What is Wastewater Reuse?

The hydrologic cycle represents the ultimate reuse of water. From the perspective of wastewater, reuse is the beneficial use of reclaimed wastewater. It is a “reuse” because the user does not have to go a river or to the groundwater to obtain this water – this water is a by-product of human sanitation and industrial processes. By removing the waste constituents from wastewater, the water can be safely used for agricultural, commercial, and industrial purposes. By volume, agricultural irrigation is the largest user of reclaimed wastewater. Other users include those who use water for industrial cooling and processing. A second category of reuse is indirect reuse. Highly renovated wastewater can be used to recharge aquifers. This is an indirect reuse because the reclaimed water is being used to supplement underground drinking water sources.

Non-potable Reuse Applications

Reclaimed water for non-potable reuse must undergo primary, secondary, and tertiary treatment. The number and choice of treatment steps will vary based on how the water will be used. However, most recycled water will undergo some form of disinfection for protection of public health. When disinfection is not used, the reuse area must be isolated from direct human or animal contact by fencing, signs, or other means. The most commonly used non-potable reuse applications are described below.

Irrigation reuse

Irrigation reuse is the direct use of reclaimed wastewater by applying it to agricultural crops or landscaped areas. Irrigation is a value-added means of dispersing the water back into the environment. Spray distribution (described another Fact Sheet in this series) uses similar equipment and methods to apply the water, but is designed for dispersal of effluent and not have the “value-added” component of crop
production. A second difference is to understand that irrigation is a seasonal water use, and when a crop or landscape does not need irrigation, then another means of reusing the reclaimed water must be determined.

The two main categories for the wastewater irrigation reuse are agricultural irrigation (crop irrigation, commercial nurseries) and landscape irrigation (parks, playgrounds, golf courses, freeway medians, landscape areas around commercial, office, industrial developments, and residential landscape areas). Any size community can incorporate the reuse of treated wastewater for landscape features. Larger communities can produce sufficient water to make agricultural crop irrigation practical. The effluent quality prior to application is important since the quality and applicable regulations dictate what sort of reuse can be done.

*Restricted irrigation reuse* is limited to crops that will not be directly consumed by humans (fodder, fiber and seed crops), and is appropriate for relatively small flows. Public access to the irrigated area is controlled. For this type of reuse, wastewater treatment must effectively remove pathogens and organic matter in order to protect public health and eliminate odors. Sites with steep slopes may not be appropriate for irrigation reuse due to excessive runoff potential. Slope may also influence the choice of vegetation used as described in the table below.

### Potential for Utilization of Irrigation Reuse relative to Slope and Vegetation Management

<table>
<thead>
<tr>
<th>Slope %</th>
<th>Fodder, fiber and seed crops</th>
<th>Turf</th>
<th>Forest</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 – 4</td>
<td>High</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>4 – 12</td>
<td>Low</td>
<td>Moderate</td>
<td>High</td>
</tr>
<tr>
<td>20-Dec</td>
<td>Excluded</td>
<td>Low</td>
<td>Moderate</td>
</tr>
<tr>
<td>&gt; 20</td>
<td>Excluded</td>
<td>Excluded</td>
<td>Low</td>
</tr>
</tbody>
</table>

*Unrestricted irrigation reuse* requires that wastewater be treated to a very high quality (Turbidity less than 2 Nephelometric Turbidity Units [NTUs]) and be disinfected. Recommended microbiological standards published for the unrestricted irrigation water are similar to drinking water quality standards. Public access to the irrigation site is not controlled. However warning signs not to use the water for drinking or to avoid human contact are prominently posted. Using high-quality reclaimed water for unrestricted irrigation of food crops for human consumption is theoretically possible for small community wastewater systems but probably only practical for large systems. The single greatest concern in small wastewater systems is the
reliability and maintenance of the disinfection portion of the treatment train. Golf course and community green-spaces are frequent receivers of unrestricted irrigation.

High quality reclaimed water can be used to irrigate golf courses or make snow at ski resorts.

