Wastewater Reuse Conserves Water and Protects Waterways

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Droughts, explosive population growth in arid parts of the country, and the continuing view that water is an infinite resource are reasons for water shortages in many areas across the nation. In response to this problem, some wastewater professionals are reusing treated wastewater and have found it to be a reliable alternative water source.

In addition to conserving highly treated, expensive drinking water, wastewater reuse reduces the release of nutrient-rich wastewater into environmentally stressed streams and rivers.

"Wastewater can be viewed as a resource, fresh water containing plant nutrients (nitrogen, phosphorus, and potassium)," says John Sheaffer, Ph.D., president, Sheaffer International, Ltd., Naperville, Illinois. "In the groundwater, these nutrients are a pollutant, but on a growing crop or turf, they are a resource. When wastewater is reused, it is not available to pollute the groundwater supply."

What is wastewater reuse?

The term wastewater reuse is often used synonymously with the terms wastewater recycling and wastewater reclamation. Because the general public often does not understand the quality difference between treated and untreated wastewater, many communities have shortened the term to water reuse, which creates a more positive image.

The U.S. Environmental Protection Agency (EPA) defines wastewater reuse as, "using wastewater or reclaimed water from one application for another application. The deliberate use of reclaimed water or wastewater must be in compliance with applicable rules for a beneficial purpose (landscape irrigation, agricultural irrigation, aesthetic uses, ground water recharge, industrial uses, and fire protection). A common type of recycled water is water that has been reclaimed from municipal wastewater (sewage)."

Reasons for Wastewater Reuse

The most common reasons for establishing a wastewater reuse program is to identify new water sources for increased water demand and to find economical ways to meet increasingly more stringent discharge standards.

Types of Reuse

Wastewater reuse can be grouped into the following categories:

- **Urban reuse**—the irrigation of public parks, school yards, highway medians, and residential landscapes, as well as for fire protection and toilet flushing in commercial and industrial buildings.
- **Agricultural reuse**—irrigation of nonfood crops, such as fodder and fiber, commercial nurseries, and pasture lands. High-quality reclaimed water is used to irrigate food crops.
- **Recreational impoundments**—such as ponds and lakes.
- **Environmental reuse**—creating artificial wetlands, enhancing natural wetlands, and sustaining stream flows.
- **Industrial reuse**—process or makeup water and cooling tower water.

Guidelines and Regulations

In 1992, EPA developed *Guidelines for Water Reuse*, a comprehensive, technical document. Some of the information contained in this manual includes a summary of state reuse requirements, guidelines for treating and reusing water, key issues in evaluating wastewater reuse opportunities, and case studies illustrating legal issues, such as water rights, that affect wastewater reuse.

EPA guidelines for three of the more common types of wastewater reuse are given in the table on page 47.

State Guidelines Vary

Many states have guidelines or regulations for the design and operation of wastewater reuse facilities, but wide discretion in interpreting EPA's guidelines has resulted in standards that differ significantly across the states. For instance, Texas prohibits using recycled water

Reuse Table

Types of Reuse	*Treatment*	*Reclaimed Water Quality*	*Reclaimed Water Monitoring*	*Setback Distances*
Urban Reuse Landscape irrigation, vehicle washing, toilet flushing, fire protection, commercial air conditioners, and other uses with similar access or exposure to the water.	Secondary[1] Filtration[2] Disinfection[3]	pH = 6–9 ≤10 mg/L biochemical oxygen demand (BOD) ≤ 2 turbidity units (NTU)[5] No detectable fecal coliform/100 mL[4] 1 mg/L chlorine (Cl_2) residual (min.)	pH – weekly BOD – weekly Turbidity – continuous Coliform – daily Cl_2 residual – continuous	50 ft (15 m) to potable water supply wells
Agricultural Reuse For Non-Food Crops Pasture for milking animals; fodder, fiber and seed crops.	Secondary Disinfection	pH = 6–9 ≤ 30 mg/L BOD ≤ 30 mg/L total suspended solids (TSS) ≤ 200 fecal coliform/100 mL[5] 1 mg/L Cl_2 residual (min.)	pH – weekly BOD – weekly TSS – daily Coliform – daily Cl_2 residual – continuous	300 feet (90 m) to potable water supply wells
Indirect Potable Reuse Groundwater recharge by spreading into potable aquifiers.	Site specific Secondary and disinfection (min.) May also need filtration and/or advanced wastewater treatment	Site specific Meet drinking water standards after percolation through vadose zone.	pH – daily Turbidity – continuous Coliform – daily Cl_2 residual – continuous Drinking water standards – quarterly Other – depends on constituent	100 ft (30 m) to areas accessible to the public (if spray irrigation) site specific

