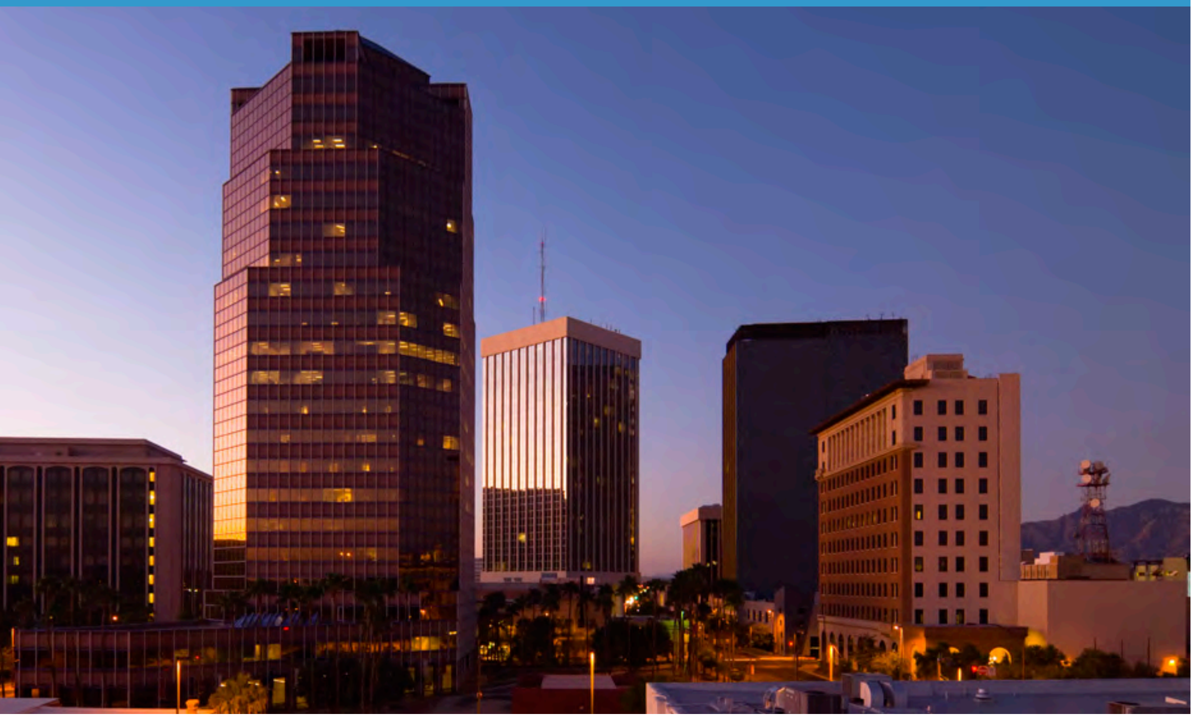
2012 Update

Water Plan: 2000–2050

City of Tucson Water Department



TUCSON WATER

WaterReliability

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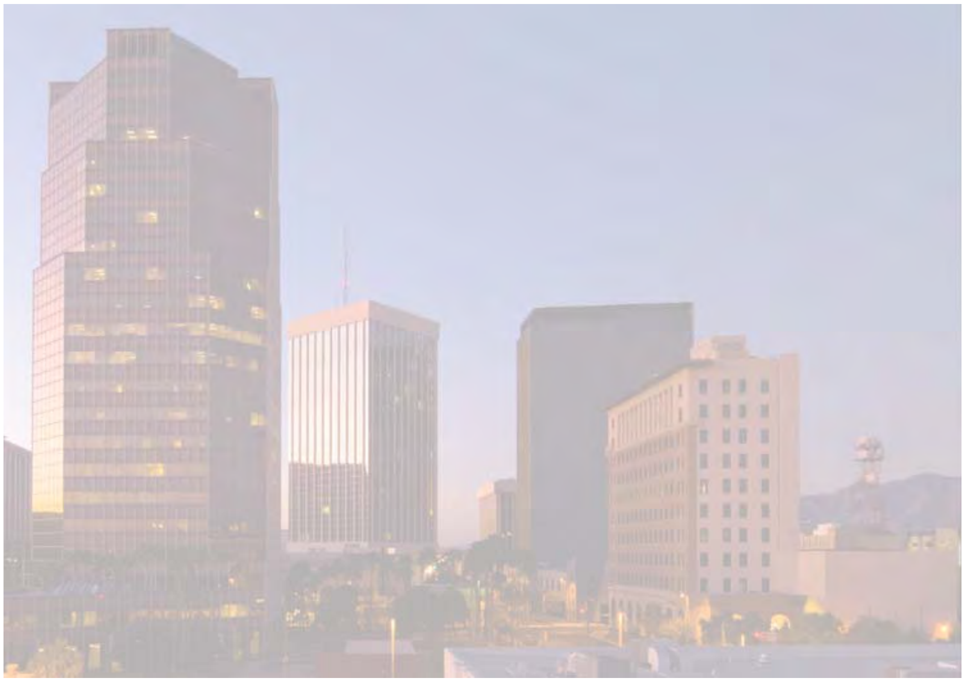
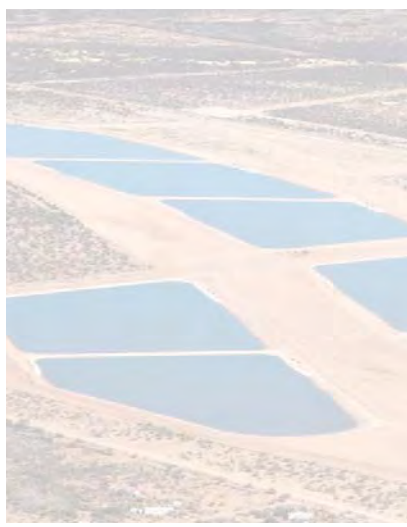
2012 Update
Water Plan: 2000–2050



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Abbreviations and Acronyms

ADD	Acquire, Develop, and Deliver
ADOA	Arizona Department of Administration
ADWR	Arizona Department of Water Resources
AMA	Active Management Area
AWBA	Arizona Water Banking Authority
AWS	Assured Water Supply
CAGRD	Central Arizona Groundwater Replenishment District
CAP	Central Arizona Project
CAVSARP	Central Avra Valley Storage and Recovery Project
CCTF	Community Conservation Task Force
CEP	Conservation Effluent Pool
Drought Plan	Drought Preparedness and Response Plan
GPCD	gallons per capita per day
HUPP	Hayden-Udall Prime Program
NGS	Navajo Generating Station
ROMP	Regional Optimization Master Plan
SAVSARP	Southern Avra Valley Storage and Recovery Project
SCADA	Supervisory Control and Data Acquisition
SHARP	Southeast Houghton Area Recharge Project
TARP	Tucson Airport Remediation Project
Tucson Water	City of Tucson Water Department

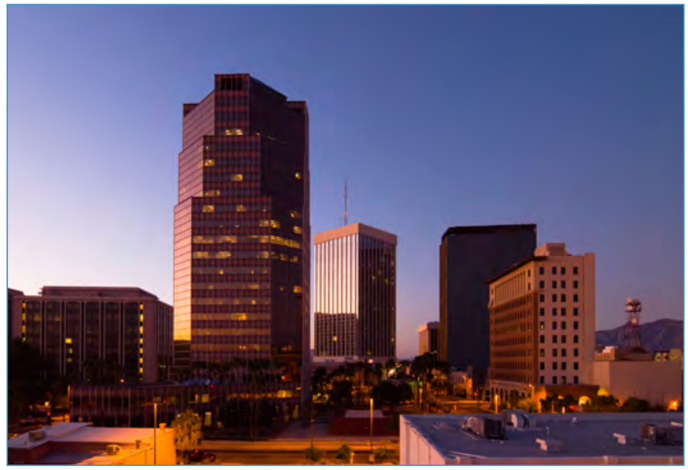
FOREWORD

Water is Tucson's most important natural resource. Responsibility for providing a reliable water supply for the community rests with Tucson Water, an enterprise utility of the City of Tucson. For over 110 years, Tucson Water has met the water needs of the community through effective planning and investment in critical infrastructure. The "story of water" in Tucson has evolved over the years—with epic highs and lows in the narrative—resulting in a current condition where a safe and reliable water supply is well-established.

However, our work is not done. Continued planning and investment activities must occur to meet the challenges of a growing community, changes in water resources availability, and aging infrastructure. This 2012 Update to *Water Plan: 2000–2050* presents a current snapshot of Tucson Water's water resources outlook. Since the last update in 2008, several key events have occurred that must be considered:

> Tucson Water has met the community's water needs for over 110 years through effective planning and investment in critical infrastructure.

- **April 2008**: The City of Tucson Mayor and Council and the Pima County Board of Supervisors initiated the Water & Wastewater Infrastructure, Supply & Planning Study to ensure a sustainable community water source. This joint effort brought the planning activities of Tucson Water and the Pima County Regional Wastewater Reclamation Department into closer alignment for our shared customers. [1]
- **August 2010**: The City of Tucson Mayor and Council adopted a Water Service Area Policy (Resolution No. 21602) that provided definition to Tucson Water's projected service area and reduced uncertainty in future water resources planning. [2]



Tucson's water future depends on planning for population growth and potential water shortages.

- **December 2010**: The U.S. Census Bureau released the results of the 2010 Census for local planning agencies to update current population counts and future projections. This was of particular importance to the Tucson area because it documented the impacts of recent economic conditions on Arizona's growth trajectory. [3]
- **December 2012**: The U.S. Bureau of Reclamation completed the *Colorado River Basin Water Supply and Demand Study* to define current and future imbalances in water supply and demand in the Colorado River Basin for the next 50 years. [4]
- **2013**: Tucson Water completed a *Recycled Water Master Plan* to identify opportunities for expanded use of this locally controlled water resource.

These events and others have been considered in developing this 2012 Update. While Tucson has achieved much in developing our current water supplies, more work lies ahead to maintain water reliability into the future.

[1] www.tucsonpimawaterstudy.com/Study.html
[2] tucsonaz.gov/water/service-area-policy
[3] www.census.gov/2010census/data/
[4] www.usbr.gov/lc/region/programs/crbstudy.html

ACKNOWLEDGMENTS

The 2012 Update to *Water Plan: 2000–2050* was completed under the direction of Joe Olsen (Planning Administrator) and Wally Wilson (Chief Hydrologist), both of Tucson Water.

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SECTION ONE

Introduction

Water reliability is a key objective of the City of Tucson Water Department (Tucson Water). Since this terminology can have different interpretations, the two primary functions of this document are to describe what water reliability means to communities served by Tucson Water and what steps the Utility is taking to maintain it. Several key areas related to water reliability provide the framework for planning our water future:

- **Water Supply**: Making the best use of Tucson's various water supplies and planning for long-term drought and climate change.
- **Water Quality**: Being the source of quality water in the community and meeting strict regulatory standards.
- **Customer Service**: Delivering quality customer service in a transparent, professional, and courteous manner.
- **Water Operations and Systems**: Providing for constant maintenance and improvement of the community's water systems.
- **Efficiency**: Working with customers to achieve water and financial efficiency.

This document explores how Tucson's water resources picture has evolved over recent years and describes near-term steps that Tucson Water will take to satisfy the water reliability factors listed above.

In 2004, Tucson Water issued *Water Plan: 2000–2050* to initiate a dialogue between the Utility and the community about the water resources challenges that needed to be addressed in the coming years. At that time, the community was faced with near-term decisions about the use of Colorado River water. These issues were resolved, and the City of Tucson now has the needed infrastructure either in place or under construction to receive its full allocation of Colorado River water through recharge and recovery.

The original 2004 *Water Plan: 2000–2050* focused on important decisions related to the use of Colorado River water. The monumental task of achieving full use of Tucson's Colorado River water allocation has since been completed.

In 2008, the first update to *Water Plan: 2000–2050* was issued, and it had a different emphasis. For over 100 years, Tucson Water had been serving not only the City of Tucson but also a number of surrounding communities.

This regional reach was instrumental in helping develop these areas; however, it was a cause for concern because there was no clear boundary beyond which the Utility would not expand. It was becoming more difficult to assure an adequate water supply for the community when the future geographical extent of that community was not defined. In the 2008 Update, the potential future boundaries of the Utility were delineated to include areas that Tucson Water was obligated to serve, areas that would potentially be served by the Utility, and areas that would be served by others.

These delineations formed the basis for the City's Service Area Policy and provided a known geographical extent that facilitates both water system development and water resources planning efforts.

Since *Water Plan: 2000–2050* was issued, the substantive issues and challenges facing the community remain largely the same. Achieving full use of the City's Colorado River water allocation was a monumental achievement. Defining the service area boundary provided a sound planning framework for moving forward. However, the challenges of

The Southern Avra Valley Storage and Recovery Project (SAVSARP) Raw Water Delivery System and Recharge Basins went into operation in 2008.

The SAVSARP Reservoir and Booster Station are under construction and targeted to go into operation in early 2014.

maintaining water reliability remain, and they are described in this document.

In addition, planning assumptions and priorities have evolved, and revised population and water demand projections have been developed.

This 2012 Update relies on *Water Plan: 2000–2050* as its primary source document and will serve as Tucson Water's most recent comprehensive revision to its long-range water resources plan. The community served by Tucson Water has the water resources available to provide a long-term, sustainable water supply. This supply is sufficient not only for Tucson Water's current residents, but also for those who are projected to join our community through the end of the 2050 horizon. Tucson Water's ratepayers have already invested in developing the Utility's water resources portfolio and its extensive water distribution systems. Over the next few years, the community's water resources challenges involve increasing system resiliency and redundancy while securing additional sustainable water supplies for future population growth.

The update consists of seven sections, including this introduction. Section Two updates the Utility's projected future water demand, including discussions of population change and water use rates. Section Three provides a comprehensive update of Tucson Water's various conservation programs as they have shaped water use within the community. Section Four reviews Tucson Water's available water resources and the current status of the City of Tucson's Assured Water Supply (AWS) designation. Section Five discusses the status of Tucson Water's potable and reclaimed water systems and emphasizes the need to continuously reinvest in our physical assets.

The final two sections (Sections Six and Seven) provide an update on the key recommendations of the plan, summarize the substantive conclusions of this 2012 Update, and discuss what may lie beyond the 50-year planning horizon.

Supporting documents are presented as Attachment A (Future Participation in Conservation Rebate Programs), which presents a series of figures pertaining to Tucson Water's conservation rebate programs.

Attachment B is the executive summary of the U.S. Bureau of Reclamation's *Colorado River Basin Water Supply and Demand Study*, while Attachment C is the executive summary of Tucson Water's 2013 *Recycled Water Master Plan*.

SECTION TWO

Population and Water Demand

The future service area population and the community's expected rate of water use are the principal factors used to project future water demand. In this 2012 Update, assumptions about the Utility's future geographical extent are consistent with the 2008 Update.

However, a dramatic change in the Tucson area's trajectory of population growth has occurred that is attributable to economic conditions that have prevailed since the last update was issued.

In addition to slower growth, per capita water use rates have decreased significantly in recent years, a trend that has been observed nationwide. This section updates the expected population that Tucson Water may serve in the future, the per capita water use rates used for planning purposes, and the resultant water demands that the Utility is projected to meet through 2050.

The New Normal

Tucson is one of the communities most affected by the economic downturn dating back to 2008. The combined effects of the mortgage crisis and the heavy reliance on development for Tucson's economy significantly changed local growth patterns. The incredible population growth that Arizona's "Sun Corridor"—which runs from Nogales in the south to Prescott in the north—witnessed leading up to 2008 dried up almost overnight.

As shown in Table 2-1, from 2000 through 2007 the Pima County population grew at an average annual rate of about 2 percent, with an annual peak of 2.8 percent from 2004 to 2005. This rate fell dramatically in 2008 and has remained well below 1 percent since then. (The negative growth between 2009 and 2010 shown in Table 2-1 was largely the result of overestimation in the years prior to the 2010 Census, rather than an actual decrease in population between 2009 and 2010.)

Even though the unemployment rate has fallen and the recession is ending, we have yet to see any signs of a return to growth rates seen in the early 2000s.

Table 2-1. *July 1 population estimates, 2000–2012*

Year	Pima County		City of Tucson		Tucson Water	
	Population	Percentage change	Population	Percentage change	Population	Percentage change
2000	848,375	—[a]	489,183	—	635,073	—
2001	865,701	2.0	495,341	1.3	645,780	1.7
2002	881,530	1.8	501,660	1.3	655,834	1.6
2003	897,838	1.8	506,868	1.0	667,287	1.7
2004	914,011	1.8	511,338	0.9	678,418	1.7
2005	940,004	2.8	519,182	1.5	686,540	1.2
2006	959,474	2.1	521,728	0.5	696,460	1.4
2007	977,258	1.9	525,837	0.8	703,157	1.0
2008	984,032	0.7	526,373	0.1	705,271	0.3
2009	984,274	0.0	523,860	–0.5	705,316	0.0
2010[b]	981,168	–0.3	520,795	–0.6	705,817	0.1
2011	986,081	0.5	522,815	0.4	706,118	0.0
2012	990,380	0.4	523,471	0.1	708,863	0.4

Source: Arizona Department of Administration

[a] not applicable

[b] July 1 estimate adjusted to the 2010 census

Long-range Planning Area

The geographical area within which Tucson Water might operate in the future is referred to as the long-range planning area. This area has not significantly changed since the last update was issued in 2008. As shown on Figure 2-1, the water service area includes the following designations:

Potential Service Areas

- locations currently served by Tucson Water (dark blue)
- undeveloped areas within the current city limits or areas outside the city limits that the Utility is obligated to serve by contract (light blue)
- potential expansion areas that might be served by Tucson Water in the future (dark and light magenta)[5]

Non-Expansion Areas

- All areas outside the dark blue, light blue, and magenta designations are areas where Tucson Water has no plans to provide direct service. This includes areas where other local water providers have chosen to pursue their own water management objectives.

The color-coded areas shown on Figure 2-1 are portrayed with limited resolution and should not be construed as a detailed, parcel-based determination of status. The potential service area (both obligated and non-obligated) can potentially be altered or expanded through the approval of future City of Tucson annexations or direction of the Tucson Mayor and Council.

The projected population outside of the potential service area is not included in Tucson Water's resource-planning projections. Nonetheless, the Utility has common interests with providers serving this population and is already providing various forms of indirect service (for example, emergency backup supply or recharge and recovery of water supplies owned by other water providers, referred to as wheeling agreements) to many of them. Tucson Water also works with local water interests to identify and assess possible resource and water supply arrangements that would be mutually beneficial.

Population Projections

Using the 2010 Census as a new starting point, the Arizona Department of Administration (ADOA) in 2012 developed Pima County population projections through 2050.

The ADOA medium population forecasts provide the foundation for the population projections used for the Tucson Water service area.

The ADOA population projection methodology is described in *Arizona State and County Population Projections, 2012–2050: Methodology Report*, dated December 7, 2012. ADOA uses a cohort-component model with modules for mortality, net migration, and fertility. The medium population projection is the primary basis for planning. The low and high population projections were produced by varying assumptions in the three modules from the medium projection.

> Tucson Water's service area population is projected to grow to about 1,090,000 by 2050.

Currently, Tucson Water serves about 71.6 percent of Pima County's population, and this percentage is assumed to hold steady until 2050. The Utility's service area population—about 709,000 in 2012—is projected to be about 890,000 in 2030 and almost 1,090,000 in 2050.

Per Capita Water Use Rates

To derive projected total water demand, we multiply the population projections by the average per capita water use of Tucson Water customers, measured in gallons per capita per day (GPCD). In the early 2000s, the total GPCD water use for Tucson Water's customer base was fairly consistent at about 177 GPCD, including both potable and reclaimed water use.

In the 2004 *Water Plan: 2000–2050* and the 2008 Update, it was acknowledged that the GPCD used to forecast future water demand should be periodically updated based on observed changes over time.

From the mid-2000s to the present, the potable GPCD rate in Tucson has decreased substantially from a high of about 160 in 2005 to about 130 in 2012. The drivers for this decrease may include increased conservation efforts, economic conditions, water and sewer rates, and other factors. Regardless of the reasons for this change, it is clear that future potable water demand should be projected using the more recent GPCD. For this update, three potable GPCD rates were used:

- 145 GPCD (high-end projection, based on the average GPCD from 2008 to 2012)
- 130 GPCD (medium projection)
- 120 GPCD (low-end projection, below the lowest GPCD ever observed)

[5] Service in these areas is only to be provided at Mayor and Council's direction through annexation or through execution of a Pre-Annexation Development Agreement.

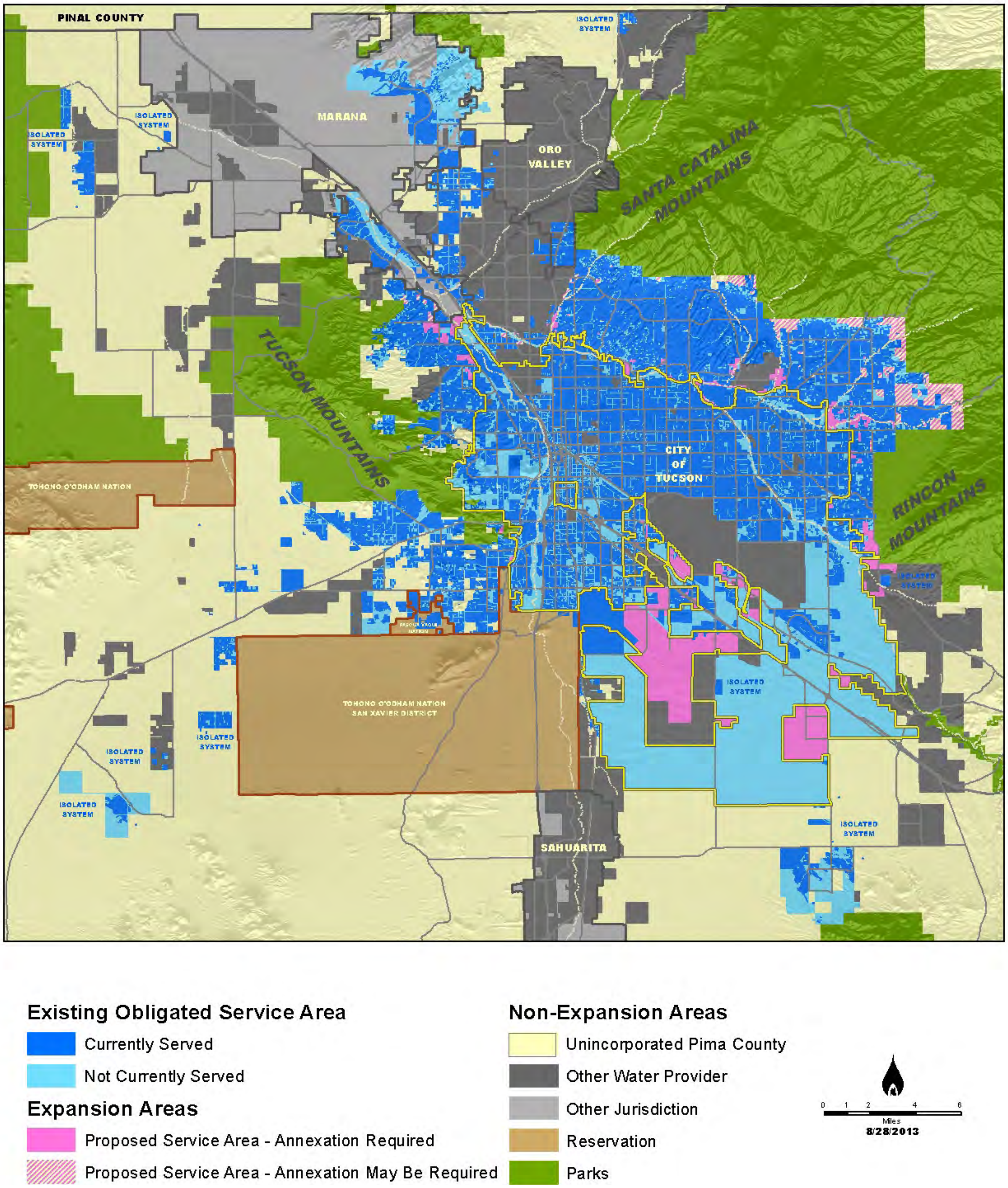
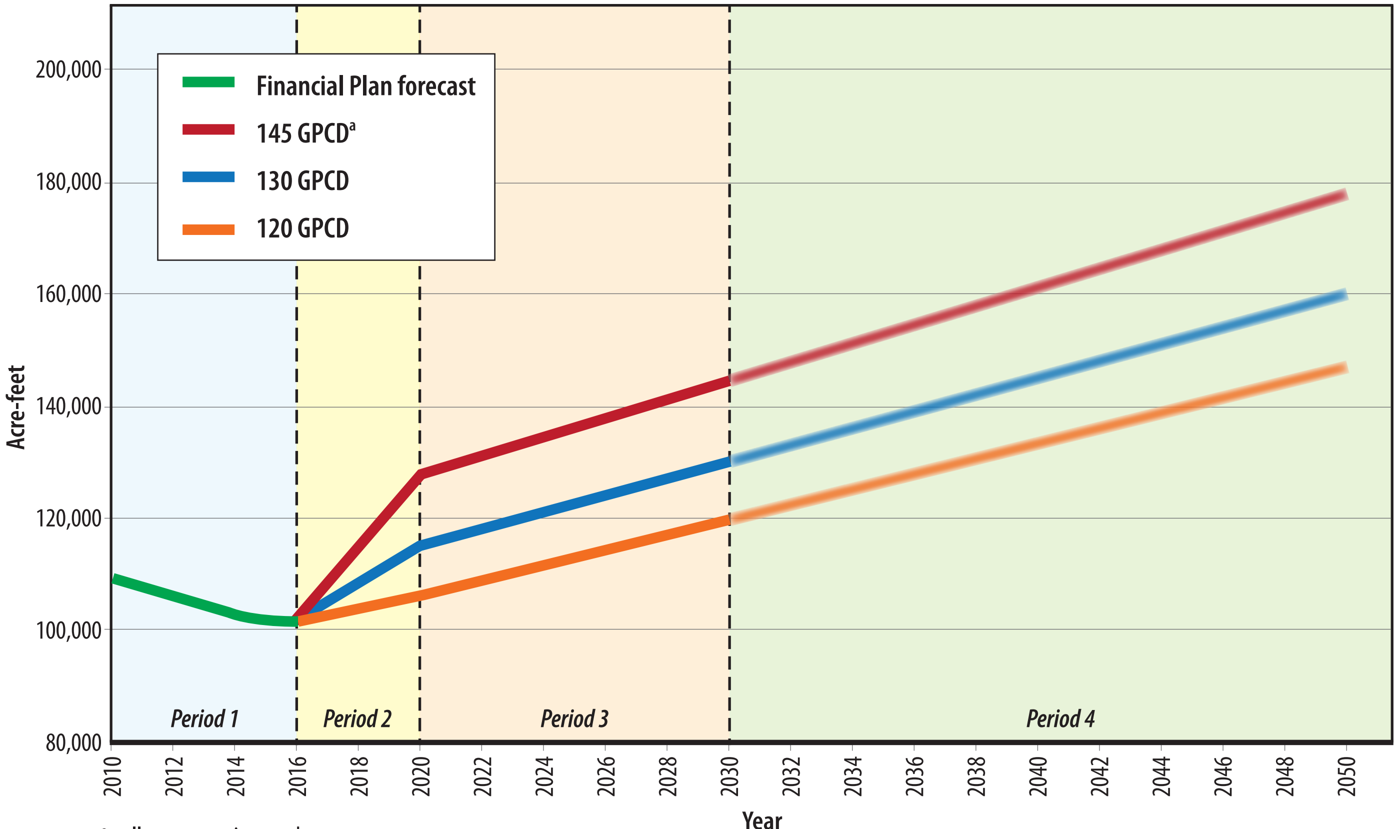


Figure 2-1. *Long-range planning area*



[a] gallons per capita per day

Notes: Period 1 shows the Financial Plan forecast from 2012 to 2016 (with 2010 and 2011 actuals). Period 2 shows the Financial Plan forecast from 2016 to 2020, with a medium population forecast. Period 3 shows the forecast from 2020 to 2030, with a medium population forecast and a constant GPCD. Period 4 shows the forecast from 2030 to 2050 with a medium population forecast and a constant GPCD, with considerable uncertainty.

Figure 2-2. *Potable demand forecast, 2010–2050*

The low-end GPCD represents continued reductions in water use through continued demand management programs and increasing system efficiencies.

In the past, use of reclaimed water grew roughly parallel to population growth and potable water demand. Tucson's reclaimed water system has since developed to the point where most large-turf areas in the service area have already converted to using reclaimed water. Reclaimed water demands will now be forecast separately from potable water demands in this 2012 Update and going forward.

Projections of Potable Water Demand

The following assumptions were used in this 2012 Update to project potable water demand (see Figure 2-2):

- Potable demands for 2012 to 2016 are based on Tucson Water's 5-year Financial Plan, which is carefully updated each year based on short-term trends and tracking of water sales, new meter installations, and other factors. Demand forecast during this period does not rely on per capita water use or population.
- Per capita water demand after 2016 is based on the three potable GPCD values discussed previously to produce an "envelope" of potential water demands:
  - 145 GPCD (high-end)
  - 130 GPCD (medium)
  - 120 GPCD (low-end)
- Potable demand from 2016 to 2020 represents an interpolation from the end of the 5-year Financial Plan forecast period to the 2022 potable water demand based on 71.6 percent of the ADOA population forecast for 2020 and the three GPCD values.
- From 2020 to 2050, the potable demand forecast is derived directly from 71.6 percent of ADOA population forecasts for Pima County and by applying the relevant GPCD values.

As shown in Figure 2-2, potential potable water demand in the Tucson Water service area is forecast to increase steadily through 2050.

The 5-year Financial Plan forecast service growth rates are much lower than the ADOA forecast population growth rates in the near-term period through 2016. The 5-year (Period 1) Financial Plan also forecasts declining total water use and declining per capita water use over this period.

A population forecast derived from the 5-year Financial Plan using service growth, for example, would be substantially less than one derived from the ADOA population forecast for this near-term period through 2016.

The rapid growth after 2016 is based on the assumption that population will return to the ADOA forecast by 2020. It should also be noted that the 5-year Financial Plan forecasts tend to be conservative; that is, there is a preference to under-forecast demand than to over-forecast, which may exaggerate the difference between 2016 and 2020.

The forecast increase in demand from the end of the 5-year Financial Plan to 2020 would be unparalleled. Of course, we have also recently experienced unparalleled decreases in demand, and it is reasonable to expect a substantial rebound in growth and per capita water use at some point.

While the forecast rebound is substantial, the high-end potable demand forecast in 2020, based on the 145 GPCD and the ADOA population, is only about 128,000 acre-feet, about 3,000 acre-feet more than in 2002 and far below our Central Arizona Project (CAP) allocation. Potable demand from 2002 to 2007 averaged 122,500 acre-feet per year, with a peak of 125,000 acre-feet in 2002.

There is considerable uncertainty regarding when and if growth will occur and whether GPCD rates will remain low. This translates to uncertainty regarding demand over the next 5 to 10 years. Given the continuing declines in demand and the struggle to return to even more modest growth rates, there is little to no risk in demand exceeding our CAP allocation within the next 10 years.

Tucson Water's potable water demand is projected to remain within the current CAP allocation for at least the next 10 years.

