

The spatial distribution of projected water demand will guide water distribution system upgrades and expansions to convey water to where it will be needed in future years.

CHAPTER FIVE

WATER DELIVERY SYSTEMS

The previous chapters discussed the local area's water-resource history, the projected service area population and total water demand, and the water resources available to meet that demand. Another critical component of water-resource planning is determining how the existing supply infrastructure can be upgraded to meet projected water demand within the 50-year planning period. This chapter describes how ground water, Colorado River water, and reclaimed water supplies are conveyed through distribution systems to where they are needed and how those supply systems will be upsized and extended to meet total water demand in future years.

Tucson Water's existing water systems serve as baselines upon which future supply and demand needs are assessed. Such an assessment ensures that the necessary infrastructure will be in place when it is needed and that the water systems will be operated efficiently to maximize service while minimizing costs.

EXISTING WATER SYSTEMS

Tucson Water operates two types of water systems: a potable system and a reclaimed (non-potable) system. Despite the fact that these are physically separate and distinct systems, both convey water from supply sources through a pressurized hydraulic system to customers situated at different elevations. A water system in its simplest form consists of one or more water resources (such as ground water, Colorado River water, and/or reclaimed water) and the facilities to convey the source water(s) to the user. Tucson Water's systems consist of a complex network of pipes, wells, pumps, reservoirs, valves, automated controls, and treatment facilities.

Existing Potable Systems

Tucson Water's potable systems are designed and operated so that the following operational and regulatory requirements are met:

- Maintain adequate system delivery pressures.
- Meet the daily peak demand.
- Meet potential fire-flow demands.
- Meet or exceed all primary drinking water standards.
- Maintain adequate system disinfection levels.
- Satisfy customer expectations.

Tucson Water’s potable water distribution systems served a population of 638,936 in 2000, and potable demand was 117,624 acre-feet. The potable systems collectively serve a 300 square-mile area.

Potable supply currently comes from more than 200 wells spread over five well fields with a collective pumping capacity of 196 MGD. Figure 5-1 shows the location of the five well fields within the Tucson basin and Avra Valley. The capacities of these well fields include about 93 MGD from the Central Well Field, 31 MGD from the Avra Valley Well Field, 9 MGD from the Southside Well Field (including the Tucson Airport Remediation Project), 9 MGD from the Santa Cruz Well Field, and 54 MGD from the CAVSARP Well Field. Average daily water demand in 2003 was 108 MGD and peak daily demand was 163 MGD.