**Industrial reuse**
Industrial facilities use reclaimed water primarily for cooling system make-up water (to replace water lost to evaporation in arid climates), boiler-feed water, process water, and general wash down. It can also be used for concrete production on construction projects. Industrial reusers may require that the water undergo additional treatment. Softening (the removal of dissolved salts) is often done to protect the heat-transfer surfaces of industrial cooling towers. These additional treatment components are typically installed close to the point at which the reuse will occur.

**Environmental/Recreational reuse**
Reclaimed water can be used to create manmade wetlands, enhance natural wetlands, and sustain or augment stream flows. With *unrestricted recreational reuse*, reclaimed water is used in an impoundment of water in which no limitations are imposed on body-contact recreational activities. An impoundment of reclaimed water in which recreation is limited to fishing, boating, and other non-contact recreational activities constitutes *restricted recreational reuse*.

**Urban reuse**
In urban reuse, reclaimed water is used for various non-potable purposes such as decorative water features, dust control, fire protection, and toilet and urinal flushing in commercial and industrial buildings. Irrigation of ornamental landscapes, parks and golf courses (described above in the Irrigation Reuse section) can also be a part of an urban reuse system.

Traditional urban water reuse systems have two major components: water reclamation treatment facilities and a reclaimed water distribution system. Infrastructure is needed to bring

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wastewater into the treatment facility (sanitary sewers), and a distribution system is needed to take the reclaimed water back out to potential users. Non-potable recycled water goes through a separate pipeline (purple pipe) system, which is completely separate from the drinking water distribution system. This “dual distribution” of potable and non-potable waters is the most expensive component of a reuse system. The non-potable distribution must be constructed to prevent cross-connections with potable water lines and ensure that non-potable water is put to appropriate use. Periodic cross connection tests ensure that the nonpotable recycled water pipelines are not accidentally connected to the drinking water system. In addition, there is ongoing monitoring and testing of the nonpotable recycled water and drinking water systems to protect the public’s health.

To avoid cross connections, all above-ground appurtenances and equipment associated with reclaimed water systems must be clearly marked. The volume of storage required to accommodate flow variations can be determined from the daily reclaimed water demand and supply curves. In order to maintain suitable water quality, covered storage is preferred to prevent biological growth and maintain chlorine residual where appropriate. If reclaimed wastewater is to be used for fire protection additional design issues must be considered. Urban potable water distribution systems are typically sized based on fire flow requirements. In residential areas, this may require installation of 6-inch diameter pipes to support fire demands where 2-inch diameter pipes may be sufficient to meet potable needs. Additional storage may also be needed.

**Indirect Potable Reuse: Aquifer Recharge**

Artificial aquifer recharge (AR) is the enhancement of natural ground water supplies using manmade conveyances such as infiltration basins or injection wells. Aquifer storage and recovery (ASR) is a specific type of AR practiced with the purpose of both augmenting ground water resources and recovering the water in the future for various uses. ASR wells are regulated as Class V injection wells under the U.S. EPA Underground Injection Control (UIC) program. As such, ASR well owners and operators are required to submit basic inventory information to the primary enforcement agency. EPA may directly implement a program, or a state may have primary enforcement authority, or "primacy". AR and ASR wells are found in areas of the U.S. that have high population density and proximity to
intensive agriculture; dependence and increasing demand on ground water for drinking water and agriculture; and/or limited ground or surface water availability. For further information on AR and ASR technology, the reader is directed to: http://www.epa.gov/safewater/asr/index.html#inventory.

Compatibility with Community Vision

Historically, few communities have pursued urban reuse programs. The main barrier has typically been cost of the non-potable transmission network described above. In a community where water is plentiful, these systems are very expensive compared to simply dispersing treated wastewater into the ground or into a receiving stream. Public perception of urban reuse systems has not necessarily been positive. This can be attributed to misconceptions regarding associated risks. Certainly, if they are not properly maintained they can pose a significant odor nuisance and a health threat. The increasing commonality of droughts and warnings of global climate change are beginning to soften these attitudes. Provided that cross-connection can be prevented, reclaimed water can be used to replace potable water in any application that does not require human consumption. If the community is willing to commit to providing the money and man-power to do the job right, the system will function well and all water brought to the community as potable water can be used at least twice prior to ultimate dispersal back into the environment. As state agencies see the potential value in adopting water reuse incentives, the number of such applications will only dramatically increase.

