

Applications of Reclaimed Water and Reuse Water Systems

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As Alabama, Georgia and Florida continue to grow in both population and in industry; the demand of water for industrial, commercial and residential uses will put more demands on water resources. The water resources that service the region are already being bitterly fought over with one state suing another and states suing the Federal government. One solution to meet the future demand for water is not only conservation measures but the reuse of wastewater for non-potable uses like golf course irrigation, and industrial uses. This paper will focus on what infrastructure will be needed to make a water reuse system feasible and what policies need to be in place to make water reuse an acceptable alternative. This paper reviews progress by several states to increase the reuse of water by comparing the categories of reuses and the accompanying regulatory requirements.

Key Words: Reclaimed Water, Reuse Water, Water Conservation, EPA

Introduction

For the past 20 years, Georgia, Florida and Alabama have been in a "Water War" fighting over water rights over the area's water resources. Georgia recently was dealt a blow by the 11th U.S. Circuit Court of Appeals when it "declared the region has no legal right to rely on Lake Lanier for most of its water supply" (Rankin, 2010). The recent drought of 2007 in the region put in sharp relief the demands for water and the need to look at alternative sources of water to supply the growth in the region. According to the U.S. Census Bureau, the 2007 estimated population for Georgia during the height of the drought was 9,523,297. Georgia's Office of Planning and Budget estimates the 2010 population of Georgia to be 9,864,970 and 2015 population to be 10,554,171 (Georgia, 2005). The 2030 population of Georgia is projected by the U.S. Census Bureau to be 12,017,838. Over the next 20 years, there will be an additional two million people putting demand on the water resources in Georgia. Georgia must meet this future need and they are looking at Florida's and California's lead in water reuse to help meet this need. Figure 1 (Lawrence, 2008) shows the existing and future water demands for the region with the yellow line representing conservation measures that include water reuse.

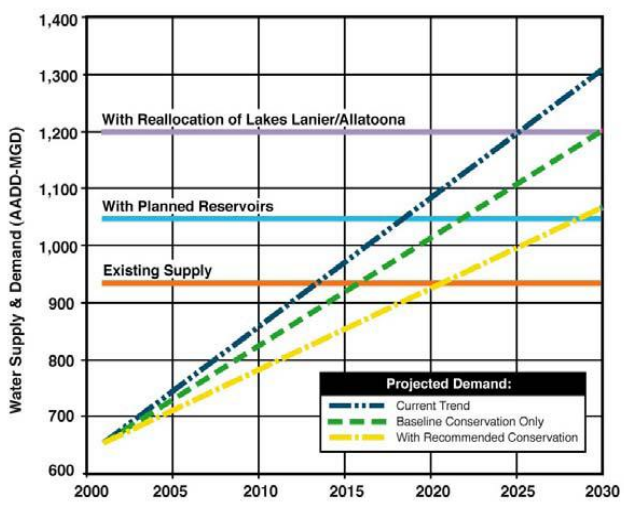

Figure 1: Projected Demand Georgia

Georgia can meet its needs to 2028 with its existing water supply by using conservation measures that include water reuse. 90% of water reuse takes place in four states and only 28 states have water reuse regulations (Miller, 2009). "In 2002, Florida reclaimed 584 mgd of its wastewater while California ranked a close second, with an estimated total of 525 mgd of reclaimed water used each day. Florida has an official goal of reclaiming 1 billion gallons per day by the year 2010" (EPA, 2004). In contrast, Georgia's reuse water program is still in its infancy with a fraction of reuse facilities and infrastructure in place. The growth in reuse water in Georgia and surrounding areas needs to outpace the growth that is projected for the next 30 to 50 years in order to catch up with the demand in water supplies. If not, the 20-year water war between the states in the area will turn into a longer more costly dispute that is fought in the courts and in Congress. However, none of the disagreements address the real problems of finite water supplies and growing populations.

