


**WASTEWATER AND RECLAIMED WATER—DISPOSAL PROBLEM OR POTENTIAL RESOURCE?**

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Abstract. Before 1980, many communities in Florida considered sewage wastewater to be a disposal problem. When it was proposed to convert wastewater to reclaimed water for crop irrigation, citrus growers were reluctant to accept the water because of fears of heavy metals, flooding, or disease problems. For various reasons, several reclaimed water projects were started, and Water Conserv II has become one of the largest agricultural irrigation projects of its type designed for the use of reclaimed water. The project distribution center is located west of Orlando and provides irrigation for over 4300 acres of agricultural crops. Reclaimed water is also provided for irrigation of the Orange County National Golf Center and West Orange Country Club. The water is chlorinated, is odorless and colorless, and has been used successfully for crop irrigation for 15 years. Excess reclaimed water is discharged to areas of rapid percolation called rapid infiltration basins (RIBs). Water quality standards were established, and continued intensive sampling insures water of excellent quality for irrigation. The reclaimed water meets drinking water standards for a number of compounds including NO₃, SO₄, Na, Cl, Cu, Zn, Se, and Ag. Initial fears that reclaimed water would cause flooding, disease, or heavy metal problems proved to be unfounded. In the sandy, well-drained soil, high irrigation rates with reclaimed water (100 inches/year) promoted excellent tree growth and caused no major problems. This reclaimed water cannot provide complete nutrition, but does supply all the Ca, P, and B required by trees under Florida conditions. Because of a recent severe drought in Florida, attitudes toward reclaimed water have changed. Once believed to be a disposal problem, reclaimed water is now considered to be a viable resource that can meet irrigation demands. Average statewide reuse flow rates have increased by 116% in 10 years.

Disposal of wastewater is a problem for many urban areas. In the 1980s, disposal of effluent was considered to be a growing problem, primarily because of environmental concerns about degradation of surface waters. Urban-area wastewater disposal had commonly been handled by treating the wastewater to a certain level and then disposing of it in the most convenient or cheapest manner. Usually, this meant discharging the water into a nearby river or lake, spraying it onto a field, or loading it into a percolation pond. Disposal was the primary consideration since the amounts of wastewater continued to increase as an unavoidable consequence of population growth. As the wastewater volume increased, con-
cerns were raised about the effects on discharge sites. This led to consideration of alternate uses such as irrigation. While the idea of converting wastewater to reclaimed water for irrigation was not a new one, using reclaimed water for irrigation was a relatively small-scale activity in Florida before 1975. Eventually, increasing disposal problems led to several large Florida projects set up to reclaim water from wastewater treatment plants for irrigation of agricultural crops or landscape vegetation. Examples include projects at Tallahassee (Allhands et al., 1995; Roberts and Vidak, 1994) and St. Petersburg (Parnell, 1988). A large project called Water Conserv II combined the interests of the city of Orlando and Orange County.

The objectives of this paper are to 1) describe the background of the Water Conserv II project, 2) briefly discuss some of the research being done using reclaimed water, and 3) describe changes in attitudes toward reclaimed water.

Background

Before 1985, Orlando and Orange County discharged treated wastewater into Shingle Creek, which flows into Lake Tohopekaliga, a lake with high recreational value. Concerns were raised over the potential eutrophication of the lake due to additional nutrient loading. Thus, the U.S. Environmental Protection Agency required Orlando and Orange County to develop an alternative plan for the disposal of their wastewater. Several plans for the disposal of wastewater were proposed, such as: 1) injecting it into deep wells, 2) building a pipeline at least 30 miles long to carry the wastewater to the Atlantic Ocean, and 3) purchasing large tracts of land for spray fields. A less expensive and more acceptable alternative was to increase the treatment level to convert the wastewater to meet reclaimed water standards and have growers apply it to their citrus groves. Growers would be required to accept either 25 or 50 in of reclaimed water per year for a 20-year period at no cost.

