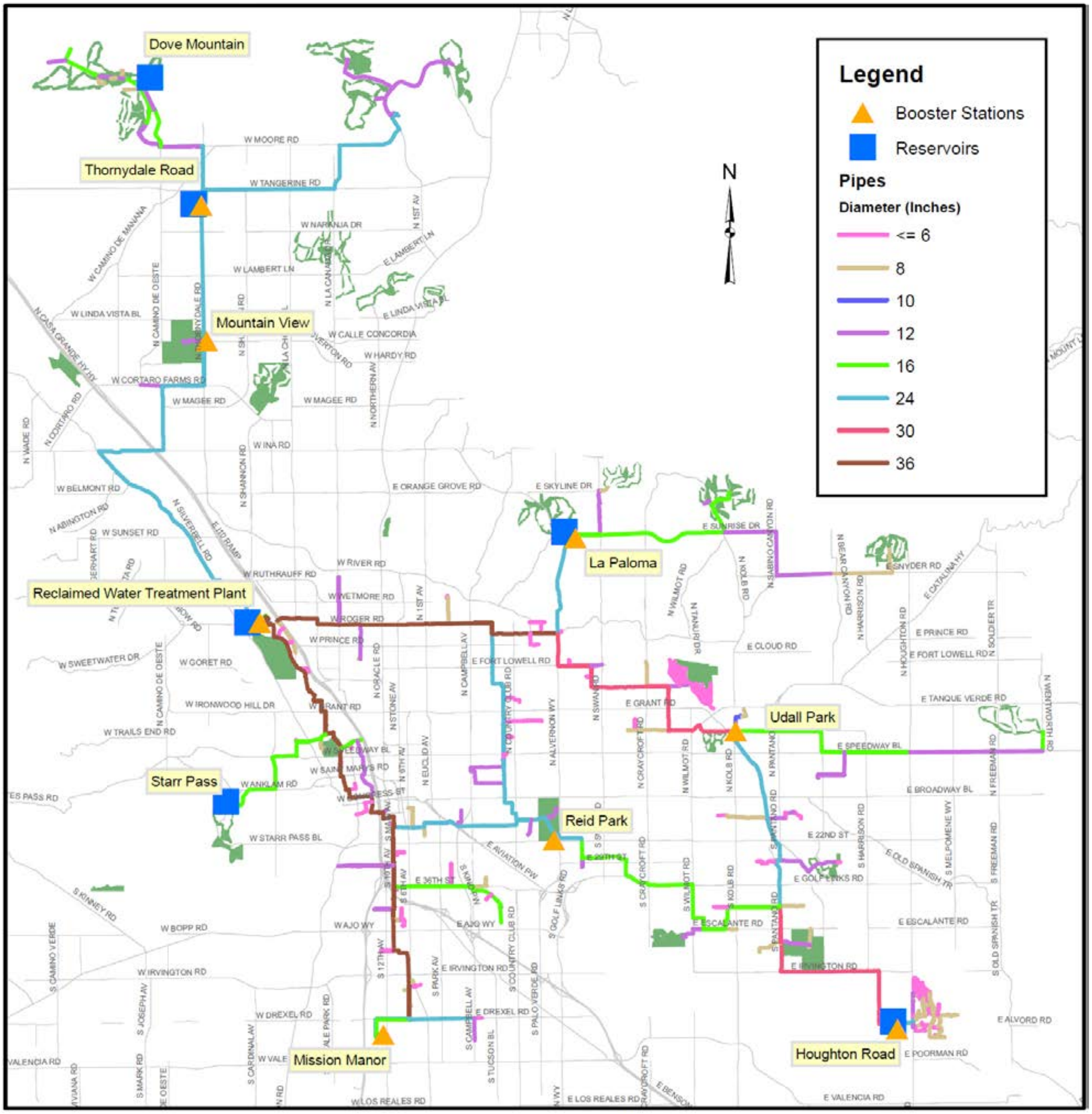

Figure 6-1. Existing Reclaimed Water System

Agua Nueva WRF, but due to hydraulic limitations, the facility currently produces only 7 to 8 MGD. Reclaimed water is also produced at the Randolph Park WRF, which is designed to treat 3.0 MGD, but has recently produced between 1.7 and 2.5 MGD.

Secondary effluent from the Agua Nueva WRF is also piped to the Sweetwater US&R Facility located on the east and west banks of the Santa Cruz River near Sweetwater Road which has a current design capacity of 10,000 AFY (8.9 mgd).

The stored water is recovered primarily for blending with the reclaimed water produced by the RWTP to meet turbidity requirements for Class A recycled water. The stored water is also recovered for use when reclaimed water demands exceed the capacity of the RWTP. The US&R Facility had been recently recharging an average of 6 MGD; however, the recharge capacity had decreased to 4.2 MGD or less until maintenance efforts had returned the recharge capacity to around 7 mgd during late summer of 2013 (the facility achieved an average recharge of 7 mgd in July, August and September of 2013). The Sweetwater US&R Facility is equipped with recovery wells that have a combined maximum extraction capacity of about 20.8 MGD.

Excess Tucson Water effluent entitlements are also discharged from both the Agua Nueva and Tres Rios WRFs to two managed in-channel recharge projects. The recharge facilities include the Santa Cruz River Managed Underground Storage Facility (Santa Cruz Phase I) and the Lower Santa Cruz River Managed Recharge Project (Santa Cruz Phase II). The Santa Cruz Phase I facility is managed under a partnership between Tucson Water and the U.S. Bureau of Reclamation, while the Santa Cruz Phase II facility is jointly managed by multiple parties. The managed recharge projects are equipped with recovery wells that have a maximum extraction capacity of about 3.7 MGD.

Distribution, Storage, and Pumping Facilities

The RWS distribution piping network consists of approximately 167 miles of pipeline ranging in diameter from 6 to 36 inches. Additionally, the RWS has approximately 15.5 million gallons (MG) of total above ground storage in reservoirs and eight booster stations.

Hydraulic Model

Tucson Water's RWS hydraulic model contains attributes of the existing RWS distribution system. The model also contains peak day reclaimed water demands for each existing reclaimed water customer. The existing RWS model is a conceptual model because it has never been formally calibrated. However, certain validation runs have been performed by Tucson Water and they consider the model suitable for master planning purposes.

Reclaimed Water Deliveries

Table 6-1 shows reclaimed water deliveries by customer type in 2010 and includes Tucson Water, Pima County, MDWID, and Oro Valley customers. The most common current use for reclaimed water within the metropolitan area is for turf and landscape irrigation of golf courses and public parks.

Table 6-1. 2010 RWS Deliveries by Customer Type

Customer Type	Total Active Sites	2010 Total Reclaimed Water Use (AF)	% of Total Consumption
Golf Courses	18	8,537	56
Parks	91	2,225	15
Water Providers	3	2,012	13
Schools	66	1,148	8
Single Family	651	394	3
Parks with Lakes	3	379	3
Agricultural	2	248	2
Residential	41	109	1
Commercial	33	77	1
Total	**908**	**15,129**	**100**

Reclaimed Water Demands

When discussing reclaimed water demands, it is important to distinguish between what has historically been delivered by the RWS and what the actual demands might be if the RWS could satisfy all demands at all times. The deliveries presented in the previous section represent what the RWS is capable of supplying under its existing configuration and operations. In 2010, the RWS deliveries amounted to an average of 13.3 MGD over the year and approximately 30.5 MGD on the peak day.

Tucson Water's existing RWS hydraulic model contains all existing customers and their "calculated" peak demands. The model demands represent what the actual peak demands might be if the RWS could supply the demands at all times. The model includes the following 2010 peak day reclaimed water demands by customer type:

- Golf courses: 25.1 MGD
- Parks, schools, and others: 10.7 MGD
- Total peak day demand: 35.8 MGD

Table 6-2 presents a comparison of actual 2010 reclaimed water deliveries and peak day demands used in the hydraulic model. The existing RWS peak demands include Tucson Water, Pima County, MDWID, and Oro Valley demands. The table illustrates that the actual reclaimed water peak deliveries are less than estimated peak demands. The RWS analysis in the next section identifies existing system hydraulic constraints that prevent serving the full peak day demands.

Table 6-2. 2010 Reclaimed Water Deliveries and Demands

	Actual Reclaimed Water Deliveries (MGD)	Modeled Reclaimed Water Demands (MGD)
Annual Average	13.3	--
Peak Day	30.5	35.8

Evaluation of Reclaimed Water System

The RWS was evaluated under existing and potential future Tucson Water customer reclaimed water demand conditions. Additional assessments were also completed to determine the impact of adding potential future demands of Pima County and other water providers, including Oro Valley, MDWID, FWID, and Spanish Trail to the RWS.

Existing System Results

The existing system analysis included an assessment of the system's production and storage capacity available to supply peak day demands. The analysis also included hydraulic modeling to identify existing system deficiencies and to evaluate alternative system improvements needed to correct those deficiencies.

Production Analysis

The RWS can currently be supplied from the RWTP, seven Sweetwater US&R Facility recovery wells, a recovery well from the Santa Cruz Managed Underground Storage Facility, and the Randolph Park WRF. As noted previously in this chapter, recent operations show that some of the facilities do not operate at their design capacities due to a number of operational and system constraints. The design and current operational production capacities of the production facilities are summarized in Table 6-3 and are compared against existing peak day reclaimed water demands.

Table 6-3 indicates that if all production facilities are operating at the intended design capacities, the RWS has adequate production capacity to supply the peak day demand, but not enough to meet Tucson Water's system performance criteria for production. Under current operational conditions, the RWS may not be able to supply existing peak day demands. Recognizing the operational constraints, Tucson Water has included the following projects in the reclaimed water capital improvement program (CIP) to provide additional reclaimed water production capacity:

- Reclaimed extraction wells EW-009 and EW-010, scheduled to be in service in 2014 and 2015, respectively, which is expected to provide an additional 6 MGD of recovery capacity at the Sweetwater US&R Facility.

Table 6-3. Comparison of Existing Reclaimed Water Production and Peak Day Demands

Component	Design Capacity (Maximum Extraction Capacity for Wells) (MGD)	Current Operational Capacity (MGD)
Tucson Water RWTP	10	7 – 8
Sweetwater US&R Facility Recovery Wells	20.8	20.8
Santa Cruz Managed Underground Storage Facility Recovery Well	3.7	3.7
Randolph Park WRF	3.0	1.7 – 2.5
Total Production Capacity	37.5	33.2 – 35.0
Peak Day Demand	35.8	
Peak Day Demand, Plus 10%[1]	39.4	

[1] *Tucson Water system performance criteria for reclaimed water production.*

- Three new recharge basins will be added to the Sweetwater US&R Facility to increase the effluent recharge capabilities from 10,000 AFY to its current permitted capacity of13,000 AFY. It is assumed that Tucson Water will continue maintenance efforts to restore the facility's current capacity to 10,000 AFY prior to bringing the new recharge basins into operation.
- The existing filters at the Tucson Water RWTP will be replaced to restore the full design capacity of the facility (10 MGD).
- The reclaimed booster pumps will be expanded from 46 MGD to 54 MGD in 2018.

If Tucson Water implements the planned construction of the new recovery wells at the Sweetwater US&R Facility and rehabilitation of the filters at the RWTP, the RWS will have sufficient production capacity to supply the existing peak day reclaimed water demands and to meet the production performance criteria.

Storage Analysis

The existing RWS was modeled to determine the required amount of system storage needed to provide hydraulic equalization (balance demands with supplies) under peak demand conditions. The modeling results indicated that a total of 25.3 MG of RWS storage is required to balance peak day demands and supplies. The existing RWS has a total operational storage volume of approximately 12 MG, which does not include storage at the Sweetwater US&R Facility or the RWTP reservoir. Therefore, a total of 13.3 MG of additional operational storage is needed to provide adequate system equalization under existing demand conditions. Alternative locations for additional storage were considered in identifying preferred system improvement alternatives as discussed in the next section.

System Improvement Alternatives

The RWS hydraulic model was used to analyze the performance of the pumping and piping components of the RWS under both existing operational (30.5 MGD) and calculated (35.8 MGD) peak day demand conditions. The analyses identified several areas of deficiencies, including negative pressures, high velocities, and high headlosses in the northwest (Dove Mountain area), northeast (La Paloma area), and along the Silverbell Road and Thornydale reaches of the RWS. Several system improvements alternatives were identified and evaluated to address the existing system deficiencies. The alternatives were also discussed with Tucson Water staff to establish improvement priorities. Figure 6-2 presents the three preferred improvements to address the existing system deficiencies.

- The **North Loop** improvements are considered the highest priority improvements to correct existing system deficiencies. The northwest area represents the highest volume of reclaimed water deliveries and provides the largest source of reclaimed water revenues to Tucson Water. This loop would also improve service to Oro Valley and would prepare the system for future additional service to MDWID.
- The **Dove Mountain Area** improvements are considered second priority improvements to correct existing system deficiencies. They would improve service to a group of high-demand customers, including the Dove Mountain golf facilities. Also, the primary improvement is a new 6 MG storage reservoir which will contribute to improving service in the entire northwest area. The improvements will address storage deficiencies and would help to improve the ability to meet contractual agreements with golf courses in this area during peak demand periods.
- The **Northeast Loop** is considered the third priority improvements to correct existing system deficiencies. The improvements would connect the pipeline along Tanque Verde Road to the pipeline along Synder Road, east of the La Paloma reservoir. The improvements are needed to supplement booster pumping and storage at the La Paloma reservoir and to address high velocities and headlosses identified in existing pipelines near the La Paloma Reservoir and along Snyder Road. The improvements, which include a new 7.3 MG reservoir at a new site near the intersection of Cloud Road and Sabino Canyon Road, will improve reliability and the ability to meet contractual agreements with golf courses in the La Paloma area during peak demand periods.

Future System Results

The future system analysis evaluated Tucson Water's reclaimed water demands to 2030 to determine additional future system improvements that will be required to maintain reliable service to Tucson Water customers. A separate analysis was also conducted to determine if the RWS could supply up to 4,000 AFY to the proposed Tucson Water/Pima County Southeast Houghton Area Recharge Project (SHARP).

SHARP Analysis

SHARP is a proposed joint Tucson Water and Pima County recycled water recharge project. The project involves recharging up to 4,000 AFY at the SHARP facility located near the RWS Houghton Road reservoir and booster station. Each entity would contribute up to 2,000 AFY to accrue long-term storage credits. Reclaimed water would be sent to SHARP only during periods of low reclaimed water demands in the system.

An analysis was performed to evaluate the ability of the existing RWS, without any improvements, to deliver reclaimed water to the SHARP site. The current limiting factor in providing reclaimed water to the SHARP site is the production capacity during peak demand days as discussed earlier in this chapter. However, for demonstration purposes, the analysis was based on delivering the 4,000 AF uniformly throughout the year (333 AF each month of the year, even during peak demand months). The modeling analysis demonstrated that the required deliveries to SHARP could be made even under peak day demand conditions. That is, if the reclaimed water was available, the existing booster stations have sufficient pumping capacity to deliver the required reclaimed water to the SHARP site on a peak day demand condition, without imposing undesirable stresses on the southeast portion of the RWS. This analysis demonstrates that the existing RWS would also be capable of delivering sufficient reclaimed water to SHARP during the low demand periods as intended.

Future Reclaimed Water Demands

Chapter 5 presented projections of additional Tucson Water customer reclaimed water demands. Table 6-4 summarizes the projected increases in Tucson Water customer reclaimed water demands.