Background

The history of water reuse in the United States can be traced back to 1912 in San Francisco, California where raw sewage was minimally treated and used as landscape irrigation for Golden Gate Park (California, 2003). Since then treatment standards have greatly increased to protect public health. In 1972, the Clean Water Act was passed to codify and set standards for the treatment of wastewater in the United States. The National Pollutant Discharge Elimination System (NPDES) was set up to control the point sources of wastewater discharge into state and public waters. In 1977, the City of St. Petersburg built the first large urban reuse system in the United States and it remains one of the World's largest reuse facilities (Andrade, 1999). In 1980, the United States Environmental Protection Agency (EPA) first publishes *Guidelines for Water Reuse*, which has been updated in 1992 and 2004 (SWFWMD, 2010). In 1992, there was a major rewrite of the guide that took it from a 106 page document to a 254 page document which added a section for international reuse (Bastian, 2004). Also, due to expanded case studies and experience over the 12 years in between revision, the guidelines were updated to reflect that gained knowledge and experience. In 2004, there was another major update that expanded the length from 254 to 478 pages which addressed concerns on emerging pathogen, contaminant and chemical issues. It also added a public participation section and expanded the indirect and direct potable reuse sections. The objective of the guidelines was "to make water managers and resource planners aware of the proven possibilities of water reclamation" (Bastian, 2004).

Reuse Water, Reclaimed Water and Recycled water are all synonymous with each other even though some states might have slightly different definitions and requirements for each. "Reclaimed water is treated wastewater and can be used for irrigation and other non-potable uses to extend our water supplies" (SWFWMD, 2010). Reclaimed water is usually treated to at least secondary standards but it depends on the intend use of that recycled water on what treatment is required. Greywater is wastewater from household activities such as laundry, dishwashing, and showering that is not treated or very minimally treated in house and used to irrigate landscaping and flush toilets. Greywater differs from "blackwater" which is sewage containing human waste. Greywater is illegal in many states and the ones that do allow greywater use have strict permitting requirements.

The primary purpose of the EPA's Guidelines for Water Reuse is to "present and summarize water reuse guidelines, with supporting information, for the benefit of utilities and regulatory agencies" (EPA, 2004) This document is not a regulatory document and there are no Federal regulations controlling the treatment and distribution of reuse water, other than having to meet the Clean Water Act and the NPDES standards. The states are left to individually implement reuse water programs and to codify regulations and standards for those programs. The objective of this is to have each state determine the program and regulations that best meet the needs and demands of their area.

In 2010, Florida has built enough water reuse facilities to process over one billion gallons per day of wastewater (EPA, 2004). Nationally, only five to six percent of the 34.9 billion gallons per day of municipal wastewater effluent is reclaimed and reused (Miller, 2000). Figure 2 and figure 3 (EPA, 2004) illustrate California's and Florida's breakdown and usage of reclaimed water. Figure 2 also shows that California utilizes their reclaimed water mainly for agricultural irrigation while Florida's main focus is on Public Access irrigation of golf courses, public parks and other public facilities. Furthermore, Florida has partnered with local utilities to provide water for cooling towers with 15% of reuse water being used by industry compared to 5% in California.

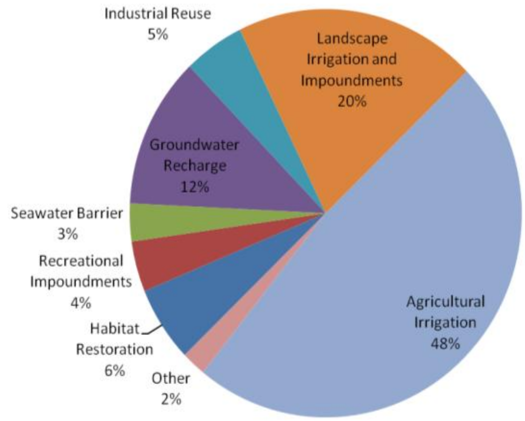

Figure 2: California Water Reuse by Type (Total 358 mgd)