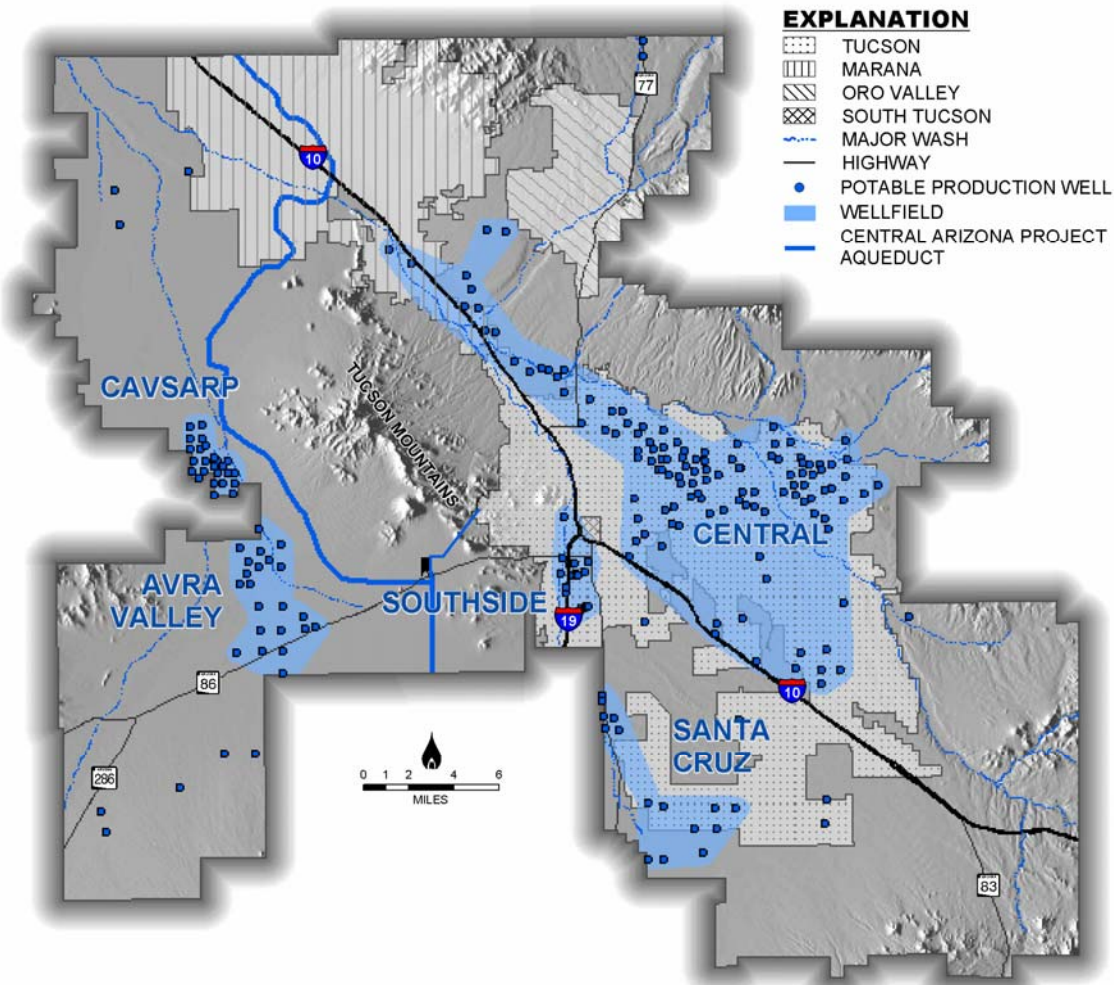


Figure 5-1: Tucson Water’s Well Fields.

The Central, Avra Valley, Southside, and the Santa Cruz Well Fields pump native ground water for supply. The ground water pumped from these wells is directly discharged to the distribution piping system or to reservoirs. The CAVSARP Well Field, however, produces a blend of recharged Colorado River water and native ground water. Figure 5-2 shows the network of large diameter pipelines in Tucson Water’s potable distribution system.