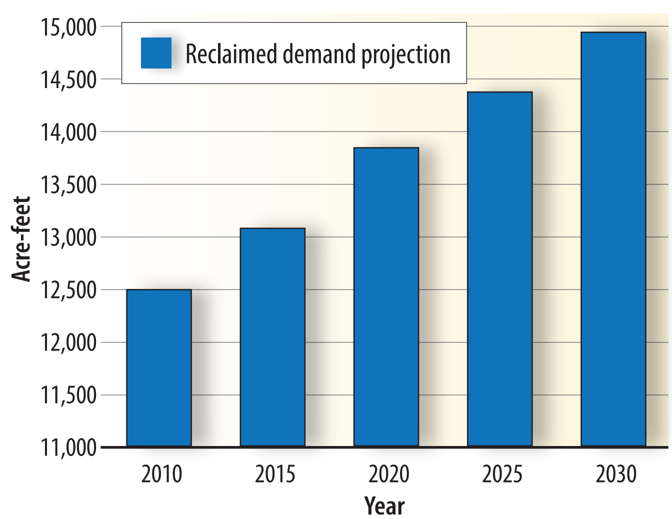
Potable demand is projected to increase from about 104,000 acre-feet in 2012 (actual) to a range between 120,000 to 145,000 acre-feet per year by 2030 (Figure 2-2) (Period 3). By 2050, the envelope of potable demand ranges from 147,000 to 178,000 acre-feet per year (Period 4).

Note that Period 4 on Figure 2-2 shows the demand forecast from 2030 to 2050 with a medium population forecast and a constant GPCD, with considerable uncertainty.

Projections of Reclaimed Water Demand

For the reclaimed water system, projections of demand are forecast based on assumptions of large-user customer additions over time (see Figure 2-3). Expansion of the reclaimed water system has been decoupled from the potable system because it now follows a different driver than population growth in the community.

The CAP canal brings renewable water 320 miles from the Colorado River to Tucson.



Note: Projections are from the *Recycled Water Master Plan* (2013).

Figure 2-3. *Reclaimed water demand forecast*

Early work on the 2013 *Recycled Water Master Plan* (in progress) considered recent reclaimed water demand and forecasts of anticipated customer additions over time. As shown in Figure 2-3, demand for reclaimed water for customers served by Tucson Water is forecast to increase from 12,500 acre-feet per year in 2010 to almost 15,000 acre-feet per year by 2030.

Note that the reclaimed water system also "wheels" recycled water owned by other water providers. (For Tucson Water, "wheeling" refers to situations where the Utility provides treatment services for a water supply owned by another provider and delivers that treated water through its own system to the other provider, which reimburses Tucson Water for this service.) Those demands will be met by the effluent entitlements controlled by those entities and do not factor into Tucson Water's water resources portfolio.

However, the ability to treat and deliver this additional reclaimed water is considered in the planning and operation of the physical infrastructure of the reclaimed water system.

SECTION THREE

Conservation

Water conservation and the efficient use of water are critical components of integrated resources planning. Tucsonans have long embraced an ethic of water conservation. Water savings generated through behavioral changes and efficiency programs have had a positive impact on the overall water supply. This is evident as Tucsonans are today using the same volume of water as they used in the mid-1990s, despite a large increase in population (see Figure 3-1). With use of CAP water, the amount of mined groundwater has been reduced to levels from the 1940s.

The community response to water conservation efforts is unique in that reductions that began in the mid-1970s have been sustained. Information and education programs that form the foundation for all other programmatic efforts have established Tucson in the forefront of the field of water conservation. As shown in Figure 3-2, it remains among the largest communities in the American Southwest that maintain a low level of per capita water use.

Water issues tend to be area-specific in nature, and the solutions must reflect that reality. This is also true of water conservation programs because each water utility must deal with unique circumstances. A community suffering from impacts of a seasonal drought will institute restrictions to address a temporary water supply issue. That response differs when there is adequate water supply, but insufficient infrastructure or diminished delivery capabilities.

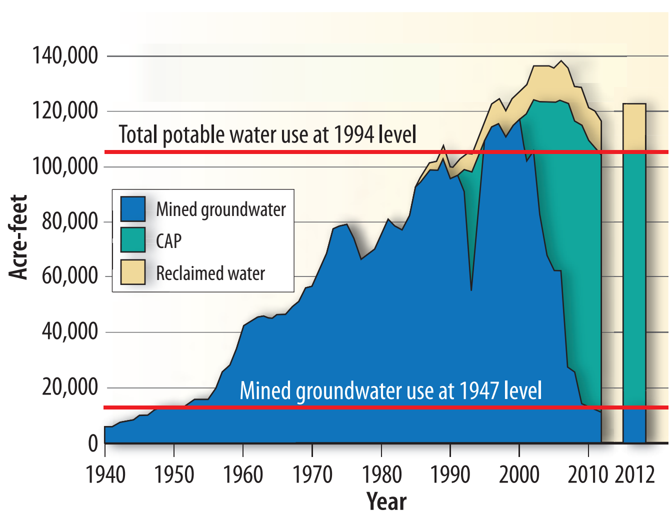


***Figure 3-1.** Water use in Tucson since the 1940s*

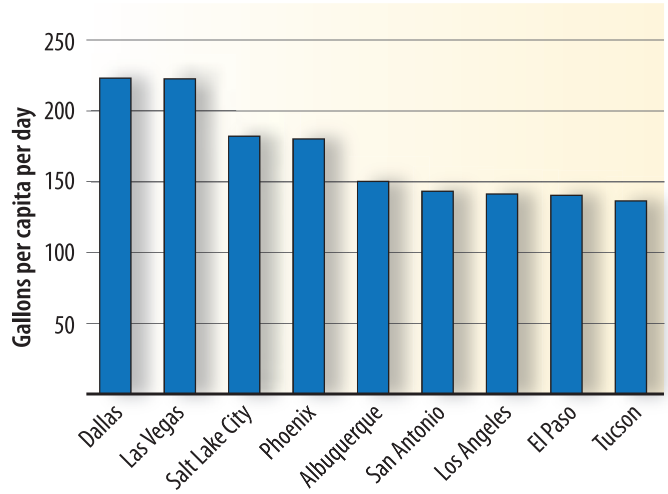


***Figure 3-2.** Per capita water use in select Southwestern cities*

All water utilities should strive for efficient water use throughout the community, but the local drivers will dictate how a program is developed, what specific measures should be implemented, and how they are evaluated with respect to water use and cost effectiveness. A well-planned conservation program provides an appropriate response to the need it is attempting to address.

In the case of Tucson Water, the conservation program that began in 1976 as “Beat the Peak” was developed in response to inadequate infrastructure to meet peak summertime demands. As time progressed, the regulatory environment changed, public perception shifted, and investments were made in infrastructure and water supplies. As a result, the drivers behind the need to promote water conservation and the efficient use of water have changed.

The highly successful “Beat the Peak” program was rebranded to reflect this change. The new program, “Be WaterSmart,” more accurately reflects the current need to consider demand management strategies that promote sustainable water use.

This section of the Water Plan identifies drivers for the “Be WaterSmart” conservation program and provides guidance for future efforts. Despite changes in drivers over time, the long-term effort to conserve water must continue to play an integral role in the community’s water management plan. A successful demand management program ensures that quality of life is not diminished. Reductions in water use from a conservation program should not aggravate operational or environmental conditions in the community.

Background and Conservation Drivers

1970s

The current ethic and tradition of water conservation programming is rooted in events of the 1970s. After several decades of growth, Tucson Water was unable to meet peak demands because of inadequate infrastructure. At that time, landscape preferences included extensive use of lawn and turf, and the overall plant palette consisted of vegetation typically found in more humid areas. The strain on the distribution system was obvious during the late afternoon hours, presumably because of high irrigation demand. During the summer, many areas of town suffered shortages or outages because of the high demand.

Several steps were taken to address the issue. The “Beat the Peak” conservation campaign was established as a means to voluntarily reduce demand to defer improvements to the overall distribution system. It consisted of public information efforts, public service announcements, and a lecture series to teach customers about desert landscaping practices and irrigation techniques. The original slogan, “Never Water Between 4 and 8, and Only Every Other Day,” reinforced voluntary curtailment during the peak demand hours. The program mascot, Pete the Beak, became the face of conservation during this time. In addition, Tucson’s Mayor and Council approved an increasing block rate structure that provided a financial incentive to conserve water.

1980s

By the 1980s, sufficient infrastructure improvements had been made to avoid the crisis conditions from a decade earlier. However, reliance on groundwater to meet public demand for water resulted in continued conservation programs focused on managing peak demand. Public information programs and an increasing block rate structure continued. Youth education programs were established to help meet conservation goals related to peak demand management. Casa del Agua, a public demonstration site educating people about residential water conservation, was established.

The 1980 Groundwater Management Act had a significant impact on regional water management planning. This Act created the Arizona Department of Water Resources (ADWR) and established regions called Active Management Areas (AMAs) within which groundwater management goals were established. Primarily designed to address overuse of regional groundwater aquifers, a series of management plans were created to provide guidance on how each AMA would attain safe yield (where groundwater withdrawals would not exceed the amount of groundwater recharged). Each management plan included water conservation requirements for all agricultural, industrial, and municipal users. This requirement was expressed as a GPCD target for individual water providers. The First Management Plan target for Tucson Water was 140 GPCD. The 1980 Groundwater Management Act reshaped Tucson Water’s conservation program because the targets emphasized long-term reductions in water use rather than peak demand management.

1990s

In the early 1990s, Tucson Water was completing construction of the Hayden-Udall Water Treatment Plant, which was designed to treat renewable Colorado River water delivered to Tucson by the CAP canal. The Hayden-Udall Water Treatment Plant was designed with excess capacity to address concerns over meeting peak demand. However, problems with initial delivery of CAP water resulted in discontinued operation of the plant. Tucson Water reverted to a groundwater system. Peak demand management remained the conservation driver for another decade until Clearwater Program facilities started producing water.

A Water Conservation Office was established in 1991 to further advance the conservation program and ensure compliance with ADWR conservation requirements. Tucson Water continued the “Beat the Peak” program, emphasizing information and education strategies. Block rates were still in place and were supported by the Xeriscape Landscape Ordinance, the Water Waste Ordinance, and plumbing code modifications.

An Emergency Water Conservation Ordinance was established to address acute water shortage resulting from system failure. New strategies included conducting studies to identify conservation potential in commercial and industrial sectors and expanding education and training programs for youth, residential customers, and the landscape industry. A rebate program encouraging the voluntary replacement of 3.5 gallon per flush toilets with new 1.6 gallon per flush fixtures was implemented. Tucson Water also joined ADWR’s Non-Per Capita Program, a conservation program driven by best management practices.

2000s

Tucson Water began to shift pumping of groundwater from the central well field to the Clearwater Program facilities. In 2001, Tucson Water began delivery of renewable Colorado River water, reducing concerns over peak demand through the increased pumping capacity provided by the Clearwater Program facilities. Central well field production was significantly reduced, but was still available to help meet high peak demand, as needed.

Tucson Water continued the "Beat the Peak" program and the various associated public information, education, and training programs. A Community Conservation Task Force (CCTF) was convened in 2005 to develop recommendations for conservation programming, and Tucson Water initiated a series of rebate programs based on those recommendations. Its emphasis remained on actions that produce long-term water savings. The Mayor and Council established a conservation fee assessed to all customers to fund the program. Tucson Water met ADWR conservation targets throughout the decade.

2010s

Tucson Water remains well within the conservation target established by ADWR. Expanded operation of the Clearwater Program facilities further reduces concerns about being able to meet peak summer demand. As noted previously, the "Beat the Peak" program was rebranded in 2012 to reflect the changing drivers of the conservation program. The new program, "Be WaterSmart," reflects an emphasis on efficiently using water year-round.

Most recently, Mayor and Council authorized an ordinance that requires the installation of secondary drain lines in new homes to facilitate the use of gray water by homeowners. A commercial rainwater harvesting ordinance was passed mandating the use of rainwater harvesting to achieve 50 percent of landscape water needs.

From "Beat the Peak" to "Be WaterSmart"

Tucson Water's success in establishing a strong culture of conservation led to a rebranding of its conservation programs.

In 1976, Tucson Water asked its customers to "Beat the Peak" each summer. They responded by using water more efficiently during the hottest months, allowing Tucson Water to keep critical groundwater wells shut down even during months of high demand.

The Beat the Peak program expanded year-round to further awareness of the importance of water efficiency. It is an important component of Tucson Water's water reliability program.

Pete the Beak remains a contributor and spokesduck. However, the new program brand, "Be WaterSmart," more accurately reflects the need to promote sustainable water use, year-round and over the long term.

Pete the Beak, Tucson Water's spokesduck, encourages customers to Be WaterSmart.

Conservation Programs

Tucson Water achieves its conservation goals through a mix of methods: public information programs, education programs, efficiency programs, direct assistance programs, and ordinances.

Public information programs promote water conservation and forms the foundation for all other efforts to achieve goals. Public information is disseminated through pamphlets and brochures, public service announcements, a website, and community events. The conservation message is conveyed through the "Be WaterSmart" brand.

These methods permit Tucson Water to inform the public of important water conservation incentives available. Public information programs are periodically evaluated by customer surveys that measure changes in knowledge and attitudes related to conservation programs, methods and techniques, and the overall need to use water more efficiently.

Education programs offered by Tucson Water since the 1990s foster a culture of conservation in Tucson. These behavioral change and training programs create an opportunity for school-aged children, teachers, landscape professionals, homeowners, business owners, and commercial property managers (essentially, the community at large) to learn and apply practices to curb demand and conserve water. Efficacy of the programs is evaluated by classroom and workshop participants as well as stakeholders. Current water conservation education programs include:

- **Youth Education Programs**: These programs are provided to elementary, middle school, and high school students and teachers. They include "Da Drops" for kindergarten through third grade, "Our Water, Our Future" for fourth grade through sixth grade, and "Tucson Toolkit" for middle school. These programs educate students with age-appropriate lessons on the water cycle, the public water system, water supply, environmental concerns, and conservation. These programs meet State of Arizona education standards.
- **Science Technology Engineering Mathematics (STEM) Academy**: This program introduces middle and high school teachers to the community's water management issues. Teachers are able to integrate what they learn into their curricula. The program is designed to ensure that teachers are able to develop instructional materials that meet State of Arizona education standards.
- **SmartScape Program**: This program offers water-efficient landscaping classes to customers in conjunction with the University of Arizona Cooperative Extension. The goal is to improve landscape water management practices in the community. It includes workshops on xeriscape, drip irrigation, and landscape water management for homeowners and landscape professionals.
    - **Resident Workshops**: These 2-hour workshops target residential customers, with topics on drip irrigation, plant selection, irrigation scheduling, and water harvesting.
    - **Landscaper Workshops**: Eight workshops teach landscape professionals, property managers, and homeowners about water conservation practices in landscape management.
- **Water Waste Enforcement**: Conservation inspectors conduct water waste inspections of commercial users throughout the Tucson Water service area. The inspections target malfunctioning irrigation systems, washing of certain surfaces, overflowing or ponding water, and misting systems operating in unoccupied areas. In lieu of fines, the inspectors seek to educate commercial property managers about how to use water efficiently.
- **Water Harvesting Demonstration Sites**: Ten demonstration sites throughout the city familiarize Tucsonans with a variety of water harvesting techniques and encourage participation in the rainwater harvesting incentive program.
- **Education Outreach**: This program offers classroom presentations and tours and supports other education-related programs. It includes student projects, Sweetwater Wetlands, and Project WET.

The SmartScape Program offers workshops on xeriscaping, irrigation systems, and water management.

Financial incentives provide another motivation for Tucson Water customers to conserve water. These incentives are offered in the form of rate structures and rebates for efficiency programs.

Tucson Water uses rate structures to send a conservation message to customers. Residential customers are charged for water using a block rate structure. As customers use more water, the unit cost increases. This rate structure dates to 1977 and has been regularly modified to respond to changes in customers' water use.

A base-rate summer surcharge is used for commercial and industrial customers. This rate structure operates as a base rate throughout the year, but imposes surcharges during the summer for water use exceeding the base rate.

In addition to the various rate structures, Tucson Water customers can participate in rebate programs for technologies that provide long-term water savings. Since 2008, Tucson Water has developed eight rebate programs that have produced an estimated savings of 534 million gallons of water through April 2013. The rebate programs are as follows:

- **Single-family Residential High-efficiency Toilet Rebate**: For single-family homes, customers receive a rebate to replace their toilets with high-efficiency toilets.
- **Multi-family High-efficiency Toilet Rebate**: For multi-family homes, customers receive a rebate to replace their

toilets with high-efficiency toilets.

- **Commercial High-efficiency Toilet Rebate**: For commercial properties, customers receive a rebate to replace their toilets with high-efficiency toilets.
- **Low-income High-efficiency Toilet Rebate**: This program subsidizes toilet replacement for low-income homeowners.
- **Single-family Residential Rainwater Harvesting Incentives Rebate**: This program incentivizes passive and active rainwater harvesting to decrease potable water use for outdoor irrigation.
- **High-efficiency Urinal Rebate**: For commercial properties, customers receive a rebate to replace their urinals with high-efficiency urinals.
- **Irrigation System Upgrades Rebate**: For commercial properties, customers receive a rebate for irrigation upgrades.
- **Single-family Residential Gray Water Rebate**: A rebate is provided to encourage homeowners to install gray water systems for irrigation.

Direct assistance from Tucson Water is another conservation approach that curbs demand. These programs provide one-on-one assistance to help customers reduce their water use. These programs include:

- **Zanjero Program**: A residential water auditing program that maximizes water conservation potential around the home. This service includes leak detection, replacement of showerheads and aerators, and toilet adjustments. Landscaping is assessed and appropriate irrigation requirements are determined. Customers receive a report showing water and dollar savings.
- **WaterSmart Business Program**: This program helps business owners and managers set goals to conserve water and use it more efficiently. Tucson Water conducts water audits to identify all uses of water and identify conservation potential. Businesses are recognized for significantly reducing water use or for introducing water efficiency into daily operations. WaterSmart businesses receive signs for display and have their profiles added to the program webpage. [6]

[6] www.tucsonaz.gov/water/ws-business

Ordinances and codes prescribe measures that ensure long-term efficiency in water use. In Tucson, these include:

- **Xeriscape Landscape (Ordinance 7522)**: Affects all commercial and multi-family construction projects. The ordinance requires adherence to xeriscape principles, including limiting high-water-use plants/features, requiring low-water-use plants, and mandating appropriate irrigation system design.
- **Plumbing Code (Ordinance 7178)**: Requires the use of water-efficient plumbing fixtures, including 1.6 gallon per flush toilets and 2.5 gallon per minute showerheads.
- **Water Waste and Theft (Ordinance 6096)**: Revised in June 2000 with tougher definitions of waste and higher penalties. Initial penalty established at a minimum of $250, with $500 for a subsequent penalty within a 3-year period. Penalties can be waived through participation in the Water Waste Diversion Program.
- **Emergency Water Conservation (Ordinance 8461)**: Allows prohibitions or limitations on certain types of water use under emergency conditions. Restricted uses include car washing, landscape watering, and filling/refilling of swimming pools.
- **Commercial Rainwater Harvesting (Ordinance 10597)**: Commercial properties subject to the ordinance must meet 50 percent of their landscape demand using harvested rainwater, prepare a site water harvesting plan and water budget, meter outdoor water use, and use irrigation controls that respond to soil moisture.
- **Residential Gray Water (Ordinance 10597)**: All new residential construction after 2010 must incorporate a gray water plumbing system stub-out.
- **Drought Response (Ordinance 10380)**: Developed in 2005, the ordinance consists of a four-stage approach to responding to drought conditions. Each stage has specific guidelines on how to efficiently use water during a drought and enforces measures to curb demand.

Method of Approach

Tucson Water uses a mix of behavioral change and efficiency programs to achieve ADWR conservation requirements and long-range planning goals. Behavioral change is accomplished by disseminating public information and providing educational opportunities. This includes programs that teach the value of curbing demand and conserving water—for example, taking shorter showers and washing only full loads of laundry. Efficiency programs focus on replacing older, inefficient systems with newer technologies. Such technologies include high-efficiency toilets and washing machines.

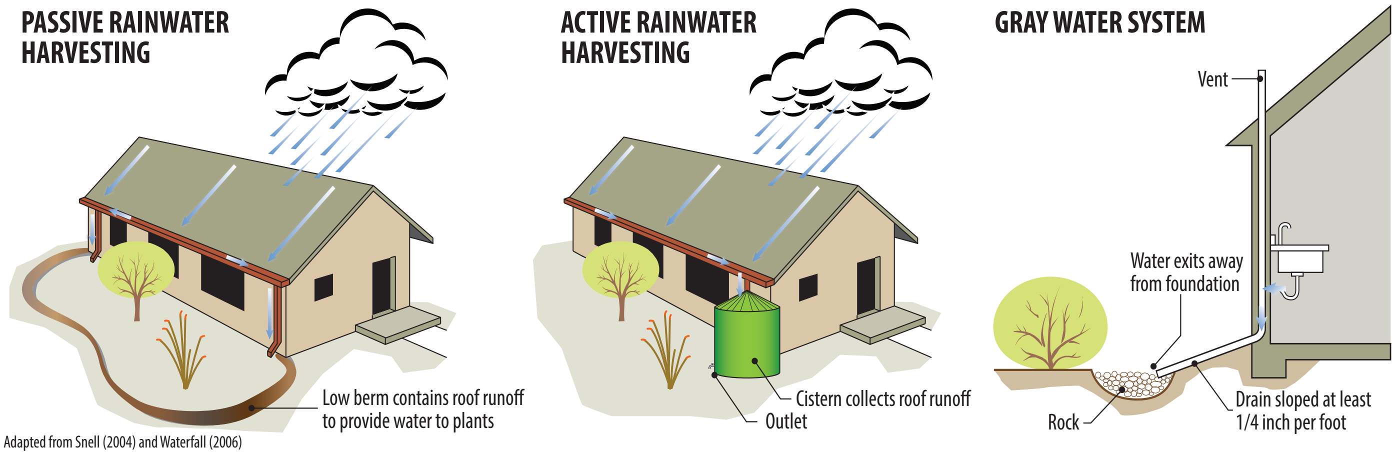


***Figure 3-3**. Examples of replacement supplies*

Another approach is supply augmentation. This includes rainwater harvesting and gray water systems. The approach targets water use for landscaping and agriculture. Programs featuring the augmentation approach are grouped with Tucson Water's efficiency programs for purposes of management and evaluation.

In addition to water-saving actions, customers are seeking ways to offset their water use through replacement supplies. Two key opportunities to become more water self-sufficient in Tucson are rainwater harvesting and gray water.

Rainwater has the distinct advantage of being delivered for free, right to homes and businesses. Rainwater can be harvested directly through either passive or active means to meet on-site irrigation needs. This harvested rainwater reduces an individual's water bill while decreasing the demand for City water, effectively lowering per capita demands on the potable water system and water resources.

Passive water harvesting is accomplished by using gutters and/or landscape features such as simple berms and catchments around plantings to direct, collect, and retain water on site. Installing a cistern with a hose bib or connecting it to an irrigation system that is fed by gravity or pumped is a more active approach to water harvesting. Examples of local water harvesting systems can be viewed at the website of the Watershed Management Group, headquartered in Tucson.[7]

Gray water is domestic wastewater that comes from washing activities and excludes water from toilets. A common source of gray water is discharge from a washing machine. Gray water is permitted for use for landscape irrigation and is another method to reduce reliance on water delivered by the City. Figure 3-3 shows examples of replacement supplies.

Efficiency programs offered by Tucson Water originated in a recommendation for more aggressive water conservation programs in the original *Water Plan: 2000–2050*. The CCTF was established in 2005 to move this recommendation forward. It comprises community stakeholders including business groups, residential customers, environmental groups, and green industry representatives.

The CCTF mission was to ensure community involvement in developing water conservation strategies. Working with a conservation planning consultant, the CCTF identified 148 potential conservation measures and eliminated those deemed inappropriate (see Figure 3-4 to learn about the steps in the planning process). The 148 conservation measures initially chosen by the CCTF were further examined through a benefit-cost analysis. The CCTF used the results to identify cost-effective measures and to decide which measures Tucson Water would pursue to conserve water.

In 2006, the CCTF published its findings in a report entitled *Water Efficiency: Water Conservation Program Recommendations for Tucson Water's Future*. It passed 19 measures, 8 of which were used to create rebate programs. The measures that passed met the threshold for total resource cost set by Tucson Water. A complete review of the CCTF process and findings is available in its 2006 report.

CCTF measures that became rebate programs are funded by the conservation fee, set in 2007 at 4 cents per 100 cubic feet of water (now 7 cents per 100 cubic feet of water). Fee revenues fully fund the conservation program.

The rebate programs conserve a considerable amount of

7 www.watershedmg.org/demo-sites

	MISSION	MEETINGS: EDUCATION	MEETINGS: RECOMMENDATIONS	RECOMMENDATIONS
COMMUNITY CONSERVATION TASK FORCE	To ensure community involvement in the development of a water conservation program strategy that will provide measurable water savings, consistent with the Long-Range Water Plan.	Hold meetings to understand local drivers: – water resource overview – conservation overview – financial operations – water use studies – Southern Nevada Water Authority	Hold meetings to consider: – consultant presentations – facilitated sessions – recommendations – drought	Present to Citizens' Water Advisory Committee: – program recommendation – policy recommendation Forward to Mayor and Council: – as is – with comments
	SCOPE OF WORK	SCOPE OF WORK	SCOPE OF WORK	PROGRAM DEVELOPMENT
CONSERVATION PLANNING CONSULTANT	Establish baseline conditions: – analyze previous survey data – collect secondary source information – estimate GPCD – develop baseline water use projections (population, income, price projections)	Profile new housing stock: – collect secondary data – map new development – estimate GPCD using Residential End Use Water Study	Develop "tool box": – use integrated planning concept – conduct economic analysis – identify important criteria – use American Water Works Association Benefit Cost Model – develop alternative conservation scenarios	Complete final tasks: – establish budget/staffing plan – develop project partnerships – implement pilot projects

Figure 3-4. *Tucson Water conservation planning process*

water. Tucson Water periodically evaluates the programs to assess their administrative processes and impacts on water use. The analysis provides guidance on how to best proceed in meeting targets for water conservation set by the CCTF.

Table 3-1 illustrates water saved in fiscal year 2013 and since the rebate programs began. It also lists the number of installed devices or rebates issued, depending on the program. The high-efficiency toilet replacement rebate programs have been, by far, the most successful.

The rebate programs began in 2008 and are evaluated against targets set by the CCTF. Projecting the programs' duration (in years) allows for evaluation of their potential to meet conservation targets. Thus, Tucson Water can shift priorities accordingly to ensure targets are met in a timely manner. Figures 3-5 to 3-7 illustrate how three of the residential programs are expected to meet their targets. Additional figures showing participation in the rebate programs are provided in Attachment A.

These figures show that while the high-efficiency toilet rebate programs are steadily moving toward goals set by the CCTF, the gray water, high-efficiency urinal, and commercial irrigation rebate programs may need to be restructured to meet the CCTF targets. While challenges exist in reaching CCTF targets, Tucson Water has experienced success in helping customers participate in conservation.

A noteworthy pilot project is the Irrigation System Upgrade Rebate Program, which offers rebates of up to $10,000 to commercial, multi-family, industrial, and institutional customers to upgrade their irrigation systems. Sites must be audited for efficiency before and after the upgrades.

Preliminary audits were conducted at 70 properties to evaluate the average distribution uniformity (evenness) of the sprinkler system's application of water. The distribution of water must be uniform to avoid excessively wet or dry areas in the landscape. With a higher uniformity, there is a lesser chance of wasted water. The irrigation system must meet or

Table 3-1. Rebate program water savings status

Program (year to date)	Installed devices/ Issued rebates	Fiscal year 2013 estimated gallons saved	Cumulative estimated gallons saved	Cumulative estimated 100 cubic feet saved	Cumulative estimated acre-feet saved
Single-family Residential High-efficiency Toilet Rebate (July 2008)	1,901	19,566,993	275,461,266	368,264	845
Multi-family High-efficiency Toilet Rebate (July 2008)	3,632	56,343,216	121,358,199	162,244	372
Commercial High-efficiency Toilet Rebate (July 2008)	136	2,050,200	55,671,975	74,428	171
Low-income High-efficiency Toilet Rebate (November 2009)	651	6,700,743	64,187,148	85,812	197
Single-family Residential Rainwater Harvesting Incentives Rebate (June 2012)	295	1,216,580	1,228,952	1,643	4
High-efficiency Urinal Rebate (January 2011)	4	71,540	643,860	861	2
Irrigation System Upgrades Rebate (July 2008)	8	1,839,600	15,636,600	20,905	48
Single-family Residential Gray Water Rebate (January 2011)	11	143,341	664,581	888	2
All programs	—[a]	**87,932,213**	**534,852,581**	**715,045**	**1,641**

[a] not applicable

exceed 65 percent distribution uniformity after the upgrade to receive a rebate.

Tucson Water expects its various rebate programs to experience continuing success. The community has embraced these programs, demonstrating a widespread willingness to take measures to conserve water. Figure 3-8 at the end of this section shows the extensive city-wide participation in the single-family and low-income high-efficiency toilet rebate programs, by location.

Drought Preparedness

Drought preparedness and demand management are inextricably linked with water resources planning. Impacts

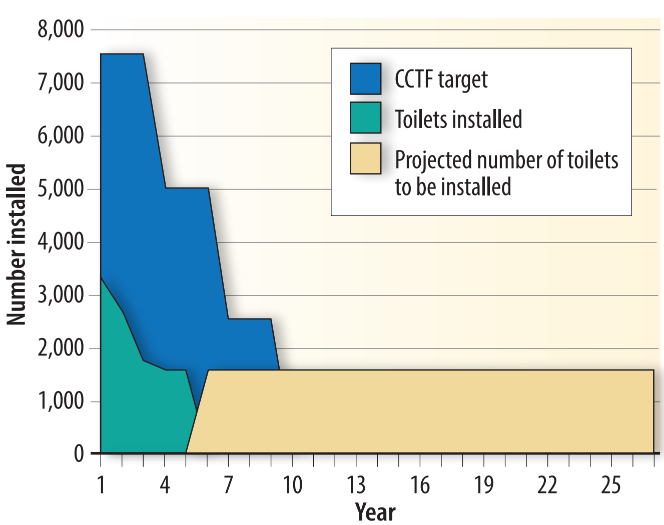


Figure 3-5. Single-family Residential High-efficiency Toilet Rebate Program future performance

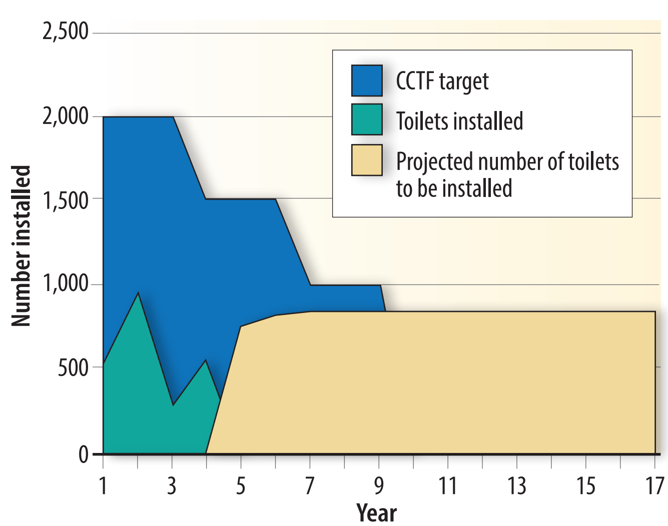


Figure 3-6. Low-income High-efficiency Toilet Rebate Program future performance

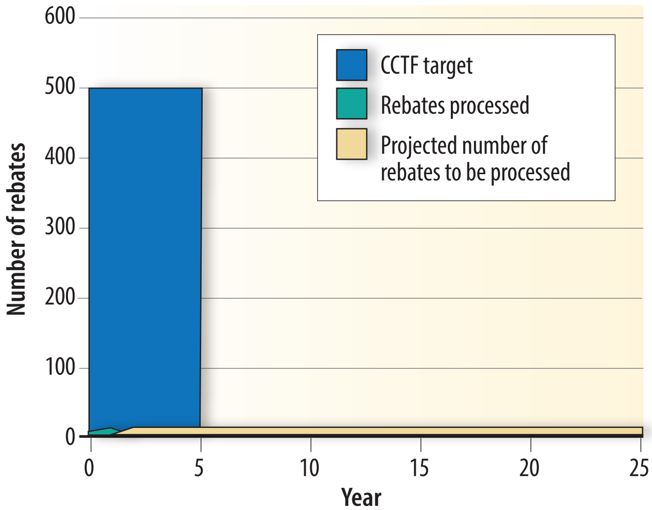


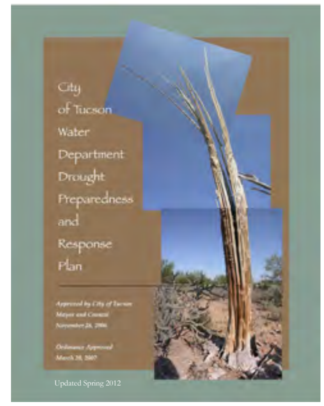
Figure 3-7. *Single-family Residential Gray Water Rebate Program future performance*

associated with drought are caused by drier-than-normal weather patterns and by the demand a community places on its available water supplies. The effects of drought can be worsened by managing available water resources inefficiently or by inadequate resource and/or systems planning.