Analysis of the RWS under future Tucson Water demands did not reveal any additional distribution system deficiencies in the 2015 and 2025 time periods. For 2020, however, an 8 MGD booster station expansion at the RWTP is required to meet peak day demands. This project is already in the Tucson Water reclaimed water CIP. For 2030 peak day demands, a 1.5 MGD booster station upgrade at the Houghton Reservoir is required to meet peak day demands.

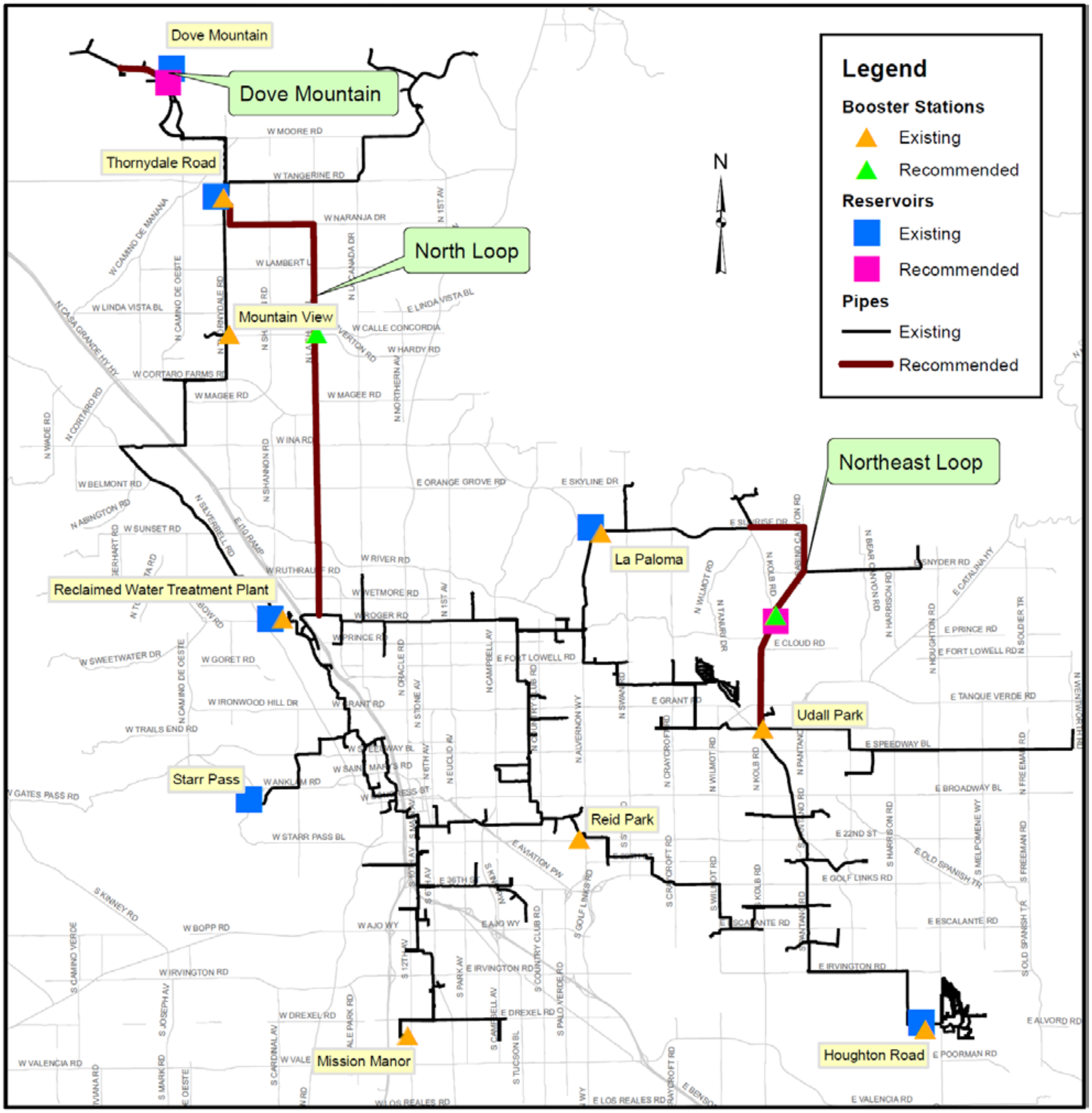

Figure 6-2. Recommended System Improvements to Correct Existing Deficiencies

Table 6-4. Projected Additional Tucson Water Customer Reclaimed Water Demands

Year	Increase in Average Day Demand (AFY)	Increase in Peak Day Demand (MGD)[1]	Peak Day Demand (MGD)[2]
2010	--	--	35.8
2015	560	1.2	37.0
2020	800	1.6	38.6
2025	500	1.0	39.6
2030	500	1.0	40.6

[1] Based on a peaking factor of 2.31.

[2] Includes existing Pima County and Oro Valley demands.

Impact of Other Entity Future Reclaimed Water Demands

Additional analyses were conducted to examine the impact of providing reclaimed water to serve additional future demands of other water providers (Oro Valley, MDWID, FWID, and Spanish Trail Water Company) and Pima County. The analyses assumed that the system improvements identified above would be implemented. The future system analyses determined the type and magnitude of improvements that might be required to serve the additional future demands.

Water Providers Analysis

An analysis was first conducted to determine the impact of the future reclaimed water demands of other water providers, including Oro Valley, MDWID, FWID, and Spanish Trail Water Company. The initial analysis indicated that if Tucson Water decides to serve the other water provider future demands, booster station upgrades would be required at the Thornydale Booster Station to satisfy the future Oro Valley demands as summarized in Table 6-5.

Table 6-5. Thornydale Booster Station Upgrade for Future Oro Valley Demands

Year	Booster Station Upgrades
2015	4.4 MGD at 270 feet Total Dynamic Head
2025	4.4 MGD at 270 feet Total Dynamic Head
2030	1 MGD at 270 feet Total Dynamic Head

The existing peak day demand for Oro Valley is approximately 3.8 MGD and the existing Thornydale Booster Station capacity for Oro Valley demands is 4.4 MGD. The peak day demand for Oro Valley is projected to increase to about 6.3 MGD in 2015 and 13.5 MGD in 2030. At the direction of Tucson Water, the required Thornydale Booster Station upgrades are included in the recommended system improvements for planning purposes. It is assumed that Oro Valley will be responsible for the booster station upgrades and the necessary improvements in their reclaimed water system to accept the additional water.

Pima County Analysis

The analysis of future Pima County demands indicated that if Tucson Water decides to serve the future Pima County demands, additional system improvements would be needed. The additional system improvements to meet future Pima County demands in 2030 would include a 1 MGD booster station upgrade at Sabino Canyon Road, a 1.5 MGD booster station upgrade at Udall Park, and 1.5 miles of 8-inch diameter pipeline along Snyder Road. The potential additional system improvements to serve future Pima County demands are provided for information only and are not included in the recommended system improvements.

Recommended Schedule of System Improvements and Costs

The recommended RWS system improvements will address existing system deficiencies and provide reliable service to existing and future Tucson Water customers, existing Pima County customers, and existing and future Oro Valley customers. The recommended improvements do not include providing service to future demands for Pima County, MDWID, FWID, and Spanish Trail Water Company.

The recommendations resulting from the RWS analysis are summarized on Figure 6-3 and in Table 6-6. Tucson Water should incorporate the recommended system improvements and costs in the reclaimed water CIP to continue its commitment to providing reliable reclaimed water service. The financial impacts of the CIP improvements, including impacts to revenues and reclaimed water impacts should be assessed as part of the implementation activities for the new recycled water program.

Table 6-6. Recommended RWS Improvement and Cost Opinions

Project No.	Improvement	Projected Capital Costs ($1,000) [1,2,3]			
		Near-Term	Mid-Term	Long-Term	Total
IMPROVEMENTS TO ADDRESS EXISTING SYSTEM DEFICIENCIES (not in current CIP)					
North Loop Improvements (Priority 1)					
P-1	Pipe - 24-inch diameter, 57,500 LF	$20,400			$20,400
BPS-1	Booster Station - 14 MGD @ 270 ft	$2,900			$2,900
Subtotal		$23,200			$23,200
Dove Mountain Area Improvements (Priority 2)					
	Pipe				
P-2	8-inch diameter, 2,300 LF	$400			$400
P-3	12-inch diameter, 5,500 LF	$1,100			$1,100
P-4	16-inch diameter, 2,100 LF	$600			$600
T-1	Storage - 6 MG	$8,300			$8,300
Subtotal		$10,200			$10,200
Northeast Loop Improvements (Priority 3)					
	Pipe				
P-5	16-inch diameter, 10,600 LF	$1,500	$1,200		$2,700
P-6	24-inch diameter, 18,800 LF	$3,700	$3,000		$6,700
BPS-2	Booster Station - 5 MGD @ 340 ft	$1,700	$1,400		$3,100
T-2	Storage - 7.3 MG	$5,600	$4,600		$10,200
Subtotal		$12,300	$10,100		$22,400
Subtotals Existing System Deficiencies		**$45,700**	**$10,100**		**$55,800**
IMPROVEMENTS TO SERVE FUTURE TUCSON WATER DEMANDS (unless noted, not in current CIP)					
BPS-3	Tucson Reclaimed Water Plant Booster Station [4] 8 MGD @ 440 ft		$2,700		$2,700
BPS-4	Houghton Road Booster Station 1.5 MGD @ 220 ft			$900	$900
BPS-5	Thornydale Booster Station [5] 4.4 MGD @ 270 ft	$2,600			$2,600
BPS-6	Thornydale Booster Station [5] 5.4 MGD @ 270 ft			$3,200	$3,200
Subtotals Future Tucson Water Demands		**$2,600**	**$2,700**	**$4,100**	**$9,400**
GRAND TOTALS		**$48,300**	**$12,800**	**$4,100**	**$65,200**

[1] *January 2012 (ENR CCI = 9176)*
[2] *Cost opinions include engineering & administration at 25% and project contingencies at 30%*
[3] *Fiscal Year ending June 30 of the year indicated*
[4] *Project included in Tucson Water's proposed 10-year CIP*
[5] *Thornydale Booster Station upgrades necessary to serve future Oro Valley reclaimed water demands. Recommended system improvement added at request of Tucson Water staff for planning purposes (Oro Valley will be responsible for the recommended improvements).*

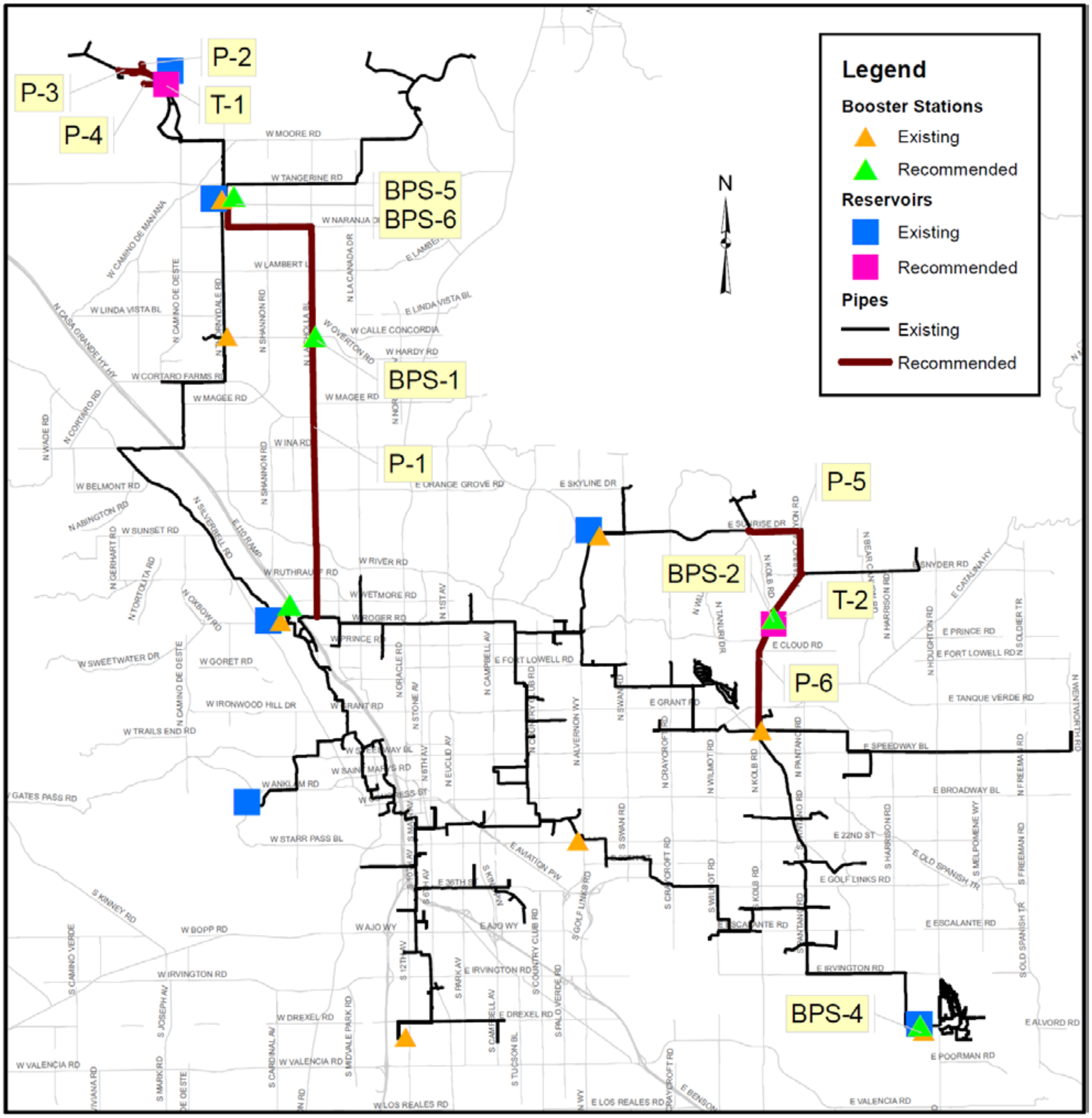

Figure 6-3. Recommended Reclaimed Water System Improvements

Chapter 7 • NEED FOR NEW RECYCLED WATER PROGRAMS

RECYCLED WATER MASTER PLAN

Chapter 7. NEED FOR NEW RECYCLED WATER PROGRAMS

New recycled water programs will enhance Tucson Water's renewable water resources portfolio and reliability efforts by putting the City's unutilized recycled water to beneficial use. Chapter 4 presented projections of Tucson Water's effluent entitlements which become recycled water after treatment, and Chapter 5 described the recycled water that is unutilized after demands in the RWS are satisfied. The unutilized recycled water could be used to replenish groundwater through recharge and, after additional advanced treatment and blending, to supplement drinking water supplies. This chapter discusses the need for new recycled water programs. Chapter 8 presents an evaluation of facility and treatment concepts for potential new recycled water programs.

The RWS demand projections presented in Chapters 5 and 6 indicate that there are limited additional demands anticipated for the RWS. Thus, any additional reuse of Tucson Water's recycled water supplies will have to involve new recycled water programs. The case for new recycled water programs is founded on the following (and is further discussed in the following sections):

- Recognizing that future impacts of sustained drought and climate change will result in shortages to the City's CAP allocation, it is necessary to fully utilize local renewable supplies to increase the reliability and sustainability of water supplies to meet future demands.
- Recycled water is the only remaining new local, renewable water resource. It is needed as part of the community's future water supply portfolio to meet increasing water demands.
- Large investments have already been made to bring CAP water into the community. The majority of this water supply is being used only once before being discharged near the downgradient end of the Tucson Basin, where much of the resource leaves the basin without additional physical or economic benefit to the community. Given the significant investments, it is not financially prudent or efficient to allow this water resource to remain unutilized.
- New recycled water programs will provide a range of benefits to the Tucson community, including increasing reliability and sustainability of its water supplies. Many other metropolitan areas in the arid Southwest have also recognized these benefits and have either already incorporated recycled water into their overall water supply or are pursuing new programs for this purpose.