[1] Secondary treatment processes include activated sludge processes, trickling filters, rotating biological contactors, and many stabilization pond systems. Secondary treatment should produce effluent in which both the BOD and TSS do no exceed 30 mg/L.

[2] Filtration means passing the effluent through natural undisturbed soil or filter media such as sand and/or anthracite.

[3] Disinfection means the destruction, inactivation or removal of pathogenic microorganisms. It may be accomplished by chlorination, or other chemical disinfectants, UV radiation or other processes.

[4] The number of fecal coliform organisms should not exceed 14/100 mL in any sample.

[5] The number of fecal coliform organisms should not exceed 800/100 mL in any sample.

Source: U.S. Environmental Protection Agency. 1992. *Guidelines for Water Reuse.* (EPA)/625/R-92/004.

to irrigate food crops while New Mexico allows surface irrigation of food crops where there is no contact between the edible portion of the crop and the treated wastewater. Some states, Pennsylvania for instance, are just beginning to look at wastewater reuse.

Recent droughts in the water-rich state of Pennsylvania have prompted water agencies to investigate wastewater reuse. “We are starting to prepare an internal position paper on wastewater reuse for management review,” says Roger Musselman, chief of permit section, Pennsylvania Department of Environmental Protection, Division of Wastewater Management, Harrisburg, Pennsylvania.”We hope to establish guidelines within the next two years.”

Pennsylvania’s experience in wastewater reuse is limited. “We’ve used it to make artificial snow and to spray irrigate a couple of golf courses,” Musselman reports. “In each instance, the state’s Department of Environmental Protection’s regional office oversaw the project. Basically, we used a high-quality effluent for these projects, so the end result was a positive one.

“Our major problem right now is the lack of agreement among the regions about the required level of treatment before reuse. Some regions closely follow EPA’s guidelines and require tertiary treatment. Other regions think wastewater with a fecal coliform level of 200 colonies per 100 mL is sufficient for irrigating a golf course. We really need to get everyone on the same page.”

Community Health Protection

In any reuse system, protecting public health is critical. Human exposure to disease-causing organisms or other contaminants in treated effluent could cause serious public health problems. For this reason, wastewater that could come in contact with the public is treated at the tertiary level, which removes most of the original pollutants. The most common disinfectants used to remove or inactivate pathogenic organisms are chlorine, ultraviolet light, and ozone.

Public Education

Education is key to overcoming public fears about a reuse system, particularly fears that relate to public health and water quality. “A broad, in-depth public relations program and a demonstration project are especially helpful when the reuse project is the first of its kind in the state,” says Curtis Stultz, assistant superintendent, Wastewater Treatment Plant for the City of Woodburn, Oregon.

The public can either be your ally or your worst nightmare. “Our citizens backed our project, but another Oregon community wasn’t as fortunate,” Stultz says. “Their treatment plant wanted to create a plantation of hybrid poplar trees where it could discharge some of its treated industrial wastewater. The plantation site was small, and the homeowner who lived next to the site had concerns about the project. Misconceptions about the treatment process, its effect on the groundwater, and the use of genetically engineered trees led the homeowner to file suit against the wastewater treatment plant. That incident was the impetus for setting up regulations in Oregon for how poplar trees are planted.”