Conversely, effective drought planning can minimize the severity of drought impacts. Thus, long-range efficiency programs need to align with the drought response plan, and vice versa. The Drought Preparedness and Response Plan (Drought Plan) was developed to conform to State law and to further reinforce the Utility's existing drought management and water resources/system buffers.

In response to recommendations developed by the Governor's Drought Task Force (2004), drought-related legislation became State law in 2005 and required all Arizona water systems to submit a drought preparedness and response plan to the State by January 1, 2007. Tucson's Mayor and Council approved the Drought Plan in November 2006 and subsequently amended the Tucson Code in March 2007 by adopting an ordinance that enforces the drought response stages and response measures embodied in the Drought Plan.

The Drought Plan addresses the inherent uncertainties associated with droughts, such as their potential duration and severity. It was developed with the understanding that drought impacts can occur locally or regionally. For instance, a local drought may involve only the Santa Cruz River watershed and nearby basins. A regional drought may encompass all or part of the Colorado River watershed, thus affecting water users in several states. Droughts can occur both locally and regionally at the same time.



The Drought Plan was approved in November 2006.

Tucson Water's Drought Plan has four response stages, ranging from mild to most stringent. These stages and their associated measures account for unique attributes of the Utility's water system, which is configured and operated to maximize reliability in both its available resources and supply infrastructure. Tucson Water's system is less vulnerable to effects of local or regional drought because the Utility has diversified its water resources portfolio.

This means that the Utility is not fully reliant on either surface water or groundwater for potable supply. In addition, Tucson Water operates a large reclaimed water system that meets a significant portion of its total water demand.

This system also serves as a drought buffer because it reduces the magnitude of peak demand on the potable system. Thus, Tucson Water and its customers benefit from greater supply resiliency in both wet and dry years.

For more information on stages, drought indicators, and response actions, refer to the Drought Plan on the City's website. [8] Annual reports on the City's drought status and compliance with the Drought Plan are also available on the website.

[8] tucsonaz.gov/water/drought-intro

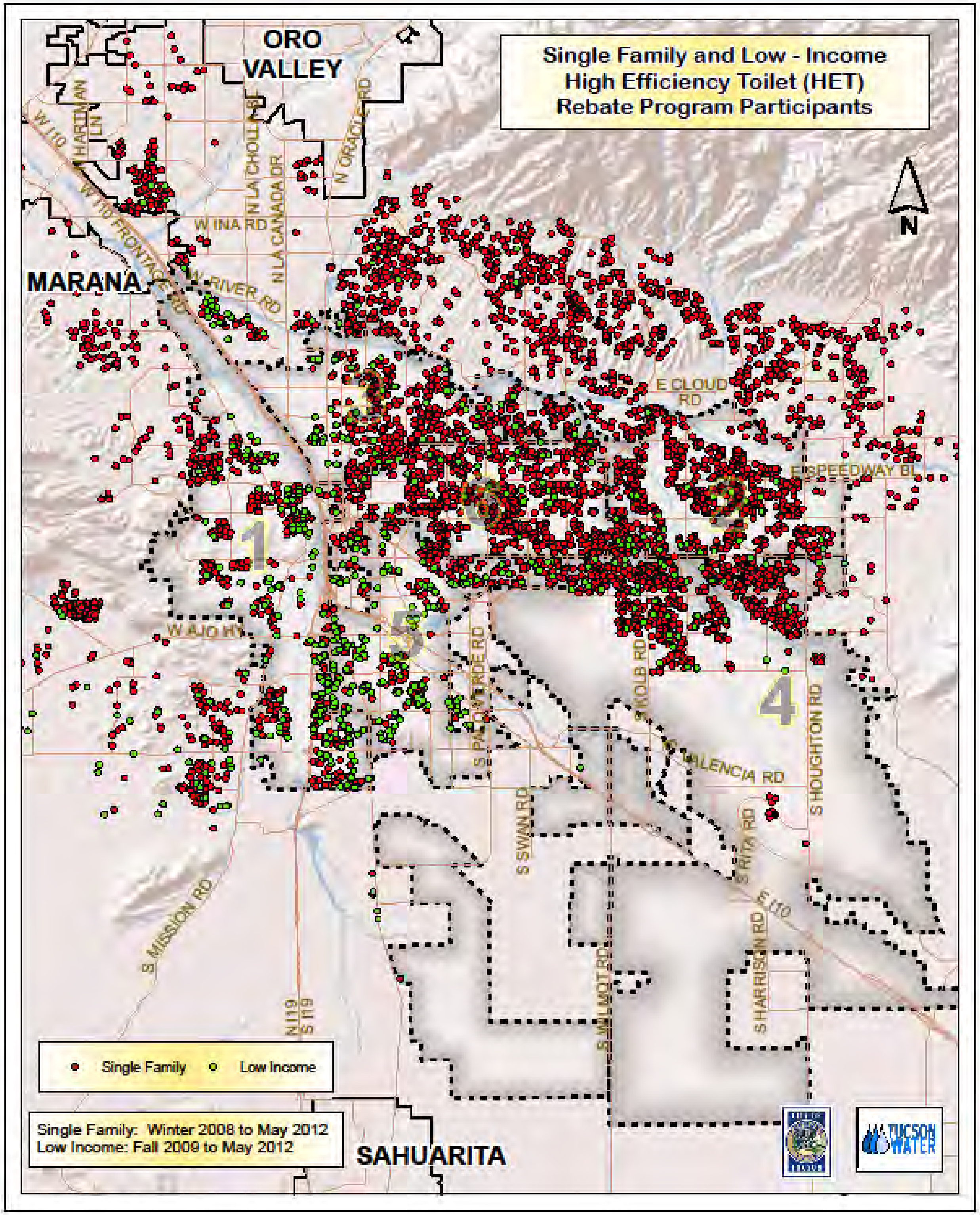


Figure 3-8. *Participation in toilet rebate program through May 2012*

SECTION FOUR

Available Water Resources

Tucson Water currently has three water resources available to meet customer demand: groundwater, Colorado River water, and recycled water. Each of these resources plays an integral part in providing a reliable water supply for the community. They each have unique legal and physical constraints on their use, as described in Chapter Four of *Water Plan: 2000–2050*. In addition to the water resources that can be provided by Tucson Water, customers also have the capability of satisfying some of their own water needs through rainwater harvesting and gray water use (see previous discussion in Section Three).

This section provides a current snapshot of how the water resources available to Tucson Water are being used today and trends that may affect their availability in future years. In addition, it summarizes Tucson Water's current AWS Program water portfolio and the potential opportunities to acquire or develop additional water resources to meet future demand and increase our water supply redundancy and resiliency.

Groundwater

Groundwater remains a vital piece of Tucson's water resources portfolio. As described in previous *Water Plan* documents, our historical reliance on this resource led to overuse and negative consequences. However, responsible use of our local groundwater is achievable and is vital to our supply reliability for the following reasons:

- to meet peak water demand during the hottest months
- to provide emergency backup to our Colorado River water supply infrastructure
- to offset the impacts of shortages on the Colorado River
- to mitigate the potential impacts of climate change on Colorado River water availability
- to serve as a short-term bridge to future renewable water supplies as they are developed (for example, desalination)

Potential constraints on the use of groundwater are discussed in *Water Plan: 2000–2050*. In general, the regional aquifer systems are placed under stress not only by Tucson Water but by other water providers, industrial and agricultural operators, and numerous private well owners. Over-pumping of these aquifers over many decades has resulted in significant water level declines, measurable land surface subsidence, and loss of riparian habitat.

For groundwater to remain a viable resource for future use, Tucson Water has continued its efforts to reduce its groundwater use to approach a hydrologically sustainable pumping rate. We are not alone in relying on the shared aquifer system, and other local water providers have taken steps to reduce their groundwater use as well:

- The Town of Oro Valley has implemented a reclaimed water system and has entered into a wheeling agreement with Tucson Water to begin using its own allocation of Colorado River water within its service area.
- Metro Water District is developing infrastructure to begin using reclaimed water and recently purchased the Avra Valley Recharge Project as a critical step toward bringing Colorado River water into its service area.
- The Town of Marana has been actively developing access to renewable water supplies, including efforts to increase its allocation of Colorado River water and to take ownership of the effluent generated within its service area.
- Pima County is partnering with Tucson Water on the Southeast Houghton Area Recharge Project (SHARP), a cooperative effort to increase the amount of recycled water stored for future use in the community.
- Recharge and groundwater savings facilities are in the design phases for eventual use of Colorado River water in the Sahuarita and Green Valley areas.

These activities—and others too numerous to list in this update—are collectively improving the state of our local groundwater supply.

From a regulatory perspective, groundwater use is regulated by ADWR's AWS Program. Tucson Water has a finite number of groundwater credits that it can pump over time, referred to as "allowable" groundwater. The Utility also has access to a small volume of annually accruing groundwater credits from "incidental" recharge, constituting 4 percent of Tucson Water's annual total demand. In addition, Tucson has access to a special class of groundwater through its Tucson Airport Remediation Project (TARP) facility, where contaminated groundwater is remediated and made available for use (see TARP discussion in Section Five). Finally, Tucson Water has the ability to use up to 12,500 acre-feet of groundwater per year that would be replenished through its contract with the Central Arizona Groundwater Replenishment District (CAGRD).

Over time, the biggest potential impediment to the long-term reliability of Tucson's groundwater supply is the AWS Program itself. The bulk of Tucson Water's groundwater pumping will debit against our allowable groundwater account. Once these paper-water credits are exhausted, all groundwater that is pumped in excess of incidental recharge must be replenished with a renewable water supply. Even though Tucson Water has reduced its annual pumping and uses groundwater at a hydrologically sustainable rate, the Utility will eventually deplete its allowable groundwater credit account. At some point, the credits remaining in this account will not be sufficient to renew the City of Tucson's AWS designation. Therefore, the City must continue to participate in ongoing statewide regulatory and policy discussions to adapt the AWS Program over time to recognize the aquifer stewardship being achieved by Tucson Water and our neighbors. This will ensure that we continue to have access to groundwater in the future.

Tucson Water's contract with CAGRD provides legal authority to pump groundwater. Under State law, the replenishment (that is, recharge) activities of CAGRD are not required to occur in the same area as the groundwater pumping it seeks to offset. Thus, CAGRD replenishment does not necessarily address local groundwater declines. Tucson Water will perform CAGRD replenishment at its recharge and recovery facilities to maintain aquifer water levels within its projected service area and to assist in achieving long-term sustainability.

Potential Additional Sources of Groundwater

Substantial quantities of groundwater might be available from less-developed basins in western Arizona such as the Harquahala basin, McMullen Valley, and Butler Valley. Transfers of groundwater from less populated areas of Arizona could yield additional water supply in the future. In addition, there are locations in Arizona with available quantities of brackish (salty) groundwater. Treatment technologies are beginning to emerge that could make this resource cost-effective for municipal supply. Additional groundwater supplies could potentially be delivered to the Tucson area by using existing excess capacity in the CAP.

Colorado River Water

Colorado River water, delivered to Tucson by the CAP, is the area's largest renewable water supply. This section provides an update on the status of Tucson Water's allocation of Colorado River water, information related to future shortage issues associated with drought, and the potential implications of climate change.

The City of Tucson has rights to the largest municipal allocation of CAP water in Arizona—currently, 144,172 acre-feet per year. Tucson's allocation has increased since the previous AWS update because of the final disposition of the Arizona Water Settlements Act of 2004. Looking forward, an allocation transfer from the Flowing Wells Irrigation District (19 acre-feet per year) is expected to be executed in 2013, which will bring the total for Tucson to 144,191 acre-feet per year.

Tucson Water's CAP allocation is managed under the Clearwater Program. Through the process of recharge and recovery, Colorado River water mixes with native groundwater to produce a blended water supply. Tucson Water currently has sufficient facilities in operation to recharge the City's full allocation. Facilities are also in place to recover the majority of the allocation for delivery to customers, with the remaining near-term recovery facilities currently under construction. The core components of the Clearwater Program include:

- The Central Avra Valley Storage and Recovery Project (CAVSARP) has a permitted recharge capacity of 100,000 acre-feet per year, with a recovery capacity of 70,000 acre-feet per year to the Snyder Hill Pump Station located at the Hayden-Udall Treatment Plant.
- The Southern Avra Valley Storage and Recovery Project (SAVSARP) has a permitted recharge capacity of 60,000 acre-feet per year, with a current recovery capacity of 15,000 acre-feet per year to the Plant 9 facility. Expanded recovery capacity (to 60,000 acre-feet per year) is currently under construction, including the SAVSARP Reservoir and Booster Station and the SAVSARP Recovered Water Transmission Line that will interconnect to the CAVSARP recovery line en route to the Snyder Hill Pump Station.
- The Pima Mine Road Recharge Project has a permitted recharge capacity of 30,000 acre-feet per year. Recovery is accomplished by the City's Santa Cruz Well Field, which is hydrologically connected to the recharge facility.

Between CAVSARP, SAVSARP, and the Pima Mine Road Recharge Project/Santa Cruz Well Field, Tucson Water will have sufficient capacity to recharge and recover its entire CAP allocation each year. Currently, the vast majority of Tucson Water's service area is served by a renewable water supply through Clearwater Program facilities.

On March 28, 2013, Tucson Water employees celebrated the 1 millionth acre-foot of water recharged in Clearwater Program facilities.

To date, over 1 million acre-feet of Colorado River water has been recharged in Clearwater Program facilities. This is the equivalent of about 10 years of potable water demand in the Tucson Water service area. In the future, additional enhancements to Clearwater Program facilities may be undertaken to expand recharge and/or recovery capacity, increase resiliency, and add system redundancy.

Colorado River Water Availability in the Future

The primary uncertainty related to Tucson's use of Colorado River water is the impact of future shortages. Several factors could, individually or in combination, result in a declaration of shortage on the Colorado River (see the 2008 Update). Tucson Water has been planning response strategies to ensure a reliable water supply for the community, even under shortage conditions:

- participating in the Arizona Water Banking Authority (AWBA) to store excess CAP water for use during a declared shortage
- maintaining robust groundwater infrastructure to temporarily increase its use, if necessary
- expanding the use of recycled water to meet community needs
- fostering conservation and other demand management activities to reduce local water demand
- maintaining the Utility's Drought Plan to prepare the community for water use curtailment, if needed
- working with Arizona water interests to protect the high priority of municipal and industrial allocations, such as Tucson Water's, within the CAP
- acquiring and developing additional renewable water resources

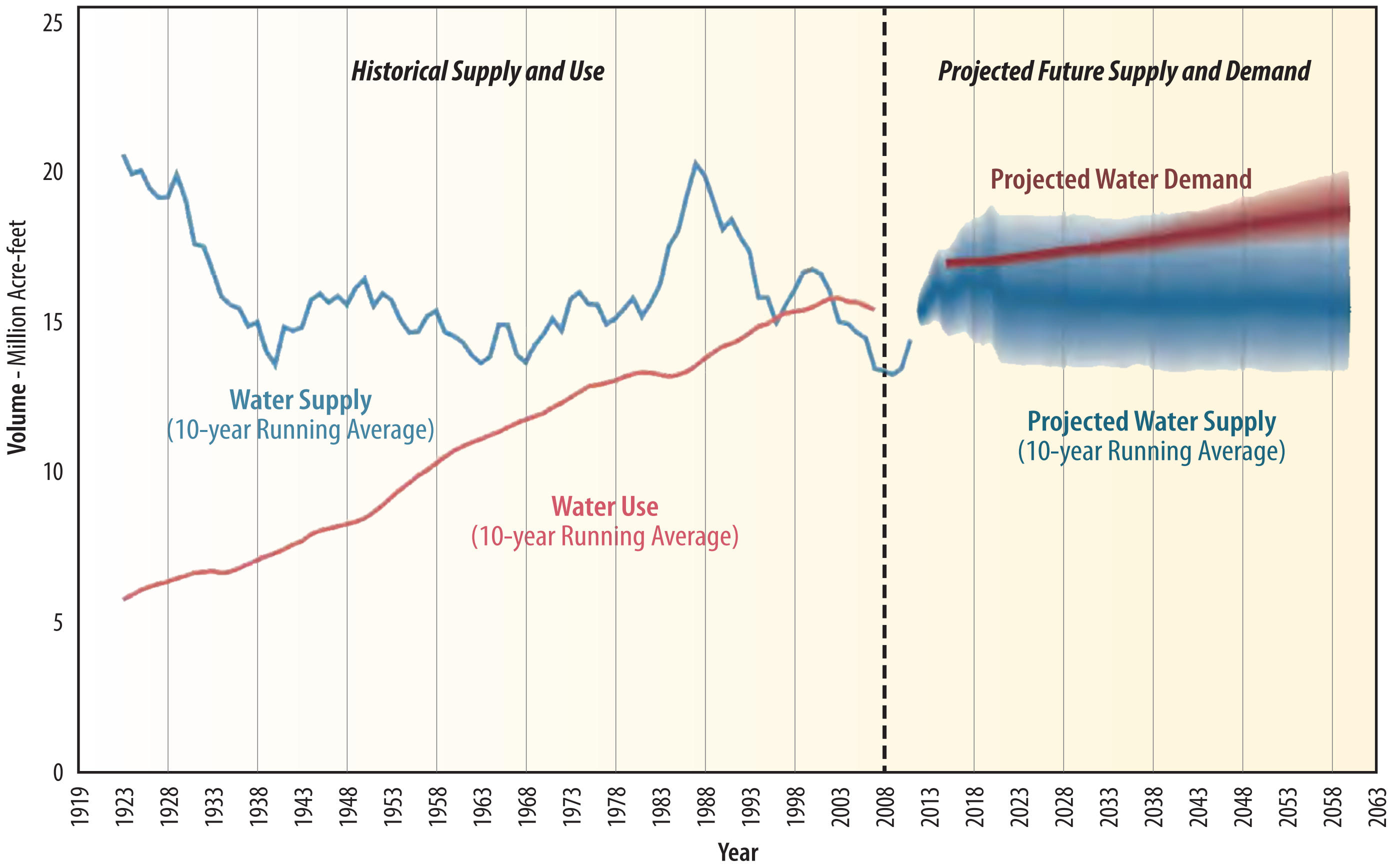
The actions taken by Tucson Water have prepared the community for eventual shortage conditions. However, exactly when a shortage may occur is a question that occupies water planners throughout the seven Colorado River Basin states and Mexico.

The most recent comprehensive look at potential shortage issues is the *Colorado River Basin Water Supply and Demand Study*, completed by the U.S. Bureau of Reclamation in December 2012. The study was intended to define current and future imbalances in water supply and demand in the Colorado River Basin and to analyze adaptation and mitigation strategies to address the imbalances.

It is interesting to note that the basin study used a scenario planning process similar to the core framework Tucson Water used in the original *Water Plan: 2000–2050*, published in 2004. The executive summary of the basin study is included as Attachment B to this document.

Results of this study as they affect Tucson Water are summarized as follows:

- Four supply scenarios were developed with assumptions about hydrologic conditions:
  - Observed Resampled – used the last 100 years of data as predictive of future conditions
  - Paleo Resampled – used reconstructions of the past 1,250 years as predictive of future conditions
  - Paleo Conditioned – used the longer period of record to estimate the durations of wet and dry periods, but constrained their magnitudes to the most recent 100-year record
  - Downscaled GCM Projected – considered the effects of climate change on water supply availability
- Six demand scenarios were developed around varied assumptions on the rate of growth in the basin states and the effectiveness of environmental actions and demand management initiatives.
- The study then compared the range of projected water demands with the range of projected water supply availabilities to evaluate the imbalance between demand and supply moving forward. A graphic depicting the imbalances is provided as Figure 4-1, reproduced from the basin study executive summary.



Source: U.S. Bureau of Reclamation, *Colorado River Basin Water Supply and Demand Study*, Executive Summary, 2012

Figure 4-1. *Supply and demand imbalances on the Colorado River*

Figure 4-1 shows that there is indeed a long-term imbalance between the volume of water that can be supplied by the Colorado River and the demands that are projected to be placed on it. This has been observed directly in recent years, although large storage reservoirs located on the river system have been able to buffer the impacts and head off a shortage. However, the magnitude of the imbalances is expected to increase through time.

How these imbalances will affect Arizona or Tucson directly was outside the scope of the study. However, the study indicates that shortages can be expected to occur in the future. The study also explored a wide range of actions that could be taken by Colorado River interests to reduce the imbalances and reduce the frequency and/or magnitude of shortages. The study essentially set a baseline for the basin states to work from in developing their individual and cooperative strategies for ensuring the long-term reliability of the Colorado River water supply.

For Tucson Water, the study provides a context for continued planning for future shortages and for participation in State-level and regional cooperative solutions. There is no crystal ball for when the first shortage will be declared. In this 2012 Update, baseline assumptions were applied to the availability of Colorado River water in the future as a 10 percent reduction starting after 2040. Considering results of the basin study, ongoing river management activities, the established shortage sharing criteria already in place, and the relative priority of Tucson's CAP water allocation within the overall pool of water, the 10 percent reduction assumption is considered conservative.

CAP planners have stated that shortages affecting Tucson's allocation are not anticipated until at least the 2030s, but will initially be mitigated using AWBA stored credits. This Update's projection of shortage considers that any reduction of CAP allocation prior to 2040 will be mitigated by AWBA credits. However, after 2040, AWBA credits distribution may be curtailed and the shortage will begin to affect Tucson's CAP allocation. At that point, Tucson's water resources portfolio of finite and renewable sources will make up the differences to meet projected demands.

Acquiring Additional Sources of Colorado River Water

The City of Tucson will continue efforts to increase its CAP allocation and to access additional Colorado River water. This may be accomplished through reallocation, lease, and/or transfer; these options are discussed in detail in Chapter Four of *Water Plan: 2000–2050*.

Over the past few years, CAP operators have led an exploratory program to establish the framework for allocation and funding of additional water supplies that may be delivered through CAP infrastructure, referred to as the ADD Water Program (Acquire, Develop, and Deliver). Tucson Water has actively participated in the ADD Water Program process and is eligible to participate in any new supplies that become available through that process.

As discussed in the 2008 Update, another potential mechanism to acquire additional Colorado River water is to participate in an "exchange" program by providing an alternate water supply. Statewide efforts have continued to explore developing a seawater desalination facility in partnership with a coastal community in the United States or Mexico that has higher-priority rights to Colorado River water. Under such a potential agreement, Tucson could, in partnership with others, provide funding to the coastal community to desalinate seawater for use in that location in exchange for more Colorado River water to import to the Tucson area through the CAP. If this type of arrangement were to occur, it would likely be many decades out. Tucson Water continues to participate in these discussions to take advantage of this potential opportunity if and when it occurs.

Recycled Water

Recycled water has been delivered through Tucson Water's reclaimed water system for nonpotable uses since the mid-1980s. It provides a sustainable alternative to mining groundwater to satisfy irrigation demand. In addition, this water source has been used for environmental purposes and for recharge, thereby augmenting local aquifers. As time passes, expanded uses of recycled water will be evaluated.

In 2010, 63,700 acre-feet of effluent were produced from the metropolitan wastewater treatment plants in the Tucson area, with an additional 400 acre-feet produced from outlying facilities. As shown on Table 4-1, the City of Tucson had entitlement to a total of about 19,600 acre-feet (30 percent) of this effluent after contributions to the Southern Arizona Water Rights Settlement Act and the Conservation Effluent Pool. Of this total, approximately 12,500 acre-feet were reused as reclaimed water within the Tucson Water service area, while the remainder was discharged to the Santa Cruz River.

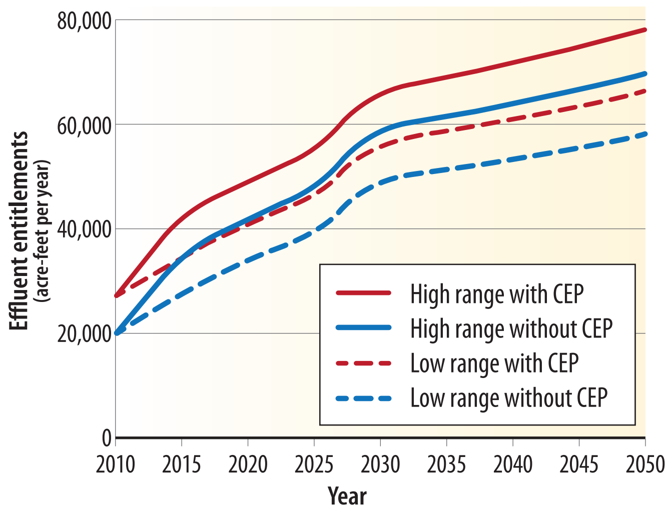
Updated projections of wastewater generation through 2030 were developed in support of the *Recycled Water*

Table 4-1. *City of Tucson recycled water entitlements, in acre-feet per year*

	2010	2015		2020		2025		2030	
Recycled water source	Actual flows	Low range	High range	Low range	High range	Low range	High range	Low range	High range
Tucson Water entitlement	19,600	27,400	34,500	33,700	41,600	39,500	48,100	48,700	58,500
Tucson Water CEP[a] contribution	7,380	7,180	7,370	7,140	7,320	7,000	7,200	6,960	7,170
Total Tucson Water entitlement	**26,900**	**34,600**	**41,900**	**40,900**	**49,000**	**46,500**	**55,300**	**55,700**	**65,700**

Source: Tucson Water, *Recycled Water Master Plan*, 2013

[a] Conservation Effluent Pool



Note: CEP = Conservation Effluent Pool

***Figure 4-2**. Tucson Water effluent entitlements*

Master Plan (2013) in consultation with the Pima County Regional Wastewater Reclamation Department. These projections indicate that Tucson's effluent entitlement (after deducting the Conservation Effluent Pool) could grow to between 48,700 and 58,500 acre-feet per year by 2030 (Table 4-1, Figure 4-2).

Historical uses of recycled water have centered on the reclaimed water system. As noted in Section Two, deliveries through the reclaimed system are projected to grow at a slower pace in the future because most large-turf users in the community have already converted to recycled water. This will leave an increasing amount of effluent available to be recycled for other uses, including groundwater storage.

In the near term, Tucson Water is entering the design phase of the SHARP. This facility, being developed in cooperation with Pima County, is intended to recharge 4,000 acre-feet per year of recycled water conveyed through the reclaimed water distribution system to the Houghton Reclaimed Water Reservoir.

The recharge credits from this stored water can be used to offset groundwater pumping elsewhere in the community or be saved for future use. The SHARP will lay the groundwork for expanded use of recycled water in the Tucson community.

As the population increases and all other available potable water supplies become fully utilized, the need for recycled water as a critical supply source will grow. This water will most likely be banked in local aquifers through a sequenced program of enhanced treatment and aquifer recharge.

Options for the future use of recycled water are explored in the *Recycled Water Master Plan* (2013), included with this 2012 Update as Attachment C. Tucson Water considers recycled water to be a vital renewable water resource that will ensure supply sustainability and drought resistance in the long term.

Potential Changes to Effluent Availability

Tucson Water has entitlement to a large volume of municipal effluent, and the Utility may be able to increase its usable share in the future. This could be achieved through agreements to lease or purchase the Secretary of the Interior's effluent entitlement as well as those of others. This would result in greater utilization of the only locally generated renewable supply that grows with the community.

The Southeast Houghton Area Recharge Project (SHARP) will be developed on City of Tucson land (above) located adjacent to the existing Houghton Reclaimed Water Reservoir (below).

***Table 4-2.** Estimated costs of water resources*

Water supply	Availability	Delivery access	Wheeling agreements	Cost of right ($/acre-foot)	Cost of delivery ($/acre-foot)	Cost of treatment ($/acre-foot)	Total cost ($/acre-foot)
Non-Indian agriculture[a]	Little to none	CAP[b] capacity	—[c]	2,300	150	200	350
CAP	Firm	Firm	None	—	150	200	350
CAP, in shortage	Firm, less shortage	Firm	None	—	210	200	410
CAP, no NGS[d]	Firm	Firm	None	—	230	200	430
ADD[e] water	Unknown	CAP capacity	With CAP and Reclamation[f]	2,000	300	200	2,500
CAGRD[g]	Firm	Firm	—	600	300	200	1,100
AWBA[h]	Firm	None	None	Unknown	—	200	Unknown
Indian leases	Unknown	Firm	None	Unknown	—	200	Unknown
Recycled water	Firm	Firm	None	—	—	1,500	1,500
Desalination water trades	Unknown	CAP capacity	With CAP and Reclamation	—	—	—	Unknown
Rainwater harvesting	Not reliable	Firm	None	—	—	—	30,000

[a] available after 2017; will be shorted first; available only if deficit occurs in potable supply; must forfeit groundwater volume received
[b] Central Arizona Project [c] not applicable [d] Navajo Generating Station [e] Acquire, Develop, and Deliver [f] U.S. Bureau of Reclamation
[g] Central Arizona Groundwater Replenishment District [h] Arizona Water Banking Authority

The source of recycled water in the area is Pima County, which operates the various municipal and nonmunicipal treatment facilities. Pima County has been implementing a series of projects under its *Regional Optimization Master Plan* (ROMP), which will define the effluent quality and quantities that will be produced at various locations. Since the 2008 Update, Pima County has made significant progress on the ROMP initiatives, including development of a new water recycling plant to replace the Roger Road Wastewater Treatment Plant and process improvements and expansion of the Ina Road Water Pollution Control Facility. These facilities are being designed to produce a higher quality of effluent for reuse and are sized to meet the community's anticipated wastewater flows. Tucson Water is working closely with Pima County to ensure the long-term availability of recycled water.

Cost of Available Resources

Acquiring and developing future water resources will have associated costs that are higher than the current rates for CAP allocation deliveries. Shortages on the Colorado River will affect the volume of water available for CAP. Since the operation and maintenance costs will not be affected by the lower volume in the canal, the unit price for delivery will increase. The costs of CAGRD, ADD water, Indian leases, and AWBA stored credits are unknown but are expected to rise—possibly significantly—in upcoming years.