Citrus grove owners initially rejected the plan because of concerns about possible heavy metal contamination, potential virus or disease problems, flooding, and lack of flexibility in water application during periods of high rainfall. Growers also raised concerns over psychological aspects and felt consumers might consider that fruit from trees irrigated with reclaimed water would be of inferior quality. Ultimately, the city of Orlando, Orange County, and the growers developed a plan that provided for the establishment of reclaimed water standards, regular monitoring of the water, greater grower flexibility on timing of use, and research on the effects of the reclaimed water on citrus tree performance. In addition to applying the reclaimed water to citrus groves, land was also purchased for Rapid Infiltration Basins (RIB) or percolation ponds for disposal of excess water. This helps recharge the Floridan aquifer. Initial funding of $180,000,000 from federal, county, and city funds established the project. Water Conserv II has since become the largest reclaimed water agricultural irrigation project of its type in the world and was the first project in Florida to receive a permit to irrigate crops for human consumption with reclaimed water (McMahon et al., 1989).

At present, the reclaimed water is applied primarily to citrus, but it is also used for irrigation of several other crops. At the Orange County National Golf Center, two golf courses with a total of 54 holes have RIB sites incorporated into them and use the reclaimed water for irrigation. At present, over 4300 acres of citrus and other crops, 12 nurseries and tree farms, and two landfill sites use this reclaimed water for irrigation. One hundred acres of willow trees are irrigated in a ‘browse farm’ to provide feed for the Walt Disney World Animal Kingdom theme park. New pipeline has been installed to extend the reclaimed water to additional citrus groves, landscape areas, and a golf course.

Water Treatment, Distribution, and Quality Standards

Two treatment facilities receive the wastewater and process it to meet reclaimed water standards for the Water Conserv II project. These facilities were upgraded to meet the stricter water quality and redundancy standards for Class I reliability (McMahon et al., 1989). In addition to the normal treatment, advanced secondary treatment capability was added to meet high-level disinfection standards. This involves coagulation and filtration facilities similar to potable water treatment plants. Pump stations at both reclamation facilities transmit the reclaimed water through a pipeline about 21 miles long to a distribution center in western Orange County. The distribution center is located in a citrus production area with deep, well-drained, sandy soils. The center can store up to 20 million gal of water in four large covered concrete tanks. A computerized control system monitors the distribution of reclaimed water 24 h a day. Water is pumped from the distribution center to either growers’ fields or to RIBs. Under current conditions, about 60% of the water goes to citrus groves and the remaining 40% goes to the RIBs. This project presently delivers about 30 million gal per day (mgd). Permitted average daily flow capacity is 44 mgd with ultimate average daily flow capacity of 50 mgd and peaks to 75 mgd.

The reclaimed water provided to citrus groves is supplemented with well water for freeze protection. Most groves are irrigated with undertree microsprinkler irrigation, which can provide some frost protection for citrus trees (Parsons et al., 1982, 1991). To provide additional water when all the growers want to irrigate on freeze nights, 25 supplemental high capacity deep wells were tied into the distribution system. These wells can provide an additional 80 mgd of water.

By contract, growers agreed to accept either 25 or 50 inches of water per acre per year for 20 years. Water is delivered at no charge to the edge of the grower’s property at a minimum pressure of 40 psi. Growers can terminate their participation in the 20-year agreement at any time through a buy-out clause by repaying the city and county $3600/acre the first year with the repayment decreasing by 5% each following year (Jackson and Cross, 1993).

The University of Florida established water quality guidelines for citrus trees. They are rigorous and apply only to the Water Conserv II project (McMahon et al., 1989; Parsons et al., 2001). The maximum average concentration limits (MACLs) for some elements and compounds such as Na, Cl, Ba, Ca, Cu, Se, Mg, SO₄, and Zn are more stringent than Florida drinking water standards. Reclaimed water with higher salt concentrations has been used successfully for irrigation in coastal areas in Florida (Maurer et al., 1995). Because of recent concerns about nitrate in the ground water, the treatment facilities have been required to meet the drinking water standard of 10 ppm for nitrate N. In terms of crop mineral nutrition, meeting the nitrate drinking water standard is a disadvantage because this reduces N supplied to the orchard.