One beneficial reuse is to use treated wastewater to flush toilets. This is being put to practice at several national parks and some large office buildings. The visitor centers at the Great Smoky Mountains National Park and Grand Canyon National Park are examples of decentralized treatment facilities that use treated wastewater to flush toilets. Several large buildings in New York, Tokyo, and Australia have installed wastewater treatment facilities on their premises and reuse the water for toilets and fire protection. State jurisdictions have been less receptive to toilet flushing as a legitimate reuse application. Irrigation reuse for agricultural crops and landscaped areas has been more widely used, but there are still issues to be
addressed and constraints within which irrigation reuse must be implemented. These are summarized in the table below.

<table>
<thead>
<tr>
<th>Type of Irrigation</th>
<th>Issues/ Constraints</th>
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<tbody>
<tr>
<td>Agricultural Irrigation</td>
<td>Surface and groundwater contamination if not properly managed</td>
</tr>
<tr>
<td>Crop Irrigation</td>
<td>Marketability of crops and public acceptance</td>
</tr>
<tr>
<td>Commercial Nurseries</td>
<td></td>
</tr>
<tr>
<td>Landscape irrigation (parks, school yards, freeway medians, golf courses, cemeteries, greenbelts, and residential)</td>
<td>Effect of water quality, particularly salts, on soil and crops, Public health concerns related to pathogens (e.g., bacteria, disease) Use area control including buffer zone may result in high user conflicts</td>
</tr>
</tbody>
</table>

Given the increased areas of water shortages, increased regulatory anti-degradation activities, and other constraints, all communities should consider the reuse of both treated wastewater and stormwater runoff in their overall community plans. One of the major advantages of reusing wastewater for irrigation is that nutrient removal is not required. Some arid states are requiring developers to assure an adequate water supply for 100 years. Irrigation reuse by the community, by commercial interests, and by the agricultural sector is certainly a means of maximizing water resources to meet such goals.

**Land Area Requirements for Wastewater Reuse Systems**

The amount of area required for non-potable urban reuse will vary according to the volume of reclaimed wastewater and location and circumstances of the intended reuse. Land area required for treatment and pumping facilities should be on the scale of 1/4 to 1/2 acre. The majority of the distribution piping and storage will be underground, and thus not interfere with above ground activities. The volume of storage required to accommodate flow variations is determined from the daily reclaimed water demand and supply curves. The more storage required, the larger the land area requirement.

The amount of land required for Irrigation reuse will depend upon the wastewater volume, the local precipitation and evapotranspiration, and the crop to be irrigated. For 100%
usage of treated wastewater, storage will likely be required to match the demand for the irrigation water. In other words, the daily demand for irrigation may be greater than the produced reclaimed water. Off season storage can help satisfy the needs during the irrigation season. The volume of storage in the warm (semiarid and arid) regions will be about 90 days of reclaimed water production. The actual volume is determined by considering the water balance of anticipated precipitation, evaporation and the water that will be used by the selected crop. In cold humid climates, significantly greater storage volume will be required to comply with restrictions on application to frozen ground.

Construction and Installation of Wastewater Reuse Systems

Urban water reuse systems have two major components: water reclamation facilities (treatment components) and a reclaimed water distribution system. For agricultural irrigation reuse, facilities to collect, treat and convey the wastewater to the point of irrigation must also be established. The nature of the irrigation reuse system construction depends on the type of irrigation system selected and the needs of the crop chosen. Because the components for each of these will vary, community leaders should consult other Fact Sheets in this series once the nature of the system components is determined. To avoid cross connections, all above-ground appurtenances and equipment associated with reclaimed water systems must be clearly marked when installation is complete.