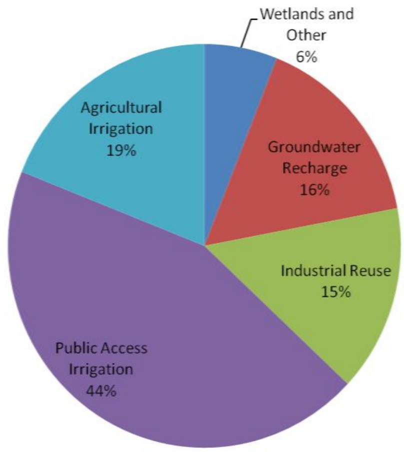

Figure 3: Florida Water Reuse by Type (Total 584 mgd)

As of 2009, 28 states have regulations governing reuse water, 13 states have guidelines and 9 states have neither regulations nor guidelines for reclaimed or reuse water (Miller, 2009). States such has California, Arizona and Florida have passed legislation encouraging the use of reuse water and made capital outlays to implement these programs and build reuse facilities as part of their overall water resource management plan. Other states have implemented regulations with "the primary intent of providing a disposal alternative to discharge to surface waters, without considering the management of reclaimed water as a resource" (EPA 2004). These states use reclaimed facilities to address discharge limits imposed on them from the NPDES to surface waters from their wastewater treatment plants and other utilities and not for the purpose of reusing wastewater for industrial or public use.

One of the main reasons most states do not have regulations on water reuse is because of legal concerns and conflicts. There are many conflicting laws and regulations on the use and reuse of wastewater and water on the Federal, State and Local levels which include water rights, water rights disputes between states and between states and the Federal government, Clean Water Act, NPDES, local ordinances, public health regulations, local water regulations, private property rights, Safe Drinking Water Act, land use and environmental regulations and service agreements for reuse water consumers. These issues will be further discussed later in this paper as it deals with the implementation of reuse systems and programs. While water reuse programs and systems have been around for over three decades, it has only been in the past ten years that there have been enough studies and data collected on these reclaimed water systems to overcome some of these obstacles in regulation. Guidelines have been updated and fine tuned from the experience gained by running successful reuse programs for over 30 years in the United States.

"Over the next 30 years the application of water reclamation technology is expected to expand the reuse of water" (Yari, 2005).

Applications

Water scarcity is a growing problem internationally, but it is also a problem in the United States. Water scarcity is not just a problem in arid dry areas but as the "Water Wars" between the states of Alabama, Georgia and Florida have shown, any state can run into the lack of water resources to support the population and growth in their state. The main drivers for water reuse are drought, climate change, population growth, increase industrial, municipal and agricultural demand and new clean water regulations putting caps on effluent discharge from wastewater treatment plants (Miller, 2009). As shown in figure 2 & figure 3, it is very important that each water resource manager look at the potential demand for reuse water in the area to fully realize a successful reuse water program. The applications for reclaimed water as defined by the EPA are: Urban Reuse, Industrial Reuse, Agricultural Reuse, Environmental and Recreational Reuse, Groundwater Recharge, and Potable Reuse. This section will review the applications of reuse water and the regulations that are typical for each type of use. This discussion will use regulations from Arizona, California and Florida due to their successful reuse programs and long-term experience with reclaimed water and it will be compared to regulations of Alabama and Georgia. These regulations focus on the treatment, biochemical oxygen demand (BOD), total suspended solids (TSS), turbidity and coliform counts.

Unrestricted Urban Reuse

Unrestricted Urban Reuse means that the public is likely to come into contact with the reclaimed water therefore a higher level of treatment is required for this purpose. As illustrated in figure 3, Florida mainly utilizes their reclaimed water for this use. According to Florida's Administrative Code 62-610.200(45) public access means an area that is intended to be accessible to the general public; such as golf courses, cemeteries, parks, landscape areas, hotels, motels, and highway medians. Public access areas include private property that is not open to the public at large, but is intended for frequent use by many persons. Public access areas also include residential dwellings. Presence of authorized farm personnel or other authorized treatment plant, utilities system, or reuse system personnel does not constitute public access. Irrigation of exercise areas and other landscape areas accessible to prisoners at penal institutions shall be considered as irrigation of public access areas. Examples of Unrestricted Urban Reuse include toilet flushing, street cleaning, construction purposes, irrigation of public parks, athletic fields, school yards and landscaped areas around public buildings, and public ornamental fountains. In general, all states that specify a treatment process require a minimum of secondary treatment per NPDES regulations and standards and some sort of disinfection prior to unrestricted urban use (EPA, 2004).