Local Renewable Water Resource

Recycled water, via use in the RWS, is already an important component of Tucson Water's current Designation of AWS with ADWR through 2015. Additional use of recycled water will be important for future extensions of the AWS Designation. Maintaining a Designation of AWS is vitally important for demonstrating availability of long-term, reliable water resources to support current and future water customers for communities in Arizona.

Recognizing the importance of its AWS Designation, Tucson Water is conducting an update to its long-range water planning efforts to prepare for application to extend the Designation in 2015. The *2012 Update to Water Plan: 2000-2050* evaluated a range of water demand and supply comparisons. Long-term water demand projections were developed based on updated 2012 State population projections (and, hence, will not parallel the effluent entitlement projections presented in Chapter 4 which were based on 2006 projected wastewater flows) and a range of water usage factors derived from historic water usage patterns. Similar to the observed recent decreases in wastewater flows, recent water demands have also decreased. To acknowledge the decreases in demand, short-term projections were based on growth projections that the City uses for financial planning. For long-range planning, however, the *2012 Water Plan Update* assumed that the water demands would recover and continue to increase. Water supplies were projected based on assumptions of CAP water shortage analyses recently completed by the U.S. Bureau of Reclamation and CAP. The range of demand and supply comparisons are illustrated on Figure 7-1 (Tucson Water, 2013).

The water demand projections used in the *Water Plan Update* are representative of only in-fill within the Tucson Water "obligated service area" as adopted on August 4, 2010 by Mayor and Council in Resolution No. 21602.

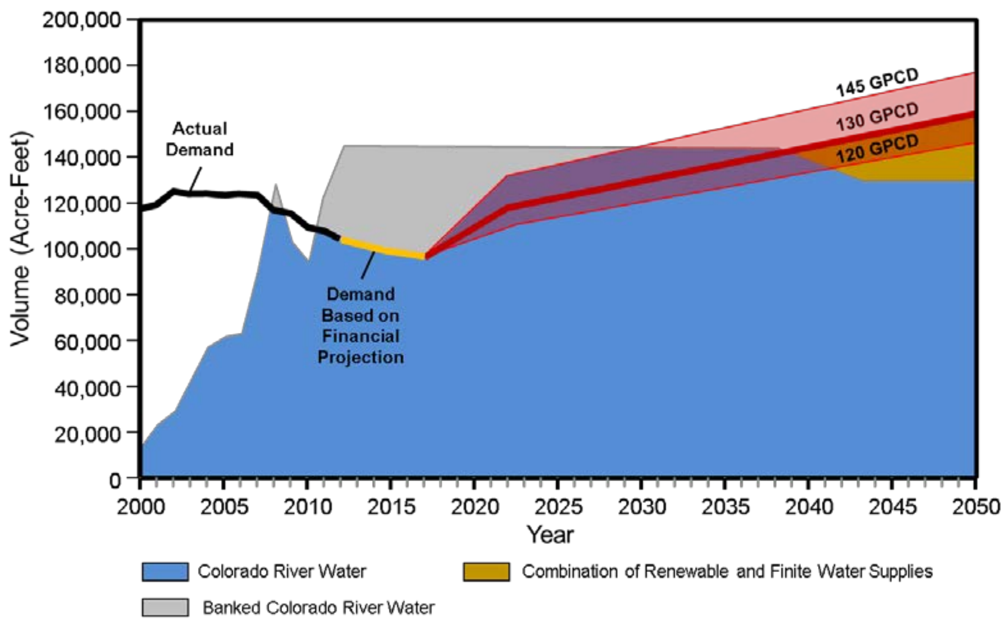

Figure 7-1. Tucson Water Demand and Supply

The *2012 Water Plan Update* concludes that current CAP water allocations will be sufficient for Tucson Water's service area through approximately 2040 based on conservative assumptions that future per-capita water demand will be 130 GPCD and that shortage to the City's CAP allocation does not occur until after 2040. After that time, the *2012 Water Plan Update* indicates that the CAP supplies can be supplemented with a combination of Tucson Water's renewable (recycled water, CAGRD replenishment, etc.) and finite (groundwater, Arizona Water Bank credits, Tucson Water's long-term storage credits, incidental recharge, etc.) water supplies to meet demands. This implies that Tucson Water will make its unutilized recycled water supply available as a renewable supply to supplement finite supplies when needed.

Because the use of renewable supplies is more reliable and sustainable than use of finite supplies, it is prudent for Tucson Water to begin establishing additional renewable supplies so that it will be available for use well before potential supply shortfalls are imminent. Recycled water is the only remaining local, renewable water supply available to Tucson Water. Other renewable supplies have a high degree of uncertainty in physical, legal, and financial feasibility.

Of Tucson Water's 2012 annual effluent entitlement of approximately 25,100 AF, it is estimated that 9,400 AF (37 percent) is directly reused, and 4,000 AF (16 percent) is banked as long term storage credits. This means that 11,700 AF (47 percent) is currently discharged and lost from the basin without the benefit of supplementing Tucson's water supplies.

The *2012 Water Plan Update* concludes that Tucson Water should:

- Continue full use of its CAP allocation and include capital programs to increase reliability, redundancy and resiliency.
- Continue efficiency and conservation efforts that will increase long-term reliability.
- Begin outreach and demonstration of advanced treatment for recycled water.

The last recommendation should be part of planning for increased use of unutilized recycled water supplies and continuing steps toward establishing this new renewable water reserve. Because there is not an immediate urgency, Tucson Water has time to carefully plan new recycled water programs. However, since planning, design, permitting, and construction for infrastructure will require significant lead time and establishment of funding, phased planning and implementation efforts should progress consistently to avert the need for urgent responses in the future.

Community Investments in Water Resources

The City of Tucson has long recognized the need to reduce its reliance on local groundwater. To bring Colorado River water into the community, Tucson Water implemented the Clearwater blended water program, including construction of the CAVSARP and SAVSARP facilities. Tucson Water also partnered with CAWCD to construct the Pima Mine Road Recharge Project (PMRRP) south of Tucson. Through recharge and recovery, Colorado River water mixes with native groundwater to produce a blended supply. These projects also increase the reliability of the community's potable water supply. They will buffer the impacts of short-term, and to some extent, long-term droughts and water shortages. Expanding the Clearwater Program with additional recharge of recycled water would only enhance and increase the reliability of the regional water supplies.

Potable water deliveries from CAVSARP started in 2001 and from SAVSARP in 2008. A portion of the water recharged at PMRRP is recovered at the City's Santa Cruz Wellfield. These facilities are the primary elements of the Clearwater Program that bring the City's annual allocation of CAP water (currently 144,191 AF) into use. The existing Clearwater Program facilities are illustrated on Figure 7-2.

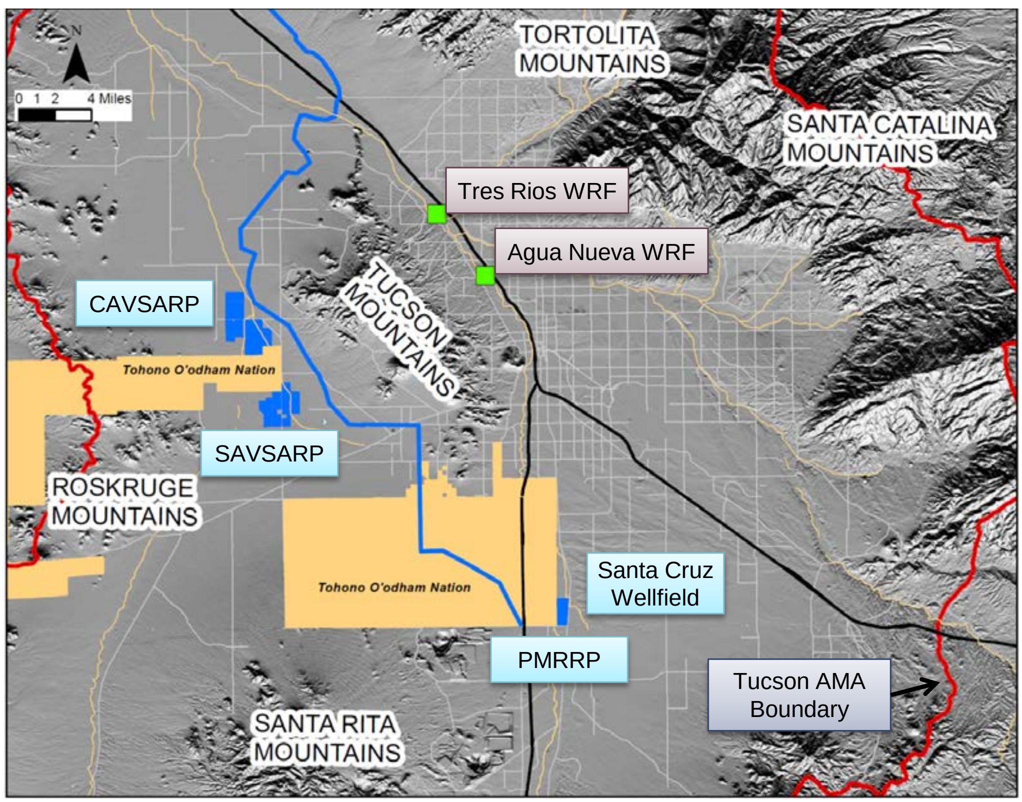

Figure 7-2. Clearwater Program Facilities

Implementation of the Clearwater program demonstrates the time frames necessary for significant public works projects. With the startup of the SAVSARP facility, it took Tucson Water approximately 13 years (1995 through 2008) to plan, design, permit, fund, and construct the Clearwater program to begin utilizing its full CAP annual allocation.

The Clearwater Program supplies a major portion of Tucson's future water supply, allowing for reduction of groundwater pumping in the Central Wellfield. Full implementation of the Clearwater Program is a primary initiative within Tucson Water's CIP planning horizon and includes the design and construction of additional recovery wells, reservoirs, boosters, and transmission mains.

The potable water used for domestic and industrial purposes is discharged to PCRWRD's wastewater treatment facilities. The community has made a significant investment in implementing PCRWRD'S ROMP to replace aged treatment infrastructure, meet new environmental regulations; and, ultimately, to improve recycled water quality. The ROMP program includes upgrading and expanding the Tres Rios WRF (formerly Ina Road WRF), building a new Agua Nueva WRF to replace the existing Roger Road WRF, and installing pumping and conveyance pipelines to transfer wastewater between the two plants. As indicated earlier, Tucson Water's recycled water is delivered by the PCRWRD facilities. A significant amount of the recycled water is unutilized and is currently discharged to the riverbed and leaves the service area without benefit to Tucson Water. The portion that is currently discharged to the riverbed is the water that can be used in a new recycled water program.

Appendix F provides additional details of the community investments to make full utilization of CAP water supplies and to treat wastewater for reuse and disposal. Table 7-1 presents a summary of capital investments that have been made to date, planned investments over Tucson Water's CIP planning horizon, and annual investments that the community will continue to make for its potable water supply and wastewater management. Table 7-1 also includes planned projects that are meant to increase the reliability, resiliency, and redundancy of the Clearwater program, including the "Hayden-Udall Prime" pipeline, augmentation mains, and the Bilby Reservoir. Annual investments include purchase of the CAP water supplies and operations and maintenance (O&M) costs for the water and wastewater facilities.

Table 7-1. Community Investments in Water Resources

Facility/Program	Capital Investments Already Made	Planned Capital Investments	Current Annual Investments
Purchase CAP allocation (144,191 AFY)	--	--	$20,800,000
Clearwater Program (Tucson Water)			
CAVSARP	$80,600,000	--	$8,300,000
SAVSARP	$47,900,000	$17,000,000	$8,600,000
PMRRP	$5,500,000	--	$200,000
Santa Cruz Wellfield	--	$6,700,000	$700,000
Reliability, Resiliency, and Redundancy Projects	--	$156,000,000	--
Subtotal Clearwater	**$134,000,000**	**$179,700,000**	**$38,600,000**
ROMP	$288,100,000	$372,000,000	$15,000,000
Totals	**$422,100,000**	**$551,700,000**	**$51,100,000**

When complete, a total of approximately $292 million will have been invested in the Clearwater Program to reliably deliver and make use of Tucson's allocation of CAP water. On an annual basis, $39 million will continue to be spent to purchase the CAP allocation and to operate and maintain the Clearwater infrastructure. On the wastewater management side, approximately $660 million will have been invested in ROMP when complete, and $15 million per year will be spent to treat and manage the effluent. All of these investments have and are being made while only a little over 50 percent of Tucson Water's recycled water is being reused or stored for future use. The remaining water, which represents a large portion of this significant community investment, provides an opportunity to conserve the resource and keep it for reuse within the service area.

Potential Benefits of New Recycled Water Programs

New recycled water programs involving recharge and replenishment of groundwater resources to supplement potable water supplies will provide a number of direct and indirect benefits to the community. Many of these benefits cannot be quantified but will impact Tucson Water and the community as a whole:

- Increased utilization of recycled water will increase the reliability of Tucson Water's future water supplies. The imported CAP water supplies are susceptible to drought, which, according to recent studies by the U.S. Bureau of Reclamation and others, is anticipated to become more problematic due to climate change. Recycled water is a renewable water supply that is not significantly affected by drought and its increased use will strengthen the resistance of the community's water supply to drought and water emergencies.

- Groundwater replenishment with recycled water will increase the sustainability of local groundwater resources. It will further protect the basin from subsidence and resulting reductions in water storage capacities.
- By increasing the reliability of the community's water supply, utilization of recycled water will also support economic development. A reliable water supply will attract more industry and businesses to the community which will increase the revenue and tax base, and ultimately contribute to community enhancements and sustain a high standard of living.
- Additional use of recycled water supplies will increase local control and management of renewable water resources. The community will become less dependent on the decisions and actions of other agencies and entities that may have different objectives for the state's renewable water resources.
- Through the use of local recycled water supplies, the community will avoid the costs of purchasing like amounts of other water and the costs of infrastructure and operations (significant pumping energy) to import the water supplies, which may be located at great distances from the community.
- Introducing recycled water into the community's water supply portfolio will expand and diversify the portfolio and reduce the risks of relying on finite supply sources. The new supply source will not only provide increased reliability, but will also increase flexibility for water supply management.
- Indirect potable reuse presents an opportunity for the community to start improving the region's groundwater quality through salinity control. By including membrane treatment processes as part of the advanced water treatment process, a side benefit is that minerals contributing to salinity can be removed from the urban water cycle, thus maintaining or beginning to improve the salinity of local supplies.
- Additional use of recycled water resources will support and promote the community's desire for sustainability, increasing efficient use of water, and protecting its water resources.

The "No Action" Alternative

Although the preceding sections present a compelling case for implementing new recycled water programs, the project team did acknowledge that in the early planning stages of projects like this, it is typical to consider a "no action" alternative. This kind of alternative would consider other options that would have to be pursued to accomplish the same objectives as the proposed project. However, because the reasons for establishing a program that would make use of the community's significant unutilized recycled water supplies are so compelling (as summarized below), the project team did not evaluate a no action alternative.