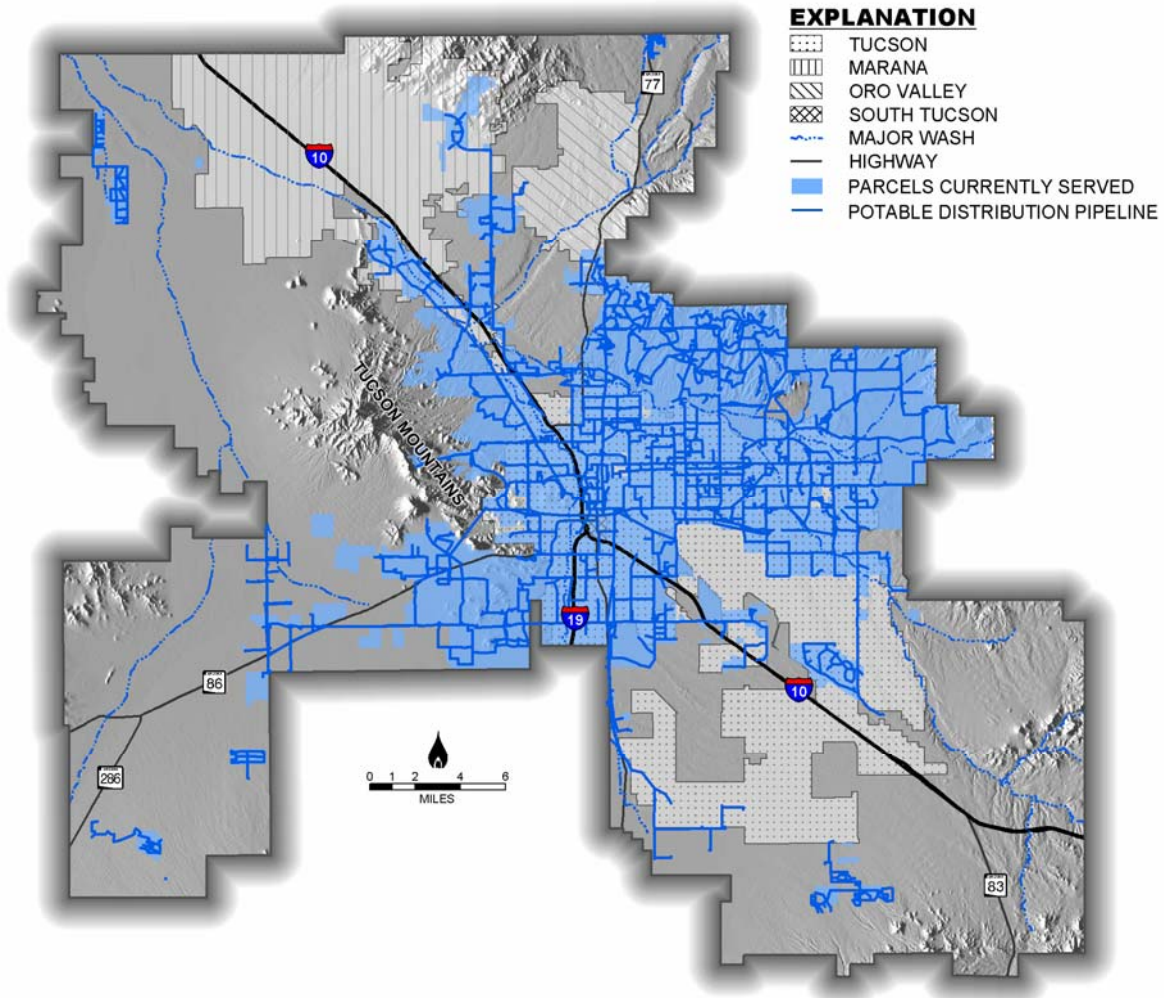


Figure 5-2: Tucson Water’s Potable Distribution System as of 2000.

At CAVSARP, Colorado River water flows through a pipeline to recharge basins. The water soaks into the ground and percolates through subsurface sediments until it reaches the water table (i.e. recharges the aquifer) where it slowly blends with native ground water. CAVSARP enables Tucson Water to greatly reduce its dependence on ground water by satisfying almost half its current total potable demand with renewable Colorado River water.

CAVSARP is one component of the Clearwater Program (Figure 4-2) which also includes the Hayden-Udall Treatment Plant and the Clearwell Reservoir. The Hayden-Udall Treatment Plant currently chlorinates and controls the pH (acidity) of the blended water

recovered at CAVSARP. The treated water is then boosted up to the Clearwell Reservoir, a 60 million-gallon covered storage facility, from where it is delivered to customers for potable supply and fire flow.

About 4,200 miles of transmission mains and distribution pipelines, with diameters ranging from 2 to 96 inches, convey water from the various potable supply sources to more than 200,000 businesses and residences. The distribution system relies on more than 50 fully enclosed reservoirs with individual storage capacities ranging from 15,000 gallons to 60 million gallons; the overall system has a total capacity of 273 million gallons. The system has 124 booster stations used to lift water from lower to higher delivery elevations.

In addition to the large, integrated central distribution system that supplies more than 99 percent of Tucson Water's potable demand, there are eight isolated potable systems supplied by dedicated production wells. Whenever practical, Tucson Water seeks to connect the small isolated systems to the central system to maximize system reliability and flexibility and to minimize operational inefficiencies.

Most of the supply wells and booster pumps are electric-powered with the remainder powered by natural gas engines. Large facilities like CAVSARP are equipped with both electricity and natural gas to ensure reliability and flexibility. Most wells, reservoirs, and booster pumps are connected to a central computer system that is monitored 24 hours a day. This system can remotely operate key elements of the delivery infrastructure and detect system malfunctions.

Tucson Water's service area is divided into 17 pressure zones which take into account the wide range of elevations associated with the many points of delivery. Each pressure zone corresponds to a change in land surface elevation of approximately 105 feet amsl. Tucson Water delivers water over an elevation ranging from 1,900 feet to 3,500 feet amsl. These zones are managed to maintain consistent system delivery pressures. Water can be transported between pressure zones via gravity and pressure reducing valves or by booster stations, both of which help to maintain system pressure. Reservoirs placed at appropriate elevations stabilize pressures in the system within acceptable ranges and provide backup storage for peak-use periods.