Table 4-2 summarizes estimated costs for many of these water resources. Values (where known) reflect current rates or engineering estimates based on treatment costs.

Assured Water Supply Program

Under the current AWS designation issued in 2007, the City of Tucson's 100-year supply of water that meets all of the AWS criteria is 185,688 acre-feet per year. However, Tucson's AWS designation is currently capped at 183,956 acre-feet, which was the projected demand volume for 2015 at the time of the AWS application. The City's current water supply portfolio is based on its physically available groundwater, Colorado River water, and recycled water supplies as demonstrated in the Designation Order.

> The AWS Program is intended to ensure Arizona's future economic security by preventing groundwater depletion through responsible water planning. Land developers must meet various criteria when proposing a new development, including a hydrologic study that shows a 100-year supply of water for that development.

Under the current AWS designation, Tucson Water must apply to modify its Designation Order once demand increases to within a 2-year growth projection of 183,956 acre-feet per year or January 1, 2014, whichever comes first. To modify the Designation Order, the Utility must demonstrate that it has developed additional water supplies that meet all requirements of the AWS Program.

Tucson Water has already developed greater access to qualifying water supplies since the current Designation Order was issued. The City's allocation of CAP water increased following the final conclusion of the Arizona Water Settlements Act, and Tucson Water has increased the physical availability of this supply through completion of the SAVSARP recharge basins and pending completion of the expanded recovery systems. The volume of qualifying recycled water will also increase through expansion of the Sweetwater Recharge Facilities currently under construction and through development of the SHARP facility.

The one water supply that has decreased over the term of the current Designation Order is the volume of allocated groundwater. As noted previously, most groundwater is considered finite under the AWS Program, and the City's groundwater account balance has been slowly dropping over the past few years.

However, the City is scheduled to receive additional groundwater credits in 2025, under State law. Based on the net increase in available water supplies that has occurred over the past few years and the lowered expectations of future water demands, it is anticipated that Tucson's next AWS designation will readily extend to 2025 before it

Table 4-3. *Current AWS designation*

Type	Current designation in acre-feet
Annual Central Arizona Project allocation	135,966
Annual Tucson Airport Remediation Project pumpage	1,189
Annual reclaimed water capacity	15,800
Annual groundwater account	13,662
Annual 4% incidental replenishment	5,830
Annual CAGRD[a] replenishment	12,500
Annual long-term storage credits	740
Total	**185,956[b]**

Note: The current designation has been in effect since 2007.

[a] Central Arizona Groundwater Replenishment District

[b] Designation was limited to 183,956 by Arizona Department of Water Resources, based on then-projected 2015 demand.

will require another modification. Table 4-3 summarizes the current AWS designation, which is based on the 2007 Designation Order.

As shown in Table 4-3, the vast majority of water contributing to Tucson Water's AWS designation comes from Tucson's annual CAP allocation (73 percent). Reclaimed water, groundwater, and CAGRD water account for next-largest components of the AWS designation.

SECTION FIVE

Water Delivery Systems

Tucson Water operates two types of water systems: a potable system and a reclaimed (nonpotable) system. These are physically separate and distinct systems that convey water from supply sources through a pressurized hydraulic system to customers situated at different elevations. Tucson Water's systems consist of a complex network of pipes, wells, pumps, reservoirs, valves, automated controls, and treatment facilities. These systems were described in detail in the original 2004 *Water Plan: 2000–2050* document. This 2012 Update provides current vital statistics for the systems and current programs to maintain reliability.

Existing Potable Water System

In 2012, Tucson Water served an area encompassing 350 square miles with a population of approximately 709,000. The vital statistics of Tucson's potable systems (Figure 5-1) include:

- 212 production wells
- 124 pumping stations
- 62 storage reservoirs totaling over 300 million gallons of capacity
- 4,200 miles of pipelines ranging from 2 to 96 inches in diameter
- 22,000 fire hydrants
- 80,000 valves
- 225,000 metered services to businesses and residences

In general, the extent and components of the potable systems have remained fairly steady since 2008 given the significant slowing of population growth. What has changed is the level of reinvestment that Tucson Water has been making for existing systems. As water systems age, they require periodic condition assessment and rehabilitation to maintain a high level of service.

Pipeline Programs

The Utility has undertaken a large number of water main replacement programs since the 1990s. As piping systems age, the number of leaks and breaks that occur tends to increase and service disruptions can become more frequent. In younger systems, maintenance crews can generally keep up with the pipeline needs. However, as issues increase in frequency, it becomes more economical to perform planned main replacement projects to renew the infrastructure. For Tucson Water, these projects are typically executed by geographic area, based on infrastructure age and observed issues, to efficiently replace the problem pipelines. As these projects are completed, the level of service in the affected areas increases and the overall system reliability is improved.

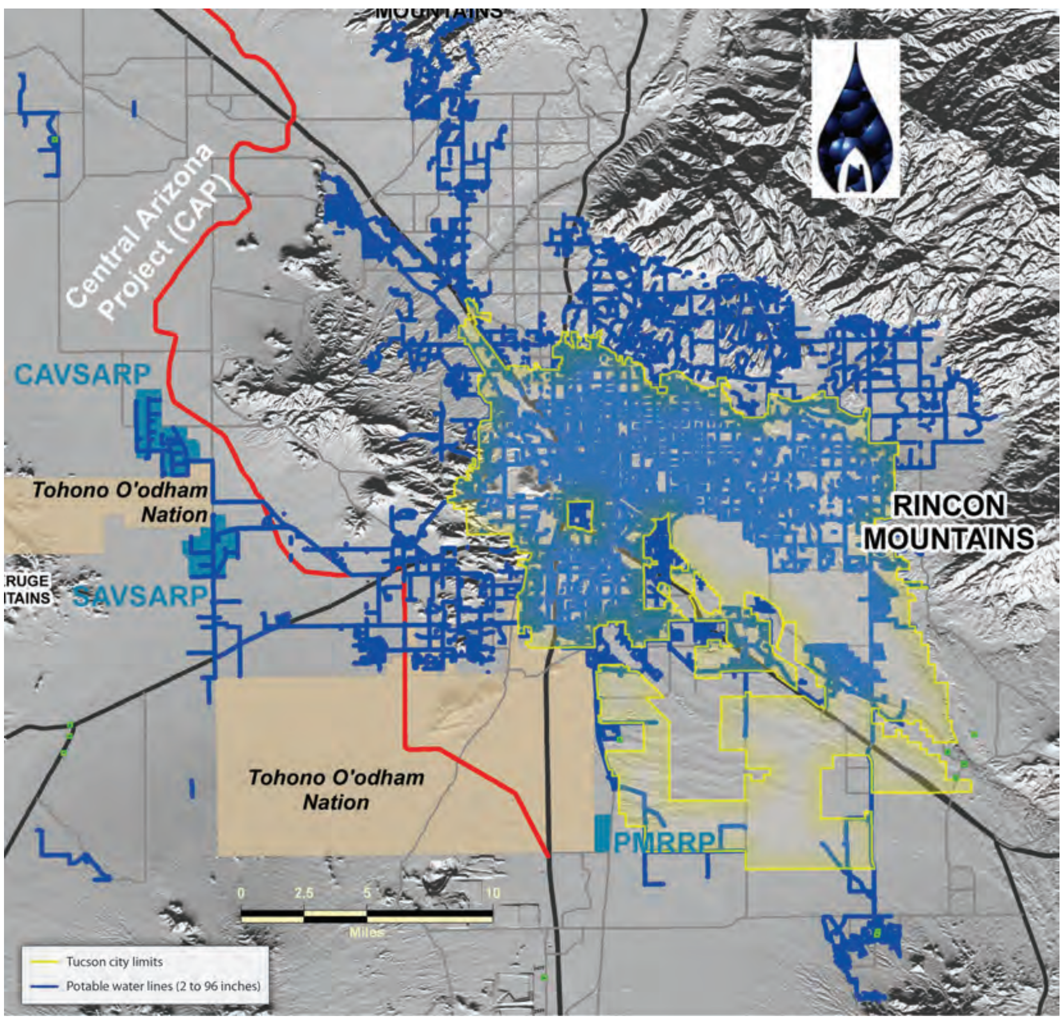


Figure 5-1. *Tucson Water's potable system pipeline network*

For the most critical pipelines, Tucson Water has installed monitoring systems to help predict leaks and breaks before they occur. The primary example in Tucson is the 96-inch transmission main that delivers Clearwater Program water from the Clearwell Reservoir (located in the Tucson Mountains) to the main system. This pipeline is critical because the bulk of Tucson's renewable water supply currently flows through this single pipeline. The main is a prestressed concrete cylinder pipe, which includes wire strands as an integral part of its construction for structural strength. As this type of pipe ages and/or becomes affected by corrosion or other failure mechanisms, the wires begin to break. By monitoring for wire breaks, Tucson Water can receive early indications of potential pipeline failure. This was recently evidenced when the Utility responded to wire break information and discovered an area of the pipeline that was at risk of failure. Through this program, Tucson Water was able to repair the pipeline as a planned event, avoiding a more catastrophic situation.

By monitoring its infrastructure regularly, Tucson Water was able to repair a 96-inch transmission main from the Clearwell Reservoir that was at risk of failure.

In addition to protecting critical infrastructure and reducing water lost through leaking pipelines, Tucson Water has instituted an ongoing meter replacement program. Aging water meters tend to lose accuracy over time, under-reporting water use as they age. This has two implications: (1) the Utility does not record and bill for all of the water used by customers, leading to lost revenue; and (2) affected customers do not have a true accounting of their water use, which might impede conservation measures. By replacing meters that have aged beyond effective service life, typically 20 years, better accounting of water use results.

Pumping Station and Reservoir Programs

Tucson Water has also been actively evaluating and improving its pumping systems and storage reservoirs. An evaluation of the energy efficiency of Tucson Water's large booster pump stations identified improvements that would save energy costs. In addition, the Utility has initiated a long-term Reservoir Rehabilitation Program to perform condition assessments and rehabilitation activities on its storage assets.

> Tucson Water used federal stimulus funds to pay for an energy audit of its booster pumps. The audit identified ways to save energy and reduce operations and maintenance costs.

The Utility took advantage of funding under the American Recovery and Reinvestment Act, loosely referred to as the Stimulus Program, to evaluate its booster pump stations. Aside from labor, energy is the largest line item in Tucson Water's operations and maintenance budget.

The Water System Booster Pump Efficiency Testing and Upgrade Program targeted booster pump modifications for the least efficient pumps, which would be upgraded following the audit process. The desired outcome was to identify "low-hanging fruit" for near-term upgrades that would immediately save energy (and, therefore, operations and maintenance costs). The effort also established a testing program to evaluate the pumping systems over time and to become more proactive in upgrading pumps, motors, and electrical systems to maintain efficiency into the future.

The Reservoir Rehabilitation Program was designed to conduct condition assessments at all of the Utility's storage assets (concrete and steel), identify issues needing repair, and implement improvements. Many of the City's reservoirs date back to the 1960s or earlier, and over 50 percent have been in service for 25 years or longer.

To date, all of the potable system reservoirs have undergone full condition assessments, improvements have been designed for nine locations (six concrete and three steel), and construction activities have been completed at four sites. The rehabilitation improvements have addressed issues with leakage, corrosion, deteriorating concrete, security, safety, and other concerns. The program will continue over the next several years to balance capital spending against the needs of the assets—with the ultimate goal of improving system reliability and reducing the risk of failure.

Water Quality Programs

The groundwater served by Tucson Water typically meets all applicable federal and State regulatory standards without further treatment. In addition, recharged and recovered CAP water also meets applicable regulatory standards and is blended with native groundwater for delivery to the potable system. Because the water delivered through the Tucson Water distribution system must be free of pathogens, Tucson Water introduces chlorine at various locations in the system to maintain a residual disinfectant in the water delivered to customers.

One source of groundwater supply used by Tucson Water does require treatment: water produced from the TARP. The TARP facility was placed into service in 1994 to remove trichloroethylene from local groundwater. In recent years, a non-regulated compound was detected at the TARP facility. 1,4-dioxane was used as a stabilizer in industrial solvents in aircraft manufacturing facilities from the 1940s to the 1970s and has been found in groundwater at the TARP well fields. Although the U.S. Environmental Protection Agency does not currently regulate 1,4-dioxane, it does issue health advisories as guidelines for drinking water utilities.

In 2011, the U.S. Environmental Protection Agency issued a new health advisory for 1,4-dioxane of 0.35 parts per billion, significantly lower than the previous 3 parts per billion. To address this, Tucson Water began planning and designing a new treatment facility with state-of-the-art technology to effectively remove 1,4-dioxane from water.

The TARP facility has been a part of Tucson Water's system since 1994.

Construction of this Advanced Oxidation Process Water Treatment Facility started in September 2012. It will work in conjunction with the adjacent TARP facility to produce up to 8 million gallons of purified water per day. The addition of the Advanced Oxidation Process to the TARP facility illustrates Tucson Water's proactive approach to water quality. While there is no current regulatory requirement to remove 1,4-dioxane, Tucson Water management and the City's Mayor and Council decided to move forward with the advanced treatment project to ensure that the community receives a high-quality water supply.

Existing Reclaimed Water System

In 2012, Tucson's reclaimed system (Figure 5-2) included:

- 4 production facilities
- 35.8 million gallons per day of capacity
- 8 pumping stations
- 6 storage reservoirs
- 165 miles of pipelines (Figure 5-2) serving:
  - 18 golf courses
  - 61 schools
  - 47 parks
  - Over 800 residential and commercial customers

Tucson Water has operated the reclaimed water system since 1984. The Utility delivered 15,200 acre-feet of reclaimed water through its reclaimed system in 2010. Of this total, 12,500 acre-feet of reclaimed water were used within the Tucson Water service area, with the balance wheeled to Pima County and the Town of Oro Valley.

In the near term, several changes and expansions to the community's reclaimed water treatment facilities are under way. Construction has begun on new recharge basins at the Sweetwater Recharge Facilities, which will expand its annual recharge capacity to 13,000 acre-feet.

Additional recovery wells are also under development to increase the production capacity. In addition, Pima County's ROMP program activities will yield improved reclaimed water quality once the new treatment works are in operation. To accommodate the improved water quality, Tucson Water will change its reclaimed water disinfection system to a chloramination approach where both chlorine and ammonia are used to preserve water quality through distribution and storage.

Future Potable and Reclaimed System Needs

Tucson Water has a number of projects and programs under way or in the planning stages to expand and improve the potable and reclaimed systems.

Potable System Needs

The time will come when renewed population growth will drive water system expansions to new areas, most often funded by developers. In the near term, investments in the potable system will focus on the rehabilitation and replacement actions described previously and on a series of capital projects intended to improve water system reliability, resiliency, and redundancy.

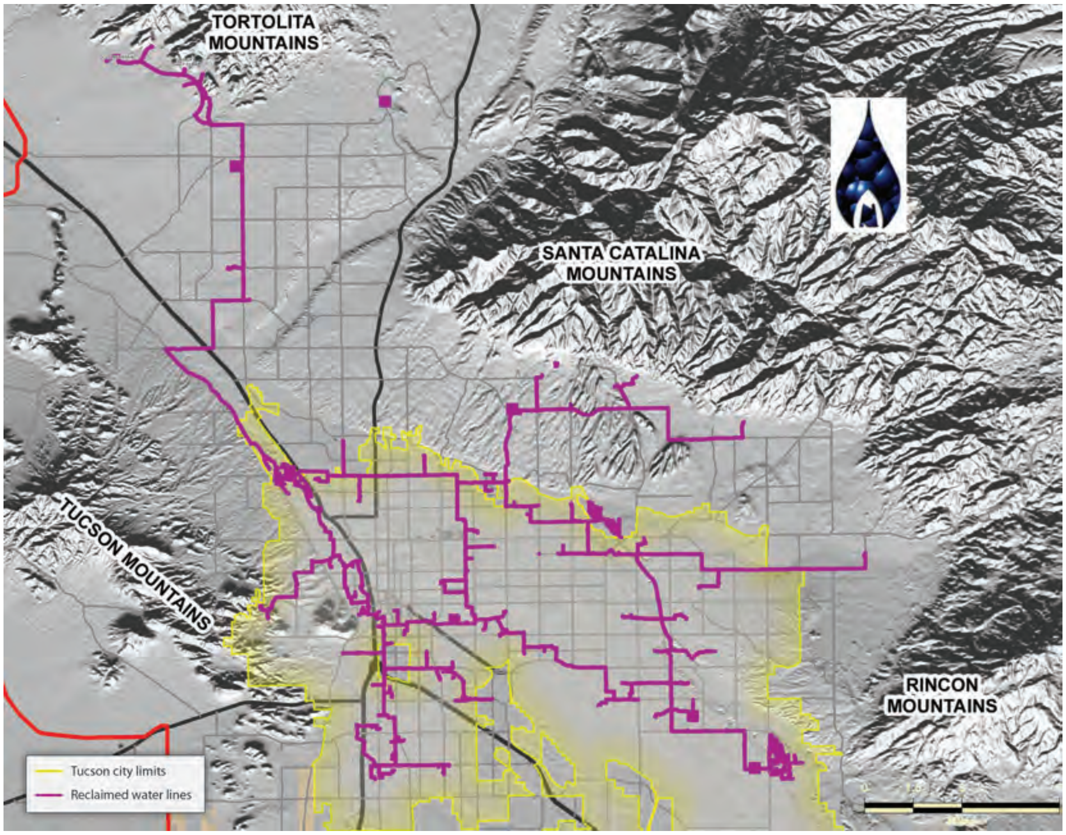


***Figure 5-2**. Tucson Water's reclaimed system pipeline network*

The first major project is effort is the Hayden-Udall Prime Program (HUPP), which will address the Utility's most serious current vulnerability—the fact that the majority of the City's renewable water supply comes into the system through a single transmission main, the 96-inch prestressed concrete cylinder pipe discussed earlier. The HUPP will provide a redundant route for recovered CAP water in the system, taking water from the Snyder Hill Pump Station south and east across the City to a point near the intersection of Country Club and Bilby Roads. Once completed, the HUPP will provide partial redundancy to the renewable water supply delivery system and increase water supply availability to the core of Tucson Water's service area.

Additional future projects include the Bilby B-Zone Reservoir and Booster Station, slip-lining the Sahuarita Supply Line, Supervisory Control and Data Acquisition (SCADA) System Upgrades, a redundant SAVSARP recovery pipeline, and various other system improvements.

Reclaimed System Needs

During development of the *Recycled Water Master Plan*, the current facilities were compared against future projected demands and were evaluated for their level of reliability.

The following projects were identified for consideration and possible inclusion in future capital project planning:

- North Loop Improvements – a pipeline to provide improved reliability and redundancy to the northern leg of the reclaimed water system
- Northeast Loop Improvements – a pipeline to provide improved reliability to the northeastern legs of the reclaimed water system
- Dove Mountain Area Improvements
- A booster station expansion and operational changes at the reclaimed water treatment plant to meet future demands (approximately 2025)
- A reservoir expansion in the southeastern part of the system (approximately 2030)

Finally, the SHARP facility is currently in the planning stages to provide a new location for aquifer recharge of recycled water. This cooperative project between the City and the County will lay the groundwork for increased use of recycled water in the community and improved reliability of the water system and water supply.

SECTION SIX

Resource Utilization and Action Plan

This section provides a renewed view of Tucson Water's recommended resource-utilization plan through 2050. It provides updates on Common Elements (recommended projects and programs) and Key Decisions identified in the prior *Water Plan: 2000–2050* documents and lists the near-term projects that are proposed to improve system reliability, resiliency, and redundancy.

Common Elements

The Common Elements are those programs and projects needed to ensure a resource-sustainable future for Tucson Water's existing customers and for future ones as well. These elements, originally identified in *Water Plan: 2000–2050*, have been actively pursued by the Utility to guarantee planning flexibility and system reliability. Table 6-1 provides the status of each project and program since the 2008 Update.

As indicated in Table 6-1, significant progress continues to be made on the projects and programs needed to secure a reliable water future for Tucson.

Decision Points

Water Plan: 2000–2050 outlined critical decisions to be made regarding the use of the City's Colorado River water and recycled water. Tucson Water has successfully implemented full use of its Colorado River water supplies and is well-positioned for the use of any future allocations that may be obtained.

The recycled water decisions still lie before the community; however, the timing of those decisions has been pushed out into the future because of the slowed pace of community growth over the past few years. The required planning work continues, and a detailed look at the future of recycled water in the community is provided in the *Recycled Water Master Plan* (Attachment C).

With the current assumptions of projected supply and demand provided in this update, several years remain before final decisions on recycled water use must be made. In the meantime, Tucson Water will need to update the City's AWS designation. Several pieces are already in place to extend the AWS designation for another 10-year period; work will begin on the renewal during 2013.

Projected Demand and Resources

A renewed look at future supply and demand in the Tucson Water service area is presented in this section. A projection of Tucson's future water use is provided based on assumptions of future water usage rates (GPCD) and the impacts of a declared shortage on the Colorado River. Five water use assumptions are highlighted below:

- Reclaimed water use will grow independently of population and is projected based on the addition of discrete new users on occasion through 2050.
- Potable demand will be met in the near term through decreasing dependency on groundwater pumping and increasing reliance on renewable Colorado River water.
- Incidental recharge refers to aquifer recharge that occurs after the Utility accesses its water sources for supply; it constitutes 4 percent of Tucson Water's annual demand.

Table 6-1. *Common Elements status*

Common Element	Status
Preserve groundwater credits	The use of renewable water supplies has been increased to reduce reliance on groundwater.
Achieve full Colorado River water use	The Utility has all infrastructure in place to take delivery of the entire allocation.
Achieve sustainable groundwater pumping	Groundwater pumping has been reduced to a sustainable level.
Evaluate effluent exchanges	Opportunities to exchange effluent and/or expand the use of this renewable supply continue to be explored.
Augment Avra Valley main	This project is scheduled for a route study in 2013, followed by design and construction over the next several years.
Develop additional reclaimed water supply	Construction of three additional recharge basins at the Sweetwater Recharge Facilities will be completed in 2013, and design of the Southeast Houghton Area Recharge Project facility is also being pursued.
Operate SAVSARP [a] Phase I	SAVSARP went into operation, and recharge rates are excellent. Initial recovery is being completed through the Plant 9 system and additional recovery capacity is currently under construction.

[a] Southern Avra Valley Storage and Recovery Project

- The City's entire CAP allocation will be recovered before the Utility's contracted CAGRD groundwater replenishment volume of up to 12,500 acre-feet per year is used.
- The point in time at which renewable water resources associated with imported Colorado River water, incidental recharge, and the City's CAGRD contracted volume are fully used varies depending on a unique combination of assumptions.

The projections provided here are based on the following assumptions: (1) potable water demand is projected based on the medium population projection from ADOA and a moderate GPCD assumption of 130, (2) to accommodate uncertainty in the future, additional demand projections were generated based on higher (145 GPCD) and lower (120 GPCD) assumptions of water use, and (3) Colorado River water is assumed to be fully available until 2040, when it is reduced by shortage. Tucson Water's supply portfolio accounts for potential near-term and future shortages on the Colorado River.

Figure 6-1 indicates that Tucson's Colorado River water allocation is sufficient to meet projected demand until at least 2030, even with the higher GPCD assumption. With reduced GPCD, this time frame could be extended. This reinforces the City's current pathway of placing a primary emphasis on use of its Colorado River water and preserving its groundwater for the future. It should also be noted that until 2030 or later, the City's storage of its entire Colorado River water allocation in excess of demand provides a source of water to directly address any future demand through 2050. The Utility has a sufficient and robust water supply to meet its current and projected mid-term water demand.

These projections also reinforce that, in the foreseeable future, additional renewable water supplies may be needed. Options will include recycled water, additional imported supplies, or a combination of both. Of these options, recycled water is the one supply that is already owned and controlled by Tucson Water, is expected to grow over time, and provides the highest degree of reliability and resiliency.

Future plan updates will continue to explore these options and ensure that the community's water supply is sustainable in the longer term.

Water Reliability

In prior plan documents, major conclusions were depicted in the form of a timeline. In this case, however, a different view is provided. This distinction is based on the fact that in previous years, Tucson was still on the pathway toward achieving a reliable and sustainable water supply. The transition from sole reliance on groundwater to a robust supply

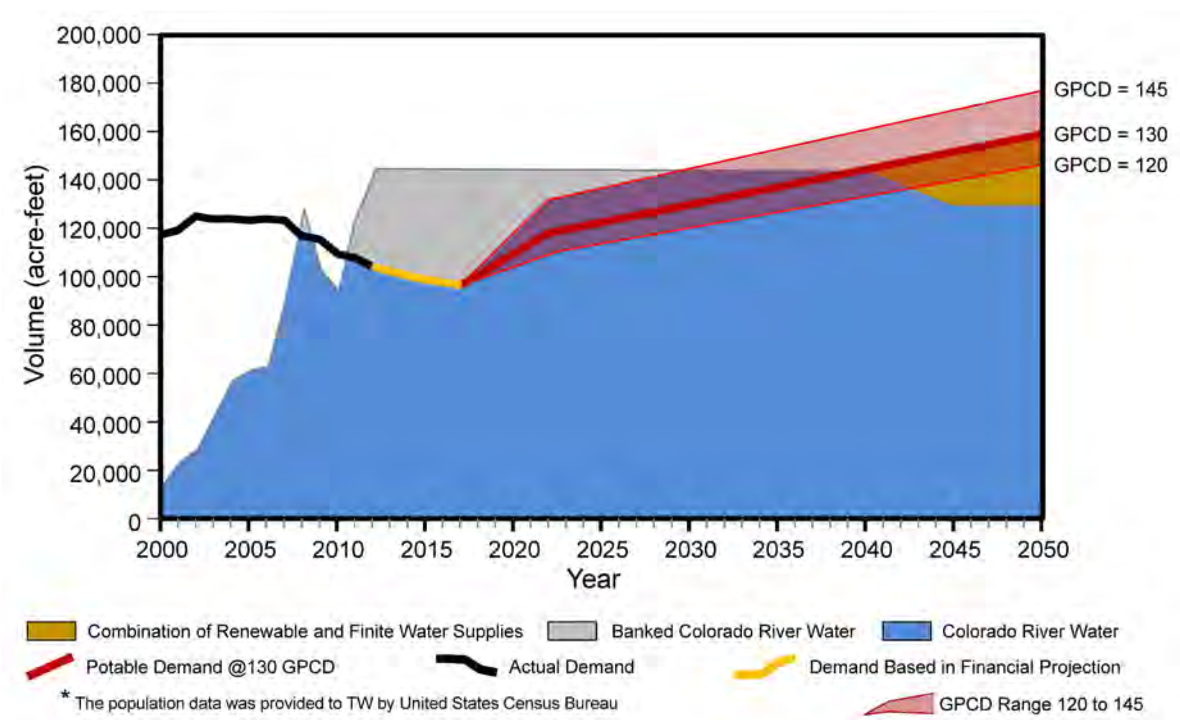


***Figure 6-1**. Supply and demand projections through 2050*

primarily reliant on renewable supplies was a long one. But, it has been achieved.

Moving forward, the primary water resources challenges facing the Tucson community are to maintain the reliable water supply as the community grows and potential shortages occur and to increase resiliency and redundancy.

Figure 6-2 shows a renewed emphasis on the water system components that treat and deliver our water supplies. Currently, facilities are in place to make full use of the City's CAP allocation. However, as discussed earlier in this Update, the system has vulnerability because most of the renewable resource is transmitted through a single pipeline. This vulnerability will be addressed by completion of the HUPP. In future years, projects to expand the recovery capacity from SAVSARP will also be implemented.

In addition to system improvements, Figure 6-2 emphasizes the primary roles of Colorado River water, groundwater, and recycled water in meeting water demand. As noted in prior documents and this Update, future water supplies will also be needed. As they are developed, they will serve to meet increased demand and improve our overall reliability, resiliency, and redundancy.

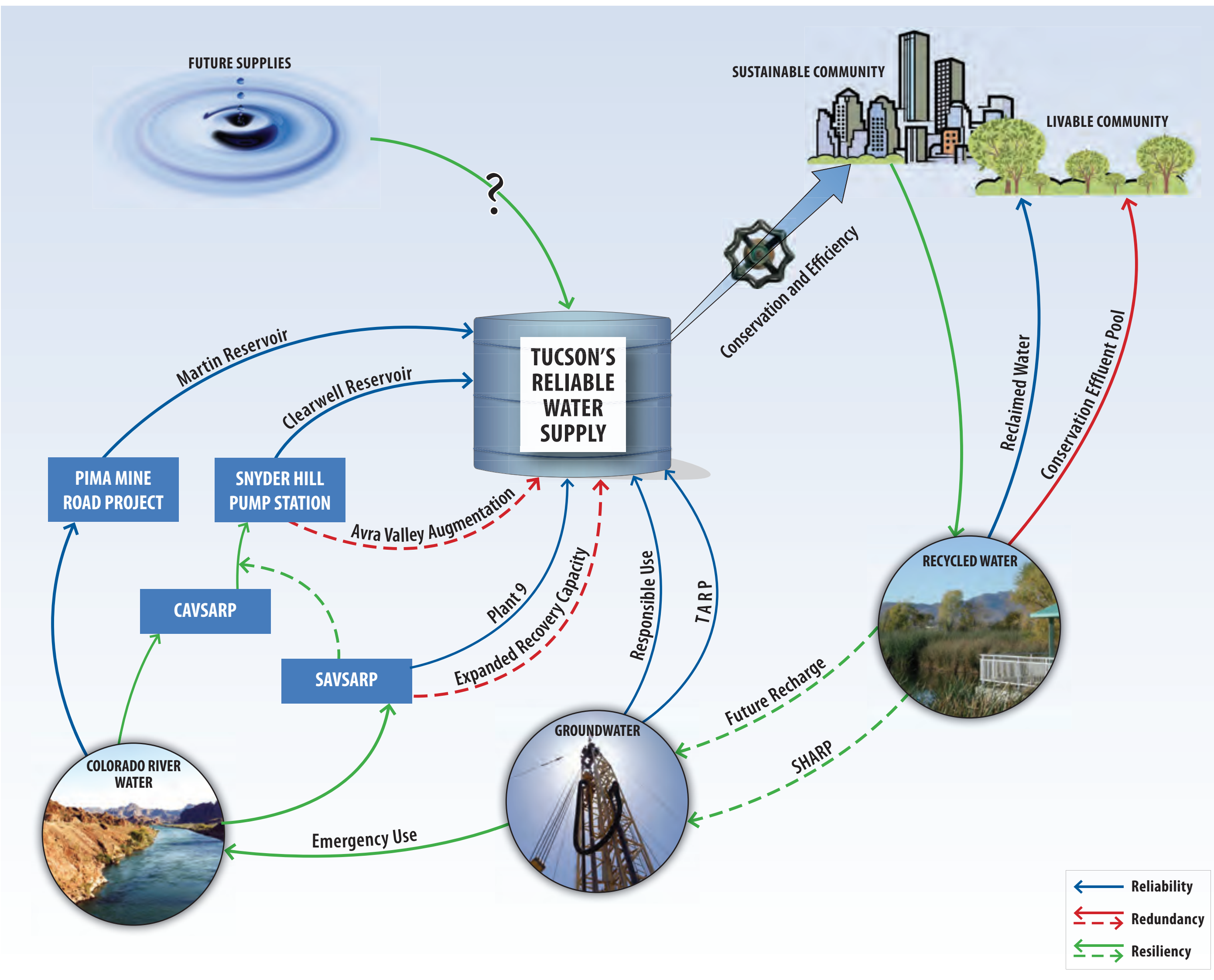


Figure 6-2. Tucson's reliable water supply

SECTION SEVEN

Conclusions

The water resources planning environment is dynamic and filled with uncertainties. In *Water Plan: 2000–2050* and its 2008 Update, Tucson Water provided recommendations that would allow the Utility to achieve specified planning goals while retaining maximum flexibility. These are updated below to reflect the actions and changes that have occurred since the 2008 Update.