- Tucson Water currently has significant unutilized recycled water supplies which will increase as new customers are connected in the future.
- Recycled water is the only remaining local renewable water resource, it belongs to Tucson Water, and too many financial resources have been expended to bring the water resource to the area to use the resource only once.
- The existence of other renewable water resources that Tucson Water could access is highly uncertain at this time, including the availability, eventual costs, and legal challenges to bring other new water supplies into the area.
- Recycled water programs involving indirect potable reuse in the arid Southwest are being widely recognized as feasible and valuable in increasing the reliability of community water supplies.
- There are many important direct and indirect benefits that could be realized with a new recycled water program, such as increasing water supply reliability, providing for environmental and economic sustainability, foregoing the costs and environmental impacts of importing other water supplies from long distances, and presenting the first opportunity to start controlling salinity in the region's groundwater resources.

Chapter 8 • NEW RECYCLED WATER PROGRAM EVALUATION

RECYCLED WATER MASTER PLAN

Chapter 8. NEW RECYCLED WATER PROGRAM EVALUATION

When Tucson Water started considering new recycled water programs in the early 2000s, indirect potable reuse (IPR) was gaining wide acceptance in the arid southwest, while direct potable reuse (DPR) was still in early investigative and discussion stages. Due to increasing water demands and continued droughts, and dwindling water supplies, the drinking water and water reuse industries are now moving more and more towards DPR. Although DPR may become a valid consideration at some point in the future, the project team decided to focus the *Recycled Water Master Plan* on IPR since the momentum for such projects in the southwest is well established. Also, DPR may face cost challenges due to the following:

- As discussed later in this chapter, an IPR program can take advantage of the significant benefits offered by soil aquifer treatment and storage within the aquifer. Since DPR would not utilize the aquifer, such a program would have to treat the substantial seasonal and diurnal variations in unutilized recycled water supplies. This would result in larger treatment facilities to treat the peak flows.
- One typical advantage of DPR is that advanced water treatment can be located close to additional potable treatment and potable distribution systems, thus the costs to convey source water or treated water could be minimized. However, because of the location of the primary potable water distribution infrastructure that has been implemented by Tucson Water for the Clearwater Program, any DPR program would have to convey either source water and/or treated water over long distances, thus offsetting any cost advantages.

Tucson Water should, however, monitor developments in the regulatory and technological advances involving DPR, and should continue to revisit the goals and objectives of the program given the advances during further implementation of a new recycled water program.

This chapter summarizes the analyses performed for alternative recycled water programs. Alternatives for new recycled water programs were identified within the framework of scenario planning efforts previously conducted by Tucson Water. Advanced treatment processes were identified, evaluated, and prioritized for the recycled water program alternatives. Conveyance, pumping, recharge and recovery, advanced treatment, and finished water transmission facilities were conceptually developed to gain an understanding of the infrastructure requirements, and for use in conceptual cost evaluations. The conceptual evaluations identify preferred recycled water program strategies recommended for further studies, testing, and demonstration. Appendix E contains the details of the evaluation of new recycled water programs.

Concepts for New Recycled Water Program

The *Recycled Water Master Plan* project has its basis, in part, from Tucson Water's scenario planning assumptions for recycled water use, originally developed in the *Water Plan: 2000-2050*. By extending the scenario planning process specifically for water reuse, Tucson Water utilized the best available information and planning assumptions to address many possible views of the future related to a potential new water recycling program. The process identified the two most significant uncertainties that will influence the development of a recycled water program:

1. Will the public accept indirect potable reuse of recycled water supplies?
2. Will the City treat recycled water beyond potable regulatory standards?

Based on an assessment of the scenario planning process, recycled water program alternatives were identified to represent a range of possibilities for the critical uncertainties identified. The recycled water program alternatives were identified and evaluated using the following process:

- Identify concepts for sources of recycled water and recharge and recovery locations. These concepts established the categories of recycled water program alternatives. Once the alternatives were established, additional concepts were identified for recycled water conveyance.
- Develop and evaluate options for advanced water treatment to identify preferred water purification approaches for the recycled water program alternatives involving IPR.
- Combine all program elements for an overall evaluation of new recycled water program alternatives.

Recycled Water Sources

The most obvious sources of recycled water will be the metropolitan area treatment facilities operated by Pima County: the Agua Nueva WRF (under construction to replace the Roger Road WRF), the Tres Rios WRF, and the Randolph Park WRF, where most of the region's wastewater is collected for treatment. For these locations, Tucson Water is to receive its recycled water at the Water Reclamation Campus, according to current City/County IGAs. Thus, for purposes of the evaluation, it was assumed that the primary source of recycled water for the metropolitan area will be the Water Reclamation Campus.

Recharge and Recovery Locations

Preferred locations for recycled water recharge would depend on whether Tucson Water decides to pursue an IPR project or if it elects just to recharge the water for long-term storage credits. If IPR is pursued, recycled water could be recharged in a location that provides ready access for subsequent recovery and introduction into the potable supply (i.e., the recharge location would provide a “wet water” benefit). If IPR is not pursued, recycled water could be recharged at a location that is a substantial distance from, or hydrologically separated from, the potable water supply. The intent would be to avoid mixing of recharged water with native groundwater used for drinking water.

Recharge and Recovery Options for IPR Programs

To reduce costs for IPR programs, recharge should occur where there is existing infrastructure to recover the water and to get it to locations meant for distribution of large volumes of potable water supply. Because of the potential volume of recycled water supply, recharge should also occur where large tracts of land are available. To take advantage of existing major potable water distribution infrastructure, potentially feasible candidates for recharge locations for an IPR program could include lands in the vicinity of CAVSARP, SAVSARP, and potentially SHARP. Both CAVSARP and SAVSARP could individually recharge the entire unutilized recycled water, whereas SHARP is planned to recharge only up to 4,000 AFY. SHARP is a joint City of Tucson and Pima County project to be constructed in Southeast Tucson near the Houghton Reclaimed Water Reservoir. Water deliveries for recharge at SHARP will be via the existing RWS. Because recycled water conveyance and recharge capacities for the SHARP alternative are limited and recovery infrastructure is not currently in place, the SHARP alternative is considered complementary to other recycled water program alternatives and is not included in the subsequent evaluations. However, the SHARP site may provide the opportunity for a demonstration project that could transition into a permanent component of a full-scale program.

Recharge within the Central Wellfield and/or close to the existing metropolitan water reclamation facilities (Agua Nueva and Tres Rios WRFs) were also considered but were not considered viable for the following reasons:

- There are no more large tracts of vacant land available within the Central Wellfield and the area is distant from the existing major potable water distribution infrastructure associated with the Clearwater Program. Any potential cost savings would be offset by the need to convey large volumes of water to the existing major potable water distribution infrastructure.
- Similarly, there are no large tracts of land available near the metropolitan water reclamation facilities. All available land is being used for water reclamation, recharge and recovery, and other RWS facilities.

- Groundwater in the vicinity of the Agua Nuevo and Tres Rios WRFs has elevated levels of many wastewater and industrial contaminants.
- The area in the vicinity of the metropolitan water reclamation facilities is surrounded by three significant Arizona Water Quality Assurance Revolving Fund (WQARF) sites. Additional significant local recharge and recovery activities would be highly constrained by the water quality remediation objectives of these sites.

Of the CAVSARP and SAVSARP locations, the CAVSARP location has the best potential because:

- The City owns substantial open property just to the north of the existing CAVSARP basins.
- CAVSARP is closer to the recycled water source.
- The opportunity to extend another major conveyance pipeline through existing rights-of-way between CAVSARP and SAVSARP are very limited.

Thus, two categories of IPR alternatives were identified:

- **"CAVSARP" Alternatives**: These concepts would utilize the existing CAVSARP recharge basins for recycled water recharge (mixing with CAP water prior to recharge).
- **"North CAVSARP" Alternatives**: These concepts would utilize new recycled water recharge basins constructed north of the existing CAVSARP basins. CAP water would continue to be recharged in the existing basins.

For all the CAVSARP and North CAVSARP Alternatives, existing infrastructure could be used to recover and convey water to the CAVSARP reservoir and booster station. However, since the existing recovery capacity at CAVSARP is limited, both categories of alternatives would require that some recharge of CAP water (in an amount equal to recycled water that is recharged) be shifted to SAVSARP.

Recharge Options for Non-IPR Programs

In order to maximize the benefits to local groundwater resources, recharge must occur within the Tucson AMA boundaries established by ADWR. Recharging recycled water outside of the Tucson AMA will not contribute to Tucson Water's long-term planning goal of achieving hydrologic sustainability. It would also not count towards long-term storage credits for Tucson Water. Lands near the southeast (upgradient) boundary of the Tucson basin could be the conceptual recharge location for this third category of alternatives, the Southeast (SE) Tucson Alternatives. The **"SE Tucson Alternative"** does not include any purposeful recovery. However, over time, the recharged water will eventually migrate to and blend with groundwater in the Central Wellfield.

Recharge in areas north of Tucson Water's service area and other developed areas were also considered but were not considered acceptable because of jurisdictional concerns associated with large-scale recharge facilities being located within the service/planning areas of others. In addition, this area is downgradient of the Tucson Water service area, and the recharged water would flow out of the drainage basin without contributing to Tucson Water's long-term planning goal of achieving hydrologic sustainability.

Summary of Concepts for New Recycled Water Program Alternatives

Table 8-1 provides a summary of the concepts for potential recycled water program alternatives. Figure 8-1 shows the locations of the concepts summarized in Table 8-1.

Table 8-1. Summary of Concepts for New Recycled Water Program Alternatives

Alternative Category	Recharge Location	Recovery Location	Recharge Capacity
CAVSARP	Existing CAVSARP basins, New basins at SAVSARP for CAP water displaced by recycled water	Existing CAVSARP recovery facilities	All unutilized recycled water
North CAVSARP	New basins North of CAVSARP, New basins at SAVSARP for CAP water displaced by recycled water	Existing and new recovery facilities north of CAVSARP	All unutilized recycled water
SE Tucson	New recharge basins Southeast of Tucson	No purposeful recovery	All unutilized recycled water

Recycled Water Conveyance Concepts

Once concepts for recycled water sources and recharge locations were established, concepts for recycled water conveyance could be envisioned. A potentially-feasible conveyance alignment from the metropolitan wastewater treatment facilities to both the CAVSARP and North CAVSARP alternatives, illustrated on Figure 8-2, is approximately 25 miles in length. This generalized alignment was identified based on the proposed conceptual alignments for conveyance facilities from the 1995 *Regional Effluent Utilization Plan Phase B* (Malcolm Pirnie, June 1995), which considered existing rights-of-way and optimizing gravity flow.

A conceptual conveyance alignment to the SE Tucson alternative, illustrated on Figure 8-3, is approximately 35 miles in length and was based on conceptual routing that considered open space and existing rights-of-way.

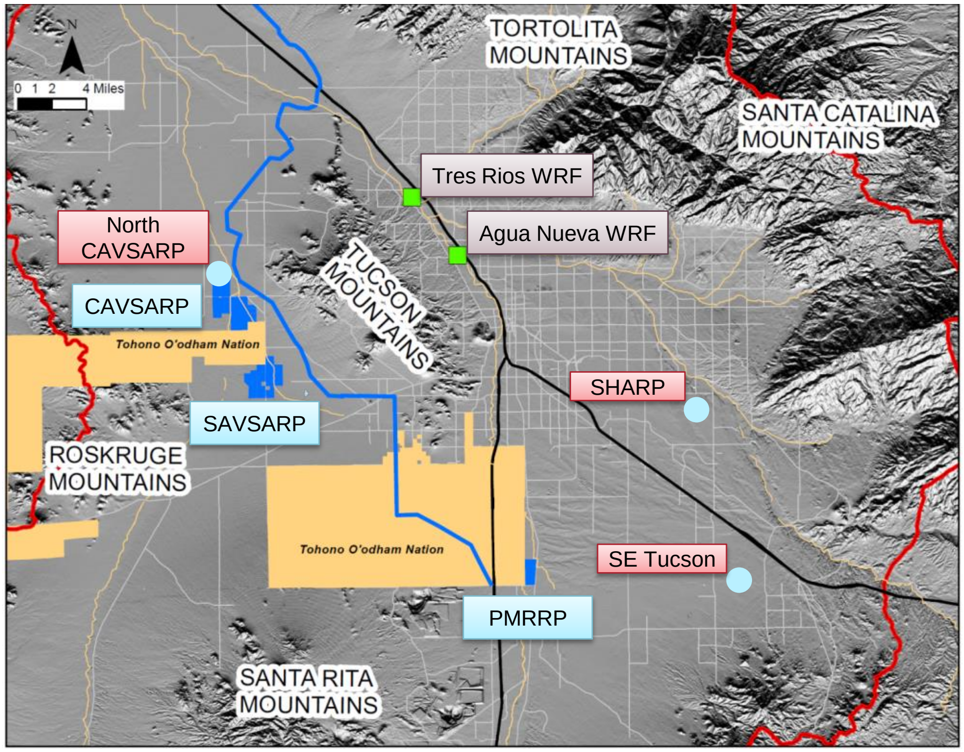

Figure 8-1. Concepts for New Recycled Water Program Alternatives

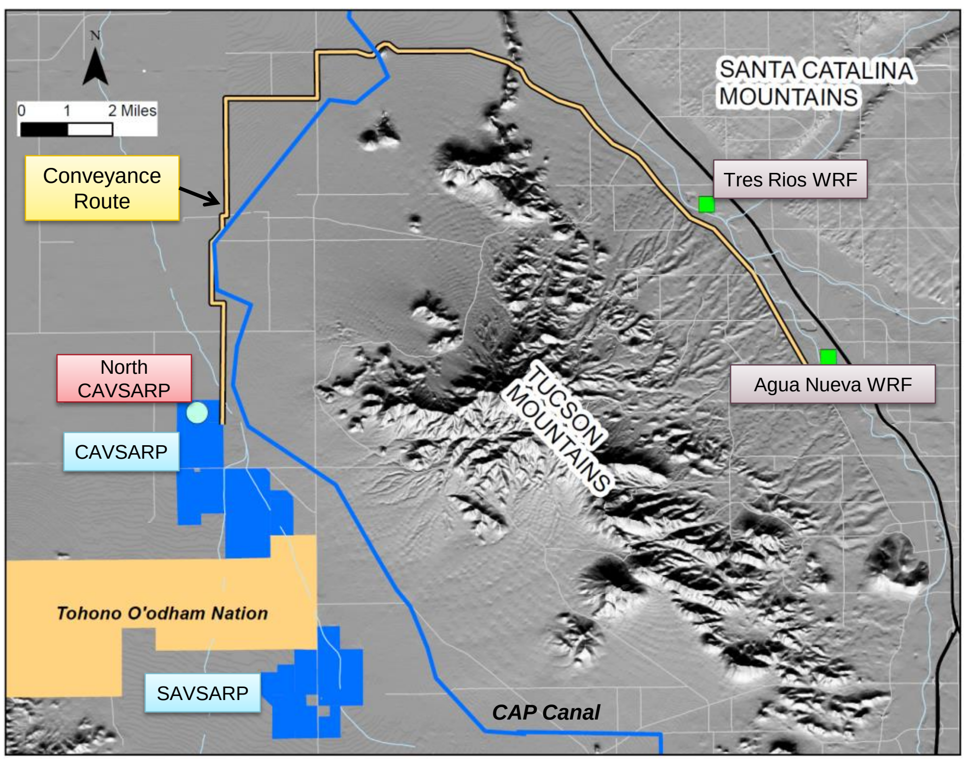

Figure 8-2. Concept for Conveyance of Recycled Water to the CAVSARP and North CAVSARP Alternatives