Construction personnel must have appropriate training and licensure for installation of pump systems, piping, and storage components for the distribution system. Requirements will vary according to jurisdiction.

Operation and Maintenance of Wastewater Reuse Systems

The reclaimed water distribution system will be an additional water utility. This makes a case for consideration of a single, combined water utility. Reclaimed water systems are operated, maintained, and managed in a manner similar to the potable water system. Water reclamation facilities must provide the required treatment to meet appropriate water quality standards for the intended use. In addition to secondary treatment, filtration and disinfection are generally required for reuse in an urban setting. In
cases where a single large customer needs higher quality reclaimed water, the customer may have to provide additional treatment onsite, as is commonly done with potable water.

Operation and maintenance (O&M) of urban wastewater reuse systems are very similar to any advanced wastewater treatment facility. There will be regulatory oversight and operator licensure will be required. In some jurisdictions beneficial reuse operators are all required to carry the States highest operational credentials regardless of plant size or process complexity. This will vary according to jurisdiction.

The O&M requirements for irrigation reuse equipment vary dramatically depending on the technology or method selected for application. Drip irrigation is a high efficiency, high maintenance technology, requiring monthly or more frequent maintenance and requiring a high level of treatment from the treatment plant providing the water to be irrigated. It is also necessary to periodically replace the drip tubing. Flood or furrow irrigation requires little O&M other than keeping the furrows level and groomed. Regardless of the O&M requirements, the operator must be knowledgeable. It is important that the effluent being irrigated be managed from the perspective of the crop and the soils. Wastewater effluent will usually have a higher amount of total dissolved solids (TDS) than the source it is taken from. This can cause a borderline water to become brackish and greatly increase the care required in using it for irrigation. The TDS of the water can increase by three to five times as it moves down through the root zone. In areas with sandy soils that receive periodic heavy rains, the soils will be self-maintaining. However, in areas with clayey soils and low rainfall, the operator must manage the salt levels in the soil to protect the long term viability of the system.

In distributed or decentralized reuse systems the O&M requirements are potentially lower owing to the use of more passive, non-O&M-intensive treatment technologies that are located closer to the reuse applications. However, if the reuse opportunities are primarily limited to a few large users, these innate advantages might be mitigated. One of the positive aspects of these systems is that they can always be sources of aquifer replenishment if other reuse opportunities are scarce.

Costs for Wastewater Reuse Systems
For the reuse of reclaimed water, the cost components are wastewater collection, wastewater treatment, and reclaimed water distribution. In areas with existing sanitary sewers and treatment facilities, the new cost will be the installation of a non-potable distribution system. There are two basic means of justifying the cost of a reuse system. The first is some limitation on the disposal of treated wastewater. As surface water discharge permits are renewed, the water quality standards are often tightened to comply with regulatory-derived Total Maximum Daily Loads (TMDLs). If a stream is listed as being impaired because of nitrogen, then new nitrogen standards will likely be imposed on the treatment facility. It might be less expensive to divert a portion of the treated wastewater to some type of beneficial reuse rather than invest in additional treatment capacity.

A second means of justifying reuse is water shortages. There are many usages of water, and very few actually require potable water. If reclaimed water can be used in place of potable water, then the potable water reservoir is conserved. Further, there is a cost savings of not having to treat raw water to potable water standards to only have it be evaporated in a boiler or used to water a lawn.

There is an expense associated with developing an irrigation system as a means of reuse. Irrigation systems can be distinguished by whether the equipment is permanently installed (stationary system) or whether it can be moved to adjacent fields (traveling system). Stationary systems such as solid-set spray or drip irrigation require less labor to operate, but have a higher initial cost. Traveling systems, such as center pivot sprinkler irrigation, linear-move, or cable-tow systems require more labor to operate but have less capital expense. Depending on the delivery technology used for irrigation reuse water, the majority of the energy used will be for pumps and irrigation sprinklers (moving sprinkling systems). If the system is automated, it will require energy to operate the computerized system to “control” the irrigation. Again, a complex array of options must be evaluated and costed out on a case by case basis.

References