Some Wastewater Reuse Advantages and Disadvantages

Advantages:

- This technology reduces the demands on potable sources of freshwater.
- It may reduce the need for large wastewater treatment systems, if significant portions of the waste stream are reused or recycled.
- The technology may diminish the volume of wastewater discharged, resulting in a beneficial impact on the aquatic environment.
- Capital costs are low to medium for most systems and are recoverable in a very short time; this excludes systems designed for direct reuse of sewage water.
- Operation and maintenance are relatively simple except in direct reuse systems where more extensive technology and quality control are required.
- Provision of nutrient-rich wastewaters can increase agricultural production in water-poor areas.
- Pollution of rivers and groundwaters may be reduced.
- Lawn maintenance and golf course irrigation is facilitated in resort areas.
- In most cases, the quality of the wastewater, as an irrigation water supply, is superior to that of well water.

Disadvantages

- If implemented on a large scale, revenues to water supply and wastewater utilities may fall as the demand for potable water for non-potable uses and the discharge of wastewaters is reduced.
- Reuse of wastewater may be seasonal in nature, resulting in the overloading of treatment and disposal facilities during the rainy season; if the wet season is of long duration and/or high intensity, the seasonal discharge of raw wastewaters may occur.
- Health problems, such as water-borne diseases and skin irritations, may occur in people coming into direct contact with reused wastewater.
- Gases, such as sulfuric acid, produced during the treatment process can result in chronic health problems.
- In some cases, reuse of wastewater is not economically feasible because of the requirement for an additional distribution system.
- Application of untreated wastewater as irrigation water or as injected recharge water may result in groundwater contamination.

Source: Organization of American States. *Water Reuse.* Unit for Sustainable Development and Environment. *www.oas.org/sp/prog/chap3_2.htm.*

Cross-Connection Control

It is crucial to be able to differentiate between piping, valves, and outlets that are used to distribute treated effluent (reclaimed water) and those that are used to distribute potable water. One method used for this purpose is color-coding components used to distribute reclaimed water not intended for drinking water. Another method is to post areas such as parks, cemeteries, and yards with warning signs stating the water is not for consumption. Signage should reflect all the major languages in the region. Florida, for instance, uses both Spanish and English.

"The City of St. Petersburg's cross-connection control program is nationally recognized as being one of the most thorough programs in place, especially for dual distribution systems," says Bruce Bates, manager of water reclamation, St. Petersburg, Florida. "We routinely inspect homeowner and commercial systems to ensure they haven't inadvertently tied their potable water system into the reclaimed system. We require backflow prevention assemblies; and we have hose bibbs for the reclaimed line in an underground service box."

Costs

Some considerations for costs include the type of reuse equipment chosen, whether or not the reuse system was constructed at the same time as the treatment plant or added on afterward, the level to which the effluent is treated, and the distance the treated effluent must travel between the treatment site and the discharge site. Many communities have defrayed costs through low-interest loans and federal, state, and local grants.

In his abstract "Wastewater Reuse for Non-Potable Applications: An Introduction," presented at the 2000 International Symposium on Efficient Water Use in Urban Areas, Takashi Asano, Ph.D., P.E., University of California, Davis, California, writes, "A common misconception in planning for wastewater reclamation and reuse is that reclaimed wastewater represents a low-cost new water supply. This assumption is generally true only when wastewater reclamation facilities are conveniently located near large agricultural or industrial users and when no additional treatment is required beyond the existing water pollution control facilities from which reclaimed water is delivered. The conveyance and distribution systems for reclaimed water represent the principal cost of most proposed water reuse projects. Recent experience in California indicates that approximately four million U.S. dollars in capital cost are required for each one million m^3 per year of reclaimed water that is made available for reuse. Assuming a facility life of 20 years and a nine percent interest rate, the amortized cost of this reclaimed water is about $\$0.45/m^3$, excluding operations and management costs."

Wastewater reuse systems range from very sophisticated and complex engineering processes to simple, natural systems. A professional engineer can examine the various processes and components to design a system that best meets your needs.

Wastewater Reuse in Florida

In 2001, Florida reused 584 million gallons per day of treated wastewater for beneficial purposes.

"In Florida, it's either feast or famine," Bates says. "Florida enjoys plentiful rainfall, but uneven distribution of precipitation has caused drought conditions, particularly in March, April, and May. To preserve water supplies, Florida's state law mandates that potable water be limited for irrigation purposes."