Demand varies not only from one day to the next but also within any given day. In addition, water supplies within the system may not be where it is needed at any given point in time; therefore, water must be conveyed from one area to another through the strategic placement of reservoirs, boosters, and wells. The distance between a supply source and the point of use can exceed 20 miles in some areas.

In addition to providing adequate water supply to Tucson Water's customers, a series of emergency system interconnects are located where the Tucson Water system abuts other water providers. These interconnects are used to supply water to other providers when they have system emergencies.

The ground water used by Tucson Water generally meets the applicable federal and state regulatory standards with little treatment. 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. Areas where ground-water contamination could pose a threat to potable supplies are being managed by controlling ground-water pumping or by pumping and treating to either augment the ground-water system or for direct potable use.

The Tucson Airport Remediation Project was developed in order to treat ground water contaminated with volatile organic compounds. Tucson Water operates the remediation project under an agreement with the EPA and other industrial and governmental agencies that pay for operation of the project and provide the treated potable water at no cost to Tucson Water. The project water treatment plant produces approximately 6.2 MGD of potable supply. During 2002, the plant treated approximately 7,000 acre-feet of water that constituted about six percent of Tucson Water's total potable supply. This intensively monitored potable water source will continue to be available in gradually decreasing amounts until the ongoing ground-water cleanup is completed. The Tucson Airport Remediation Project may continue for another 20 to 30 years.

Tucson Water's *Environmental Monitoring for Public Access and Community Tracking (EMPACT)* program was developed with a grant from the EPA. The *EMPACT* goals include implementing enhanced monitoring of the Utility's potable distribution system, providing the community with near "real-time" water-quality information on Tucson Water's web site (www.cityoftucson.org/water), and creating community partnerships to better inform water consumers about water-quality and resource issues. The water-quality monitoring and data collection tools provided through *EMPACT* also enable the Utility to track and respond to real-time changes in system water quality.

Existing Reclaimed Water System

Tucson Water's reclaimed (non-potable) system is designed and operated so that the following operational and regulatory requirements are met:

- Meet the daily peak demand.
- Meet or exceed all reuse regulations.
- Maintain adequate system disinfection levels.
- Satisfy customer expectations.

Tucson Water has operated a reclaimed system since 1984. Reclaimed water usage in 2000 was 10,897 acre-feet, which was about eight percent of total water demand. The system takes secondary effluent from Pima County's Roger Road Wastewater Treatment Plant, further treats it to a higher standard, and delivers it for turf irrigation and other non-potable uses. The layout of the reclaimed water system is shown on Figure 5-3. The utilization of reclaimed water for non-potable uses has helped to conserve higher-quality water sources for potable water supply and to relieve some of the demand on the potable system.