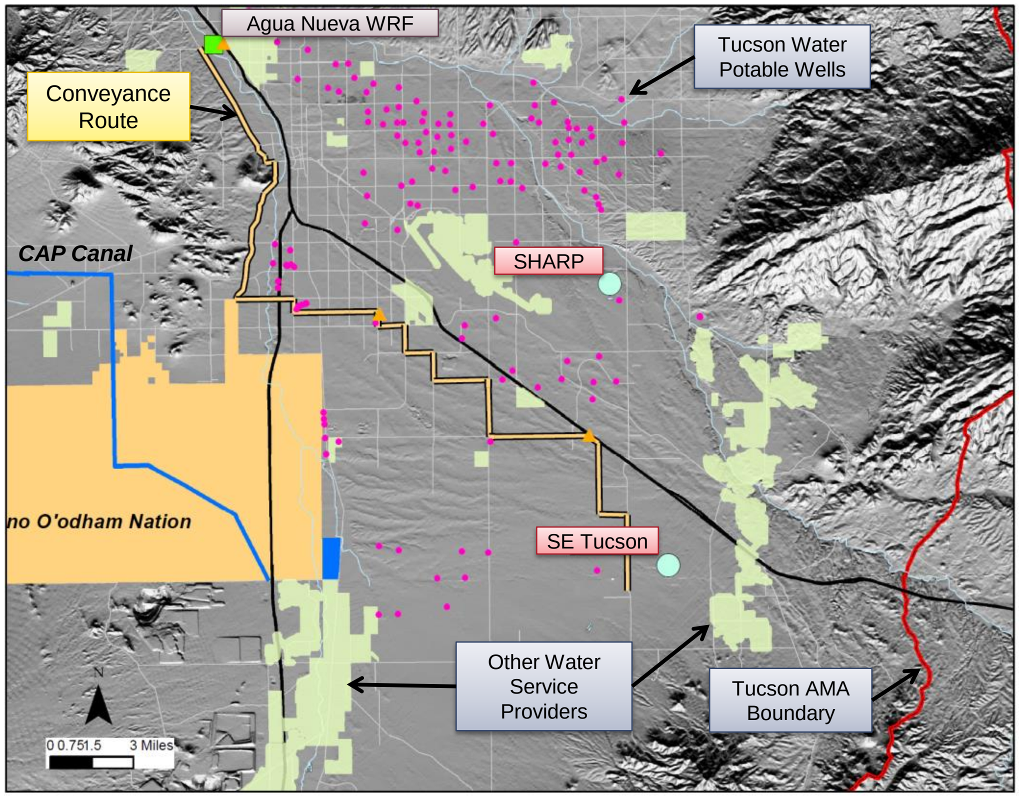

Figure 8-3. Concept for Conveyance of Recycled Water to the SE Tucson Alternative

The Need for Advanced Water Treatment

To secure support and investment for new recycled water projects, Tucson Water will need to build trust with respect to multiple issues, but especially water quality. Being transparent with respect to the motivations and logic behind key decisions is an effective way to build trust. This clearly applies to advanced water treatment decisions regarding IPR. Specifically, some may challenge Tucson Water's recommendation for advanced treatment when it is not technically necessary to meet safe drinking water standards. The case for using advanced treatment for IPR has two main components:

- First, IPR projects typically offer compelling benefits, such as increasing water reliability, improving overall water quality, etc. Tucson Water does not want to risk losing these benefits by proposing a treatment approach that complies with the SDWA, but may not create the water quality confidence necessary to secure public acceptance. This is based in part on the idea that meeting regulations is often viewed as "doing the minimum." The problem is that doing the minimum will be perceived as inappropriate when proposing recycled water to augment potable supplies. Also, advanced treatment has, to some degree, become the standard for IPR projects.

- Second, a multi-step advanced treatment process is the state-of-the-art and further reduces public-health risks, which is a powerful benefit given the nature of wastewater. If membrane treatment is employed, then Tucson Water can add salinity reduction benefits to the equation, which is relevant since Tucson is faced with increasing water supply salinity.

The bottom line is that advanced treatment is not over-investment, but a prudent approach to reducing public health risks and the risk that the community might reject a highly valuable project because of water quality concerns.

Evaluation of Advanced Treatment Process Options

Advanced water treatment processes can be employed to provide multiple barriers for removal of pathogens and diverse barriers for removal of trace organic contaminants in recycled water projects. Several factors may impact selection of a treatment technology, including source water characteristics, treated water quality goals, operational complexity, residuals management, operations and maintenance, and energy and chemical requirements.

In the review of the *Recycled Water Master Plan*, the NWRI Independent Advisory Panel evaluated topics related to: public health and safety, public outreach and advocacy, groundwater, advanced treatment technologies (such as use of advanced treatment technologies to reduce mineral content, attenuate contaminants of emerging concern, etc.), and other topics related to indirect potable reuse.

Advanced water treatment process options were identified to achieve water quality goals established for Tucson Water. Candidate treatment processes, combined into process trains, were then evaluated and compared based on conceptual costs and non-cost advantages and disadvantages.

The identification and evaluation of advanced water treatment options were completed with input and review by an Independent Advisory Panel comprised of national and global experts on water reuse. The independent advisory panel was established and facilitated with the assistance of the National Water Research Institute (NWRI). The NWRI's mission and the Independent Advisory Panel's charge and makeup were described in Chapter 1. With regards to advanced water treatment, the NRWI panel reviewed the work to identify recycled water program alternatives and helped to shortlist advanced treatment process options for detailed evaluations.

Water Quality Goals

Advanced water treatment (AWT) will apply only to alternatives which involve introduction of recycled water into the existing Clearwater blend produced by the CAVSARP and SAVSARP facilities. Water quality goals for AWT were developed for the point where recycled water would be introduced into the Clearwater blend, as shown on Figure 8-4. Soil aquifer treatment provided during the recharge step is considered part of the advanced treatment process trains. Denitrified wastewater effluent for recycled water recharge would be provided by the PCRWRD metropolitan area regional wastewater water reclamation facilities.

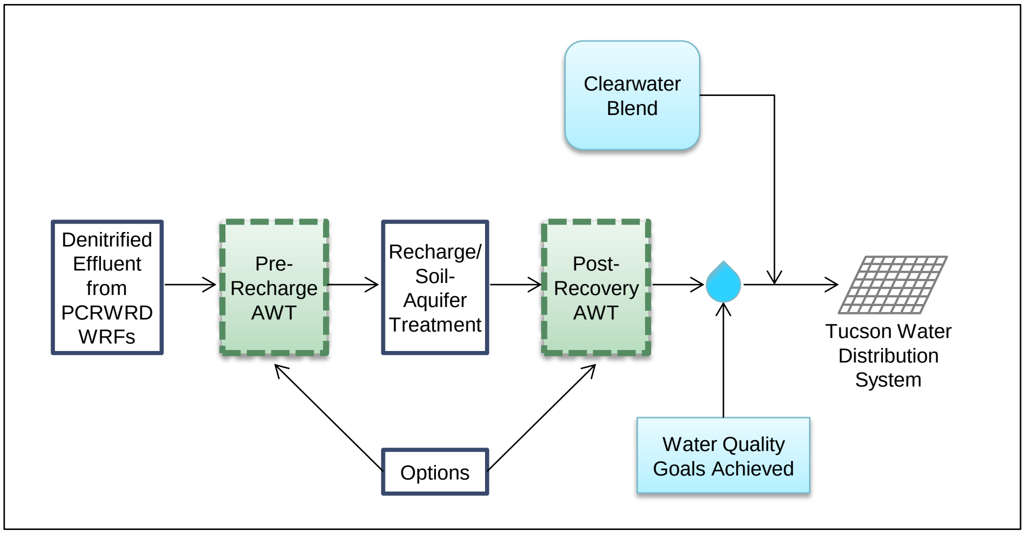

Figure 8-4. Target Location for Achieving Water Quality Goals

While AWT was considered for the SE Tucson Alternative, it was concluded that because this alternative is not considered IPR, providing AWT is not necessary and would not be cost-effective. Therefore, AWT for this alternative was not evaluated.

Table 8-2 presents water quality parameters, rationale, and numeric goals for AWT that were developed based on federal and state drinking water standards, quality of existing supplies, improvement of existing supply quality, and practices of other leaders in IPR (i.e., California). The water quality goals were also established with the assistance of the NWRI's Independent Advisory Panel, which brought to bear the experiences and lessons learned from similar IPR projects across the country and the world.

Advanced Water Treatment Process Train Options

Treatment process trains to achieve the water quality goals were identified by reviewing available treatment technologies and assessing their capabilities for removing wastewater constituents individually and together. Contaminant removal efficiencies depend in large part on the location of water treatment with respect to recharge, either before recharge (pre-recharge) or after recovery (post-recovery). Although pre-recharge treatment may prevent the perception of degrading the groundwater quality, the process is expected to be more costly and energy intensive. Pre-recharge treatment facilities must be sized to accommodate significant variations in unused recycled water during the year. In addition, the natural water treatment benefits of soil aquifer treatment (SAT) would not be realized. Post-recovery treatment is efficient for inland applications and provides the opportunity for SAT as a natural process for removal or reduction of many contaminants. SAT also provides pre-treatment that can benefit downstream treatment steps, such as eliminating filtration prior to membrane treatment and reducing treatment residuals production. Therefore, post-recovery treatment has the potential to be more cost-effective due to two key benefits:

Table 8-2. Advanced Water Treatment Water Quality Goals

Parameter	Rationale	Numeric Goals
Particulate	Comply with federal/state drinking water standard	0.3 Nephelometric Turbidity Units (NTU; 95%, 1 NTU max)
Total Organic Carbon[1]	Comparable to Clearwater blend	~0.5 milligram per liter (mg/L)
Mineral content – Hardness	1. Partial stream treatment 2. Full flow treatment	1. ~250 mg/L 2. ~100 mg/L
Mineral content – Total Dissolved Solids (TDS)	1. Partial stream treatment (meet CAP concentration) 2. Full flow treatment	1. ~650 mg/L 2. ~250 mg/L
Nutrients	Comply with federal/state drinking water standard (70% of MCLs)	Nitrate < 7 mg/L as N Nitrite < 0.7 mg/L as N
Viruses	California draft regulations (2011)[2]	12 log reduction value (LRV)
Cryptosporidium	California draft regulations (2011)	10 LRV
Total Coliform, Fecal Coliform, *E. coli*	Meet LT2[3] requirements	Non-detect
Giardia	California draft regulations (2011)	10 LRV
Contaminant Candidate List 3 (CCL3) Pathogens	Meeting LT2 requirements will comply with CCL3 Pathogens	
Microconstituents	Removal consistent with water treatment industry practice	
Nitrosamines	Potential 10 nanogram per liter (ng/L) future standard	
Refractory Chemicals	Removal consistent with water treatment industry practice	

[1] *The concentration of Total Organic Carbon (TOC) in the Clearwater blend may change over time, and the numeric goal for TOC may be adjusted in the future to be comparable to the Clearwater blend.*

[2] *Draft Regulations for Groundwater Replenishment Reuse projects under Title 22, California Code of Regulations, Div. 4 Environmental Heath, Ch. 3 Recycling Criteria (CA Dept. of Public Health 11/21/2011).*

[3] *Long Term 2 Enhanced Surface Water Treatment Rule (LT2).*

- The aquifer provides storage to buffer seasonal fluctuations in unutilized recycled water, resulting in smaller treatment facilities that can be operated at uniform flows year-round.
- SAT maximizes water quality benefits through natural treatment during recharge, reducing advanced treatment process needs.

AWT process options were also discussed with several local and international academic recycled water experts. These experts brought to bear not only the experiences of successful IPR programs across the county, but also the state-of-the-art in water treatment research. The discussions focused on emerging trends in treatment for IPR projects, including different perspectives for inland versus coastal IPR projects, since concentrate management is more difficult for inland IPR projects. Based on recent research and experience, several of the experts advocated post-recovery treatment for inland IPR projects due to the potential for flow equalization, lower costs, and lower energy requirements.

AWT technologies were identified for mainstream treatment and concentrate (brine) treatment. Table 8-3 provides a summary of the AWT process technologies and the classes of contaminants removed by each option.

Table 8-3. Summary of Advanced Water Treatment Technologies

Advanced Treatment Process	Classes of Contaminants Removed	
	As a Primary Removal Mechanism	As a Secondary/Potential Removal Mechanism
Main Stream Treatment Technologies		
MF/UF	Particulates	Pathogens, Viruses
RO/NF	Particulates, TOC, Mineral Content, Microconstituents	Nutrients, Pathogens, Viruses
SAT	TOC, Nutrients, Pathogens	Particulates, Microconstituents, Viruses
GAC	Particulates, TOC, Microconstituents	--
UV-AOP	Microconstituents, Pathogens, Viruses	--
Concentrate Treatment Technologies		
Ozone	--	TOC, Microconstituents, Pathogens, Viruses
BAC	Particulates, TOC	Pathogens, Viruses
IX	Nutrients, Mineral Content	--
EDR	--	Mineral Content
GAC	Particulates, TOC, Microconstituents	--

Mainstream Treatment Technologies

- **Microfiltration (MF) and Ultrafiltration (UF)**: Pressure-driven membrane processes used to remove particulate matter, including turbidity and microorganisms. MF and UF are effective pre-treatment processes for reverse osmosis and nanofiltration.

- **Reverse Osmosis (RO) and Nanofiltration (NF)**: Pressure driven membrane processes in which hydraulic pressure in excess of a membrane's osmotic pressure is applied to push water through a dense membrane. Removal is not solely based on size exclusion, but also on diffusive and electrostatic properties. The key difference between NF and RO is that NF does not remove monovalent ions (i.e., sodium and chloride). RO usually requires higher operating pressures than NF.
- **Soil Aquifer Treatment (SAT)**: A natural treatment process in which the water to be treated is recharged in basins allowing water to percolate through the soil column where it undergoes physical, biological, and chemical transformation. The soil column acts as a natural filter, microorganisms break down the biodegradable organic matter, and there is additional purification through neutralization, oxidation, precipitation, and adsorption reactions. SAT is also effective for degradation of microconstituents. Ozonation can be employed prior to SAT to increase the dissolved oxygen concentration and break down organic carbon, which could improve biological reactions.
- **Granular Activated Carbon (GAC)**: GAC offers large available surface area via its porous pore structure which contaminants can diffuse into and adsorb onto. GAC is effective for removal of broad classes of microconstituents and also provides other water quality benefits, such as removing taste and odor compounds. GAC is often utilized after ozonation, which is called Biologically Activated Carbon (BAC).
- **Ultraviolet/Hydrogen Peroxide Advanced Oxidation Process (UV-AOP)**: UV photolysis of hydrogen peroxide generates hydroxyl radicals (•OH) that have an oxidation potential greater than other strong oxidants. Hydroxyl radicals are non-selective and have fast reaction rates with organic and inorganic species present in natural waters. UV-AOP is effective for disinfection and destruction of broad classes of microconstituents. GAC can also be used for hydrogen peroxide quenching after UV-AOP.

Concentrate Treatment Technologies

- **Ozone (O_3)**: Ozone is an unstable gas that is slightly soluble in water and is a very powerful oxidant. During ozonation, the two main oxidants, ozone and hydroxyl radicals, are formed during the decomposition of ozone. Ozone is very reactive with a number of common constituents, including natural organic matter (NOM). During concentrate treatment, ozone is an effective pre-treatment process for oxidation of TOC.
- **Biologically Activated Carbon (BAC)**: As indicated above, GAC is often utilized after ozonation, which is called BAC. During concentrate treatment, BAC is an effective pre-treatment process for removal of particulates and TOC.
- **Ion Exchange (IX)**: Contaminant cations and anions can be removed from water using IX with resins or adsorption onto granular metal oxides/hydroxides. For

concentrate treatment, IX is primarily used for the removal of nutrients and hardness.