St. Petersburg, Florida, is home to the oldest municipal dual distribution system in the United States, and one of the largest in the world. The system supplies potable water through one distribution network and non-potable water through the other.

The city's four water reclamation treatment plants handle more than 40 million gallons of wastewater each day. When the water enters the plant, it is screened through a bar screen structure

Photo by Susan Horvat

to remove large debris and then goes to a grit chamber to allow the sand and grit to settle. After settling, the water is biologically treated in special aeration basins to allow billions of microorganisms to consume organics in the wastewater. After biological treatment, the water is filtered through deep bed, dual media filters and then clarified. To complete the process, the water is disinfected with chlorine.

The treated effluent flows through 260 miles of pipe to more than 10,000 homes and businesses, including 9,340 residential lawns, 51 schools, 86 parks, six golf courses, and 11 commercial cooling towers. Forty million gallons of treated wastewater can be stored onsite; after that, the water is stored 900 feet below the ground in deep well injection.

"The public loves the service," Bates says. "Statistically, it takes wastewater from five homeowners to provide enough water for one lawn, so our biggest criticism has been that we can't serve everyone. Currently, we serve approximately 10 percent of our population."

One reason the public has responded so favorably is that reused wastewater is billed on a flat rate, not on consumption. "Using potable water would cost between five to 10 times more than reused wastewater," Bates says. "When we first started the program back in the 1970s, no one was sure how the program would be received, so it was marketed at a low, flat rate to win people over and was subsidized through other revenues. But charging a flat rate was a big mistake. People don't conserve because there is no economic incentive associated with it. The $5 monthly user fee doesn't come close to covering our capital and operating costs for this service."

St. Petersburg is setting up several pilot programs in which meters will be used to determine consumption rates. "We'll only be gathering baseline data," Bates says. "Moving from a flat rate to a consumption rate is a political decision the mayor would have to make, and it will require serious discussion in order to convince our customers."

Reuse in Woodburn, Oregon

When the Oregon Department of Environmental Quality revised the total maximum daily load for the Pudding River, the city of Woodburn had to decide between lowering the ammonia level in its wastewater or finding an alternative discharge site. After investigating a variety of options, Woodburn chose to refurbish its treatment plant to include a wastewater reuse facility.

Gaining public acceptance was at the top of the list. "Management put together a citizen's committee, created an educational video about the facility, conducted poplar plantation tours, organized school science poplar projects, sent out flyers and mailers, and got newspaper coverage," Stultz says. "We hired a retired public relations woman from the community to assist us. We made sure that the community understood what we wanted to do and how we were going to do it. It was a lot of effort, but it was well worth it."

In 1999, Woodburn was ready to discharge treated effluent through micro-spray sprinklers into its newly developed poplar tree plantation. "This was the perfect solution for us," Stultz said. "We have a lot of farmland around us, and the soil was adequate for the application, so we didn't have to do much preparation work."

"The great thing about poplar trees is that they grow quickly and use lots of water,"he adds. "A four-year-old tree, for instance, would uptake 10.6 acreages of water. We generally produce about two million gallons a day of wastewater, and we can irrigate the 88-acre plantation with 1.5 million gallons a day during our critical dry months from June through September. The remaining one-half million gallons a day is discharged to our receiving stream. Because the amount of wastewater being discharged into the stream has been greatly reduced, the receiving stream is able to dilute the concentrations of ammonia so that the levels are within regulations." The amount of wastewater taken into the treatment plant slows down during the November rainy season when the receiving stream is naturally high, providing a greater dilution factor for loadings.

Wastewater is treated using a biological nutrient removal aeration basin, a clarifier, and sandfilters, bringing it to tertiary treatment. Treated effluent is disinfected in an ultraviolet unit and then diverted into a basin for chlorination. While this level of treatment exceeds the requirements for a nonfood crop, management decided to use the precautions since the treatment plant had the equipment to do it.

After chlorination, the treated effluent is pumped into a manifold system that distributes it to the poplar plantation through an underground piping system. Micro-spray sprinklers are used to irrigate the plantation, but there is an offset of 35 feet from the property line where irrigation does not occur. In addition, the plantation is completely fenced and surrounded by signs warning intruders that treated effluent is being discharged.