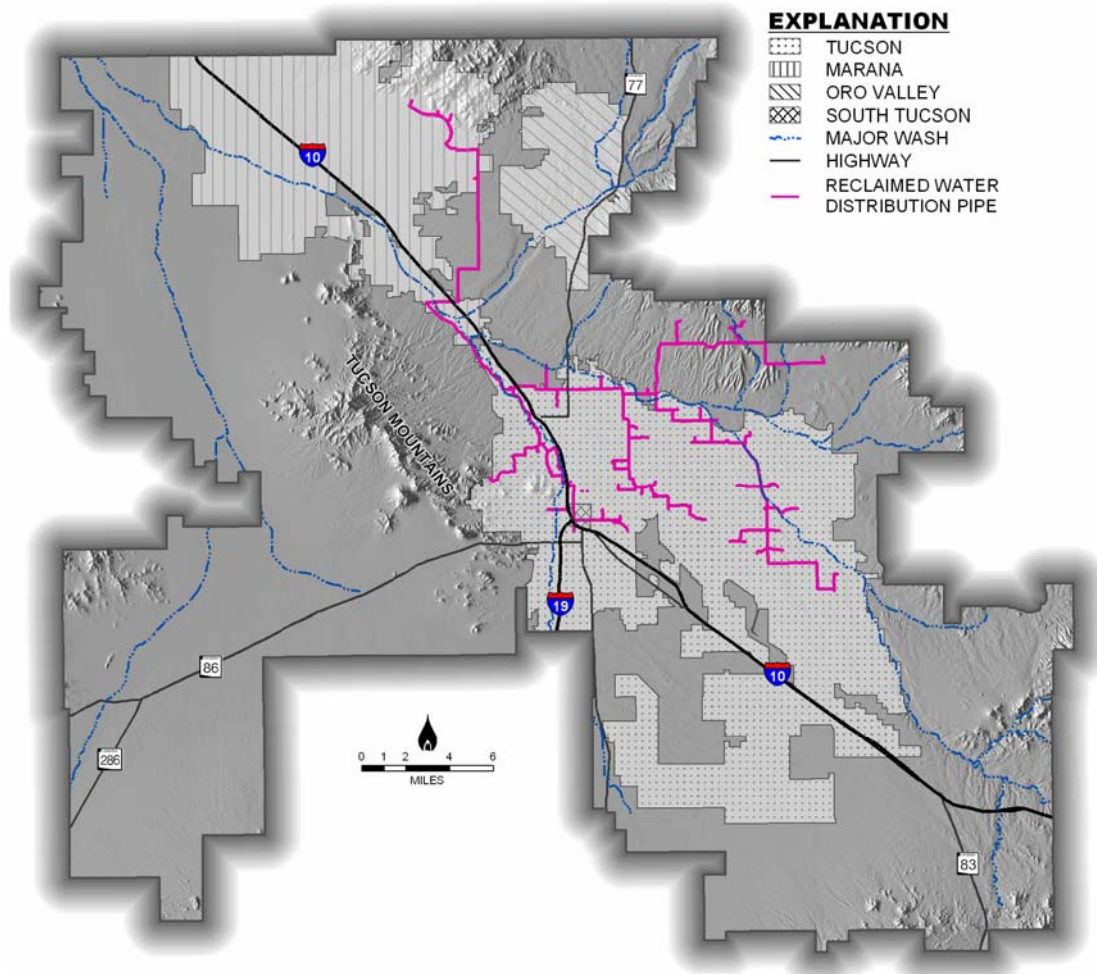
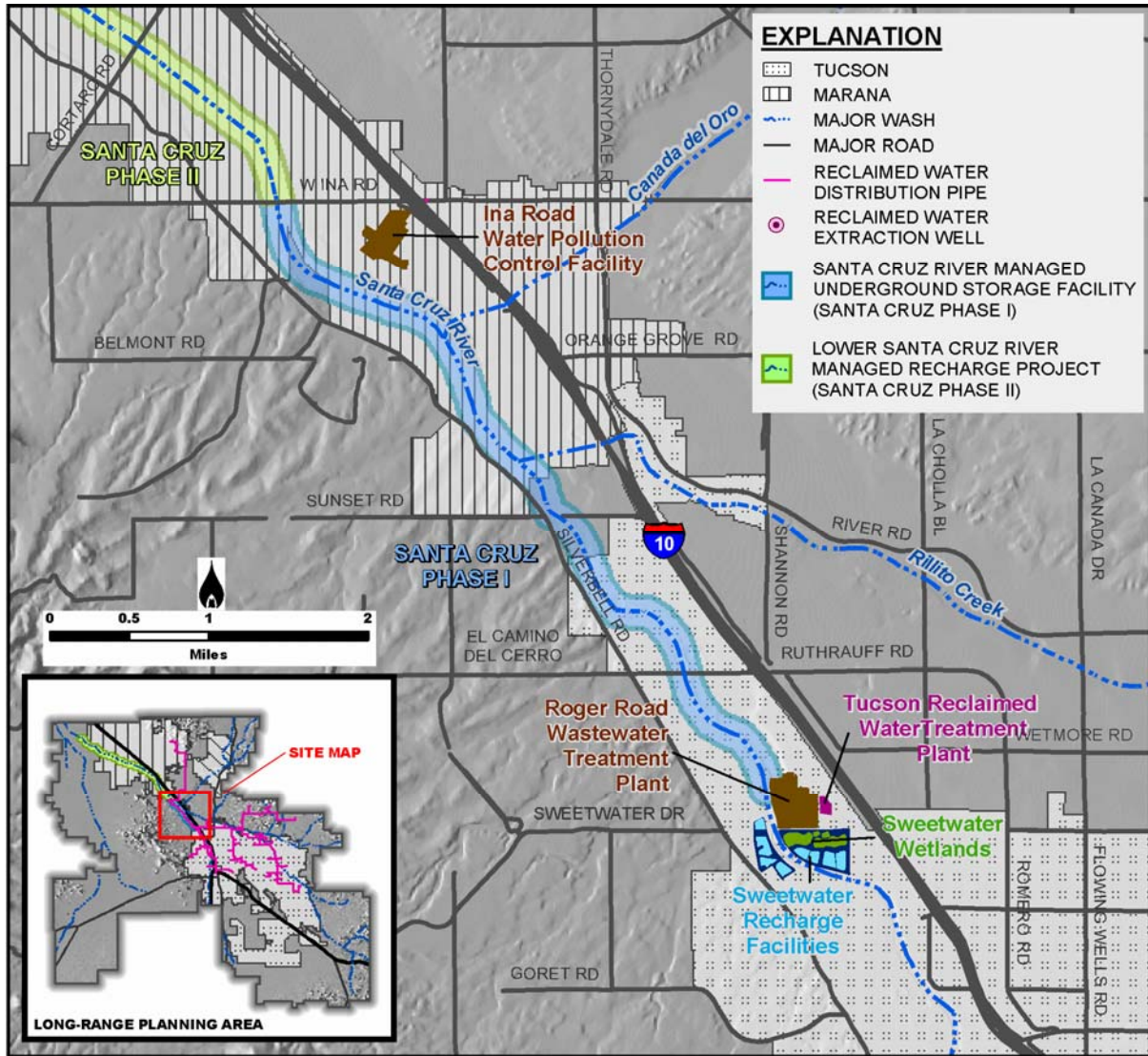