- **Electrodialysis Reversal (EDR)**: Membrane process driven by electric potential in which ions are transferred through ion exchange membranes by means of a direct current voltage. EDR also has a low scaling potential and is more appropriate for concentrate treatment since EDR does not concentrate silica.
- **Granular Activated Carbon (GAC)**: As mentioned in Section 5.5.1, GAC is effective for removal of broad classes of microconstituents and also provides other water quality benefits through adsorption. During concentrate treatment, GAC is used to remove particulates, TOC, and microconstituents.

Based on the review of advanced treatment technologies, the treatment process trains that were selected for evaluation are presented in Table 8-4 and include pre-recharge, post-recovery, and concentrate treatment processes.

In the CAVSARP Alternatives, recycled water would be recharged along with CAP water. Thus, all of the CAVSARP Alternatives employ pre-recharge AWT. If post-recovery treatment was assumed for the CAVSARP alternatives, treatment would have to be applied to the full amount of the recovered CAP/recycled water blend, dramatically increasing the required design capacity and costs. The CAVSARP-1, -2 and -3 treatment trains also include full stream membrane treatment (RO or NF) to assess maximum salinity control, while the CAVSARP-4 and -5 treatment trains include partial stream membrane treatment (RO or NF) to match the mineral content of CAP water.

The North CAVSARP Alternatives present the potential opportunity to isolate the recharge and recovery of recycled water from existing CAP water recharge and recovery operations. Pre-recharge treatment would be sized to accommodate the fluctuations in unutilized recycled water, while post-recovery treatment could be sized to take advantage of the storage and buffering benefit of the aquifer.

Cost Evaluation of Advanced Treatment Process Alternatives

The treatment process trains were defined in sufficient detail for development and comparison of conceptual costs. Conceptual design criteria were developed and used to size treatment facilities and estimate operational requirements. This information was then used to develop conceptual opinions of capital costs, annual O&M costs, and 20-year present worth values for each process train alternative. Appendix E provides the details of the cost evaluation of advanced treatment process alternatives.

The unutilized recycled water projections presented in Chapter 5 were used to develop conceptual design flows for sizing of treatment facilities. The pre-recharge treatment alternatives would require treatment for the peak recycled water availability and would operate to accept wide flow fluctuations through the year. The post-recovery treatment

Table 8-4. Summary of Treatment Process Train Alternatives

Alternative[1]	Pre-Recharge Treatment	Natural Treatment & Storage	Post-Recovery Treatment	Concentrate Treatment
CAVSARP Category of Alternatives				
CAVSARP-1	MF, NF, UV-AOP	Recharge	Disinfection	O_3, BAC, IX, EDR
CAVSARP-2	MF, RO, UV-AOP	Recharge	Disinfection	O_3, BAC, IX, EDR
CAVSARP-3	MF, RO	Recharge	Disinfection	O_3, BAC, IX, EDR
CAVSARP-4	MF, RO (partial), UV-AOP	Recharge	Disinfection	O_3, BAC, IX, EDR
CAVSARP-5	MF, RO (partial), O_3	Recharge	Disinfection	O_3, BAC, IX, EDR
North CAVSARP Category of Alternatives				
North CAVSARP-1	MF, NF, UV-AOP	Recharge	Disinfection	O_3, BAC, IX, EDR
North CAVSARP-2	MF, RO, UV-AOP	Recharge	Disinfection	O_3, BAC, IX, EDR
North CAVSARP-3	-	Recharge/SAT	RO, UV-AOP, GAC (for H_2O_2 quenching), Disinfection	EDR
North CAVSARP-4	O_3	Recharge/SAT	RO, Disinfection	EDR, GAC
North CAVSARP-5	O_3	Recharge/SAT	RO (partial), UV-AOP (partial), GAC (for H_2O_2 quenching), Disinfection	EDR, GAC

[1] *The SE Tucson alternative is not shown because it does not have AWT.*

alternatives could take advantage of aquifer storage and buffering and treat the annual average availability, thereby allowing operation at nearly constant flows year-round.

Table 8-5 summarizes the range of design flows based on the analysis of unutilized recycled water in Chapter 5. The cost evaluation of treatment options was conservatively based on conceptual sizing of facilities for only the 2020 Low Range projection of unutilized recycled water. The Low Range flows are based on 90 percent of the most recent regional, official wastewater flow projections and assuming that the CEP allotment was being fully used by non-Tucson Water users. The flow basis for O&M cost estimates were the annual average recycled water availability.

The level of accuracy for the cost opinions corresponds to Class 5 estimates as defined by the Association for the Advancement of Cost Engineering (AACE) International. Class 5 estimates are generally prepared based on limited information and have a

Table 8-5. Summary of AWT Design Flows

Advanced Treatment Location	Flow Basis (MGD)			
	2020		2030	
	"Low Range"[1]	"High Range"[1]	"Low Range"	"High Range"
Pre-Recharge (flows are peak month recycled water availability)	19	32	26	41
Post-Recovery (flows are annual average recycled water availability)	7	19	13	26

[1] Basis for Low Range and High Range are defined in Chapter 5.

typical accuracy range of -30 percent to +50 percent. This level of cost estimating is typically done for project screening, feasibility studies, and concept evaluation. The cost opinions include 25 percent for engineering and administration and 30 percent for project contingencies. Appendix E provides the detailed cost evaluation results.

An initial cost evaluation was completed for all alternatives listed on Table 8-4. The purpose of the initial cost evaluation was to identify a short list of preferred AWT process trains. The initial cost evaluations, therefore, only included the AWT process train components and did not include recycled water conveyance and recovered water infrastructure. The estimated 20-year total present worth values for the AWT process train alternatives are summarized on Figure 8-5. The green bars on Figure 8-5 represent the accuracy range of the Class 5 estimates as defined above.

Figure 8-5 illustrates that the post-recovery treatment trains, North CAVSARP-3,- 4 and -5, are estimated to have the lowest total present worth costs, approximately 65 percent less than the pre-recharge treatment train alternatives. The alternatives with partial stream RO or NF treatment, CAVSARP-4 and -5, have the median total present worth. The alternatives with pre-recharge treatment and full flow RO or NF treatment, CAVSARP-1, -2, and -3 and North CAVSARP-1 and -2, have the highest total present worth.

Matrix Evaluation of AWT Process Train Alternatives

The treatment train alternatives were further analyzed using a matrix evaluation to identify the preferred treatment train alternatives. The matrix evaluation was based on important criteria for decisions regarding a future recycled water program employing IPR. The evaluation was accomplished by systematic scoring and weighting of the decision criteria for each of the treatment train alternatives.

The decision criteria identified as most important to Tucson Water in selecting preferred treatment train alternatives include the following:

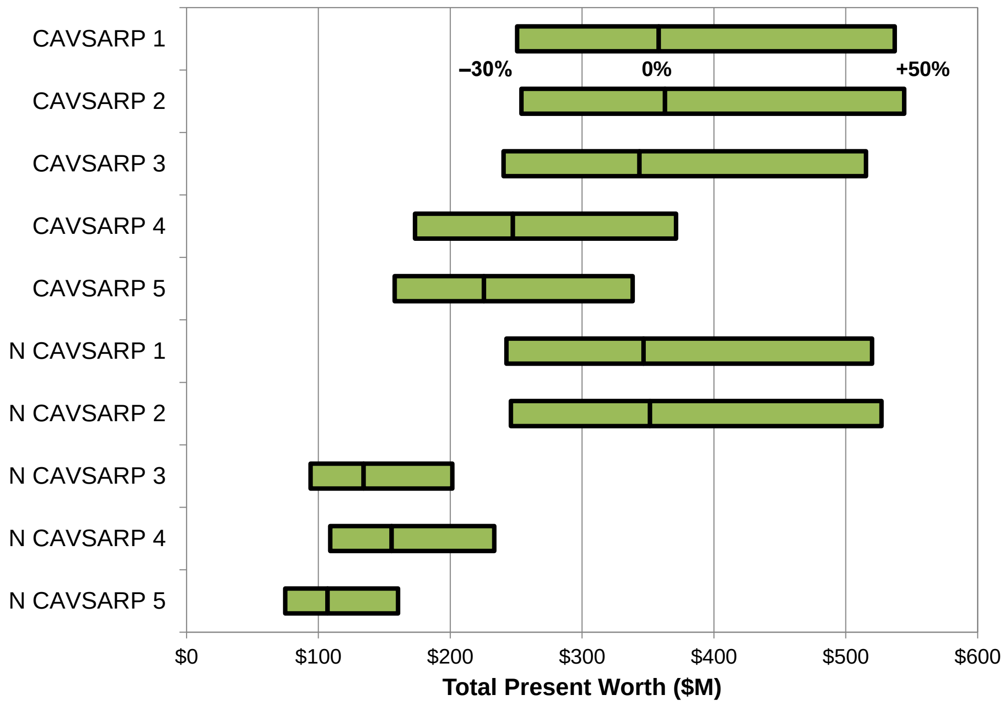

Figure 8-5. Present Worth Cost Comparison of Advanced Treatment Train Alternatives

- **Public acceptance**: Perceived potential for positive or negative public sentiment due to water quality, neighborhood factors, and water rate impacts. Alternatives with the greatest potential for public acceptance are preferable.
- **Cost**: Relative capital costs, O&M costs, and present worth. Alternatives with lower costs are preferable.
- **Multiple barrier approach**: A robust approach that provides multiple treatment technologies to remove a wide range of constituents, ensuring water quality goals are met. Alternatives that utilize a multiple barrier approach to treatment are preferable.
- **Mineral content reduction**: Ability to begin addressing groundwater basin salinity issues or, at a minimum, to meet upper mineral content goals for the Clearwater blend (650 mg/L TDS). Alternatives that address basin salinity issues are preferable.
- **Proven IPR process**: Treatment trains utilized in successful IPR programs at other locations. Alternatives that utilize a proven IPR process are preferable.
- **Refractory chemicals**: Ability to remove or destroy challenging non-biodegradable refractory chemicals. Alternatives that perform better with respect to removal or destruction of refractory chemicals are preferable.

- **Microconstituent removal**: Treatment effectiveness in removing or destroying broad classes of compounds, including pharmaceuticals and personal care products (PPCPs), endocrine-disrupting compounds (EDCs), industrial and agricultural compounds, etc. Alternatives that are more effective in removing microconstituents are preferable.
- **Energy usage**: Power requirements for treatment operations. Alternatives that use less energy are preferable.
- **Institutional and regulatory complexity**: Number and complexity of required agency approvals/permits and support, potential for regulatory scrutiny, and effects on agreements with regional stakeholders. Alternatives that are less susceptible to regulatory and institutional challenges and require fewer and less complex permits or approvals are preferable.
- **Operational complexity**: Complexity of facility operations and need for operator attention. Alternatives with fewer and less complex facilities to operate, requiring lower staffing requirements, are preferable.
- **Utilization of existing infrastructure**: Ability to recharge and recover with existing infrastructure or through planned improvements already anticipated in the capital improvement program. Alternatives that maximize the use of existing infrastructure are preferable.
- **Concentrate quantity**: Volume of treatment process concentrate (brine) requiring additional treatment to maximize water recovery. Alternatives that generate the least amount of concentrate are preferable.

Details of the matrix evaluation for treatment process alternatives are presented in Appendix E. The evaluation resulted in the following key conclusions:

- There is a preference for full-stream RO or NF treatment as they provide the most opportunity to begin addressing basin salinity issues.
- North CAVSARP is preferred over CAVSARP for the recharge location.
- Pre-recharge treatment is preferred over post-recovery treatment, due primarily to the project team's perception of potential public concerns with recharging recycled water before subjecting it to AWT.
- The CAVSARP Alternatives are not preferred because mixing of CAP water and recycled water during recharge will require larger and more costly facilities needed to treat the recovered CAP/recycled water blend.

The results of the matrix evaluation were also discussed with the NWRI Independent Advisory Panel. The Panel was in general agreement with the matrix evaluation results and recommended that subsequent planning efforts should be conducted with several modifications to the highest ranking treatment train alternatives. Based on a combination of the matrix evaluation and recommended modifications from the NWRI panel, the three treatment train alternatives identified as the most preferred are summarized in Table 8-6.

Table 8-6. Summary of Preferred Advanced Treatment Train Alternatives

Alternative	Pre-Recharge Treatment	Natural Treatment & Storage	Post-Recovery Treatment	Concentrate Treatment
North CAVSARP-1	MF + NF + UV-AOP	Recharge	Disinfection	O_3 + BAC + IX + EDR
North CAVSARP-3	-	Recharge/SAT	SAT + NF + UV-AOP + GAC (for H_2O_2 quenching) + Disinfection[1]	EDR
North CAVSARP-4	-	Recharge/SAT	SAT + NF + Disinfection[1]	EDR + GAC

[1] *Treatment process train was modified from Table 8-4 based on NWRI recommendations.*

Evaluation of New Recycled Water Program Alternatives

The preferred treatment train alternatives were combined with the other recycled water program components for conveyance and recovery to develop the following overall recycled water program alternatives:

- North CAVSARP-1
- North CAVSARP-3
- North CAVSARP-4
- SE Tucson – No Advanced Water Treatment

Facility Requirements for Recycled Water Program Alternatives

Facility concepts were refined, and conceptual cost opinions were further developed. The evaluation of overall recycled water program alternatives were based on the same conceptual design flows presented in Table 8-5 (2020 and 2030 Low Range flows), except for sizing source water conveyance pipelines. It is standard practice to size conveyance pipelines for longer planning horizons than treatment facilities, as service lives for pipelines are longer, and future pipeline replacement or augmentation is disruptive and costly. Thus, based on the evaluation of unutilized recycled water in Chapter 5, the conveyance facilities were sized based on a 2050 Low Range flow.

In addition to source water conveyance and AWT, additional transmission infrastructure is required for the North CAVSARP alternatives to convey recovered water from North CAVSARP to the existing CAVSARP reservoir and booster pump station.

Table 8-7 summarizes the basis of facility sizing and facility requirements for each major component of the recycled water program alternatives. Appendix E provides further details of the facility concepts for each alternative.

Conceptual Cost Opinions for Recycled Water Program Alternatives

Similar to the initial evaluation of AWT train options, the level of accuracy for the cost opinions corresponds to Class 5 as defined by the AACE International. Appendix E provides the detailed cost evaluations. The conceptual capital and annual O&M cost opinions for the overall recycled water program alternatives are presented in Table 8-8 and Table 8-9, respectively.

Potentially Related Costs at SAVSARP Facilities

In addition to the costs summarized in Table 8-8 and Table 8-9, the CAVSARP and North CAVSARP alternatives could also include potentially related costs of a SAVSARP expansion for the CAP water that would be displaced by recharge of recycled water at the CAVSARP and North CAVSARP facilities. The need for a SAVSARP expansion is unknown at this time and will depend on the actual amounts of water recharged at CAVSARP due to actual participation of all facility partners, actual facility operational capabilities, etc., which will only be determined after the facilities have been operated for some time.

Table 8-8 and Table 8-9 do not include the potentially related costs of a SAVSARP expansion which could include 40 acres of new recharge basins (to recharge up to 10 MGD) and 3.9 miles of 60-inch pipeline from the CAP Canal turnout to the recharge basins at an estimated capital cost of $27 million. The potential costs could also include an estimated $1.3 million in annual O&M to recharge an average of 7 MGD.

Conceptual Unit Costs for New Recycled Water Program Alternatives

Table 8-10 summarizes conceptual unit costs to provide new recycled water supplies through a Tucson Water IPR program. The estimated capital and O&M costs in the table do not include potentially related capital costs for a SAVSARP expansion because the need for the expansion has not yet been firmly established. Unit costs in the table are presented for both Year 2020 and 2030, Low Range recycled water flows.

