Urban Infill - It's Not Just For Vacant Land
Tucson, Arizona Identifies Low Volume Reclaimed Water Customers

Karen Dotson, AICP, Tucson Water, Tucson, AZ

Timothy Francis, P.E., Malcolm Pirnic, Phoenix, AZ

Abstract

Land development in Tucson has often occurred in a "leap-frog" fashion. Prime real estate is quickly developed, leaving the smaller parcels lying between the large developments vacant. As a result, expensive infrastructure is underutilized. Much as land development has focused on the prime parcels, the construction and marketing of Tucson's reclaimed water system has historically been oriented towards serving and recruiting the prime customers: golf courses and other high volume turf irrigation uses. The result being a network of pipe stringing together high volume customers with only a few small volume customers located between them.

Because Tucson receives only 11 inches of rain a year, there is a strong community conservation ethic. This ethic, coupled with political commitment and the proximity of the reclaimed system to many potential small volume customers, led to the decision to develop the reclaimed system as a community resource. A master plan focusing on "infilling" the reclaimed water system by connecting smaller volume irrigation customers was developed and adopted. This infilling of the existing system with small volume customers has many advantages, including: the conversion of existing groundwater users to a renewable resource; reduction of demand on Tucson Water's potable system; more efficient use of existing infrastructure and improved operational efficiencies.

Using a GIS database developed during the master planning process, over 1,000 potential new reclaimed customers were identified within a 400 square mile planning area. By linking information from the County Assessor's files and Tucson Water customer billing records, with maps of the existing and proposed reclaimed system, this database allowed quick identification and prioritization of potential customers close to reclaimed water lines. During the next 5 years, more than 300 new small volume customers (not including single family houses) will be connected to the reclaimed system.

Tucson, A Water Conscious Community

Tucson, located in the Sonoran Desert, receives only 11 inches of rain a year and has no periennal surface water supply. As a result, Tucson has always been a water-conscious community. The Tucson area is growing rapidly, at a rate of 2.5 to 3 percent annually. Today the only source of water is groundwater. While the City has an allocation of Colorado River water that it will begin to use within the next several years, wastewater is the only supply that will continue to grow as the population increases. Therefore, reclaimed water plays an increasingly important role in the water supply picture.

The City has committed to the increasing the use of effluent as part of its long-range water supply plan. This commitment anticipates that effluent reuse will be 15 percent of the total water demand by 2005 and will continue at this level through the year 2100. Tucson's reclaimed water system is unique in several ways. Rather than a means to dispose of treated wastewater, it is an important and growing water supply for this desert community.

Unlike many systems that focus solely on large volume customers, the Tucson system is developing into a community system that serves a variety of customers: golf courses; cooling towers; school grounds; parks, apartment and townhouse complexes, and single family detached homes.

Planning and Development of the Reclaimed Water System

Early Planning Efforts

The City began planning for its reclaimed water system in the early 1980's in response to community pressure that the declining groundwater supply not be used to irrigate the golf resorts that were beginning to locate in the region. During this initial planning process, potential large volume irrigation and industrial reclaimed water customers were identified in a 1,000 square mile regional planning area that encompassed the City, areas in the unincorporated County and three neighboring towns. A preliminary evaluation of connecting the identified customers to the system was conducted. Then a master plan using these customers as the cornerstones of the system was developed. A network of 24-and 36-inch pipe was designed to link the customers. Initially, ten miles of large diameter pipe were installed to serve the first customer, a golf resort.

Ten years after the initial construction of the system, the master plan was updated. The same regional planning area of 1,000 square miles was used. Again, the plan focused on large volume irrigation customers, cooling towers, and this time looked at agricultural applications and long-term recharge.

The Reclaimed Water System Today

Since the first customer received reclaimed water from the 10 MGD filtration plant, 75 more miles of pipe have been added to the system. There are now 15 million gallons of storage available in five reservoirs. In addition, about half (12,500 acre-feet/year) of the total annual production capacity comes from a recharge and recovery facility.

During 1999, almost 10,000 acre-feet of reclaimed water were delivered to over 260 customers. Sixty-five percent of this water was delivered to 12 golf courses. Another 20 percent was delivered to parks. The remainder was delivered to small volume customers, including: schools (6.8 percent); single family (1.7 percent); agriculture (2.6 percent); commercial (1.2 percent); multi-family (0.6 percent); and street landscape (1.2 percent).

Vision for the Future

In recognition of the changing political conditions in the Tucson region, a third master planning process was undertaken in the fall of 1998. Two of the towns included in the previous regional planning efforts were in negotiation with Tucson to develop their own reclaimed water systems. As a result of the on-going talks, these towns were excluded from the planning area, reducing it from 1,000 to 400 square miles.

With the decision to reduce the planning area came the need to rethink how the use of reclaimed water could continue to be increased. Targeting small volume potential customers located in proximity to existing pipelines appeared to be the solution. The concept of "infilling" the existing system was supported by circumstances that existed within the reduced planning area:

- The majority of the reclaimed water system infrastructure was located within the corporate boundaries and Tucson Water's service area.