Environmental monitoring is accomplished by sampling from wells in the RIB areas and alternate application sites. Groundwater is tested for nitrates, priority pollutants, primary and secondary drinking water standards, and other parameters. The water is chlorinated, which provides virtually complete removal of viruses and bacteria (McMahon et al., 1989). The water is colorless and odorless. Florida regulations presently state that only indirect contact methods such as drip, subsurface, or ridge and furrow irrigation can be used to irrigate the ‘salad crops’. Any type of irrigation method can be used to irrigate tobacco, citrus, or other crops that
will be “peeled, skinned, cooked, or thermally processed” before human consumption (York et al., 2000).

Reclaimed Water Research at Water Conserv II

Growers have now used Water Conserv II reclaimed water successfully for over 15 years. At the request of growers, studies were initiated to determine the effects of this reclaimed water on citrus trees. The first studies were conducted in commercial groves to make comparisons between reclaimed and well water (Koo and Zekri, 1989; Zekri and Koo, 1990). In these plantings, growers using reclaimed water commonly used more water than those using well water. Hence, soil water content has usually been higher in the groves using reclaimed water. Appearance of trees irrigated with reclaimed water was usually better than the trees irrigated with well water (Koo and Zekri, 1989; Wheaton et al., 1996).

Since disposal of large quantities of wastewater was of concern early in this project, it was important to determine if citrus could tolerate high application rates of reclaimed water. In research plantings, very high rates were applied to two citrus varieties, ‘Hamlin’ orange [Citrus sinensis (L.) Osb.] and ‘Orlando’ tangelo (C. paradisi Macf. × C. reticulata Blanco) trees on four rootstocks. In addition to normal rainfall of approximately 50 in/year, these trees were irrigated with rates of up to 100 in/year (approx. 2 in/week). Application of 2 in/week of reclaimed water in a 20-acre experimental planting significantly increased canopy volume and fruit yield compared to 0.32 in/week of well and reclaimed water applications (Parsons and Wheaton, 1992; Parsons et al., 2001). Because of the scheduling method used, the lower irrigation rate did not provide adequate water for optimum tree growth and production. The excessive irrigation of the 100 in/year treatment diluted the juice soluble solids somewhat, but because of the greater total fruit production, total soluble solids per acre were increased at the 100-in irrigation rate.

Weed growth was rank because of the high reclaimed water irrigation rate (Parsons and Wheaton, 1992; Zekri and Koo, 1993). Weed growth was controlled with proper herbicide use and mowing.

Irrigation with reclaimed water increased soil P, Ca, Na, and pH (Parsons and Wheaton, 1992; Zekri and Koo, 1993). Much of the Na in the soil was leached below the upper 3 ft, the depth where most of the fibrous roots are located. This reclaimed water supplies all the P, Ca, and B required by trees in central Florida soils. Leaf P and Ca levels were also increased. Leaf levels of Na, Cl, and B were elevated but remained below toxic levels.

Because the nitrate level is low (less than 10 mg/L), the amount of N extracted from this reclaimed water is unknown. In one grower study, young trees that were given no fertilizer and irrigated only with Water Conserv II reclaimed water took 2 to 5 years to show N deficiency symptoms and yield declines (Ross, 1993, pers. comm.). Other work in the Vero Beach area showed that reclaimed water alone did not provide adequate nutrition for young grapefruit tree growth (Maurer and Davies, 1993). Preliminary data showed that high application rates of reclaimed water maintained yield for one year, but yields declined in the second year without additional fertilizer application (Wheaton et al., 1996).

A second research planting was established to study the effects of irrigation and fertilizer application rate on ‘Ambersweet’ (Citrus spp. hybrid), a recently released orange variety. Current treatments include two irrigation rates and N applied at different rates as dry soluble fertilizer or via fertigation. Yield and juice soluble solids generally increased with increasing fertilizer and irrigation rates, and were slightly higher for fertigation compared to application of dry materials. This study showed that ‘Ambersweet’ might be more sensitive to water and nutritional stress than other orange varieties.

A third planting was set up to evaluate possible new mandarin varieties for the north central citrus ridge region. Two commercial varieties, ‘Fallglo’ and ‘Sunburst’ (Citrus spp. hybrids), plus six new selections were planted in 1993. The purpose was to determine if a mandarin season could be established that allowed for continuous harvest because of differences among the selections in their times of maturity. Rootstocks were included to see if the time of maturity of each selection could be expanded. To date, the rootstock effects on juice quality and the range in time that legal maturity is achieved have been minimal.