Table 8-7. Summary of Recycled Water Program Alternative Facility Components

Component	North CAVSARP-1		North CAVSARP-3		North CAVSARP-4		SE Tucson	
2020 Flow Basis	7 MGD (Average) and 19 MGD (Peak)							
2030 Flow Basis	13 MGD (Average) and 26 MGD (Peak)							
2050 Flow Basis[1]	32 MGD (Peak)							
Recycled Water Source	Pima County Water Campus							
Recharge Location	North CAVSARP						SE Tucson	
Recycled Water Conveyance								
Pipeline	25 miles of 48-inch DIP Pipe						35 miles of 48-inch DIP Pipe	
Pumping	32 MGD Pump Station (100 ft TDH)						3-32 MGD Pump Stations (1,200 TDH)	
Advanced Treatment Location	Pre-Recharge		Post-Recovery		Post-Recovery		None	
Mainstream Treatment Train	MF + NF + UV-AOP + Recharge		Recharge/SAT + NF + UV-AOP + GAC for H_2O_2 quenching		Recharge/SAT + NF		None	
Mainstream Treatment Sizing								
Flow Basis (Year)	2020	2030	2020	2030	2020	2030	2020	2030
MF (MGD)	22.1	30.3						
NF (MGD)	17.7	24.2	6.6	12.2	6.6	12.2		
UV-AOP (MGD)	19	26	7	13	7	13		
GAG for H_2O_2 quenching (MGD)			7	13				
SAT Recharge Acreage (acres)	76	104	112	153	112	153	86	117
Concentrate Treatment Train	Ozone + BAC + IX +2-Stage EDR		2-Stage EDR		2-Stage EDR + GAC		None	
Concentrate Treatment Sizing								
Flow Basis (Year)	2020	2030	2020	2030	2020	2030	2020	2030
Ozone (MGD)	4	5.2						
BAC (MGD)	4	5.2						
GAC and Cartridge Filtration (MGD)					1.6	3.1		
IX (MGD)	4.4	6.1						
EDR (MGD)	4.3	5.9	1.6	3.1	1.6	3.1		
Solids Handling	2.5	3.4						
Evaporation Pond Acreage (acres)	273	373	109	204	109	204		
Recovered Water Transmission Piping	4 miles of 48-inch HDPE Pipe						None	

[1] *For sizing of recycled water conveyance facilities.*

Table 8-8. Conceptual Capital Cost Opinions for Recycled Water Program Alternatives

	North CAVSARP-1		North CAVSARP-3		North CAVSARP-4		SE Tucson	
Flow Basis (Year)	2020	2030	2020	2030	2020	2030	2020	2030
CAPITAL COSTS ($ million)								
Recycled Water Conveyance								
Pipeline	$98.4		$98.4		$98.4		$141	
Pumping	$10.9		$10.9		$10.9		$36.6	
Mainstream Treatment								
MF	$44.5	$61.0						
NF	$50.9	$69.0	$26.4	$47.7	$26.4	$47.7		
UV-AOP	$11.7	$16.0	$5.3	$9.9				
GAC (for H_2O_2 quenching)			$3.5	$5.3				
SAT Recharge	$6.1	$8.3	$9.0	$12.3	$9.0	$12.3	$13.0	$17.7
Concentrate Treatment								
Ozone	$12.5	$16.3						
BAC	$5.6	$6.9						
GAC and Cartridge Filtration					$4.2	$7.1		
IX	$10.8	$13.6						
EDR	$13.4	$18.7	$10.0	$21.2	$10.0	$21.2		
Solids Handling	$2.9	$3.9						
Evaporation Ponds	$61.2	$83.1	$25.7	$46.3	$25.7	$46.3		
Recovered Water Piping			$13.7		$13.7			
TOTAL CAPITAL	**$329**	**$406**	**$203**	**$266**	**$198**	**$256**	**$191**	**$196**

Table 8-9. Conceptual Annual O&M Cost Opinions for Recycled Water Program Alternatives

	North CAVSARP-1		North CAVSARP-3		North CAVSARP-4		SE Tucson	
Flow Basis (Year)	2020	2030	2020	2030	2020	2030	2020	2030
ANNUAL O&M COSTS ($ million)								
Recycled Water Conveyance								
Piping and Pumping	$0.2	$0.3	$0.2	$0.3	$0.2	$0.3	$1.1	$1.1
Mainstream Treatment								
MF	$0.6	$1.1						
NF	$1.7	$3.1	$1.7	$3.1	$1.7	$3.1		
UV-AOP	$1.0	$1.5	$0.4	$0.8				
GAC (for H_2O_2 quenching)			$0.2	$0.3				
SAT Recharge	$0.02	$0.03	$0.03	$0.04	$0.03	$0.04	$0.04	$0.05
Concentrate Treatment								
Ozone	$0.3	$0.8						
BAC	$0.2	$0.2						
GAC and Cartridge Filtration					$0.7	$1.3		
IX	$0.7	$1.3						
EDR	$0.3	$0.7	$0.4	$0.7	$0.4	$0.7		
Solids Handling	$0.06	$0.08						
Evaporation Ponds	$1.6	$2.2	$0.5	$1.0	$0.5	$1.0		
Recovered Water Piping			$0.02		$0.02			
TOTAL ANNUAL O&M	**$6.7**	**$11.1**	**$3.4**	**$6.1**	**$3.6**	**$6.4**	**$1.1**	**$1.2**

Table 8-10. Conceptual Unit Costs for New Recycled Water Program Alternatives ($ million)

Item	North CAVSARP-1		North CAVSARP-3		North CAVSARP-4	
Mainstream Treatment Train	MF + NF + UV-AOP + Recharge		Recharge/SAT + NF + UV-AOP + GAC (for H_2O_2 quenching)		Recharge/SAT + NF	
Flow Basis (Year)	2020	2030	2020	2030	2020	2030
Capital Costs	$329	$406	$203	$266	$198	$258
Annualized Capital Costs[1]	$19.0	$23.5	$11.7	$15.4	$11.5	$15.9
Annual O&M Costs	$6.7	$11.1	$3.4	$6.1	$3.5	$6.4
Total Annual Costs	$25.7	$34.6	$15.1	$21.5	$15.0	$21.3
Annual Water Supply	7 MGD (7840 AFY)	13 MGD (14,560 AFY)	7 MGD (7840 AFY)	13 MGD (14,560 AFY)	7 MGD (7840 AFY)	13 MGD (14,560 AFY)
Unit Cost ($/AF)[2]	**$3,300**	**$2,400**	**$2,000**	**$1,500**	**$2,000**	**$1,500**

[1] *Based on an interest rate of 4% and term of 30 years.*

[2] *Unit cost based on Annual Water Supply.*

Comparison of New Recycled Water Program with Other Southwest Water Supply Projects

Other Arizona cities, as well as other large cities in the arid Southwest, are conducting long range planning to assure water supply reliability. Because much of the existing water supplies have been allocated, many projects being contemplated involve moving water supplies over long distances and utilizing waters with impaired quality (brackish water, seawater, recycled water, etc.). A new Tucson Water recycled water program can be put into perspective by comparing its costs per unit of new water supplied with those of other recent and proposed Southwest water supply projects. In addition, the energy requirements (in kilowatt-hours per acre-foot, KWH/AF) to deliver the water can be compare relative sustainability.

Comparison of Unit Costs of New Water Supplies

Due to near allocation of all renewable water supplies and increasing water scarcity, more than 70 participants, including CAWCD and major municipalities in central and southern Arizona, formed a working group to conduct the Acquisition, Development, and Delivery (ADD) Water process. Their purpose is to develop a range of distinct alternatives for sharing and paying for the additional water needed to support current and future population in Maricopa, Pinal and Pima counties. Water supplies being investigated include brackish groundwater from the southwest Phoenix metropolitan area, the Lower Colorado River area, and/or desalinated seawater, perhaps from as far away as Mexico. The ADD Water program is currently dormant and did not result in any defined projects, nor costs for achieving its goals. CAWCD is now focused on the policy and pricing issues associated with wheeling non-CAP water through the CAP Aqueduct system.

In 2010, the Arizona Legislature established the Water Resources Development Commission (WRDC) to assess Arizona's water demand for the next 25, 50, and 100 years and to determine existing and potential new supplies to meet the demands. The WRDC identified and evaluated potential future water supplies but concluded that there are numerous hydrologic, technical, legal, and economic challenges that may preclude actual development of the supplies. After preparing a Final Report in October 2011, the WRDC prepared a Supplemental Report in September 2012 (Water Resources Development Commission, 2012). The Supplemental Report contains recommendations for establishing a statewide funding mechanism for water resource development projects and included an appendix of proposed projects with conceptual project descriptions, implementation issues, and costs.

Finally, other southwest communities have developed, or are currently planning, additional water supplies to address current and future water scarcity. These projects have been defined in white papers, conference proceedings, study reports and engineering design reports. Available cost information from the Arizona WRDC and other southwest community efforts were compiled and are presented in Appendix G. The cost information was updated to 2012 costs using Engineering News Record Construction Cost Indices (ENRCCI) so they can be compared with the Tucson Water recycled water program alternatives.

The resulting comparison of unit water supply costs for the Tucson Water and other Arizona and southwest community projects is illustrated on Figure 8-6. The analysis presented in Appendix G and on Figure 8-6 is a general representation of gross program costs, i.e., any cost offsets such as grant funding were removed from the costs to provide comparable information as much as possible. However, there may be project variables involved that may not make all the projects directly comparable. For example, public perceptions may have impacted treatment process selections, coastal versus inland projects require different concentrate management, etc. However, the figure does generally indicate that the potential costs for a Tucson Water recycled water program is comparable, and perhaps favorable, compared to many of the water supply projects shown, particularly at the higher recycled water flow rates.

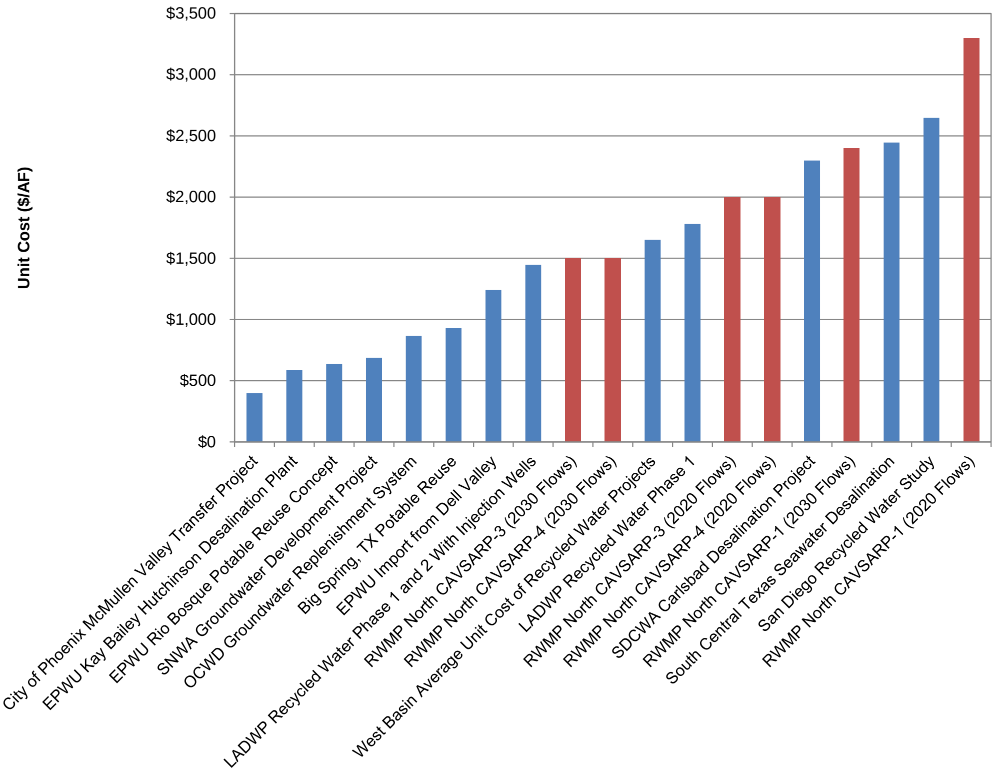

Figure 8-6. Comparison of Unit Costs of Southwest Water Supply Projects

Summary of Findings and Conclusions

The preferred new recycled water program alternatives that include groundwater replenishment, advanced water treatment, and IPR are North CAVSARP-1, -3, and -4 for the following reasons:

- Applying RO or NF in the treatment process provides an opportunity to begin addressing and managing groundwater basin salinity issues. It is estimated that these processes can remove approximately 4,000 tons per year and 7,500 tons per year of salt (for 2020 and 2030 recycled flows, respectively) from the water supply under all three alternatives.
- The North CAVSARP recharge location allows recycled water to be efficiently recharged separately from CAP water, allowing greater control in recharge, monitoring, recovery, and treatment of recycled water. Keeping the CAP and recycled water recharge and recovery operations separate will minimize potential public concerns related to mixing of the two water supplies, treatment facility sizing and costs, and potential permitting impacts to the existing CAVSARP recharge operations.

- The North CAVSARP-3 and -4 alternatives (post-recovery advanced water treatment) have lower costs because they require smaller capacity treatment facilities, use the natural treatment offered by SAT, and use less energy.
- The North CAVSARP-1 alternative (pre-recharge advanced water treatment) is still considered competitive and may offer certain benefits. As such, it should continue to be considered in follow-up implementation activities.

Although it would contribute to long-term storage credits, the SE Tucson alternative (no advanced treatment, no purposeful recovery) would not directly contribute to increasing water supply reliability for the Tucson community as the other alternatives would.

The costs for potential new recycled water programs for the Tucson community are comparable with costs facing other Southwest U.S. communities for developing new water supplies.

Based on the evaluation of recycled water program alternatives, the North CAVSARP-1, -3 and -4 alternatives merit further investigation regarding feasibility for a new recycled water program employing IPR. Significant potential implementation challenges can be further investigated and resolved through research, testing, and demonstration efforts.

Implementation Considerations

A new recycled water program can be refined and implemented based on the findings and recommendations of the *Recycled Water Master Plan* using a phased multi-year approach. The implementation plan should identify near- and long-term activities and capital improvement program requirements to support sustained progress toward realization of this renewable water supply. The implementation plan should be structured around addressing the following key uncertainties that have been identified through the evaluations in this *Recycled Water Master Plan:*

Conveyance Pipeline to Avra Valley

The capital costs for the conveyance pipeline are estimated to range from 30 percent to over 50 percent of the total capital costs for the program alternatives. These estimates are based on an assumed pipeline alignment that covers over 25 miles and assumed conceptual unit costs. Right-of-way acquisition challenges and opportunities for minimizing costs were not addressed at this master planning level of detail. Additional investigations should be conducted early on to acquire the necessary rights-of-way in advance of additional development that may occur along the alignment. The investigations should include the following:

- An alignment study that investigates alternative pipeline corridors and pumping requirements to refine design concepts and cost opinions, identifies right-of-way issues, and identifies the most feasible alignment.

- Identification of potential opportunities for regional cooperation, which could impact conveyance pipeline capacity needs.
- Identification of recycled water source issues (physical and institutional) that can be addressed to potentially reduce conveyance costs (e.g., can source water be diverted from the Tres Rios WRF rather than the Agua Nueva WRF?).