Updated Recommendations

Many of the recommendations and conclusions noted in the 2008 Update remain the same and have already been implemented, while others are currently in progress or were revised to reflect the changing planning environment. The updated recommendations are summarized below.

- **Continue to Fully Utilize Colorado River Water**: With the CAVSARP, SAVSARP, and Pima Mine Road Recharge Project, the Utility has had sufficient recharge capacity in place to fully use its CAP allocation since 2009. The Utility purchased its full 144,172 acre-feet allocation in 2012 and 2013.
- **Manage Water Demand**: Tucson Water is taking a number of actions to further manage demand, including expanding conservation programming, reducing lost and unaccounted for water, encouraging the practice of water harvesting, and providing public information programs. Additional demand management efforts have been evaluated and recommended by the CCTF to further reduce per capita potable water use.
- **Fully Utilize Recycled Water for Future Supply**: Tucson Water recommends a resource management goal to maximize future use of the City's effluent through additional treatment and recharge in order to augment the aquifer within Tucson Water's service area. A public outreach plan with treatment testing and technology demonstrations will be the first phase of accomplishing this goal.
- **Emphasize "Wet" Water Management Strategies**: The community's sustainable future ultimately depends on maintaining a physical hydrologic link between renewable water sources and the infrastructure needed to reliably convey those waters to customers within the projected service area.
- **Sustainable Groundwater Use**: Tucson Water plans to limit its groundwater withdrawals at or below the hydrologically sustainable level to ensure the long-term viability of the aquifer within the Utility's service area.
- **Preserve City's Groundwater Credits for the Longer Term**: Tucson Water will use its groundwater credits as short-term transitional supplies while additional renewable supplies are acquired and/or developed. This would ensure that the water resources needed to support new growth will be hydrologically sustainable.
- **Acquire Additional Water Supplies**: The City of Tucson is exploring opportunities to acquire potentially available supplies to augment its water resources portfolio. The search for additional water resources will become increasingly competitive and costly, both locally and statewide. The Utility is encouraged that the Central Arizona Water Conservation District and stakeholder organizations are actively exploring ways to play a leading role in acquiring additional supplies for water interests in the three-county service area (encompassing Pima, Pinal, and Maricopa Counties).
- **Continue to Expand Regional Cooperation**: Tucson Water has taken steps to initiate new cooperative efforts and expand existing ones with local providers. These cooperative actions focus on acquiring additional sources of water, developing resource credit banking agreements, and initiating arrangements to wheel renewable resources within the region.
- **Continue to Accomplish Goals of the Action Plan**: Achieving the goals of the Action Plan for Sustainable Tucson will continue as recommendations in this Plan are implemented.

Demand Efficiency

Tucson Water works to secure a sustainable and reliable water supply for Tucson residents and water customers. Current water supply planning focuses on a long-term sustainable water supply and coordinated management of surface water and groundwater supplies. Tucson Water will continue to evaluate and update its water conservation program to ensure per capita water use does not exceed projections.

Additionally, Tucson Water is committed to meeting requirements set by ADWR's Third Management Plan. ADWR has set a 140 GPCD goal for residents in each AMA in the state. The Tucson AMA has already achieved this goal and is currently at 135 GPCD. Tucson Water is also committed to meeting ADWR's Fourth Management Plan preliminary potable GPCD goal for Tucson of 168.

Per capita water use is a key performance measure for any municipal water conservation program. Tucson's annual potable per capita water demand for 2012 was 135, down from 165 GPCD in 2000 and far below the Fourth Management Plan target. The current Tucson GPCD indicates that water is used more efficiently and demand continues to be curbed. This culture of conservation will support Tucson Water's future goals, policies, and objectives for conservation:

Goal

- Protect and enhance water resources through conservation and efficient water use.

Policies

- Provide an equitable distribution of conservation benefits throughout the customer classes and the community.
- Employ a mix of methods to achieve desired results.
- Develop and use guidelines for evaluating water conservation programs to modify existing programs and develop new ones.

Objectives

- Reinforce and strengthen the community's water conservation ethic.
- Maintain compliance with regulatory requirements.
- Ensure adequate supplies are available to meet customer demand and public health and safety needs.

One method of ensuring that new programs meet recommended goals, policies, and objectives is beginning new water conservation programs with a 3-year pilot phase. Community acceptance and cost effectiveness can be evaluated before they are approved for transition from pilot to permanent status. Low participation rates can be examined through surveys and marketing studies to aid efforts to promote greater participation.

Efficiency projects shall be evaluated to ensure that water savings are cost-effective. The current avoided-cost model used to evaluate cost effectiveness should be reviewed and compared with other models to determine which is most appropriate.

In addition, Tucson Water will strive for better coordination with other agencies, departments, and organizations on water management issues. This includes assessing green infrastructure, the urban heat island effect, etc., to evaluate the costs associated with efficient water use to improve the community's quality of life. Water use studies will identify the potential for improving water use efficiencies.

Lastly, the current Mayor and Council policies for water conservation appear to reflect conditions and needs from the 1980s. These should be updated to reflect the current situation.

Reassessing the Future

The recommended plan will periodically be reassessed and revised as planning assumptions and uncertainties unfold over time. Within the 50-year planning horizon, new water planning futures will undoubtedly materialize while those currently envisioned may evolve or fade away.

Tucson Water will continue to update and improve the planning tools developed to support this planning process. These tools will allow the Utility to update planning projections and to complete comprehensive revisions in an expeditious manner. Future updates and/or comprehensive revisions to this plan may be initiated by the following:

- Specific direction provided by the City of Tucson Mayor and Council.
- Significant changes in population or GPCD projections.
- Significant changes in the current or projected availability of Colorado River water.
- Marked changes in the regulatory environment in terms of water-quality and/or water-use requirements.
- Advent of new technologies that could alter costs and/or the technical effectiveness of planning elements.
- Major shifts in the water quality or resource preferences of Tucson Water customers.

Through integrated resource planning, Tucson Water has a portfolio of water resources that includes Colorado River water, groundwater, and recycled water. Tucson Water will ensure a reliable water future within its service area by continuing to reduce the community's reliance on groundwater while maximizing the use of renewable supplies. This includes ensuring water availability for the environment.

The Utility is also committed to continue upgrading its water storage and conveyance facilities, thus ensuring a highly reliable, redundant, and resilient link between its water supply sources and the community's many points of use.

By achieving the recommended objectives and continuing its commitment to planning and investment, Tucson Water will have sufficient water supplies to meet the community's water needs into the future. Even with an expected shortage in Colorado River water availability and gradually increasing demands, Tucson has a reliable portfolio of renewable and other water supplies throughout the current planning horizon of 2050.

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Attachment A

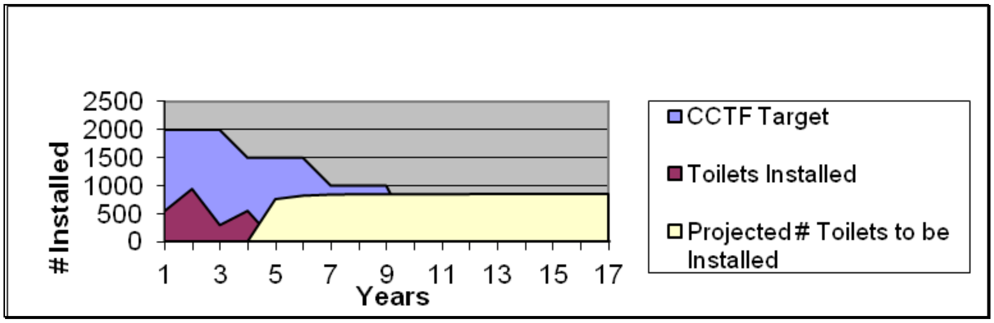
Future Participation in Conservation Rebate Programs

Participation in Conservation Rebate Programs

This appendix contains a series of figures illustrating participation in Tucson Water's conservation programs, emphasizing how the programs are measuring up to goals set by the Community Conservation Task Force (CCTF). Figures A1 through A7 show the number of units installed or rebates issued through the conservation programs to date, along with an extrapolation of how many years will pass until the CCTF goals are met. Figures A8 through A14 illustrate the geographic distribution of program participation throughout the Tucson Water service area.

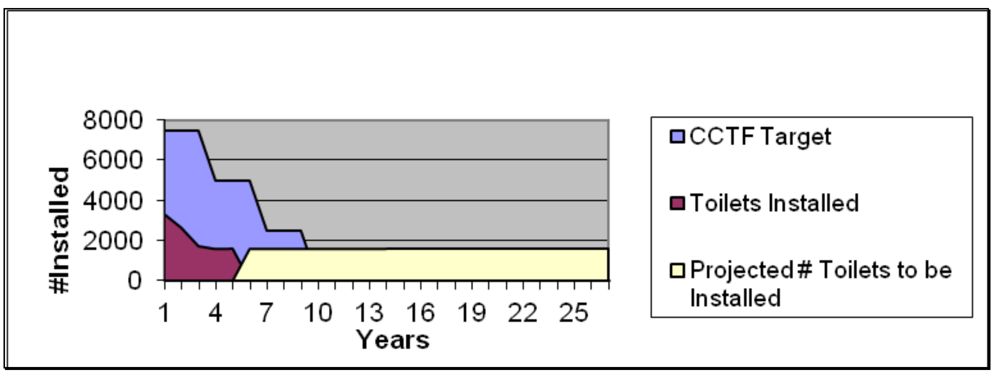
Figures

Figure A1. Community-based low-income high-efficiency toilet program replacement rate (July 2008)



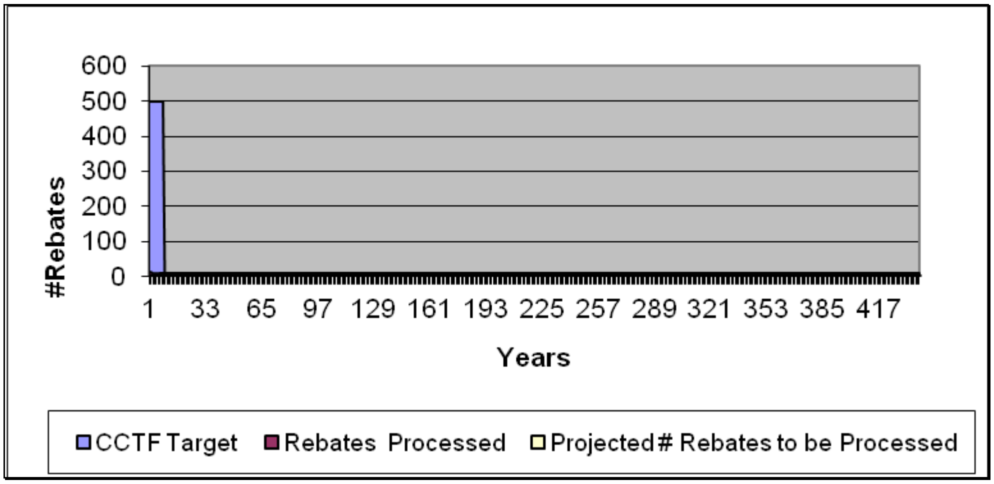
Since the program's inception in fiscal year (FY) 2008, 2,430 low-efficiency toilets have been replaced with high-efficiency toilets. At the current rate of replacement, it will take 17 years to meet the CCTF target. The CCTF target was set at 13,500 toilets to be replaced in 9 years (1.5 percent of the toilets projected to be changed out during that time). A market analysis is scheduled for FY 2014 that will recommend methods of increasing participation to accelerate program completion.

Figure A2. Single-family high-efficiency toilet program replacement rate (July 2008)



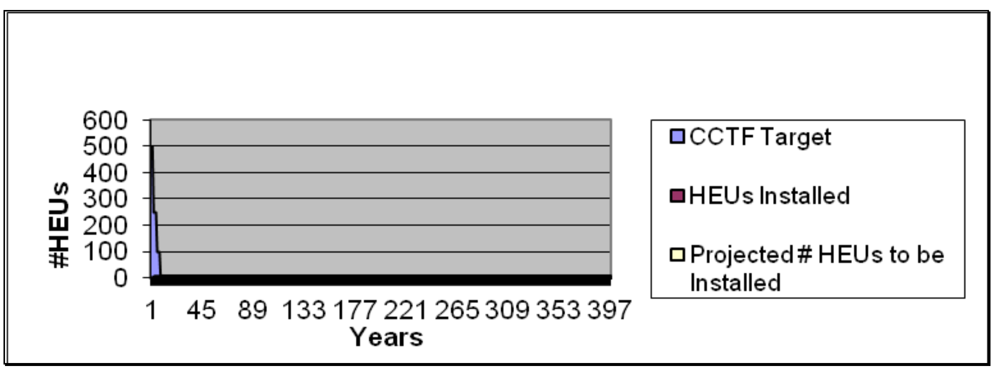
Since the program's inception in FY 2008, 9,542 low-efficiency toilets have been replaced with high-efficiency toilets. At the current rate of replacement, it will take 28 years to meet the CCTF target. The CCTF target was set at 45,500 toilets replaced in 9 years (roughly one-third of the toilets projected to be changed out during that time). A market analysis is scheduled for FY 2014 that will recommend methods of increasing participation to accelerate program completion.

Figure A3. Single-family gray water rebate incentive program installation rate (January 2011)



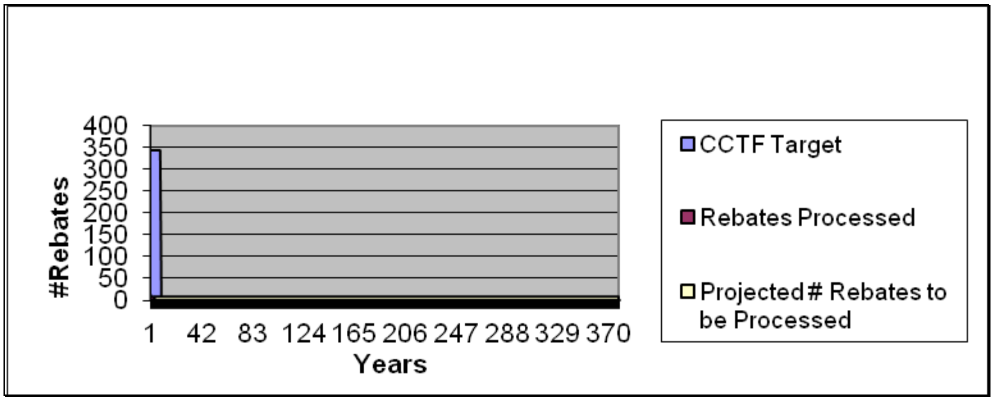
Since the program's inception in FY 2011, 28 gray water systems have been installed. At the current rate of installation, it will take 440 years to meet the CCTF target, which was set at 4,500 systems installed in 9 years (note that little supporting information was available to set the target for this program). In FY 2013, the rebate amount increased from $200, or one-third of the cost to install a system, to one-half the cost (up to $1,000). This increase was meant to boost program participation. A market analysis is scheduled for FY 2014 that will recommend methods of increasing participation to accelerate program completion.

Figure A4. Commercial/Industrial high-efficiency urinal program replacement rate (January 2011)



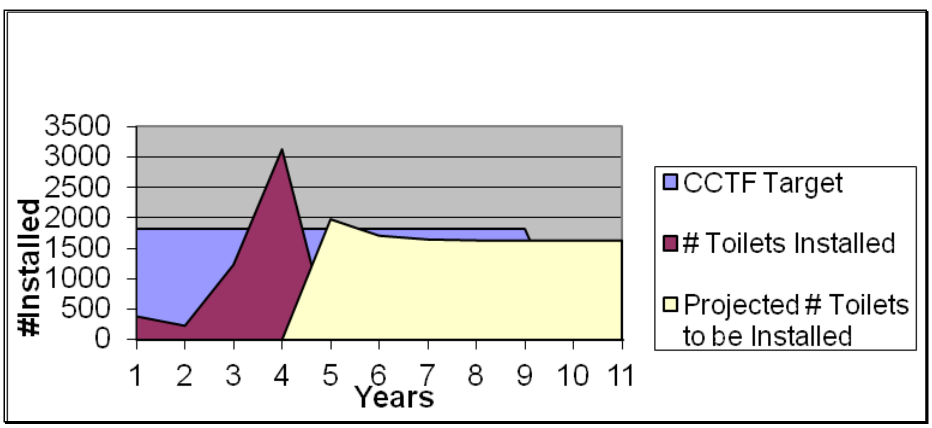
Since the program's inception in FY 2011, 15 low-efficiency urinals have been replaced with high-efficiency urinals. At the current rate of replacement, it will take 398 years to meet the CCTF target, which was set at 2,550 urinals replaced in 9 years (roughly one-half of the urinals in the Tucson Water service area). To increase participation rates, beginning in January 2013, the rebate was increased from $200 to $500 and the range of urinal options was expanded to include waterless models. A market analysis is scheduled for FY 2014 that will produce recommendations for increasing participation to accelerate program completion.

Figure A5. Commercial/Multi-family irrigation system upgrade program upgrade rate (July 2008)



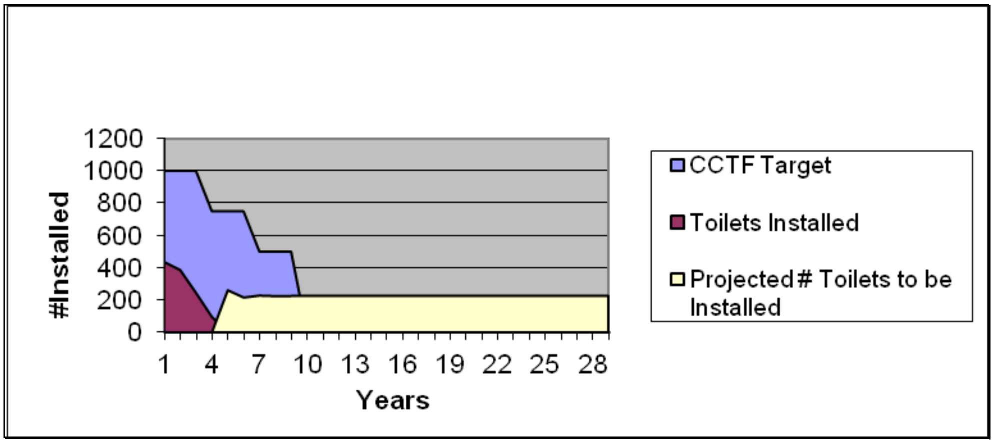
Since the program's inception in FY 2008, 30 irrigation systems have been upgraded. At the current rate, it will take 378 years to meet the CCTF target, which was set at 3,087 systems upgraded in 9 years (roughly 45 percent of the multi-family irrigation stock in the Tucson Water service area). A revised program will be implemented in the fall of 2013 to encourage participation. A market analysis is scheduled for FY 2014 that will recommend methods of increasing participation to accelerate program completion.

Figure A6. Multi-family high-efficiency toilet program replacement rate (2008)



Since the program's inception in FY 2008, 5,492 low-efficiency toilets have been replaced with high-efficiency toilets. The CCTF target was set at 16,443 toilets replaced in 9 years (an annual participation rate of 2 percent of low-efficiency toilets in multi-family dwelling units). At the current rate, it will take 11 years to meet the CCTF target. A market analysis scheduled for FY 2014 will recommend methods of increasing participation to accelerate program completion.

Figure A7. Commercial high-efficiency toilet program replacement rate (July 2008)



Since the program's inception in FY 2008, 1,291 low-efficiency toilets have been replaced with high-efficiency toilets. The CCTF target was set at 6,750 toilets installed in 9 years (roughly 20 percent of the low-efficiency toilets in the Tucson Water service area). At the current rate, it will take 29 years to meet the CCTF target. A market analysis is scheduled for FY 2014 that will recommend methods of increasing participation to accelerate program completion.

Figure A8. Single-family and low-income high-efficiency toilet rebate program participants

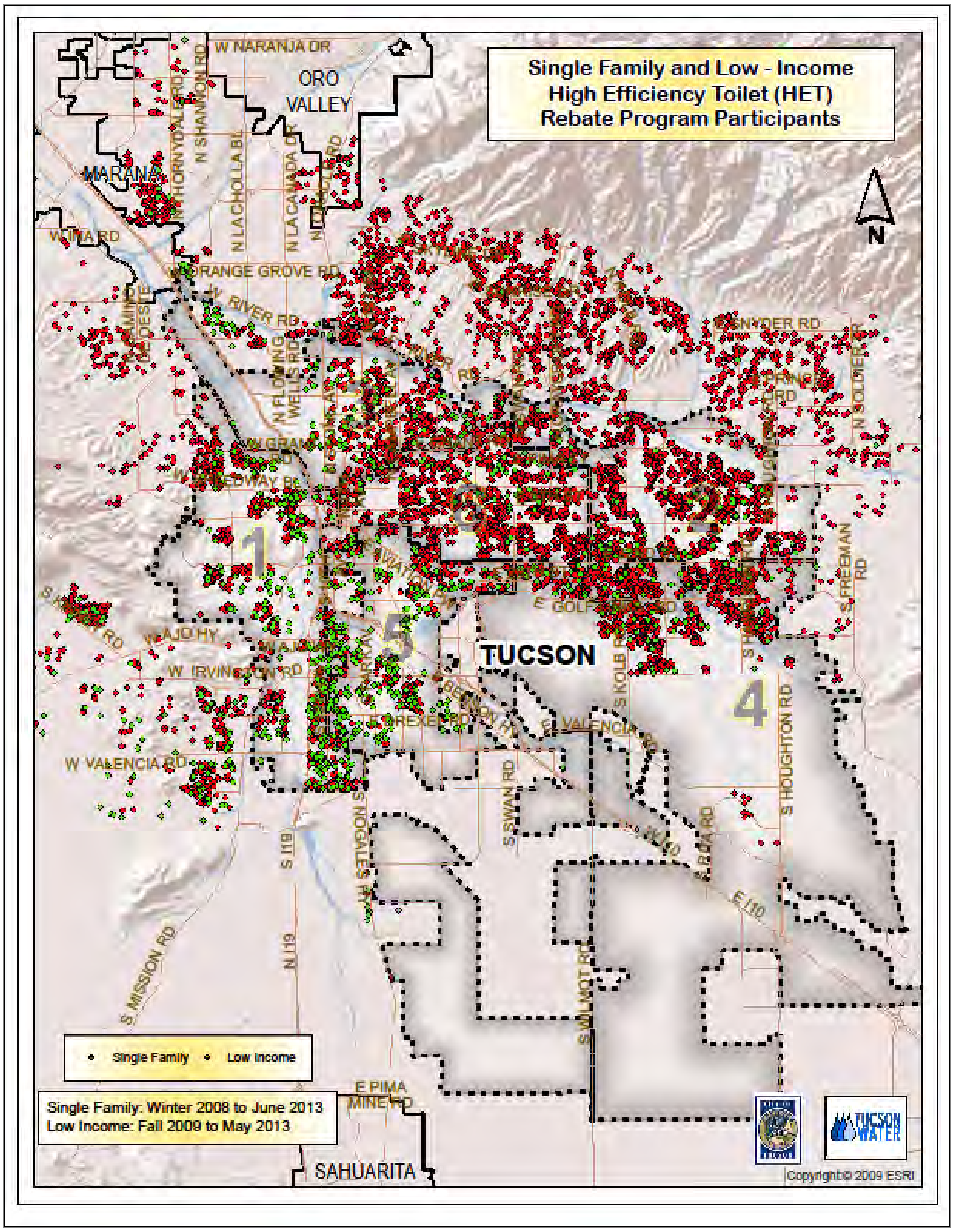


Figure A8 illustrates the distribution of the single-family and low-income programs. As expected, distribution of both programs has the highest uniformity in areas where housing stock has the greatest density. Together, these programs ensure single-family households across the service area have an opportunity to participate in water savings by changing out low-efficiency toilets.

Figure A9. Commercial and multi-family high-efficiency toilet rebate program participants

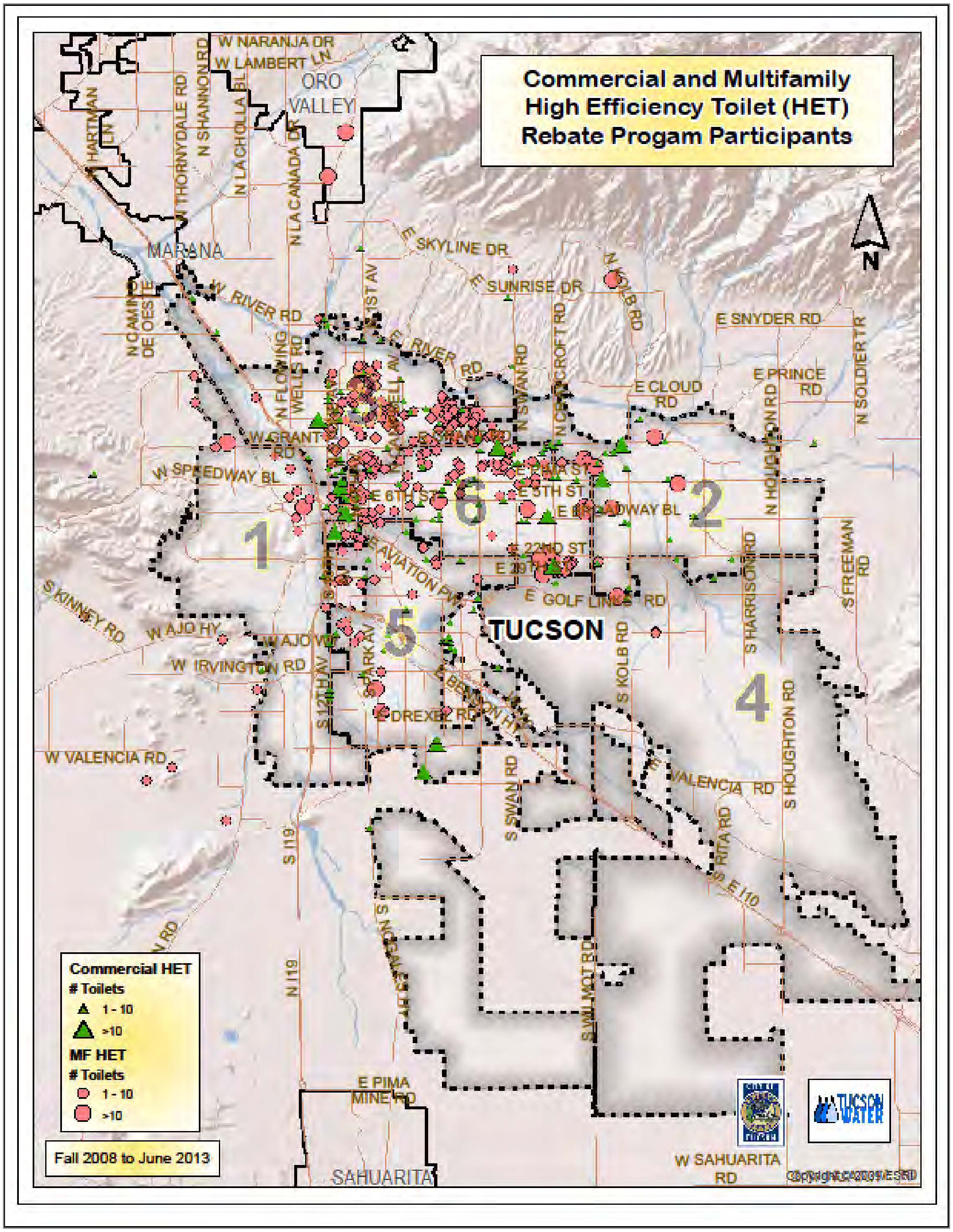


Figure A9 illustrates how participation in the commercial and multi-family high-efficiency toilet rebate programs has the highest distribution in central Tucson, where both commercial uses and multi-family housing stock have the greatest density.

Figure A10. Rainwater harvesting demonstration sites and rebate program participants

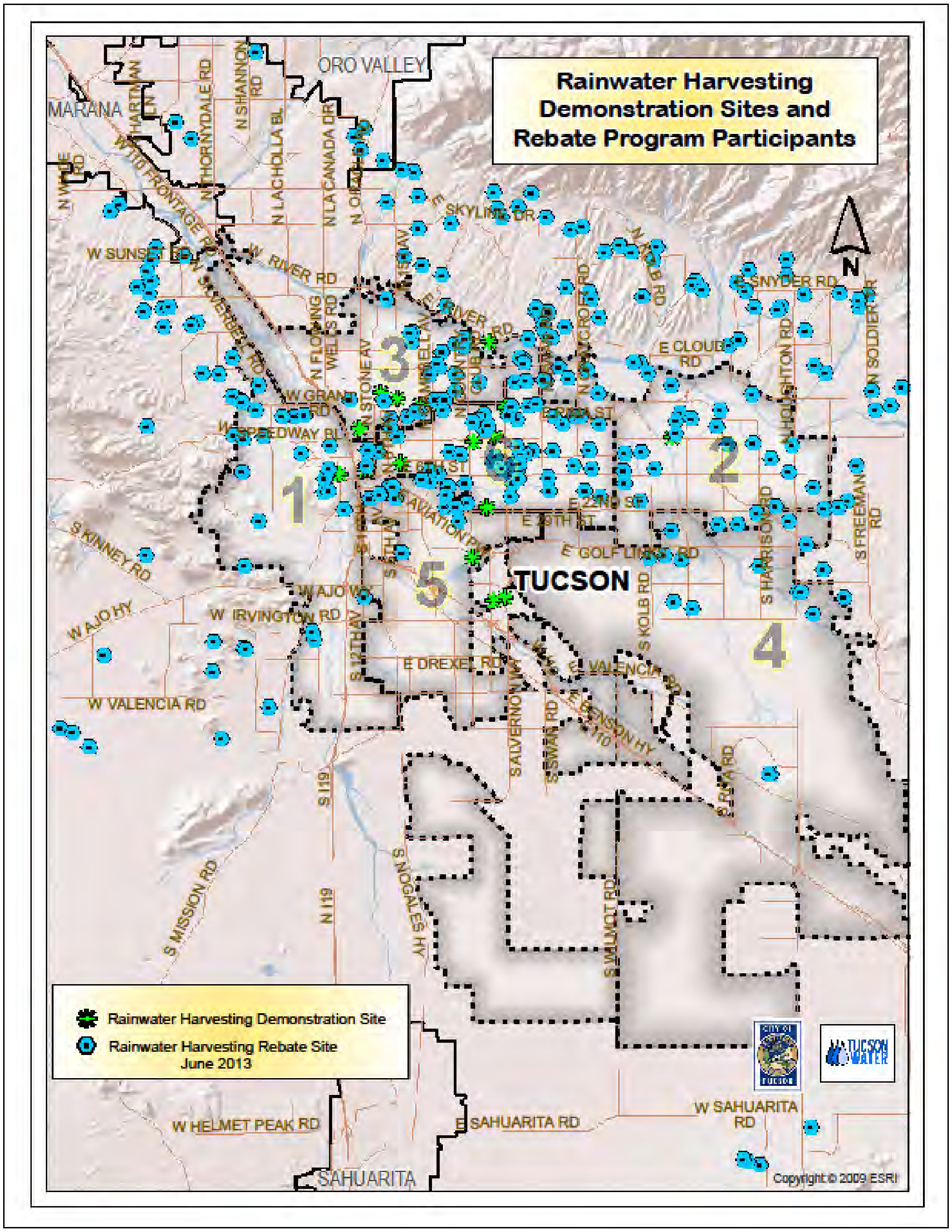


Figure A10 illustrates the distribution of rainwater harvesting demonstration sites and rainwater harvesting rebate program participants. The rainwater harvesting demonstrations sites are centralized, located in both public and commercial sites. Rebate program participant distribution tends to focus on the central and northern areas of the Tucson Water service area. A market analysis is scheduled for FY 2014 that will recommend methods of increasing participation across the Tucson Water service area.