- All of the City-owned golf courses, most of the City's large parks, and most of the golf resorts/private golf clubs were already using reclaimed water, accounting for about 85 percent of the total annual demand.

- Most of the potential new large volume reclaimed water customers were, or would be, located outside of the reduced planning area.

- A heightened community awareness about declining groundwater levels had focused political and property-owner attention on the conversion of small volume irrigation uses to reclaimed water.

Therefore, a goal was established for this third master planning process: to provide a practical and economical strategy for increasing the reclaimed water system's customer base in areas where infrastructure existed. Focusing on those small volume potential customers in proximity to existing pipelines, Malcolm Pirnie, Inc. developed a master plan to direct the "infill" of the pipelines between large volume customers.

Using GIS to Identify Potential Customers

The previous planning efforts utilized conventional methods to identify reuse customers. These methods included review of aerial photography, street maps, and previous planning studies. Other sources of information included the Arizona Department of Water Resources (ADWR) water use records for large volume water users, as well as the City of Tucson's customer water billing records. The 1994 planning effort added to the database by using manual searches of selected categories in the local telephone directory to identify potential commercial, industrial, government/institution, and multi-family residential customers. These efforts involved tedious, labor-intensive searches that were successful only in identifying the largest reuse customers.

The City's current objective to emphasize connecting customers that can be served by the existing infrastructure required identification of smaller customers with smaller reclaimed water demands, as well as certain classes of customers that have not been considered before. Because the methods used previously were considered too labor-intensive and cumbersome, GIS and database methods were selected to assist in the current search for reuse customers.

The Search for Potential Customers

Initially, a comprehensive search of the planning area was conducted to identify the "universe" of potential customers. The initial search was accomplished by querying the Pima County Land Information System (LIS) database. The LIS electronic database contains 65 GIS coverages. One of these coverages contains property parcel information including land features and boundaries, ownership, and the Pima County Assessor's land use codes.

The Assessor's Office assigns land use codes to delineate the primary land use associated with each property parcel located in the County. There are currently 127 general land use codes being used.

Land use codes which are generally associated with turf areas or other non-potable water uses were identified, and the land use field of the GIS coverage was queried to identify property parcels with those land use codes.

Besides the typical large irrigation water users (golf courses, parks, schools, etc.), other land use types which use less irrigation water were considered: multi-family residential (apartments, condominiums); motels and hotel/resorts; shopping centers; office buildings; nursing care facilities; hospitals; and plant nurseries.

Using these techniques, 1,000 potential reclaimed water customers were identified within the planning area.

Besides the geographical locations of the potential customers, the resulting GIS database included information on land use type, property ownership, land parcel acreage, current water provider and source of water supply, groundwater withdrawal rights, etc.

Addition of Reclaimed Water Demands to the Database

Annual reclaimed water use was estimated for each potential customer and added to the GIS database. The demands were estimated based on water use factors developed from a number of sources. First, the ADWR water use records for facilities having greater than 10 acres of turf were reviewed. Second, the GIS customer database was linked to the Tucson Water customer billing database, and the various customer billing classes and water service code information within the billing database was used to estimate water use factors for many of the potential customers with less than 10 acres of turf. Third, a survey of nearly 700 of the potential reclaimed water customers conducted during the master planning effort yielded estimates of actual water use for many of the survey respondents. And finally, typical land- or turf-area-based water use factors were applied for customers that did not fall into any of the other estimating methods.

With the water use factors entered into the GIS database, a total new annual demand of 19,500 acre-feet was calculated for the 1,000 potential reuse customers in the planning area. Once completed, the resulting GIS customer database could be used to quickly and easily examine, sort and summarize potential reclaimed water demand according to a number of categories: e.g., by type of user, by volume of demand, by geographical area, by current water service provider and/or source of current water supply, etc.

The GIS database of potential customers was instrumental in the typical master planning activities of identifying and evaluating reclaimed water system expansion alternatives.

Prioritizing System Infill Customers

The GIS database was used to identify and prioritize groupings or clusters of customers that could be economically connected to the existing infrastructure, and to the infrastructure that would be built in the near-term (within 5 to 10 years).

Initially, the GIS database was queried and only potential customers within ½-mile of existing reclaimed water pipelines were identified and mapped. The database and GIS mapping software were also used to graphically illustrate the relative reclaimed water demands of each customer. The location of each customer was represented by a circle, and its relative demand was represented by circle size. The resulting GIS map was used to visually identify customer clusters with the apparent highest densities of reclaimed water demand. For each potential infill cluster, pertinent data was extracted from the GIS database and summarized, including demands, customer names and types, number of customers, current water service provider, etc. Using this methodology, 32 customer clusters were identified (each cluster was approximately one square-mile in size). The number of customers within each cluster ranged from one to 29, and the annual reclaimed water demands ranged from 16 to 860 acre-feet.