A fourth area has been planted with deciduous crops to determine their suitability as alternative crops for citrus in this region. These include peaches, grapes, pecans, figs, plums, and several others.

A new planting to evaluate ‘Valencia’ orange somaclones selected for juice characteristics was established in 2000. In addition to citrus, several forage crops are being evaluated. Research is also being conducted on the effects of reclaimed water application on golf course groundwater quality and forestry tree species for biomass production (Morgan et al., 2000; Parsons et al., 1999).

Changes in Attitude

Attitudes in Florida toward reclaimed water have changed since the mid-1980s. Before then, treated sewage effluent was considered to be an urban disposal problem. Treated effluent had no beneficial use, and the low-cost method for disposal was discharge into a river, lake, ocean, or spray field. When the Water Conserv II project was proposed, most growers opposed it because of fears about salts, heavy metals, odors, contaminants, flooding, disease, and potential tree damage. To overcome these objections, water quality standards were established. Since the Water Conserv II project began, the initial fears of flooding, disease, and tree damage have proved to be unjustified. Being very low in heavy metals, this reclaimed water has had no adverse effects. Sufficient flexibility was given to growers so they could acceptably manage their water in a region that has quite variable rainfall.

The benefits of this project are now apparent. Orlando and Orange County benefit by meeting the mandate for zero discharge of effluent into surface waters. Withdrawal from the Floridan aquifer for irrigation is reduced. This helps avoid lowering of groundwater levels. Some fertilizer elements are provided to the crop by the reclaimed water. Because reclaimed water has been used safely and effectively, some groups and agencies are promoting the use of reclaimed water as a way to make up for water shortages. A serious drought in central Florida lasting from 1999 through June 2001 has greatly increased interest in water reuse. Statewide reuse flow increased by 116% to 575 mgd from 1999 to 2000. In 2000, agricultural reclaimed water irrigation reached 14,414 acres of edible crops and 20,868 acres of other crops (Florida DEP, 2001).

Conclusions

For a reclaimed water irrigation project to be successful, all parties involved should benefit. In the case of Water Conserv II, the city and county benefit by disposing of large quantities of treated wastewater. By giving flexibility to the growers, the city also avoids the high cost of purchasing and maintaining additional land for percolation ponds. Other cities in Florida have purchased land for reclaimed water disposal and planted it with citrus or other
crops. These cities usually have to hire additional personnel or consultants because they do not commonly have the resources to produce crops as economically as commercial growers. By giving the water to growers, Water Conserv II avoids many of the costs, risks, and day-to-day problems of farming. The growers benefit by getting a low cost, reliable, and flexible source of water that can be used for both irrigation and freeze protection.

Because of population growth and a number of below normal rainfall years, increased competition for water has led to greater restrictions on agricultural water use. Reclaimed water usually has few restrictions on its use, and thus becomes more valuable during droughts. Annual energy savings from eliminating irrigation pumping costs can be as much as $100/acre (McMahon et al., 1989).

Salt content and maintenance of water quality are major issues for a reclaimed water project to be successful. Because of possible future mishaps, growers insisted on the ability to stop using the water later on if problems developed. Such an “escape clause” for the growers acts as an incentive for the water reclamation facilities to maintain the reclaimed water at acceptable quality levels. This creates a “checks and balances” situation where all groups involved benefit if the water quality is maintained. Even though Na and Cl concentrations increased slightly above the maximum average concentration limits (70 and 100 ppm, respectively) in spring, 2001, these limits have kept the water at acceptable quality levels for citrus irrigation.

Reclaimed water is no longer considered to be a disposal problem, but a limited resource of value. Quality of the water, along with supply and demand forces, will ultimately determine how much reclaimed water is used for irrigation or other purposes. Some growers still have concerns that there is a psychological stigma attached to reclaimed water that may damage the market quality of Florida citrus that has been built up over the years. Nevertheless, initial opposition to the use of reclaimed water has decreased as demand for the water has increased. In the case of Water Conserv II, reclaimed water has been used in a productive and environmentally safe manner in a successful cooperative effort between growers and government agencies that has solved problems for both and proven the value of reclaimed water.

### Literature Cited