Figure A11. Gray water, irrigation, and high-efficiency urinal rebate program participants

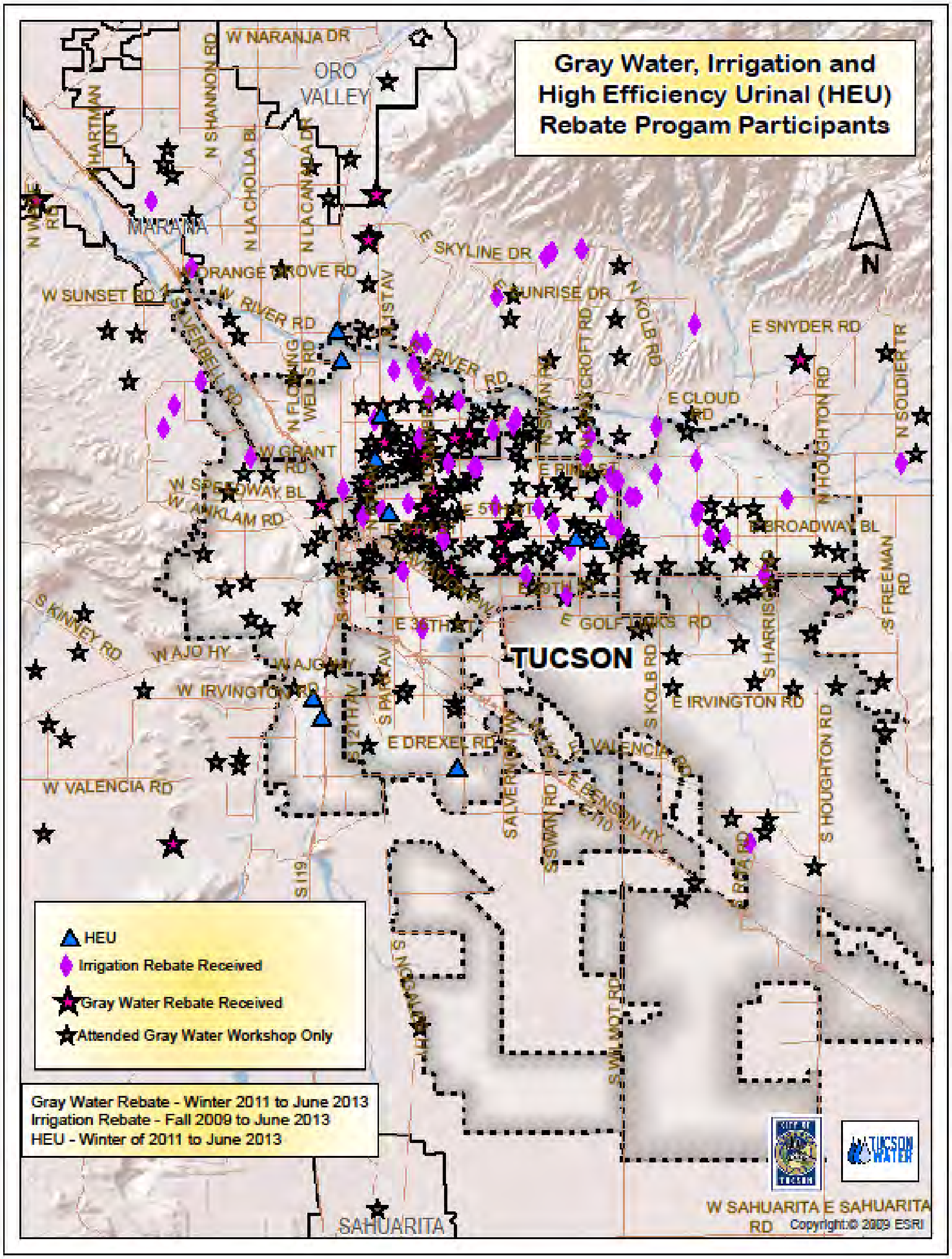


Figure A11 illustrates the distribution of the gray water, irrigation, and high-efficiency urinal rebate program participants. The distribution for each program tends to be centralized. A market analysis is scheduled for FY 2014 that will recommend methods of increasing participation across the Tucson Water service area.

Figure A12. Tucson Water school-age education programs

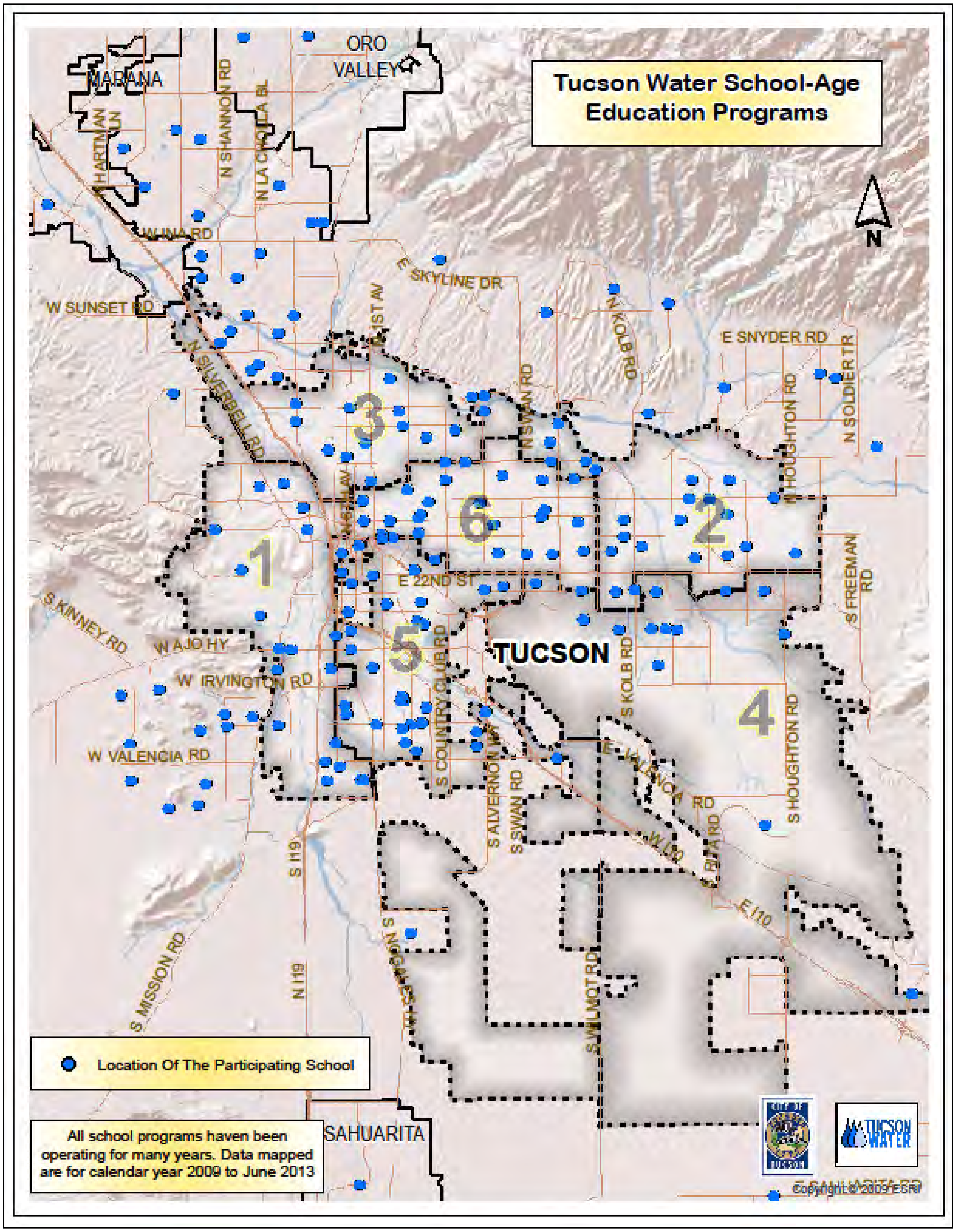


Figure A12 illustrates the distribution of the Tucson Water school-age education programs. The school-age education programs are offered to all schools that would like to participate in the program and are evenly distributed throughout the Tucson Water service area.

Figure A13. SmartScape class attendees

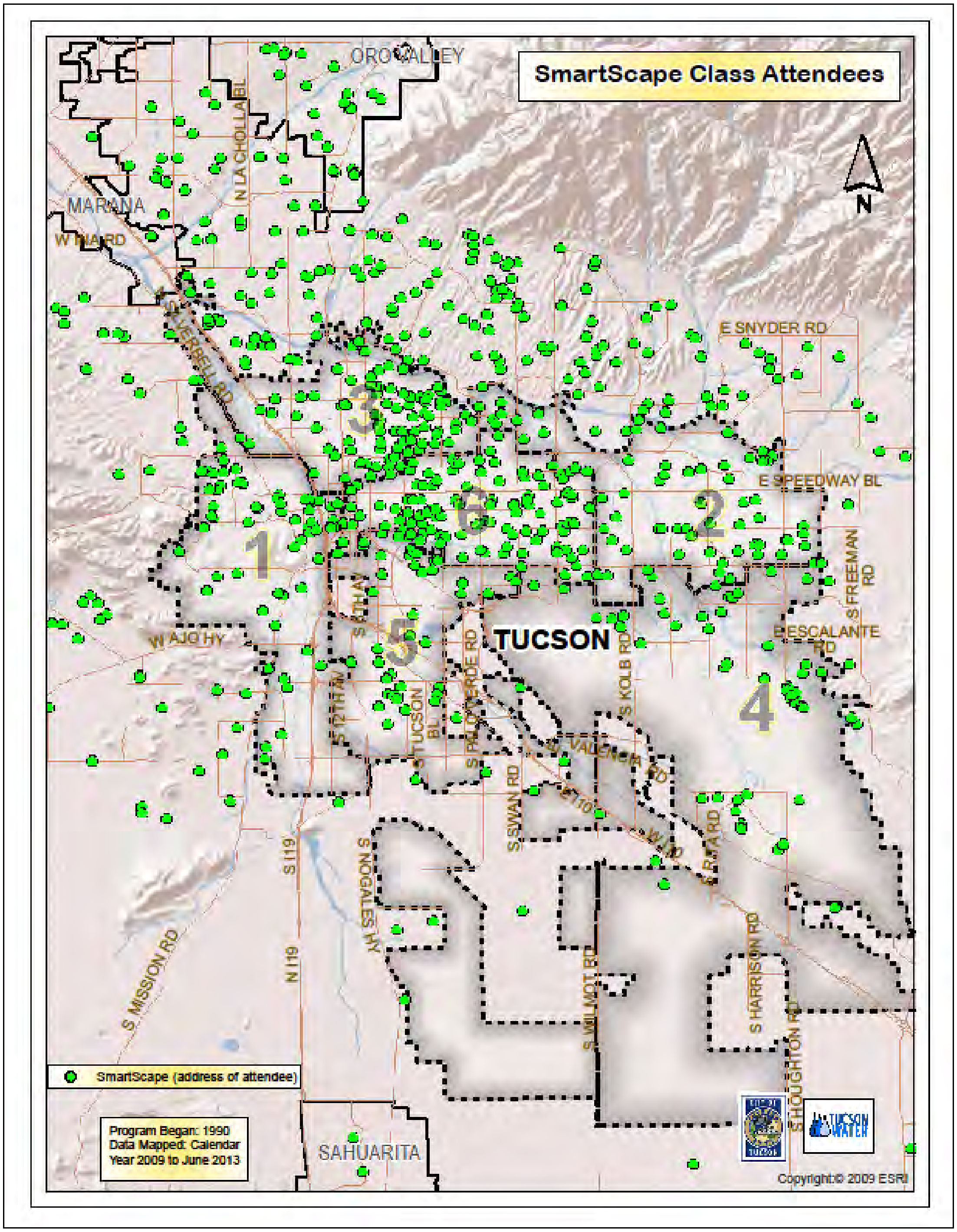


Figure A13 illustrates the distribution of the SmartScape class attendees. The distribution is both dense and uniform, showing that enrollment is high and that the classes are well-attended across the Tucson Water service area.

Figure A14. WaterSmart Business Program participants

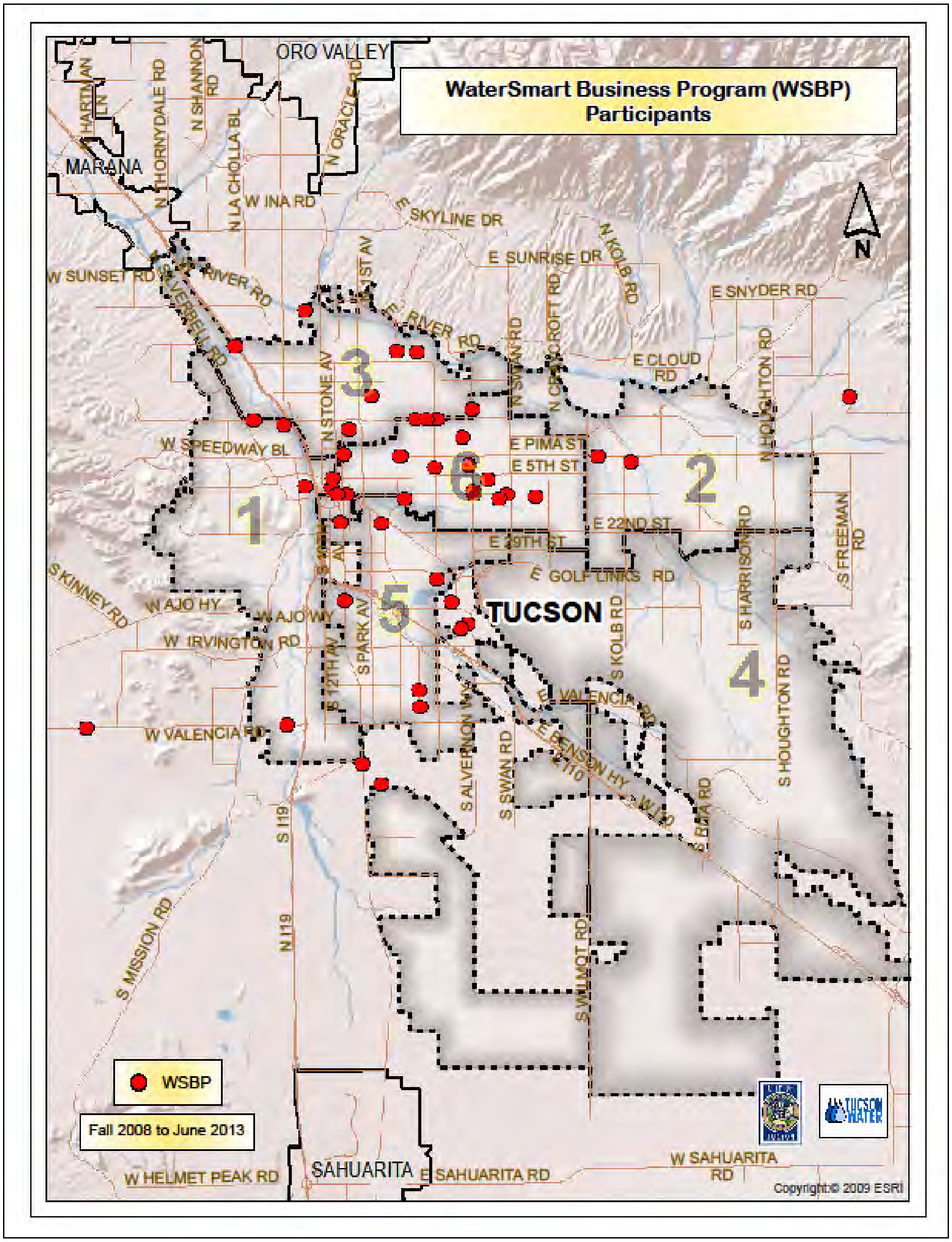


Figure A14 illustrates the distribution of the WaterSmart Business Program participants. The distribution tends to be centralized and located in commercial-use corridors, as expected. The WaterSmart Business Program is currently being redesigned to increase participation.

Attachment B

Executive Summary, Colorado River Basin Water Supply and Demand Study

RECLAMATION
Managing Water in the West

Colorado River Basin Water Supply and Demand Study

Executive Summary – Pre-Production Copy

U.S. Department of the Interior
Bureau of Reclamation

December 2012

Colorado River Basin Water Supply and Demand Study

Executive Summary – Pre-Production Copy

U.S. Department of the Interior
Bureau of Reclamation

December 2012

Executive Summary

Spanning parts of the seven states of Arizona, California, Colorado, New Mexico, Nevada, Utah, and Wyoming (Basin States), the Colorado River Basin (Basin) is one of the most critical sources of water in the West. The Colorado River and its tributaries provide water to nearly 40 million people for municipal use, supply water used to irrigate nearly 5.5 million acres of land, and is also the lifeblood for at least 22 federally recognized tribes (tribes), 7 National Wildlife Refuges, 4 National Recreation Areas, and 11 National Parks. Hydropower facilities along the Colorado River provide more than 4,200 megawatts of generating capacity, helping to meet the power needs of the West and offset the use of fossil fuels. The Colorado River is also vital to the United Mexican States (Mexico) to meet both agricultural and municipal water needs.

The Colorado River system is operated in accordance with the Law of the River[1]. Apportioned water in the Basin exceeds the approximate 100-year record (1906 through 2011) Basin-wide average long-term historical natural flow[2] of about 16.4 million acre-feet (maf). However, the Upper Basin States have not fully developed use of their 7.5-maf apportionment, and total consumptive use[3] and losses in the Basin has averaged approximately 15.3[4] maf over the last 10 years. Because of the Colorado River system's ability to store approximately 60 maf, or nearly 4 years of average natural flow of the river, all requested deliveries were met in the Lower Basin despite recently experiencing the worst 11-year drought in the last century. However, there have been periodic shortages throughout the Upper Basin and the adjacent areas of the Basin States that receive Colorado River water.

The challenges and complexities of ensuring a sustainable water supply and meeting future demand in an over-allocated and highly variable system such as the Colorado River have been recognized and documented in several studies conducted by the Bureau of Reclamation (Reclamation) and the Basin States over the past several decades. Looking ahead, concerns regarding the reliability of the Colorado River system to meet future Basin resource[5] needs are even more apparent, given the likelihood of increasing demand for water throughout the Basin coupled with projections of reduced supply due to climate change.

It was against this backdrop that the Colorado River Basin Water Supply and Demand Study (Study) was conducted. Funded by the Reclamation through the Basin Study Program under

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[1] The treaties, compacts, decrees, statutes, regulations, contracts and other legal documents and agreements applicable to the allocation, appropriation, development, exportation and management of the waters of the Colorado River Basin are often collectively referred to as the Law of the River. There is no single, universally agreed upon definition of the Law of the River, but it is useful as a shorthand reference to describe this longstanding and complex body of legal agreements governing the Colorado River.

[2] Natural flow represents the flow that would have occurred at the location had depletions and reservoir regulation not been present upstream of that location.

[3] Consumptive use is defined as water used, diminishing the available supply.

[4] Basin-wide consumptive use and losses estimated over the period 2002-2011, including the 1944 Treaty delivery to Mexico, reservoir evaporation, and other losses due to native vegetation and operational inefficiencies.

[5] Resources include water allocations and deliveries for municipal, industrial, and agricultural use; hydroelectric power generation; recreation; fish, wildlife, and their habitats (including candidate, threatened, and endangered species); water quality including salinity; flow- and water-dependent ecological systems; and flood control.

the Department of the Interior's WaterSMART (Sustain and Manage America's Resources for Tomorrow) Program and the agencies[6] representing the Basin States, the Study was conducted by Reclamation's Upper Colorado and Lower Colorado Regions and the representatives of the Basin States' agencies. The purpose of the Study was to define current and future imbalances in water supply and demand in the Basin and the adjacent areas of the Basin States that receive Colorado River water over the next 50 years (through 2060), and to develop and analyze adaptation and mitigation strategies to resolve those imbalances. The Study did not result in a decision as to how future imbalances should or will be addressed. Rather, the Study provides a common technical foundation that frames the range of potential imbalances that may be faced in the future and the range of solutions that may be considered to resolve those imbalances.

The Study Area is shown in figure 1 and is defined as the hydrologic boundaries of the Basin within the United States, plus the adjacent areas of the Basin States that receive Colorado River water. In many adjacent areas, the Colorado River supply is in addition to other water supply sources used to meet water demands.

[6] The non-Federal cost-share partners are: Arizona Department of Water Resources, the (California) Six Agency Committee, Colorado Water Conservation Board, the New Mexico Interstate Stream Commission, the Southern Nevada Water Authority, the Utah Division of Water Resources, and the Wyoming State Engineer's Office.

FIGURE 1
The Study Area

The Study was conducted in collaboration with stakeholders throughout the Basin. Interest in the Study was broad, and stakeholders included tribes, agricultural users, purveyors of municipal and industrial (M&I) water, power users, and conservation and recreation groups. Through outreach efforts, these interested parties were engaged and their input was considered. This broad participation and input was critical to the Study.

Because of the inherent complexities of the Study and the many diverse interests and perspectives, interim reports and technical updates were published to reflect technical developments and the ongoing input of stakeholders. Throughout the course of the Study, eight of these interim products were published. The final documentation for the Study is organized into three major parts: this *Executive Summary*, a *Study Report*, and seven Technical Reports.

Project participants and stakeholders are encouraged to comment on the information provided in the final *Study Report* and associated Technical Reports. Written comments should be submitted within 90 days following the release of this report. The comments will be summarized and posted to the Study website, and may inform future planning activities in the Basin. Instructions for submitting comments are also provided on the Study website at: http://www.usbr.gov/lc/region/programs/crbstudy.html

1.0 Projected Future Water Supply and Demand Scenarios

The amount of water available and changes in the demand for water throughout the Basin over the next 50 years are highly uncertain and depend on a number of factors. The potential impacts of future climate change and variability further contribute to these uncertainties. Nevertheless, projections of future water supply and demand were needed to assess the reliability of the Colorado River system to meet Basin resource needs and to identify options and strategies to mitigate future risks to those resources. To be beneficial, these projections must be sufficiently broad to capture the plausible ranges of uncertainty in future water supply and demand. A scenario planning process was used to guide the development of scenarios that provided a broad range of projections, resulting in four scenarios related to future water supply and six scenarios related to future water demand.

1.1 Water Supply Scenarios

Since 2004, Reclamation has conducted a multi-faceted research and development programs to investigate and implement a variety of methods for projecting future streamflow for Colorado River planning studies. Based on this work and the information gathered in the scenario planning process, four water supply scenarios were quantified and analyzed. These scenarios are titled Observed Resampled, Paleo Resampled, Paleo Conditioned, and Downscaled General Circulation Model (GCM) Projected and are described as:

- **Observed Resampled:** Future hydrologic trends and variability are similar to the past approximately100 years.
- **Paleo Resampled:** Future hydrologic trends and variability are represented by reconstructions of streamflow for a much longer period in the past (nearly 1,250 years) that show expanded variability.

- **Paleo Conditioned:** Future hydrologic trends and variability are represented by a blend of the wet-dry states of the longer paleo reconstructed period (nearly 1,250 years), but magnitudes are more similar to the observed period (about 100 years).
- **Downscaled GCM Projected:** Future climate will continue to warm with regional precipitation and temperature trends represented through an ensemble of 112 future downscaled GCM projections.

Under the Downscaled GCM Projected scenario, the mean natural flow at Lees Ferry over the next 50 years is projected to decrease by approximately 9 percent, along with a projected increase in both drought frequency and duration as compared to the observed historical and paleo-based scenarios. The range of this result varies amongst the individual GCM projections that comprise this scenario with some of the GCM projections showing a larger decrease in mean natural flow than 9 percent while others showing an increase over the observed historical mean. Droughts[7] lasting 5 or more years are projected to occur 50 percent of the time over the next 50 years. Projected changes in climate and hydrologic processes include continued warming across the Basin, a trend towards drying (although precipitation patterns continue to be spatially and temporally complex) increased evapotranspiration and decreased snowpack as a higher percentage of precipitation falls as rain rather than snow and warmer temperatures cause earlier melt.

The process of using GCM projections and hydrologic modeling to generate projections of future streamflow presents a number of uncertainties and reflects methodological choices made in the Study. For example, choices of different downscaling techniques or the selection of a different hydrologic model to determine streamflow would yield different results. Notwithstanding minor methodological and reporting differences, the results presented in this report are consistent with Reclamation's report to Congress published in March 2011[8] in fulfillment of the requirements within Section (§) 9503 of the SECURE Water Subtitle of the Omnibus Public Land Management Act of 2009 (Public Law 111-11).

1.2 Water Demand Scenarios

Historically, Reclamation has considered a single projection of future demands in long-term Basin planning studies. The Study considered a range of projections of demand, developed through a scenario planning process, which is a significant and important advancement in long-term water planning in the Basin. These demands were based on data and information provided by the Basin States, tribes, federal agencies, and other water entitlement holders. Through the scenario planning process, the most critical uncertainties affecting future demand were identified (for example, changes in population and water use efficiency) and were combined into six scenarios, as follows: Current Projected (A), Slow Growth (B), Rapid Growth (C1 and C2), and Enhanced Environment (D1 and D2).

Based on these scenarios, and factoring in both Mexico's allotment and water loss due to evaporation and operations, the Colorado River demand for consumptive uses is projected to range between about 18.1 maf under the Slow Growth (B) scenario and about 20.4 maf under

[7] For the purpose of the Study, a drought period occurs whenever the running 2-year average flow at Lees Ferry falls below 15.0 maf, the observed historical long-term mean.

[8] Bureau of Reclamation, 2011. SECURE Water Act Section 9503(c) – Reclamation Climate Change and Water 2011.

the Rapid Growth (C1) scenario by 2060. The largest increase in demand is projected to be in the M&I category, owing to population growth. Population within the Study Area is projected to grow from about 40 million in 2015 to between 49.3 million under the Slow Growth (B) scenario and 76.5 million under the Rapid Growth (C1) scenario by 2060. Additionally, the water demand assessment confirmed that the Lower Division States have demand for Colorado River water beyond their 7.5 maf basic apportionment across all scenarios.

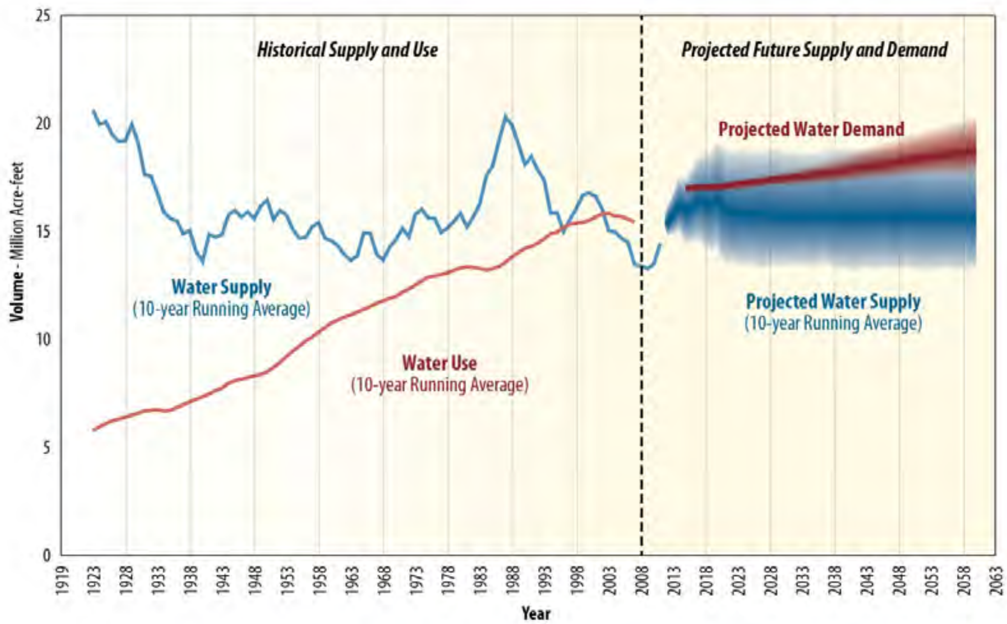
Non-consumptive[9] demands, such as those associated with uses for hydropower and recreation and ecological resources, were included through the development of system reliability metrics and were not quantified in the same manner as demand for consumptive uses. For example, non-consumptive flow targets supporting the environment and recreational activities were developed for several locations throughout the Basin. The impact on these resources was assessed across all combinations of supply and demand scenarios in the Study's system reliability analysis.

2.0 Projected Future Water Supply and Demand Imbalances

The range of the projected future water supply and demand in the Basin, as determined through the scenario process, is shown conceptually in figure 2. Without additional future water management actions, a wide range of future imbalances is plausible, primarily due to the uncertainty in future water supply. Comparing the median of water supply projections against the median of the water demand projections (medians are indicated by the darker shading), the long-term projected imbalance in future supply and demand is about 3.2 maf by 2060. The imbalance, however, can be much greater (or less) under any one of the multiple plausible future supply and demand scenarios. The projected imbalance in figure 2 does not consider the effect of reservoir storage, which has and will continue to be used to meet Basin resource needs when demand exceeds supply. Through modeling and the use of system reliability metrics, which consider the effects of reservoir storage, the potential impacts associated with these imbalances to Basin resources were assessed.

[9] Non-consumptive use is defined as water used without diminishing available supply.

FIGURE 2
Historical Supply and Use[1] and Projected Future Colorado River Basin Water Supply and Demand[1]



[1] Water use and demand include Mexico's allotment and losses such as those due to reservoir evaporation, native vegetation, and operational inefficiencies.

3.0 Options and Strategies to Resolve Supply and Demand Imbalances

The Basin States have made significant investments in developing other water resources and implementing programs and policies to balance current and future supplies with existing and future demands. Many of these efforts have resulted in solutions to past water management challenges and will continue to provide benefit to the system in meeting the challenges that lie ahead.

To identify a broad range of additional potential options to resolve water supply and demand imbalances, input from Study participants, interested stakeholders, and the general public was solicited for consideration in the Study. The solicitation period was from November 2011 through February 2012, and those interested in submitting ideas were asked to complete and submit an option submittal form. During this period, over 150 options were received and were organized into 4 groups: 1) those that increase Basin water supply (Increase Supply), 2) those that reduce Basin water demand (Reduce Demand), 3) those that focus on modifying operations (Modify Operations), and 4) those that focus primarily on Basin governance and mechanisms to facilitate option implementation (Governance and Implementation). Despite the submission of several options that may ultimately be considered too costly or technically infeasible, the Study explored a wide range of options with the goal of ensuring that all viable options were considered.

From these broad groups, categories of options were developed, and each submitted option was assigned to one category based on its primary function. Recognizing that every option submitted could not undergo further evaluation due to time and resource constraints, representative options that spanned the range of the option categories were developed. About 30 representative options were developed to ensure the concepts embodied in each submitted option were reflected and were further evaluated. Many of the representative options were evaluated quantitatively, which entailed an assessment of cost, yield, and timing in addition to assignment of a rating ("A" through "E") to 14 other criteria, listed in table 1.