Figure 5-3: Tucson Water’s Reclaimed Distribution Pipeline System in 2000.

The secondary effluent that is received from Pima County’s treatment facilities is either filtered at the Tucson Reclaimed Water Treatment Plant or recharged in a number of facilities. The recharge facilities include the Sweetwater Recharge Facilities, the Santa Cruz River Managed Underground Storage Facility (Santa Cruz Phase I) and the Lower Santa Cruz River Managed Recharge Project (Santa Cruz Phase II) as shown in Figure 5-4. The Santa Cruz Phase I facility is co-owned with the U.S. Secretary of the Interior and the Santa Cruz Phase II facility is jointly owned by multiple parties.

The Tucson Reclaimed Water Treatment Plant is capable of treating up to 10 MGD. The Sweetwater Recharge Facilities are permitted to annually recharge and recover up to 6,500 acre-feet of reclaimed water to meet seasonal peak demand requirements. The recovered effluent is blended with filtered water from the reclaimed plant, disinfected with chlorine, and boosted to customers through the reclaimed water distribution system. The total delivery capacity of blended water from the reclaimed plant and the Sweetwater Recharge Facilities is 27 MGD. Santa Cruz Phase I is permitted to recharge approximately 9,300 acre-feet of effluent annually. The regulations that govern managed recharge facilities award credits for

only 50 percent of the effluent that is recharged. The City of Tucson and the Secretary of the Interior evenly share the credits accrued at Santa Cruz Phase I; therefore, Tucson Water can accrue approximately 2,300 acre-feet of recharge credits per year. Effluent recharged under Santa Cruz Phase I is recovered through a well, disinfected, and conveyed through the reclaimed distribution system to customers. Santa Cruz Phase II is co-owned by several local entities and recharges effluent on behalf of Tucson Water as well as others with effluent entitlements. This facility does not currently have a recovery component.



Other reclaimed facilities consist of reservoirs, booster stations, disinfection equipment, and over 135 miles of pipeline. Although less complex than the potable system, the reclaimed system is also monitored 24 hours a day by a centralized computer system and must also meet specific operational criteria and comply with regulations. Reclaimed water system pressures must also be managed but a wider range of pressure fluctuations are more acceptable than in the potable delivery system where delivery pressures are more stringently

controlled. Similar to the potable system, the reclaimed system's booster pump stations move water for many miles and over substantial changes in elevation from supply source to points of service. Reclaimed water storage reservoirs ensure that the system can meet peak water demand. The network of pipelines delivers reclaimed water to more than 600 services which include parks, schools, golf courses, commercial and industrial facilities, and some residences.