The irrigation system can be shut down in five-acre blocks, providing the capability for spot irrigation. The system is operated from a microcomputer and requires only minimal daily input and supervision.

Should the plantation or a pump fail, the treatment plant can discharge the effluent into a five-acre lagoon that it maintains for emergency storage.

"The system went in pretty smooth. There are just some minor changes I'd make when we expand," Stultz says. "For instance, some of our employees have a farming background, and there are certain steps that we tried to get the engineers to do before planting the trees that would have been helpful. The field was plowed, leveled, and then grass and a four-inch cutting were planted into the bare ground. When we irrigated, we had a weed control problem and had to manually remove the grass from around the cuttings.

"What we recommended was planting grass seed on the site for a year or two and spraying and harvesting it for grass seed," he says. "This would condition the soil, and there wouldn't be any weeds. Then you plant the trees in your stream lines and rows without disturbing the soil. This way, grass is already growing and weeds aren't a big problem."

This natural system creates an attractive habitat for wildlife, provides 30 to 50 percent more evapotranspiration capacity than would a different crop of equal size, and provides a new source of revenue. Trees can be harvested every seven to 12 years, and revenue from the sale of woodchips can be used to offset a portion of the capital and operation and maintenance costs of the system.

The city plans to expand the facility every five years to match population growth. By 2020, the site will cover 300 acres and will reuse five million gallons of wastewater per day.

Reuse in Hawaii

In August 2000, the City of Honolulu opened its first reuse facility on Oahu and, at 13 million gallons per day, it is the largest in the Hawaiian Islands. The Honouliuli Water Recycling Facility (HWRF) was built to preserve limited potable water and to satisfy a 1990s decree mandating the city reduce the amount of wastewater effluent it discharges into the Pacific Ocean.

Originally, the city entered into a public/private partnership with USFilter™ Operating Services, now known as Veolia Water. According to the agreement, Veolia would design, build, own, and operate the facility for 20 years and then turn it over to the city.

One month before the facility opened, however, the city decided that the Honolulu Board of Water Supply (HBWS) would purchase the HWRF and contract Veolia Water to operate it. "By buying the facility, we're in control of the operation, and we receive the profits by sort of taking out the middle man profits," Clifford Jamile, manager and chief engineer of the Board of Water Supply, reports in a July 2000 Board of Water news release. "We feel the effects are twofold. One, we will save millions of gallons of drinking water per day currently used for irrigation or industrial purposes. Two, the profits from the sale of reclaimed water adds another revenue to our base, and we can pass the savings on to the customer."

The HWRF was built adjacent to the Honouliuli Wastewater Treatment Plant so that it could "T" into the plant's effluent outfall. The facility produces two grades of high-quality recycled water, R-1 water, which is used for landscape, agriculture, and golf course irrigation, and reverse osmosis water (RO), which is used for industrial purposes, such as boiler feed water and ultra-pure process water.

"When one of the industrial customers uses the RO water, the island saves 600,000 gallons a day of drinking water. With all the industrial users combined, we save about 2.5 million gallons a day of drinking water," says Ken Windram, project manager for Veolia Water.

Both types of recycled water begin with secondary treated effluent from the Honolulu wastewater treatment plant. The R-1 and the RO processes are shown in Figure 1.

Switching to RO water turned into a savings for industrial users. "When rain water filters through the lava structure in the ground, it picks up between 60 to 70 parts