TABLE 1
Criteria Used to Evaluate Representative Options

Technical	Environmental	
Technical Feasibility Implementation Risks Long-Term Viability Operational Flexibility	Permitting Energy Needs Energy Source Other Environmental Factors	
Social	**Other**	
Recreation Policy Legal Socioeconomics	Quantity of Yield Timing Cost	Hydropower Water Quality

Whereas many of the criteria were assigned a qualitative rating, the assessment of cost, quantity of yield, and timing entailed numeric estimates to facilitate the grouping of these options into portfolios and the modeling of those portfolios. Costs were computed as present day annualized capital, operating, and replacement cost per acre-foot of option yield. It should be noted that the assessment of these criteria was at an appraisal level and there are many associated uncertainties, especially with respect to estimates regarding costs and quantity of yield. For representative options for which the criteria listed in table 1 was not suitable, such as those options in the Governance and Implementation group, a qualitative description was provided. A summary of the representative options within the Increase Supply, Reduce Demand, and Modify Operations groups and the cost, yield, and timing, and inclusion in portfolios, where applicable, is provided in table 2.

The Governance and Implementation group consists of ideas and suggestions related to three major categories: Water Management and Allocation, Tribal Water, and Data and Information. Most concepts related to Water Management and Allocation and Tribal Water have significant legal and policy considerations and were included in the Study but were not assessed. Where appropriate, these concepts will require future discussions beyond the scope of the Study. Data and Information ideas recommended future data and tool development to support future planning activities in the Basin.

TABLE 2
Summary of Representative Options Including Cost, Timing, Potential Yield, and Inclusion in Portfolios

Option Type	Option Category	Representative Option	Estimated Cost ($/afy)	Years before Available	Potential Yield by 2035 (afy)	Potential Yield by 2060 (afy)	Option Included in Portfolio
Increase Supply	Desalination	Gulf of California	2,100	20 – 30	200,000	1,200,000	Portfolios A, B (up to 400 kafy)
		Pacific Ocean in California	1,850–2,100[1]	20–25	200,000	600,000	Portfolios A, B (up to 400 kafy)
		Pacific Ocean in Mexico	1,500	15	56,000	56,000	Portfolios A, B
		Salton Sea Drainwater	1,000	15–25	200,000	500,000	All Portfolios
		Groundwater in Southern California	750	10	20,000	20,000	All Portfolios
		Groundwater in the Area near Yuma, Arizona	600	10	100,000	100,000	All Portfolios
		Subtotal			**776,000**	**2,476,000**	
	Reuse	Municipal Wastewater	1,500–1,800	10–35	200,000	932,000	All Portfolios
		Grey Water	4,200	10	178,000	178,000	Portfolio C
		Industrial Wastewater	2,000	10	40,000	40,000	All Portfolios
		Subtotal			**418,000**	**1,150,000**	
	Local Supply	Treatment of Coal Bed Methane-Produced Water	2,000	10	100,000	100,000	Portfolios A, B
		Rainwater Harvesting	3,150	5	75,000	75,000	Portfolio C
		Subtotal			**175,000**	**175,000**	
	Watershed Management	Brush Control	7,500	15	50,000	50,000	None
		Dust Control	220–520	15–25	280,000	400,000	Portfolios A, C
		Forest Management	500	20–30	200,000	300,000	None
		Tamarisk Control	400	15	30,000	30,000	Portfolios A, C
		Weather Modification	30–60	5–45	700,000	1,700,000	All Portfolios (up to 300 kafy)
		Subtotal			**1,260,000**	**2,480,000**	

TABLE 2
Summary of Representative Options Including Cost, Timing, Potential Yield, and Inclusion in Portfolios

Option Type	Option Category	Representative Option	Estimated Cost ($/afy)	Years before Available	Potential Yield by 2035 (afy)	Potential Yield by 2060 (afy)	Option Included in Portfolio
Increase Supply	Importation	Imports to the Colorado Front Range from the Missouri or Mississippi Rivers	1,700–2,300	30	0	600,000	Portfolios A, B
		Imports to the Green River from the Bear, Snake[1] or Yellowstone Rivers	700–1,900	15	158,000	158,000	None
		Imports to Southern California via Icebergs, Waterbags, Tankers, or from the Columbia River[1]	2,700–3,400	15	600,000	600,000	None
		Subtotal			**758,000**	**1,358,000**	
Reduce Demand	M&I Water Conservation	M&I Water Conservation	500–900	5–40	600,000	1,000,000	All Portfolios
		Subtotal			**600,000**	**1,000,000**	
	Agricultural Water Conservation	Agricultural Water Conservation	150–750	10–15	1,000,000	1,000,000	All Portfolios
		Agricultural Water Conservation with Transfers	250–750	5–15	1,000,000	1,000,000	All Portfolios
		Subtotal			**1,000,000[2]**	**1,000,000[2]**	
	Energy Water Use Efficiency	Power Plant Conversion to Air Cooling	2,000	10	160,000	160,000	All Portfolios
		Subtotal			**160,000**	**160,000**	
Modify Operations	System Operations	Evaporation Control via Canal Covers	15,000	10	18,000	18,000	None
		Evaporation Control via Reservoir Covers	15,000	20	200,000	200,000	None
		Evaporation Control via Chemical Covers on Canals or Reservoirs	100	15–25	200,000	850,000	None

TABLE 2
Summary of Representative Options Including Cost, Timing, Potential Yield, and Inclusion in Portfolios

Option Type	Option Category	Representative Option	Estimated Cost ($/afy)	Years before Available	Potential Yield by 2035 (afy)	Potential Yield by 2060 (afy)	Option Included in Portfolio
		Modified Reservoir Operations	N/A	15	0–300,000	0–300,000	None
		Construction of New Storage	2,250	15	20,000	20,000	None
		Subtotal			**588,000**[3]	**1,238,000**[3]	
	Water Transfers, Exchanges, and Banking	Water Transfers and Exchanges (same as Agricultural Water Conservation with Transfers)	250–750	5–15	1,000,000	1,000,000	All Portfolios
		Upper Basin Water Banking[4]	N/A	10	500,000	800,000	Portfolios A,C
		All Options			**5,735,000**[5]	**11,037,000**[5]	

[1]Among the more than 150 options submitted to Reclamation as responsive to the *Plan of Study*, additional importation of water supplies from various sources, including importation of water from the Snake and Columbia River systems, were submitted to the Study. Such options were appropriately reflected in the Study but did not undergo additional analysis as part of a regional or river basin plan or any plan for a specific Federal water resource project. This Study is not a regional or river basin plan or proposal or plan for any Federal water resource project

[2] The two agricultural water conservation representative options derive potential yield from similar measures and are thus not additive

[3] Subtotal assumes 150,000 afy for the Modified Reservoir Operations representative option.

[4] The values related to Upper Basin Banking reflected assumptions developed for modeling purposes. It was assumed that bank water is generated through conservation; therefore, the potential yield of the bank is consistent with the Upper Basin portion of agricultural and M&I conservation and energy water use efficiency

[5] Total does not account for several options that may be mutually exclusive due to regional integration limitations or are dependent on the same supply.

When considering all options and all categories, the potential yield is approximately 5.7 maf per year (mafy) by 2035 and more than 11 mafy by 2060. However, not all options are equally feasible or reliable in the long term. Some options, such as imports into southern California via submarine pipelines, water bags, icebergs, or those related to watershed management (e.g. weather modification or dust control), have either significant technical feasibility challenges or significant questions regarding their reliability. Excluding options that rate low for these factors, the potential yield is reduced to approximately 3.7 mafy by 2035 and to approximately 7 mafy by 2060.

Recognizing no single option will be sufficient to resolve future projected supply and demand imbalances, groups of options, or portfolios, were developed to reflect different adaptive strategies. Each portfolio consists of a unique combination of options that were considered to address Basin resource needs—for example, the water elevation in Lake Mead— that may exist under future combinations of supply and demand. Four portfolios were evaluated in the Study and represent a range of reasonable but different approaches for resolving future supply and demand imbalances. The portfolios are not intended to represent all possible strategies for grouping options. Further, the Study does not result in the selection of a particular portfolio or any one option from any portfolio. The objective of the portfolio analyses is to demonstrate the effectiveness of different strategies in resolving future supply and demand imbalances.

Using the ratings associated with the criteria listed in table 1 to express certain preferences towards a future strategy, resulted in two portfolios, *Portfolio B* and *Portfolio C*. Two other portfolios were then developed, *Portfolio A* and *Portfolio D*, to represent a highly inclusive strategy (includes all options in either *Portfolio B* or *Portfolio C*) and a highly selective strategy (includes only options in both *Portfolio B* and *Portfolio C*). The four portfolios considered in the Study are summarized in table 3.

Portfolio B is based on a strategy that seeks long-term water supply reliability through implementation of options with high technical feasibility and long-term reliability. The strategy can be defined as seeking options with proven technology that, once in place, will produce reliable long-term yield. The strategy represents a low-risk strategy in the long term, but allows greater risk with respect to permitting and implementation.

Portfolio C focuses on options that are technically feasible but also may have lower environmental impacts—low energy needs, lower carbon energy sources, low permitting risk, and low impacts to other environmental factors. The strategy can be defined as one that prioritizes options providing long-term solutions that are flexible and seek to enhance ecological and recreational flows while minimizing the effects on other Basin resources. The strategy represents a low-risk strategy in the near term but allows greater risk with respect to long-term performance of conservation measures.

TABLE 3
Study Portfolios

Portfolio Name	Portfolio Description
Portfolio A	Is the least restrictive and contains all options that are in both *Portfolio B* and *Portfolio C*.
Portfolio B	Includes options with high technical feasibility and high long-term reliability; excludes options with high permitting, legal, or policy risks.
Portfolio C	Includes only options with relatively low energy intensity; includes an option that results in increased instream flows; excludes options that have low feasibility or high permitting risk.
Portfolio D	Is the most selective and contains only those options that are included in both *Portfolio B* and *Portfolio C*.

4.0 Evaluation of Opportunities to Resolve Supply and Demand Imbalances

The evaluation of the effectiveness of the four portfolios at resolving future potential supply and demand imbalances consisted of the following: identifying the reliability of the system at meeting Basin resource needs under all future supply and demand scenarios without portfolios in place (termed “Baseline” system reliability); defining of vulnerable conditions—those stressing to Basin resources; and evaluating the effectiveness of portfolios as measured by their ability to improve system reliability and reduce vulnerabilities relative to the Baseline. The estimation of cost and other tradeoffs associated with implementing the four portfolios was also explored.

The performance of Basin resources was measured through system reliability metrics (metrics). With broad stakeholder involvement, a comprehensive set of metrics that span six resource categories (Water Delivery, Electrical Power, Water Quality, Flood Control, Recreational, and Ecological Resources) was identified. From those metrics, levels reflecting vulnerability or resource risk were identified. The combination of a particular metric and the assumed level of risk are termed "vulnerability." Two important vulnerabilities that provide an overall indication of system reliability are: 1) Lake Mead elevation dropping below 1,000 feet above mean sea level (msl) in any month and 2) Lee Ferry deficit[10], when the 10-year running total flow at Lee Ferry, Arizona is less than 75 maf.

Baseline system reliability was modeled considering all combinations of the supply and demand scenarios. Additionally, two operational assumptions regarding Lake Powell and Lake Mead operations past the effective period of the Colorado River Interim Guidelines for Lower Basin Shortages and Coordinated Operation for Lake Powell and Lake Mead in 2026 were considered. Since each supply scenario has over 100 individual sequences, the Baseline system reliability is comprised of over 20,000 simulations. Despite the findings from the water demand assessment that the Lower Division States have demand for Colorado River water beyond their 7.5 maf basic apportionment, the Baseline system reliability assumes deliveries to the Lower Division States remain consistent with and within their basic apportionment.

In summary, the Baseline analysis indicates that without action, it will become increasingly difficult for the system to meet Basin resource needs over the next 50 years. Future projected development of water supplies and increased consumptive use in the Upper Basin combined with potential reductions in future supply results in reduced volumes of water stored in system reservoirs. With lower water elevations in reservoirs, the needs for resources such as hydropower and shoreline recreation were less frequently satisfied, while water delivery shortages increased. Decreases in flows in key river tributaries have negative implications for flow-dependent resources such as boating recreation and river ecology. These findings fully support the need to develop and evaluate options and strategies to help resolve the water supply and demand imbalance. Vulnerabilities for the latter period of the Study period (2041 through 2060) under Baseline conditions are summarized in table 4.

The Baseline system reliability also reveals that many combinations of future water supply and demand result in management challenges. In fact, most combinations stress some Basin resources through 2060. In the near-term (2012 through 2026), water demands are similar across scenarios, and the largest factor affecting the system reliability is water supply. In the mid-term (2027 through 2040), the demand for water is an increasingly important element in the reliability of the system, as are assumptions regarding the operations of Lakes Powell and Mead. In the long-term (2041 through 2060), the futures that consider the Downscaled GCM Projected water supply scenario, which incorporates projections of future climate, show a high inability to meet resource needs, regardless of the demand scenario and the operation of

[10] Article III(d) of the Colorado River Compact stipulates that the Upper Division States will not cause the flow of the river at the Lee Ferry Compact Point to be depleted below an aggregate of 75 maf for any period of 10 consecutive years. For the purpose of the Study, a Lee Ferry deficit is defined as the difference between 75 maf and the 10-year total flow arriving at Lee Ferry.

Lakes Powell and Mead. The first stage in the portfolio analysis revealed that when all options in the most inclusive portfolio (*Portfolio A*) are implemented immediately upon availability, and without meeting demand of the Lower Division States above 7.5 maf, plausible futures still exist in which the system is vulnerable. While the implementation of these options results in a sizeable reduction in vulnerability (the percentage of futures resulting in Lake Mead elevations being less than 1,000 feet msl is reduced from about 19 percent to 3 percent), these results indicate that complete elimination of Basin vulnerability is not likely attainable.

Because the Lower Division States have demand for Colorado River water above their 7.5 maf basic apportionment, any Basin-wide strategy must take this into consideration. As such, the portfolio analysis was designed to not only implement options to reduce system vulnerability but also to satisfy the Lower Division States' demand above the 7.5 maf basic apportionment. Augmentation, reuse, and conservation (with and without transfers) were the only options included in the portfolio analysis that could be used to satisfy these demands.

A summary of the system reliability results with the four portfolios in place is also summarized in table 4. Each portfolio was modeled under all future conditions that comprised the Baseline reliability, resulting in over 20,000 simulations for each portfolio. The portfolios were modeled such that options were implemented only when needed to address specific vulnerabilities, thus minimizing the investment simulated in the analysis. As shown in the table, inclusion of the portfolios was projected to improve the ability to meet Basin resources needs (i.e. reduce vulnerabilities). The vulnerabilities related to critical Upper Basin and Lower Basin water delivery metrics were reduced by 50 percent or more. The results for metrics related to electrical power, water quality, recreation, and ecological resources demonstrate reductions of a similar percentage in vulnerabilities. Only the metric related to flood control below Hoover Dam shows a slight increase in vulnerability due to the potential for higher reservoir storage (and higher likelihood of high release) when portfolios were included.

Although these reductions in vulnerabilities are encouraging, vulnerabilities continue to be present under some conditions, even when every option was implemented as soon as it was assumed to be available. This result is primarily because of the hydrologic conditions driving those vulnerabilities. Statistical analysis was performed to determine the specific hydrologic conditions (e.g., droughts of a particular length) that tended to result in certain critical vulnerabilities (e.g., Lee Ferry deficit and Lake Mead elevation less than 1,000 feet msl). Under Baseline conditions, the potential for these critical vulnerabilities was found to be strongly correlated to long-term mean natural flows at Lees Ferry below the historical average of 15.0 maf and droughts of 8 years or greater in duration.

Although the implementation of the portfolios does not completely eliminate the occurrence of such critical vulnerabilities, the portfolios are successful in significantly improving the resiliency of Basin resources to these vulnerable hydrologic conditions. With portfolios in place, the system is able achieve similar levels of reliability under more adverse hydrologic conditions. Specifically, with portfolios in place, the long-term average flow to which the Basin is vulnerable is about 0.5 mafy less and the magnitude of the 8-year period of lowest flows is reduced about 1 mafy. This type of information provides insight into specific hydrologic conditions that the system should be able to successfully endure and can inform water managers when crafting strategies to effectively hedge against those events.

TABLE 4
Summary of System Reliability Outcomes (Percent of Years Vulnerable) for Baseline and Portfolios for All Scenarios, 2041–2060 Period

Resource	System Vulnerability	Baseline	Portfolio A	Portfolio B	Portfolio C	Portfolio D
Water Delivery	Upper Basin (Lee Ferry Deficit)	**7%**	2%	2%	3%	3%
	Lower Basin (Lake Mead pool elevation below 1,000 feet msl)	**19%**	3%	3%	5%	6%
Electrical Power	Upper Basin Generation (below 4,450 gigawatts per hour per year for 3 consecutive years)	**18%**	9%	10%	10%	11%
	Lower Basin Generation (Lake Mead pool elevation below 1,050 feet msl)	**42%**	14%	14%	29%	20%
Flood Control	Critical River Stage below Hoover Dam (greater than 28,000 cubic feet per second)	**1%**	4%	4%	3%	34%
Water Quality	Salinity below Parker Dam (greater than numeric criteria)[1]	**0%**	0%	0%	0%	0%
Recreation	Colorado River Boating (days less than current conditions with variable hydrology)	**30%**	14%	16%	17%	19%
	Lake Powell Shoreline Facilities (pool elevation less than 3,560 feet msl)	**24%**	11%	11%	12%	13%
	Lake Mead Shoreline Facilities (pool elevation less than 1,080 feet msl)	**57%**	31%	30%	37%	39%
Ecological	Colorado River Flow (less than targeted flow conditions)	**38%**	40%	28%	28%	31%
	Hoover Dam to Davis Dam Flow Reductions (annual flow change greater than 845 thousand acre-feet)	**12%**	4%	4%	7%	8%

[1] Due to modeling limitations, values reported do not include results from the Downscaled GCM Projected scenario.

Although the portfolio analysis successfully demonstrated that system reliability can be improved, it is not without significant cost and performance tradeoffs. Figure 3 illustrates the performance across portfolios by water supply scenario in terms of addressing the critical Upper Basin and Lower Basin vulnerabilities.

Portfolio B favors options believed to have higher certainty of available water supply once implemented. As shown in figure 3 (on the right), this portfolio performs as well or better than all the other portfolios for addressing the Lower Basin vulnerability. The portfolio is less effective than *Portfolios A* and *C* for the Upper Basin vulnerability (figure 3, left), particularly in the Downscaled GCM Projected supply scenario (bottom row).

Portfolio C, while focused on options that favor lower energy needs and less environmental impacts, is more dependent on shifting social values towards additional water conservation and reuse. Choosing to implement options characterized as having low energy needs (as a surrogate for potential environmental impacts) might come at the expense of having a less certain long-term water supply. However, this portfolio performs well for addressing the Upper Basin vulnerability (figure 3, left) and is particularly effective under the Downscaled GCM Projected supply scenario (figure 3, bottom row). The effectiveness of this portfolio for addressing Upper Basin reliability vulnerabilities is largely attributable to the inclusion of an Upper Basin water bank that specifically targets this vulnerability. *Portfolio C* is less effective, however, at addressing the Lower Basin reliability vulnerabilities (figure 3, right).

FIGURE 3
Percent of Years Vulnerable for Upper Basin (left) and Lower Basin (right) Vulnerabilities in 2041–2060 with Portfolios, by Water Supply Scenario

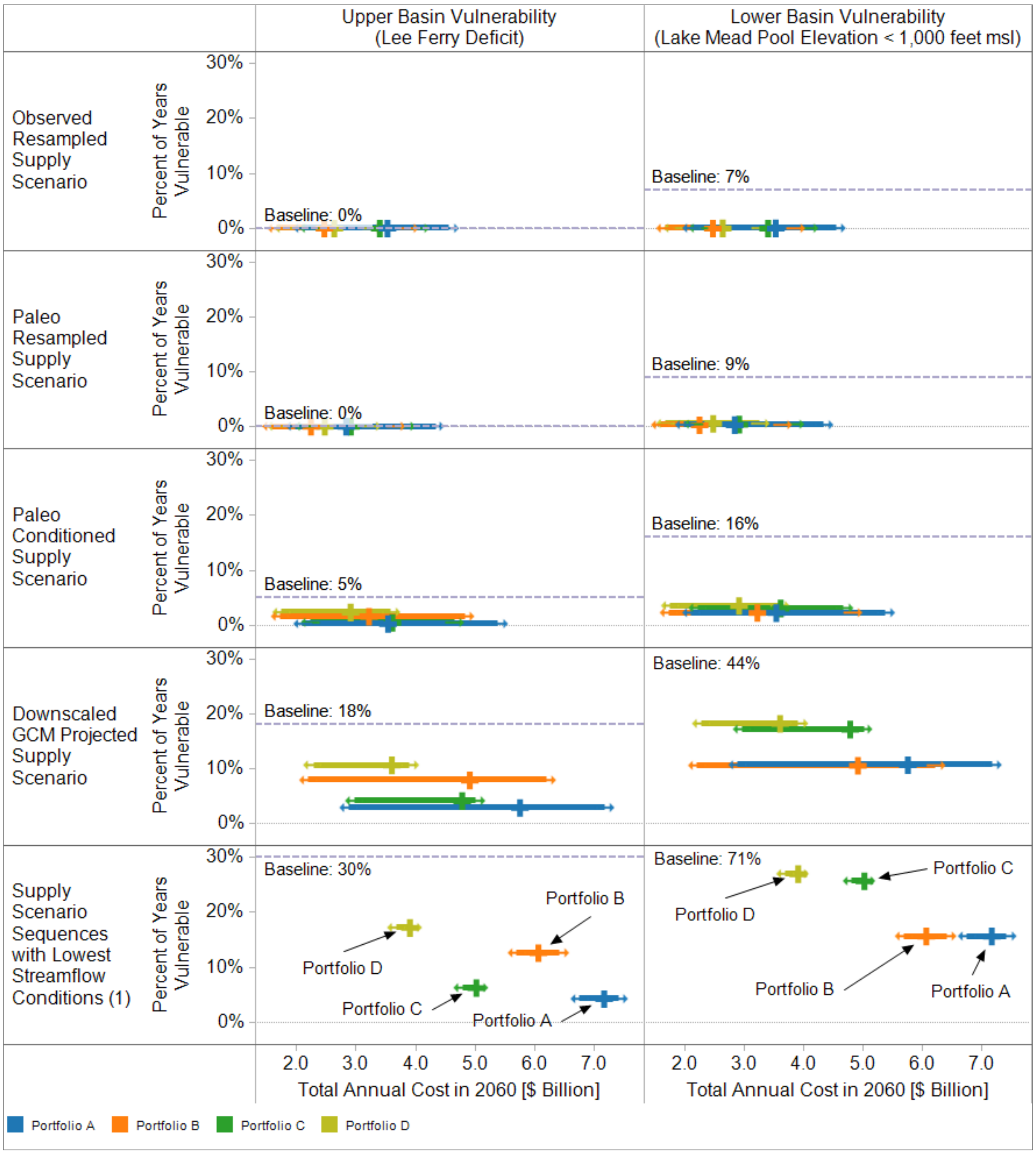
Water Supply Scenario	Portfolio	Upper Basin Vulnerability (Lee Ferry Deficit)	Lower Basin Vulnerability (Lake Mead Pool Elevation < 1,000 feet msl)
Observed Resampled	Baseline	0%	7%
	Portfolio A	0%	0%
	Portfolio B	0%	0%
	Portfolio C	0%	0%
	Portfolio D	0%	0%
Paleo Resampled	Baseline	0%	9%
	Portfolio A	0%	0%
	Portfolio B	0%	0%
	Portfolio C	0%	0%
	Portfolio D	0%	1%
Paleo Conditioned	Baseline	5%	16%
	Portfolio A	0%	2%
	Portfolio B	2%	2%
	Portfolio C	0%	3%
	Portfolio D	2%	4%
Downscaled GCM Projected	Baseline	18%	44%
	Portfolio A	3%	11%
	Portfolio B	8%	11%
	Portfolio C	4%	17%
	Portfolio D	11%	18%
		Percent Years Vulnerable (10% 20% 30% 40% 50%)	Percent Years Vulnerable (10% 20% 30% 40% 50%)

Tradeoffs also exist with respect to portfolio costs, and these differ depending on the specific future conditions. As shown in figure 4, the annual cost, in 2012 dollars, for implementing the portfolios ranges from approximately $2.5 billion to $3.5 billion in the year 2060 when considering the median of the Observed Resampled supply sequences, and from $3.6 billion to $5.8 billion when considering the median of the Downscaled GCM Projected supply sequences. The variability of the cost (reflected by the inter-quartile range or the length of the bars) reflects the varying size of the portfolios in different future conditions. Because of the appraisal-level option cost estimating used in the Study, the cost values contain additional uncertainty not directly reflected in these estimates. Across three supply scenarios (Observed Resampled, Paleo Resampled, and Paleo Conditioned), *Portfolios B* and *D* are generally shown to be less costly than *Portfolios A* and *C*. For the Downscaled GCM Projected water supply scenario tradeoffs between portfolios begin to become apparent. Specifically, *Portfolio C* leads to fewer vulnerable years with respect to Upper Basin vulnerability than *Portfolios A* and *B*, with an upper range of costs that is also lower than those for *Portfolios A* and *B*. Conversely, *Portfolio A* generally leads to the fewest vulnerable years with respect to Lower Basin reliability than other portfolios.

The differences among the portfolios become more apparent in terms of costs and ability to reduce vulnerability as one focuses on the future conditions that are particularly stressing to the

Basin. For water supply conditions that are less favorable, such as in the "Lowest Streamflow" subset of sequences (figure 4, bottom row), two distinct tradeoffs between reduction in vulnerability and cost across the portfolios are apparent. For the Upper Basin vulnerability, *Portfolio C* both performs better than *Portfolios B* and *D* in terms of reducing this vulnerability and has a lower range of costs than *Portfolios A* and *B*. For the Lower Basin vulnerability, however, *Portfolio B* reduces vulnerability more than *Portfolios C* and *D* and also results in lower costs than *Portfolio A*.

FIGURE 4
Portfolio Cost and Percent of Years Vulnerable for Upper Basin (left) and Lower Basin (right) Vulnerability for 2041—2060 across Water Supply Scenarios and Lowest Streamflow Conditions



(1) Lowest Streamflow Conditions are defined as those in which the average of the 2012—2060 natural flow at Lees Ferry is less than 14 mafy and the lowest 8-year natural flow at Lees Ferry from 2012–2060 averages less than 11 mafy.

Although the portfolios explored in the Study address water supply and demand imbalances differently, there are commonalities across the options implemented for each portfolio. All of the portfolios incorporate significant agricultural water conservation, M&I water conservation (1 maf each of both additional M&I and agricultural conservation was implemented in all portfolios), energy water use efficiency, and some levels of weather modification. However, some options were implemented more frequently in response to challenging water supply conditions. For example, ocean and brackish water desalination, wastewater reuse, and importation options were implemented for the most challenging water supply conditions in portfolios in which they were included. Future planning will require careful consideration of the timing, location, and magnitude of anticipated future Basin resource needs. The purpose of exploring these portfolios is not to identify a "best" portfolio or strategy, but to acknowledge that there are various ways to address the water supply and demand imbalance and to recognize that each approach has implications to be considered in future planning processes and decision-making.

5.0 Study Limitations

Although the technical approach of the Study was based on the best science and information available, as with all studies, there were limitations. The detail at which results are reported or the depth to which analyses were performed in the Study was limited by the availability of data, assessment methods, and the capability of existing models. These limitations provide opportunities for additional research and development and the improvement of available data, which will be pursued in efforts independent of the Study. Notable Study limitations include the following:

- **Ability to Assess Impacts to Basin Resources –** The ability to assess impacts to Basin resources, particularly in the Upper Basin, was limited by the spatial and temporal detail of the Colorado River Simulation System (CRSS), the primary model used in the Study. In particular, the Study's assessment of water deliveries at local level, and ecological and recreational impacts were affected by these limitations. Future efforts will evaluate ways to improve the assessment of these resources in future studies which will include enhancements to CRSS, as appropriate.
- **Treatment of Lower Basin Tributaries –** CRSS uses historical inflows (not natural flows) based on USGS streamflow records for four tributaries below Lees Ferry (the Paria, Little Colorado, Virgin, and Bill Williams rivers). In addition, the Gila River is not included in CRSS. The current treatment of these tributaries limited the ability of the Study to fully assess the natural supply of the Basin, and the data and methodological inconsistencies present in the Reclamation's Consumptive Uses & Losses Reports limited the ability of the Study to gain a more complete understanding of historical consumptive use in the Basin. The Basin States will also work with Reclamation in fulfilling the commitments regarding the Lower Basin tributaries specifically described in *Technical Report C – Water Demand Assessment, Appendix C11*.
- **Treatment of Agricultural Land Use in Water Demand Scenarios –** The development of the water demand storylines included participation from a broad range of stakeholders. The storylines were developed to represent a range of plausible futures regarding future demand. However, the assumptions in some storylines with regard to key driving forces resulted in the

same directional changes in demand across the storylines. For example, the assumptions of continued conversion of agricultural land use to urban land use and lower-economic value crops being phased out in some areas led to overall agricultural land use (i.e., the number of irrigated acres) decreasing over time over all scenarios. Although some scenarios do show increasing agricultural land use at a state and local level, given recent projections of increased agricultural productivity necessary to meet future food needs, plausible futures should include increases in land use.

- **Option Characterization Process –** The option characterization process strived for objectivity and consistency. The limitations identified during the characterization process included geographic limitations due to the extensive size of the basin and regional variety, the appraisal-level of the analysis, potential subjectivity during the characterization process, and significant uncertainty due to limited data. Specifically for those options associated with agricultural and M&I conservation and reuse, a detailed assessment by individual location for those options was not performed. Instead, these options were characterized at a Basin-wide level. The resulting assumptions were adopted for purposes of the Study and do not necessarily reflect achievable, or even desirable, local conservation goals for individual municipalities or agricultural locations. Further, not all stakeholders in the Study were in agreement with all characterization results, but it was recognized that future efforts beyond the Study should result in more in-depth assessments of the options and reduced uncertainty.
- **Consideration of Options –** Due to the legal, regulatory, and sometime technical complexity of the options submitted, not all categories of options submitted underwent a quantitative assessment. As such, portfolios were largely limited to groups of options that lend themselves to modeling implementation within the Study's timeframe, i.e. those that increase supply or reduce demand, with the exception of the Upper Basin water bank concept. The options modeled in CRSS do not necessarily reflect the entire range of innovative options and strategies that should continue to be explored in future efforts.

6.0 Future Considerations and Next Steps

Colorado River water managers and stakeholders have long understood that growing demands on the Colorado River system, coupled with the potential for reduced supplies due to climate change may put water users and resources relying on the river at risk of prolonged water shortages in the future. The magnitude and timing of these risks differ spatially across the Basin. In particular, areas where demand is at or exceeds available supply are at a greater risk than others. The Study builds on earlier work and is the next significant step in developing a comprehensive knowledge base and suite of tools and options that will be used to address the risks posed by imbalances between Colorado River water supply and resource needs in the Basin.

The Study confirms that the Colorado River Basin faces a range of potential future imbalances between supply and demand. Addressing such imbalances will require diligent planning and cannot be resolved through any single approach or option. Instead, an approach that applies a wide variety of ideas at local, state, regional, and Basin-wide levels is needed. The Study's portfolio exploration demonstrated implementation of a broad range of options can reduce Basin resource vulnerability and improve the system's resiliency to dry hydrologic conditions while meeting increasing demands in the Basin and adjacent areas receiving Colorado River water.