Water delivered through the reclaimed system must meet Class "A" reclaimed water standards which are designed to protect human health if the public comes into direct physical contact with the water. Tucson Water treats the effluent through filtration and/or through soil aquifer treatment associated with the recharge process.

IDENTIFYING POTABLE AND RECLAIMED SYSTEM NEEDS

Existing and future water system needs can be identified and evaluated by using computer models to simulate the system. These computer representations of the potable and reclaimed systems are called hydraulic models. These models use software to represent a system's various hydraulic elements such as sources of supply, pipelines, reservoirs, pumps, valves, and so on. To simulate a complex system, the entire distribution network is simplified or "skeletonized." The model consists of mathematical formulas used to calculate the effects of actual and projected supply inputs and demand outputs on system pressures. The results of a modeling assessment are portrayed schematically and are used to assess future potable and reclaimed system improvements.

Future Potable System Needs

Future potable water system needs are determined by applying a GPCD water use factor to population projections within Tucson Water's projected service area. As described in Chapter Three, population projections are distributed spatially to locate future delivery system needs. Projected water demands are grouped by pressure zone to identify the required capacities of projected storage reservoirs and booster stations. These future facilities are schematically located within the hydraulic model at actual elevations closest to their associated demands. Hypothetical pipelines are laid out between facilities, typically on existing rights-of-way or section lines, to convey water from one to the other. The hydraulic model is used to size the projected pipelines and to ensure there is adequate water supply, storage, and pressure to meet the projected demands in 2030 and 2050. This necessitates adding infill capacity to the existing infrastructure. Extensions of the system to areas currently not served will require new pipelines and facilities as shown in Figure 5-5.

The primary areas for infrastructure expansion are projected to be in the south, southwest, and southeast portions of the Long-Range Planning Area. These are the areas where Tucson Water anticipates providing direct service in the future. Other water providers will be responsible for meeting their own future demands. However, depending on future agreements, their water resources may be treated and delivered (wheeled) to their respective service areas through Tucson Water's potable system.