Once the GIS database of potential infill clusters was developed, ranking and prioritizing of the clusters was accomplished by screening and manipulating the database. First, potential customers that were considered unlikely to connect to the reclaimed water system were removed from each cluster. These unlikely customers included daycare centers, customers currently within the service area of water providers other than Tucson Water, and customers that currently obtain irrigation water from private wells. Within the Tucson Water service area, water from private wells is the least expensive, averaging about $80 per acre-foot compared to the reclaimed water rate of $475 per acre-foot.

The GIS database was modified to remove the demands of the unlikely customers and the resulting modified clusters were ranked according to total irrigation demand, with clusters having higher demands receiving higher rankings. With modification of the database, three of the customer clusters dropped out of consideration as their demands went to zero.

Additional screening of the remaining clusters involved modifying the rankings for clusters exhibiting similar levels of demand. One modification was based on number of customers. Higher priorities were given to clusters with fewer numbers of customers under the assumption that the fewer the customers, the less difficult it could be to implement infill within the cluster. Another modification was based on giving higher priority to clusters that were located along existing reclaimed water pipelines as opposed to pipelines that would be built in 5 or 10 years. Using this methodology, the remaining customer clusters were given priority rankings from one to 29.

The Advantages of an Infill Program

Using the information developed with the GIS database and a hydraulic model of the reclaimed system, a master plan for the reclaimed system was developed. This plan focused on small volume customers that could be connected to the existing infrastructure and those that could be connected to the new pipelines identified in the hydraulic modeling process. This infilling of the existing system will have many advantages, including: the conversion of existing groundwater uses to a renewable resource; reduction of demand on Tucson Water's potable system; more efficient use of existing infrastructure; and improved operational efficiencies.

In a region that is withdrawing groundwater three and a half times faster than it is being replenished, all programs to reduce groundwater use are important. Today reclaimed water accounts for nearly eight percent of Tucson Water's total demand. The implementation of the Master Plan will increase the use of reclaimed water, moving the City towards its goal of meeting 15 percent of the total demand with reclaimed water.

Tucson Water's potable demand for the peak summer day is twice the average day demand. By removing irrigation customers, with their large summer peak demands, from the potable system, the need for improvements and expansions to the potable system can be eliminated or delayed. This results in savings to the potable system that can be used to offset some of the expense of the reclaimed system.

The pipelines in the existing reclaimed system were designed with about twice the capacity as is required to meet the current peak day demand of 22 million gallons. Since many of the large volume customers that were originally projected to connect to the system fall outside of the reduced planning area, the pipeline capacity allocated to them will be unused if small volume infill customers are not connected to the system.

Improved operational efficiency will also be an important benefit of this infill program. For example, there are reaches of pipe that, while designed to have a large volume customer at the end currently do not. As a result, there are insufficient flows in these pipelines to keep the water fresh. The connection of small volume customers along these pipelines will improve flow velocities and reduce or eliminate the need to flush the lines.

Over the next five years, a total of 3,698 acre-feet of demand is planned to be added to the reclaimed system. This will be a 34 percent increase in use. It is anticipated that by the end of the five-year period, reclaimed water deliveries to golf courses, as a percentage of all annual deliveries, will drop from the current 65 percent to about 54 percent, and deliveries to parks will drop from the current 20 percent to 18 percent. Reclaimed water deliveries to small volume customers, including elementary schools, multi-family residential and townhouses, commercial, and street landscaping is expected to increase from the current 15 percent of total deliveries to about 28 percent.

The City's five-year reclaimed water capital improvement program totals $43,851,000. The program includes: 26 miles of new reclaimed pipeline; 10 MGD additional production capacity from recharge and recovery facilities; 17.3 MG of new reservoir capacity; and 19 MGD of new booster capacity.

Conclusions

Tucson is a pioneer in the use of reclaimed water for municipal irrigation. The 16-year old system is one of the largest community reclaimed systems in the United States. Developed originally to serve large volume customers, it has matured into a community system that will serve an increasing number of small volume customers located in close proximity to existing pipelines.

This infilling of the existing system with small volume customers has many advantages, including: the conversion of existing groundwater users to a renewable resource; reduction of demand on Tucson Water's potable system; more efficient use of existing infrastructure; and improved operational efficiencies. In order to identify and prioritize the many potential small volume reclaimed water customers, Tucson Water used GIS and other database techniques to make the process faster, easier, and more comprehensive than the conventional methods used in the past

The resulting database was very useful for easily and rapidly identifying customer groupings, or clusters, and prioritizing them for connections to the system based on demand, number of customers and proximity to existing pipelines.

Tucson has wholeheartedly embraced the concept of reusing wastewater. City voters recently authorized $32,000,000 in bond funding to improve and expand the reclaimed system during the next five years. This five-year bond program is consistent with the master plan developed by Malcolm Pirnie, Inc. and adopted by the Tucson Mayor and Council in December 1999.