The Study indicates that targeted investments in water conservation, reuse, and augmentation projects can improve the reliability and sustainability of the Colorado River system to meet current and future water needs. Ultimately, the Study is a call to action. To implement the water conservation, reuse, and augmentation projects identified in the Study, significant additional efforts are required immediately. These additional efforts, or next steps, include a commitment to further analysis and planning in many areas related to the Study.

In summary, there are several future actions that must take place to move implement solutions to resolve imbalances in the Basin. First, significant uncertainties related to water conservation, reuse, water banking, and weather modification concepts must be resolved in order to adequately implement these approaches. Second, costs, permitting issues, and energy needs relating to large-capacity augmentation projects need to be identified and investigated through feasibility-level studies. Third, opportunities to advance and improve the resolution of future climate projections should be pursued and enhancements to the operational and planning tools used in the Colorado River system to better understand the vulnerabilities of the water-dependent uses, including environmental flows, should be explored. Fourth, as projects, policies, and programs are developed, consideration should be given to those that provide a wide-range of benefits to water users and healthy rivers for all users.

In recognition of their ongoing joint commitment to future action, Reclamation will convene the Basin States along with tribes, other Colorado River water entitlement holders, conservation organizations, and other interested stakeholders in early 2013 to conduct a workshop to review the recommended next steps and initiate actions to implement next steps to resolve the current and potentially significant future imbalances in the Colorado River system. In early 2013 Reclamation will also consult and work with tribes regarding tribal water issues reflected in this report.

Disclaimer

The Colorado River Basin Water Supply and Demand Study (Study) is funded jointly by the Bureau of Reclamation (Reclamation) and the seven Colorado River Basin States (Basin States). The purpose of the Study is to analyze water supply and demand imbalances throughout the Colorado River Basin and those adjacent areas of the Basin States that receive Colorado River water through 2060; and develop, assess, and evaluate options and strategies to address the current and projected imbalances.

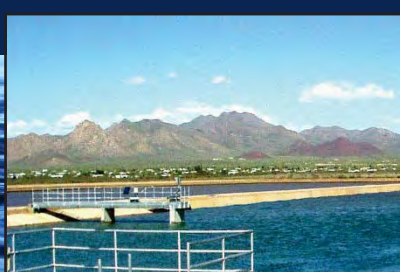
Reclamation and the Basin States intend that the Study will promote and facilitate cooperation and communication throughout the Basin regarding the reliability of the system to continue to meet Basin needs and the strategies that may be considered to ensure that reliability. Reclamation and the Basin States recognize the Study will have to be constrained by funding, timing, and technological and other limitations, which may present specific policy questions and issues, particularly related to modeling and interpretation of the provisions of the Law of the River during the course of the Study. In such cases, Reclamation and the Basin States will develop and incorporate assumptions to further complete the Study. Where possible, a range of assumptions will typically be used to identify the sensitivity of the results to those assumptions.

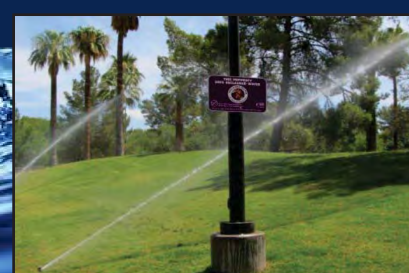
Nothing in the Study, however, is intended for use against any Basin State, any federally recognized tribe, the Federal government or the Upper Colorado River Commission in administrative, judicial or other proceedings to evidence legal interpretations of the law of the river. As such, assumptions contained in the Study or any reports generated during the Study do not, and shall not, represent a legal position or interpretation by the Basin States, any federally recognized tribe, Federal government or Upper Colorado River Commission as it relates to the law of the river. Furthermore, nothing in the Study is intended to, nor shall the Study be construed so as to, interpret, diminish or modify the rights of any Basin State, any federally recognized tribe, the Federal government, or the Upper Colorado River Commission under federal or state law or administrative rule, regulation or guideline, including without limitation the Colorado River Compact, (45 Stat. 1057), the Upper Colorado River Basin Compact (63 Stat. 31), the Utilization of Waters of the Colorado and Tijuana Rivers and of the Rio Grande, Treaty Between the United States of America and Mexico (Treaty Series 994, 59 Stat. 1219), the United States/Mexico agreement in Minute No. 242 of August 30, 1973, (Treaty Series 7708; 24 UST 1968) or Minute No. 314 of November 26, 2008, or Minute No. 318 of December 17, 2010, or Minute No. 319 of November 20, 2012, the Consolidated Decree entered by the Supreme Court of the United States in Arizona v. California (547 U.S 150 (2006)), the Boulder Canyon Project Act (45 Stat. 1057), the Boulder Canyon Project Adjustment Act (54 Stat. 774; 43 U.S.C. 618a), the Colorado River Storage Project Act of 1956 (70 Stat. 105; 43 U.S.C. 620), the Colorado River Basin Project Act of 1968 (82 Stat. 885; 43 U.S.C. 1501), the Colorado River Basin Salinity Control Act (88 Stat. 266; 43 U.S.C. 1951) as amended, the Hoover Power Plant Act of 1984 (98 Stat. 1333), the Colorado River Floodway Protection Act (100 Stat. 1129; 43 U.S.C. 1600), the Grand Canyon Protection Act of 1992 (Title XVIII of Public Law 102-575, 106 Stat. 4669), or the Hoover Power Allocation Act of 2011 (Public Law 112-72). In addition, nothing in the Study is intended to, nor shall the Study be construed so as to, interpret, diminish or modify the rights of any federally recognized tribe, pursuant to Federal Court Decrees, State Court Decrees, treaties, agreements, executive orders and federal trust responsibility. Reclamation and the Basin States continue to recognize the entitlement and right of each State and any federally recognized tribe under existing law, to use and develop the water of the Colorado River system.

Attachment C

Executive Summary, Recycled Water Master Plan

RECYCLED WATER MASTER PLAN





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Executive Summary

December 2013

Registered Professional Engineer (Civil)
CERTIFICATE NO.
23571
GEORGE P.
MASEEH
Date Signed 12/20/2013
ARIZONA U.S.A.

EXPIRES 09/30/2015

MALCOLM PIRNIE | ARCADIS

The Water Division of ARCADIS

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.

WaterReliability

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.

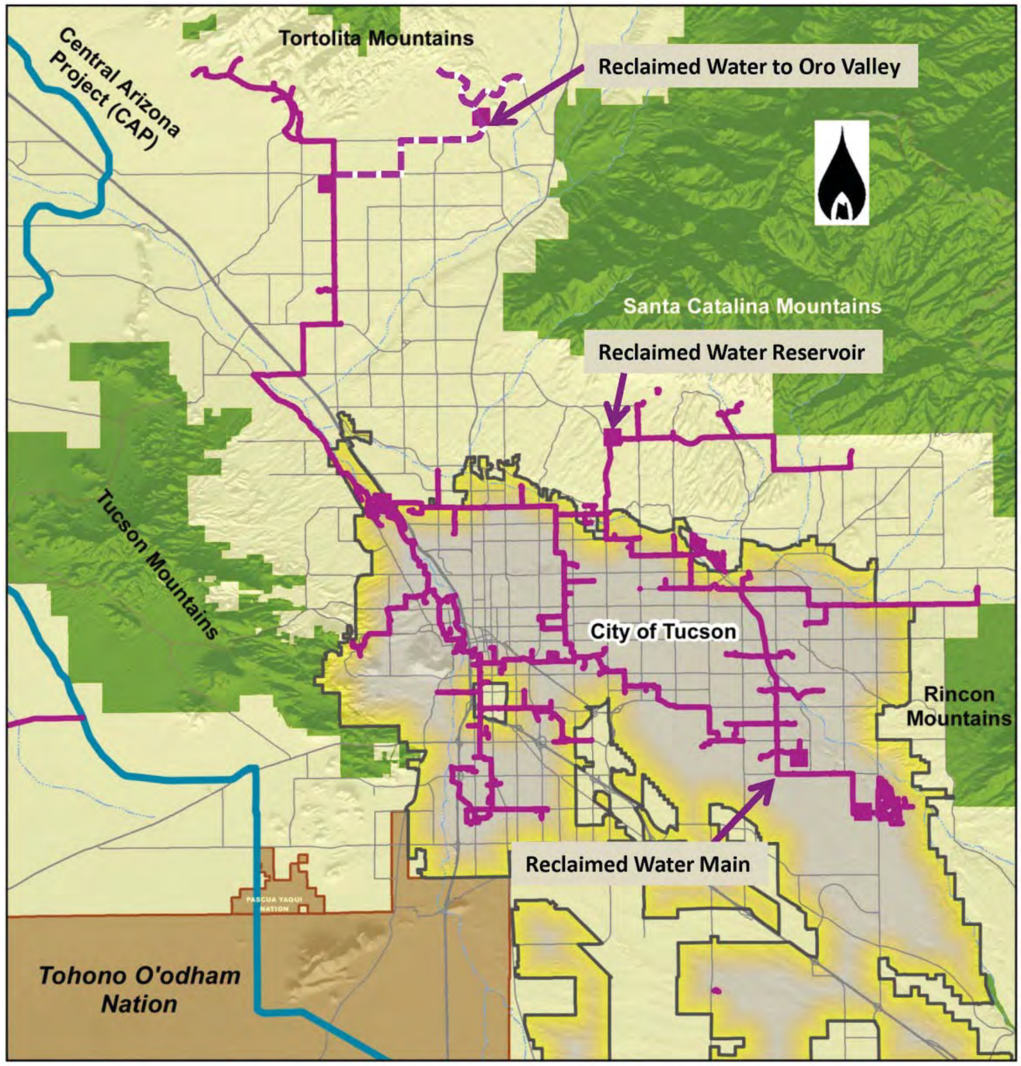

Figure ES-1. **The Reclaimed Water System (RWS)**

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.

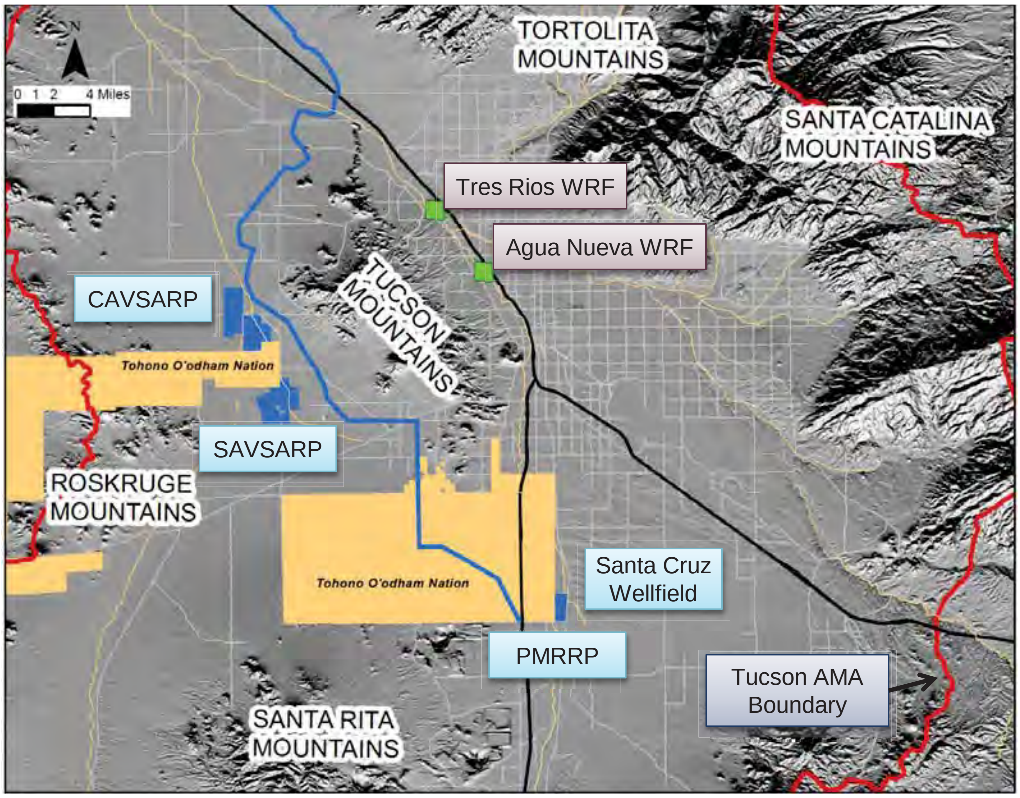

Figure ES-3. Clearwater Program Facilities

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).

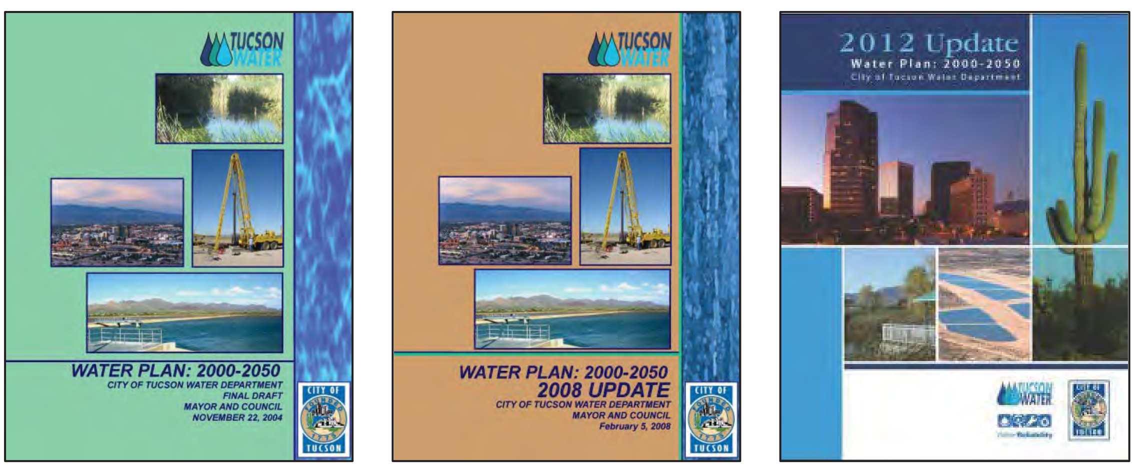

Figure ES-4. Tucson Water's Long Range Water Planning Documents

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).

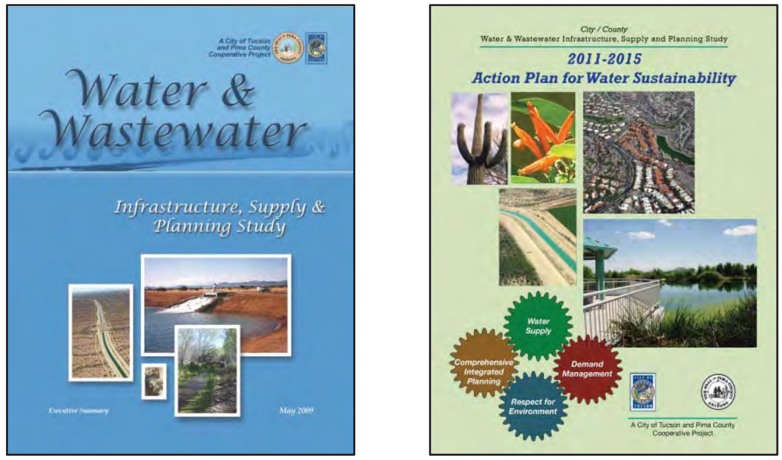

Figure ES-5. City/County Joint Long-Range Water & Wastewater Planning

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.

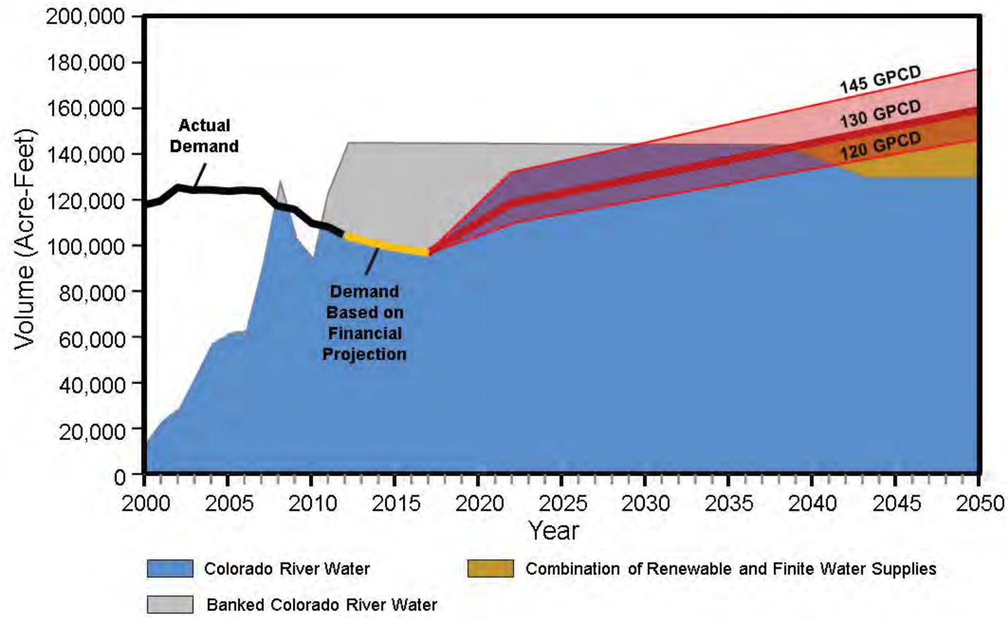

Figure ES-6. **Projected Water Demand and Supply for Tucson Water's Obligated Service Area**

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).*

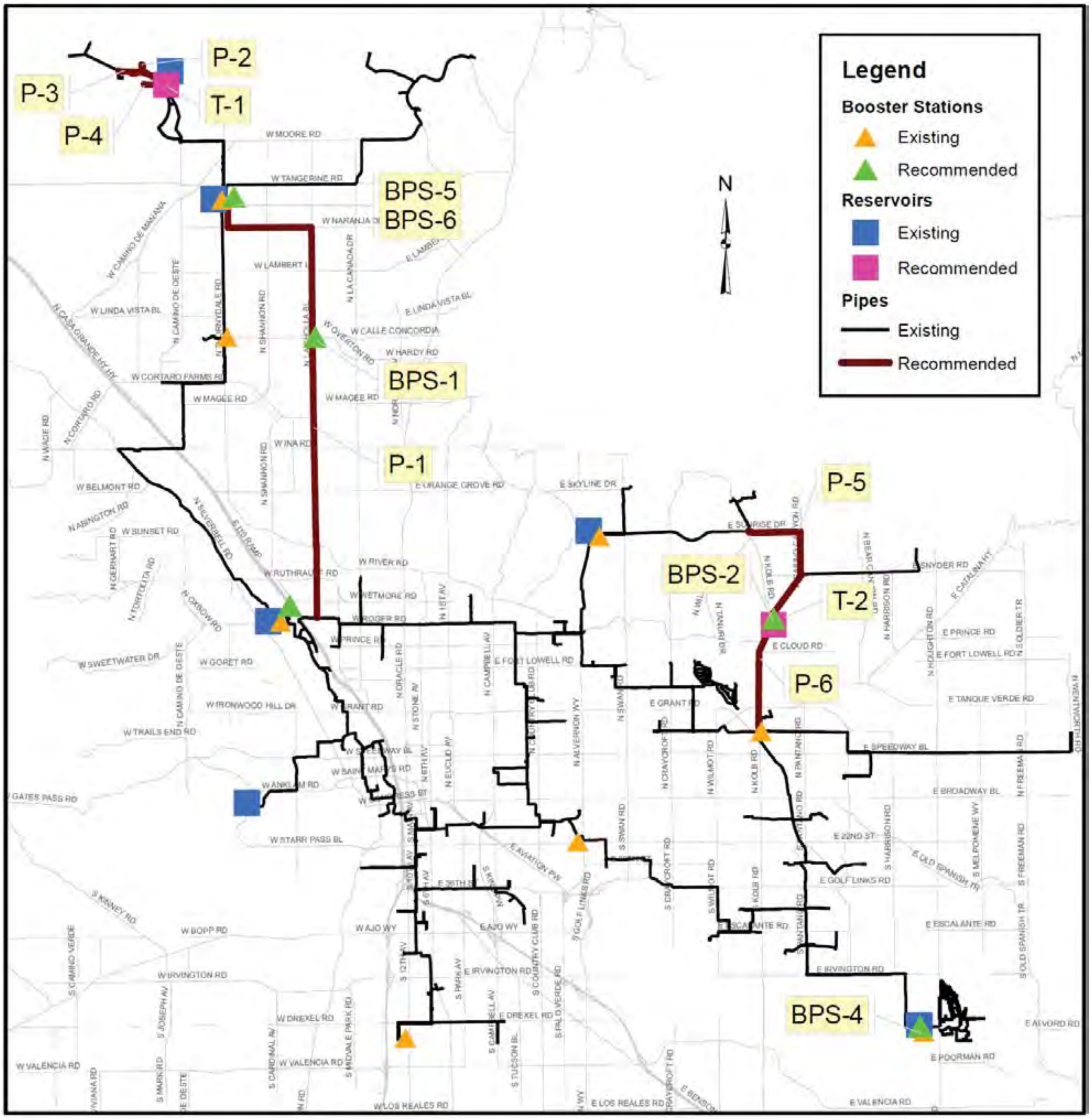

Figure ES-7. Recommended RWS Improvements

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).

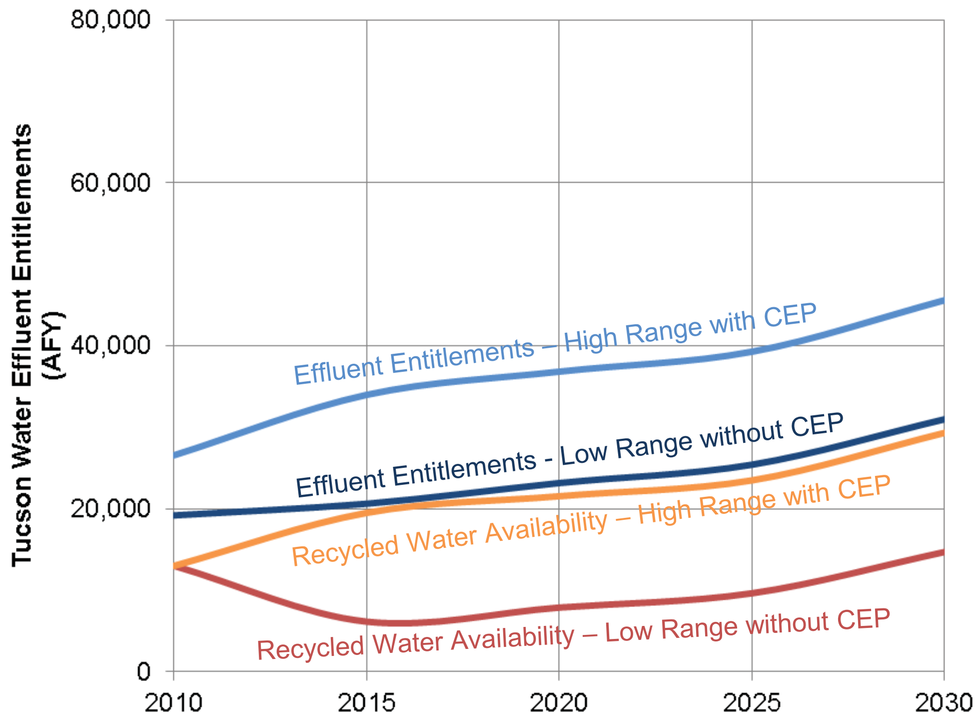

Figure ES-8. **Effluent Entitlements and Recycled Water Available For Other Programs from Metropolitan Area Reclamation Facilities**

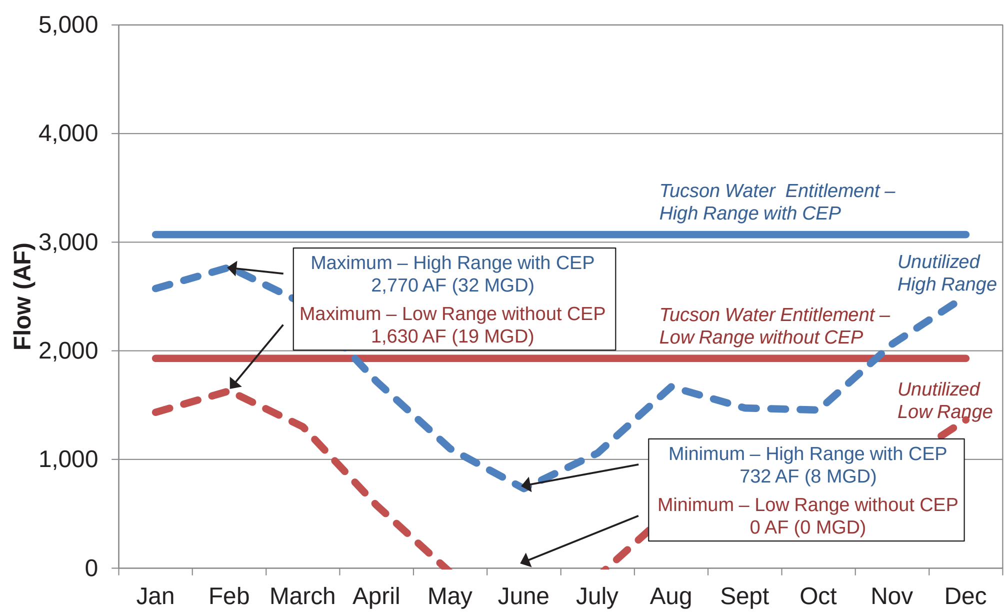

Figure ES-9. **2020 Projection of Seasonal Distribution of Recycled Water Resources from Metropolitan Area Reclamation Facilities**

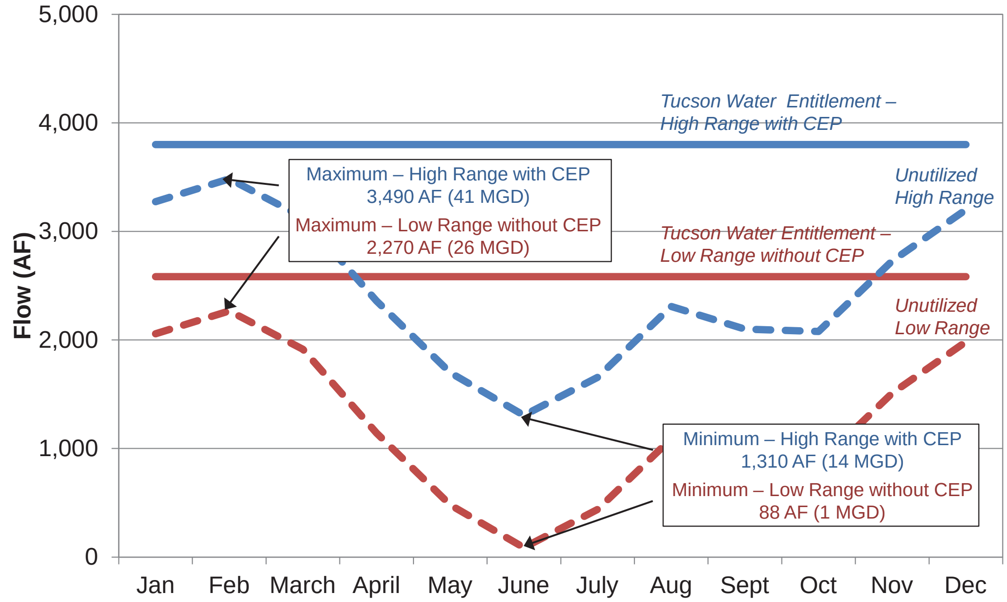

Figure ES-10. 2030 Projection of Seasonal Distribution of Recycled Water Resources from Metropolitan Area Reclamation Facilities

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.

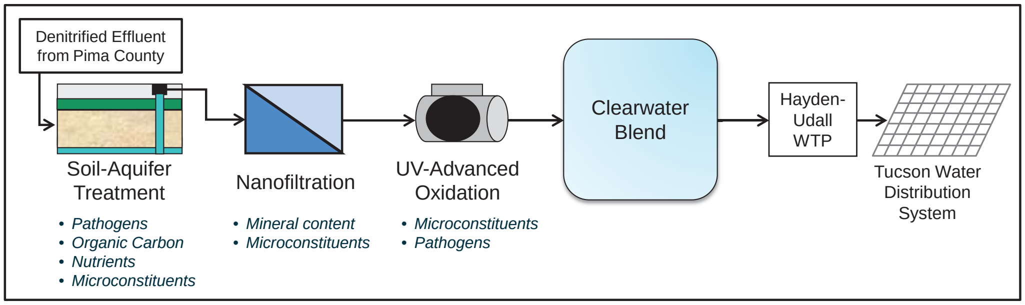

Figure ES-11. Example Advanced Water Treatment Schematic

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).

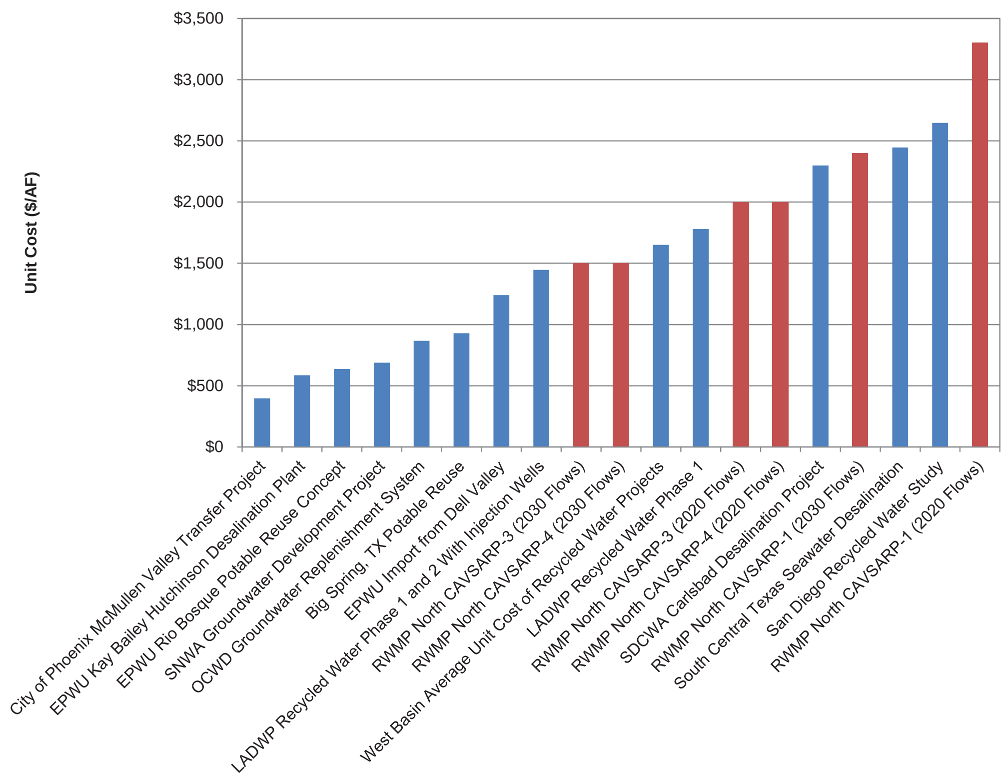

Figure ES-12. Comparison of Southwest Water Supply Projects

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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