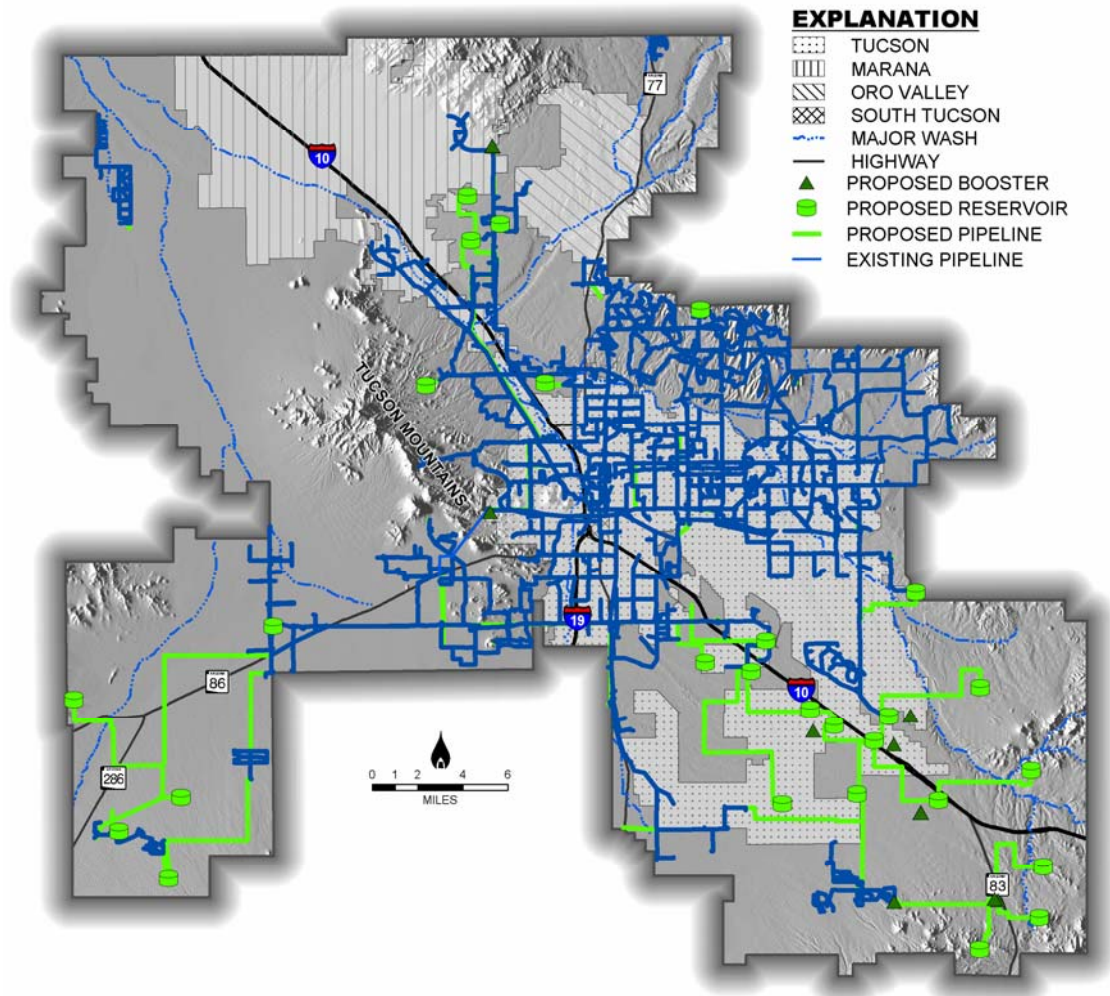


Figure 5-5: Potential Expansions of Tucson Water’s Potable System through 2050.

Tucson Water’s annual potable demand in 2000 was 117,624 acre-feet. This equates to an average demand rate of 105 MGD. Based on the population projections within Tucson Water’s projected service area, average potable demands are projected to be 214 MGD (241,000 acre-feet per year) and 227 MGD (253,000 acre-feet per year) for 2030 and 2050, respectively. This equates to projected peak daily demands of 386 MGD in 2030 and 408 MGD in 2050 based on a peak-day planning factor of 1.8 which assumes that 1.8 times more water will be delivered on a peak day than on an average day. The peak daily demand commonly occurs in the month of June.

Cost-estimating functions of the hydraulic model were used to conduct a planning-level assessment of capital costs needed to expand and upgrade the potable distribution system through 2050. As shown in Table 5-1, the capital costs are projected to be almost \$500 million by 2030 with an additional \$50 million by 2050. The system expansion costs will average about \$20 million annually through 2030. This annual rate of capital expenditure will only cover incremental costs for system expansions and does not include other costs required

to maintain or replace existing infrastructure or to bring additional renewable water supplies into use.

Year	Projected Service Area Population	Water Demand (Acre-Feet)	Expansion Cost
2030	1.22 million	241,000	\$500 million
2050	1.28 million	253,000	\$50 million
Total Estimated Cost			\$550 million

Table 5-1: Projected Potable System Expansion Costs in 2030 and 2050 (current dollars).

Future Reclaimed Water System Needs

Reclaimed water for non-potable use has historically remained constant at about eight percent of total water demand. Accordingly, this plan assumes that at least eight percent of the projected total water demand will continue to be met by reclaimed water. At the present time, most reclaimed system customers are large turf facilities such as parks, golf courses, and schools. The capital improvement projects scheduled in the next decade will increase system capacity and water supplies and will improve operational efficiency to meet increasing future non-potable demand.

As with the potable system, it is expected that the bulk of the future growth in reclaimed water demand will occur in the southern portions of Tucson Water’s projected service area. In addition to the existing non-potable uses, the reclaimed delivery system could be utilized to convey water to selected recharge locations to augment ground-water supplies during low demand periods.

PUTTING THE PLANNING PIECES TOGETHER

Developing spatially distributed demand projections for the service area provides the information required for determining where to build new pipelines, boosters, and reservoirs. Water supplies and water treatment needs are based not only on projected water demands but also on the availability of source waters and the acceptability of those sources for supply. The water-resource component of the long-range planning process is described in Chapter Six, *The Planning Process*.