Facility Planning at North CAVSARP Site

The conceptual evaluations were based on assumed locations for recharge, treatment and recovery of recycled water within available City property north of the CAVSARP facilities. Additional investigations should be conducted to refine the site concepts including development of a preliminary site design that identifies all recharge, treatment, recovery and conveyance facilities that will be needed.

Hydrogeologic Investigations

A hydrogeological assessment should be conducted north of the CAVSARP facilities to assess overall feasibility for recycled water recharge and recovery, determine water retention times in the ground, and the potential for isolating the recycled water recharge and recovery operations from the existing CAVSARP operations. This assessment should provide enough information to support effective public outreach and to support facility permitting.

Role of SHARP in Future Recycled Water Program

Additional work should be conducted to clearly define the role of SHARP in a new recycled water program, whether as a site for treatment demonstration testing, demonstration of recharge and recovery effectiveness, or both. Questions that should be addressed include the following:

- Ability to reliably deliver up to 4,000 AFY of reclaimed water to the SHARP site through the existing RWS.
- Appropriateness of the SHARP site for IPR advanced treatment demonstration efforts based on availability of utilities, public access, and other factors.
- Groundwater quality impacts.
- Ability to manage recharged water for demonstration testing, seasonal underground storage and recovery for the RWS, and/or for long-term underground storage.

Cost and Effectiveness of Advanced Treatment and Concentrate Management

The preferred treatment and concentration management processes should be investigated and refined through additional research, bench- and pilot-scale testing, and demonstration efforts. A literature review should be conducted to monitor evolving trends in recycled water treatment and concentrate management and to assist in the design of bench- and pilot-scale testing and demonstration project opportunities. All testing and demonstration efforts should be carefully planned to provide information for project implementation, including refinement of facility layouts, treatment evaluations, impact of blending advanced treated water with other Clearwater blend water, sustainability analysis (comparison of energy requirements and carbon footprints with other potential water supplies, e.g., additional CAP water), and cost estimates. The program should also develop sufficient information for permitting of the program facilities and operations. Opportunities for collaboration with key entities such as the University of Arizona and Pima County in these investigations should be explored.

Public Outreach

Public outreach efforts should be developed to engage local and regional stakeholders regarding a new recycled water program. The efforts should leverage lessons learned from similar programs, engage experts in the recycled water industry, and provide public information on best management practices developed for groundwater replenishment and IPR. The program should also leverage an advanced treatment demonstration program to educate the public through activities such as site tours, expert presentations, and treated water tasting. The research conducted of other successful IPR programs (detailed in Appendix A and summarized in Chapter 2) has shown that a demonstration program is a key factor in building public acceptance.

Financial Plan for Implementation

The estimated costs for a new recycled water program are significant. A financial plan should be developed for the program that considers a range of funding alternatives, impacts to water rates, and sensitivities to different implementation horizons.

Chapter 9 • CONCLUSIONS AND RECOMMENDATIONS

RECYCLED WATER MASTER PLAN

Chapter 9. CONCLUSIONS AND RECOMMENDATIONS

This chapter presents a summary of conclusions and recommendations resulting from the RWS analyses and evaluation of new recycled water program alternatives. The recommendations for the RWS will allow Tucson Water to continue providing reliable reclaimed water service into the future. The recommendations for new recycled water programs provide guidance for Tucson Water to continue development of a program to build a new renewable water supply that will increase reliability and help meet the community's future water demands.

Reclaimed Water System

The RWS analyses identified improvements that will allow Tucson Water to continue providing reliable reclaimed water service, both in the near-term and in the long-term. The recommended improvements will address existing system deficiencies and improve service for existing and future Tucson Water customer demands, which include existing Pima County and Oro Valley Water Utility demands. The analyses also determined the impacts of potentially serving the future demands of Pima County, Oro Valley, MDWID, FWID, and Spanish Trail Water Company.

Conclusions for the Reclaimed Water System

- The calculated current peak day reclaimed water demand is 36 MGD and the projected 2030 peak day demand is 41 MGD (includes existing Pima County and Oro Valley demands), while the current production capacity of the RWS is 34 to 36 MGD. The current CIP projects to construct new recharge basins and recovery wells at the Sweetwater US&R Facility and to rehabilitate the filters at the RWTP will increase capacity to meet existing and future peak day demands.
- An additional 13 MG of RWS storage is needed for equalization under existing and future demand conditions.
- As it is configured and operated today, the existing RWS distribution system (piping and pumping) can only supply 31 MGD on a peak demand day. This is because the RWS is deficient (negative pressures, high velocities, and high headlosses) in the Dove Mountain area, La Paloma area, and along the Silverbell Road and Thornydale Road pipeline reaches. If the deficiencies are corrected, Tucson Water can dramatically improve reclaimed water service to satisfy the calculated peak day demands and reliably meet contractual commitments.

- If sufficient reclaimed water production is available, the existing RWS has sufficient capacity (piping and pumping) to deliver 4,000 AF uniformly throughout the year (333 AF each month) to the proposed Tucson Water/Pima County SHARP site, even during peak demand months.
- Additional booster station expansions at the Tucson RWTP (8 MGD) and at the Houghton Reservoir (1.5 MGD) will be required to meet the projected 2030 Tucson Water demands. A booster station expansion at the RWTP is already in the City's reclaimed water CIP.
- If the RWS serves the future demands of Oro Valley, MDWID, FWID, and Spanish Trail Water Company, additional booster station upgrades would be required at the Thornydale Booster Station (4.4 MGD in 2015, 4.4 MGD in 2025, and 1 MGD in 2030), primarily to serve future Oro Valley demands.
- If the RWS serves the future demands of Pima County, additional system improvements would be required including booster station upgrades at the Sabino Canyon Road (1 MGD) and Udall Park (1.5 MGD) sites, and 1.5 miles of 8-inch diameter pipeline along Snyder Road.

Recommendations for the Reclaimed Water System

The recommended RWS system improvements are presented in Chapter 6 (Figure 6-3 and Table 6-6). The RWS recommendations include the following to address existing system deficiencies:

- The **North Loop Improvements** are the highest priority improvements. The northwest area represents the highest volume of reclaimed water deliveries and provides the largest source of reclaimed water revenues. This loop would also improve service to Oro Valley and would prepare the system for future service to MDWID.
- The **Dove Mountain Area Improvements** are the second highest priority improvements. The primary improvement is a new 6 MG storage reservoir which will improve service in the entire northwest area. The improvements will address storage deficiencies and would improve the ability to meet contractual agreements with golf courses during peak demand periods.
- The **Northeast Loop Improvements** are the third priority improvements and would supplement booster pumping and storage at the La Paloma reservoir, and address high velocities and headlosses in nearby pipelines. The improvements which include a new 7.3 MG reservoir will improve reliability and the ability to meet contractual agreements with golf courses in the La Paloma area during peak demand periods.

The RWS recommendations to serve future Tucson Water reclaimed water demands (including existing Pima County and existing and future Oro Valley demands) include the following:

- For 2020 demands, a booster station expansion at the RWTP. This project is already in the Tucson Water reclaimed water CIP.
- For 2030 demands, a booster station upgrade at the Houghton Road Reservoir.
- To serve future Oro Valley demands, booster station expansions by 2015, 2025 and 2030 at the Thornydale Road Reservoir (Oro Valley will be responsible for these improvements).

New Recycled Water Programs

Limited additional demands are anticipated for the RWS. New recycled water programs are therefore required to put Tucson Water's unutilized recycled water to beneficial use. The unutilized recycled water could be used to replenish groundwater and, after additional advanced treatment, to supplement potable water supplies.

The Case for a New Recycled Water Program

There are several very compelling reasons for Tucson Water to establish a program to make use of the community's significant unutilized recycled water supplies:

- The impacts of sustained drought and climate change in the Southwest will result in shortages to the City's CAP allocation, and will increase the cost to purchase and deliver the water to Tucson.
- The existence of other renewable water resources that Tucson Water could access is highly uncertain at this time, including the availability, eventual costs, and legal challenges to bring other new water supplies into the area.
- Tucson Water currently has significant unutilized recycled water supplies which will increase as new customers are connected in the future.
- Recycled water is the only remaining new local, renewable water resource. It can be used to establish additional renewable water supplies and help to decrease reliance on CAP supplies and increase the reliability and sustainability of the community's water supplies.
- Tucson Water customers have made large investments and are still making investments to bring CAP water into the community and to manage its wastewater. A new recycled water program will leverage these investments and maximize utilization of the valuable recycled water resource that is currently discharged to the riverbed and leaves the basin without further benefit to Tucson Water customers.

- Recycled water programs involving IPR in the arid Southwest are being widely recognized as feasible and valuable in increasing the reliability of community water supplies.
- A new recycled water program will provide a range of other tangible direct and indirect benefits to the Tucson community, including:
  - Increased reliability and sustainability of local groundwater resources.
  - Support for economic development.
  - An opportunity to begin salinity management for groundwater resources.
  - Support for the community's desire for sustainability and protection of water resources.

Conclusions for New Recycled Water Programs

Evaluations were conducted to identify preferred recycled water program alternatives that should be taken forward for detailed evaluations, testing, and demonstration efforts. Advanced treatment processes were identified, evaluated, and prioritized for new recycled water program alternatives. The alternatives were developed for conceptual cost evaluations, including conveyance, pumping, recharge and recovery, advanced treatment, and finished water transmission facilities.

The preferred new recycled water program alternatives that include groundwater replenishment and IPR are North CAVSARP-1, North CAVSARP-3, and North CAVSARP-4, for the following reasons:

- Inclusion of RO or NF is highly valuable to meet water quality goals for IPR, especially where salinity control is an important goal. Besides providing a high degree of water treatment, they provide an opportunity to begin addressing and managing water supply salinity issues because they remove minerals and other constituents that contribute to salinity. These processes can remove between 4,000 tons per year and 7,500 tons per year of salt (for 2020 and 2030 recycled flows, respectively) from the water supply under all three alternatives.
- The North CAVSARP-3 and -4 alternatives (post-recovery advanced water treatment) are preferred because they require smaller capacity treatment facilities, use the natural treatment offered by SAT, use less energy, and, consequently, have lower overall costs.
- The North CAVSARP recharge location allows recycled water to be efficiently recharged separately from CAP water, allowing greater control in recharge, monitoring, recovery, and treatment of recycled water. Keeping the CAP and recycled water recharge and recovery operations separate will minimize treatment facility sizing and costs, potential public concerns of mixing CAP water with recycled water, and permitting impacts to the existing CAVSARP operations.

- Although it would contribute to long-term storage credits, the SE Tucson alternative (no advanced treatment, no purposeful recovery) would not directly contribute to Tucson Water's primary objective of increasing water supply reliability for the Tucson community.

Table 9-1 summarizes the estimated costs for the preferred recycled program alternatives.

Table 9-1. Summary of Conceptual Costs for New Recycled Water Program Alternatives ($ million)

Item	North CAVSARP-1		North CAVSARP-3		North CAVSARP-4	
Treatment Train	MF + NF + UVAOP + Recharge		Recharge/SAT + NF + UV-AOP + GAC (for H_2O_2 quenching)		Recharge/SAT + NF	
Flow Basis (Year)	2020	2030	2020	2030	2020	2030
Capital Costs[1]	$329	$406	$203	$266	$198	$258
Annualized Capital Costs[2]	$19.0	$23.5	$11.7	$15.4	$11.5	$15.9
Annual O&M[1] Costs	$6.7	$11.1	$3.4	$6.1	$3.5	$6.4
Total Annual Costs	$25.7	$34.6	$15.1	$21.5	$15.0	$21.3
Annual Water Supply	7 MGD (7840 AFY)	13 MGD (14,560 AFY)	7 MGD (7840 AFY)	13 MGD (14,560 AFY)	7 MGD (7840 AFY)	13 MGD (14,560 AFY)
Unit Cost ($/AF)	**$3,300**	**$2,400**	**$2,000**	**$1,500**	**$2,000**	**$1,500**

[1] *See Tables 8-8 and 8-9 for conceptual cost estimates.*

[2] *Based on an interest rate of 4% and a term of 30 years.*

The unit costs for potential new recycled water programs for the Tucson community are comparable with costs that other communities in Arizona and in other parts of the arid Southwest have invested or are planning to develop new water supplies.

Recommendations for New Recycled Water Programs

The business case to continue implementation efforts for a new recycled water program is compelling. Tucson Water should take advantage of the time available to put a program in place and start building a new renewable water supply for the future.

A new recycled water program can be refined and implemented based on the findings and recommendations of the *Recycled Water Master Plan* using a phased, multi-year approach. The implementation plan should identify near- and long-term activities and capital improvement program requirements to support sustained progress toward realization of this renewable water supply. The implementation plan should be structured around addressing the following key uncertainties that have been identified:

- **Conveyance Pipeline to Avra Valley:** Additional investigations should be conducted to acquire the necessary rights-of-way in advance of additional development that may occur along the alignment. The investigations should include a study to identify the most feasible pipe alignment, refine cost estimates, identify potential additional regional contributors, and identify any reclaimed water source issues (physical and institutional) that can be addressed to reduce costs.

- **Facility Planning at North CAVSARP Site:** Additional investigations should be conducted to refine the North CAVSARP site concepts and to develop a preliminary site design that identifies and locates all recharge, treatment, recovery and conveyance facilities.

- **Hydrogeologic Investigations**: Investigations should be conducted of the North CAVSARP site to refine the recharge and recovery concepts, define the water retention times in the ground before recovery, assess the ability to segregate the recycled water recharge and recovery operations from the CAVSARP operations, and provide information for permitting.

- **Role of SHARP in Future Recycled Water Programs:** Additional work should be conducted to clearly define the role of SHARP in a new recycled water program. This work should include determination of the ability to reliably deliver recycled water to the SHARP site, the site's potential for a demonstration project, groundwater quality impacts, and the ability to manage recharged water at the site for demonstration testing, recharge and recovery for the RWS, and/or for long-term underground storage.

- **Cost and Effectiveness of Advanced Treatment and Concentrate Management:** The preferred treatment and concentration management processes should be investigated and refined through additional research, bench- and pilot-scale testing, and demonstration efforts. A literature review should be conducted to monitor evolving trends in recycled water treatment and concentrate management and to assist in the design of bench- and pilot-scale testing and demonstration project opportunities. All testing and demonstration efforts should be carefully planned to provide information for project implementation, including refinement of facility layouts, treatment evaluations, impact of blending advanced treated water with other Clearwater blend water, sustainability analysis, and cost estimates. The program should also develop sufficient information for permitting of the program facilities and operations. Opportunities for collaboration with key entities such as the University of Arizona and Pima County in these investigations should be explored.

- **Public Outreach:** Public outreach efforts should be developed to engage local and regional stakeholders regarding a new recycled water program. The efforts should leverage lessons learned from similar programs that have been particularly successful, engage experts in the recycled water industry (including those that have planned and implemented outreach programs for similar projects), and provide public information on best management practices developed for groundwater replenishment and IPR. The program should also leverage an advanced treatment demonstration program to educate the public through activities such as site tours, expert presentations, and treated water tasting.

- **Financial Plan for Implementation:** The estimated costs for a new recycled water program are significant. A financial plan should be developed for the program that considers a range of funding alternatives, impacts to water rates, and sensitivities to different implementation horizons.

Due to increasing water demands, continued droughts, and dwindling water supplies, the drinking water and water reuse industries are now moving towards DPR. Although DPR may become a valid consideration at some point in the future, this *Recycled Water Master Plan* focuses on IPR since the momentum for such projects in the Southwest is well established. Tucson Water should, however, monitor developments in the DPR regulatory and technological advances, and should continue to revisit the goals and objectives of the program, given the advances, during further implementation of a new recycled water program.

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