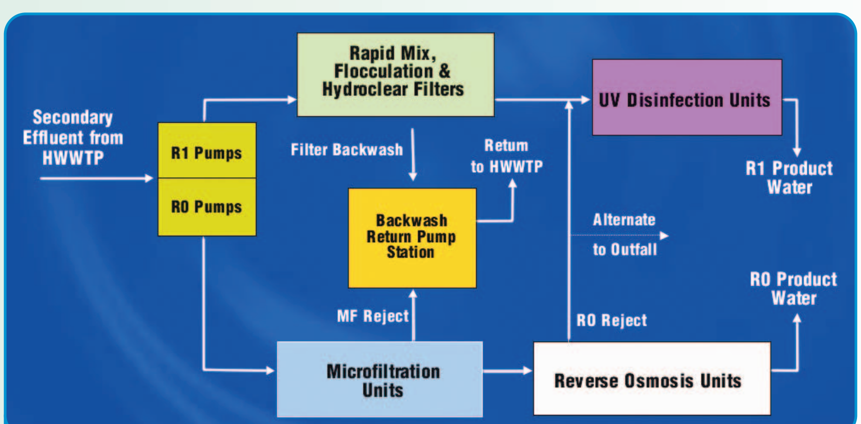

FIGURE 1 BWS Water Reclamation Facility—Simplified Flow Diagram

silica per million gallons in the drinking water," Windram says. "The silica turns into glass when it enters the boilers, costing the power plants and refineries a substantial sum of money to demineralize the water to remove it."

The HWRF, on the other hand, reduced the silica from 60 to 70 parts per million to about 1 part per million gallons of water. "Industrial users had paid the city and county $1.98 per thousand gallons for drinking water," he says. "In addition, they spent $5 to $12 per thousand gallons to demineralize the water.

"We charge industrial users about $5 per thousand gallons for recycled water," Windram continues, "yet they save between $2 and $7 per thousand gallons, depending on their daily flow rate, because ultra-pure RO water allows more demineralizer production gallons between backwashes, greatly reducing the amount of regeneration chemicals used."

When the HWRF first opened, irrigation users such as golf courses paid only 25 cents per thousand gallons of R-1 water. Over a three-year period, the rate was increased to 65 cents. Providing water at such low prices enticed users to replace groundwater with recycled water for nonpotable uses. The R-1 water users are pleased with the results. Chlorides were reduced from 800 to 1,600 for groundwater to less than 300 chlorides for recycled water, and chloride sensitive vegetation is now plentiful on the golf courses.

"Because of the dissolved nitrogen and phosphorus compounds in the R-1 water, the golf courses have reduced their purchases of commercial fertilizers, and the 'play' on the courses has really improved," Windham says. "Also, when other Oahu golf courses have to reduce water use during the summer season, the HWRF-watered golf courses continue to irrigate with the drought-proof recycled water supply."

The greatest obstacle to recycled water was public acceptance. "It's simply a matter of explaining the technology that is involved here and the standards required by the department of health before we can discharge the water," Windram said.

Veolia Water and the HBWS developed a public outreach program that educated the public through facility tours, newsletters, brochures, and public presentations at neighborhood board meetings, community meetings, church associations, and schools.

The Future of Reuse

Actions promoting wastewater reuse are everywhere. New Jersey, for instance, has formed a ten-member commission to investigate wastewater reuse for non-potable urban uses such as irrigation, dust control, and fire fighting.

Both New York and Louisiana have pending legislation dealing with different aspects of reuse. And several cities—Odessa, Texas, and Denver, Colorado, among them—have started constructing resuse systems.

Wastewater reuse is a proven technology that has been used for more than 40 years across the U.S. It is a drought-proof, renewable supply of water that will help communities keep water tables from dropping, water resources from shrinking, and waterways from becoming polluted.

For More Information

The National Environmental Services Center (NESC) maintains a list of manufacturers and consultants in its Manufacturers and Consultants Database. The URL is: www.nesc. wvu.edu/nsfc_manu facturers.htm.

NESC also has products related to reuse. The Winter 1999 issue of the newsletter Pipeline *(product # SFPLNL16) is devoted to the topic, as is the book* Guidelines for Water Reuse *(WWBKDM72). To order either of these products, call NESC at (800) 624-8301 or send an e-mail to info@mail.nesc.wvu.edu.*

On the Internet, EPA Region 9 has some links to specific areas at www.epa.gov/region9/water/recycling. *The WateReuse Association has a Web site at* www.watereuse.org.

A version of this article originally appeared in the summer 2004 issue of Small Flows Quarterly *(SFQ). Published by NESC, SFQ is a magazine devoted to small community wastewater issues.*

A member of NESC for more than eight years, **Caigan McKenzie**, has had a number of her water and wastewater articles reprinted in a variety of publications.