In table 1 is the comparison of treatment and water quality standards for unrestricted urban reuse between the five states chosen for this discussion.

Table 1

Reclaimed water quality and treatment requirements for unrestricted urban reuse

	Arizona	California	Florida	Georgia	Alabama
Treatment	Secondary treatment, filtration, and disinfection	Oxidized, coagulated, filtered, and disinfected	Secondary treatment, filtration, and high-level disinfection	Secondary treatment, coagulation, filtration, and disinfection	NR
BOD	NS	NS	20 mg/l $CBOD_5$	5 mg/l	NR
TSS	NS	NS	5 mg/l	5 mg/l	NR
Turbidity	2 NTU (Avg)	2 NTU (Avg)	NS	3 NTU	NR
	5 NTU (Max)	5 NTU (Max)			
Coliform	**Fecal**	**Total**	**Fecal**	**Fecal**	NR
	None detectable (Avg)	2.2/100 ml (Avg)	75% of samples below detection	23/100 ml (Avg)	
	23/100 ml (Avg)	23/100 ml (Max in 30 days)	25/100 ml (Max)	100/100 ml (Max)	

NS – Not specified by state regulations
NR – Not regulated by the state

Alabama has no regulations or guidelines pertaining to unrestricted urban reuse. Most states that have reuse water guidelines require turbidity to be between 2 to 5 NTU. “Florida requires continuous on-line monitoring of turbidity as an indicator that the TSS limit of 5.0 mg/l is being met” (EPA, 2004). States usually monitor TSS or Turbidity but rarely both since the wastewater operate can determine one from the other from weekly monitoring. As of 2004, no states have set limits on harmful pathogens for unrestricted urban reuse but Florida does require monitoring of *Giardia* and *Cryptosporidium.* The definition for Florida’s High Level Disinfection is that it requires fecal coliform be removed below detection limits and requires filtration before disinfection per Florida Administration Code 62-600.440(4) (Prieto, 2008).

Industrial Reuse

Industrial reuse water is popular use for reclaimed water because it is a steady source of income for municipalities and they are large users of water resources. Industrial uses include cooling water, process water, boiler makeup water, pulp and paper production and use in the chemical and petroleum industry. Nine states (California, Florida, Hawaii, New Jersey, North Carolina, Oregon, Texas, Utah and Washington) have regulations or guidelines controlling the water quality for reclaimed water for industrial uses. The values listed in table 2 for Florida are state minimums; additional treatment is required based on the specific use for the reclaimed water such as wash water, open cooling water tower, process water for wastewater treatment plants, and industrial process water. Some of the drivers for industrial reuse are that it is cheaper water, no need to get a consumptive use permit, drought proof and looks “green” (Prieto, 2008). Some of the concerns for industrial use of reclaimed are corrosion, scaling and biological growth. Corrosion is a concern in cooling water no matter if the facility uses potable water or reclaimed water. The key is to monitor the water for dissolved solids concentrations and to cycle water out of the system to prevent damage to the system. Scaling from dissolved minerals like calcium, magnesium and phosphates can be controlled by monitoring and chemically treating the water to prevent scaling. Biological concerns can be addressed by adding chlorine to levels of 2.0 mg/l that will kill most microorganisms that causes corrosion or deposits in cooling systems (EPA, 2004). However, most of these concerns are applicable to potable water also and most cooling water is treated already to address these concerns. Table 2 shows the comparison of treatment and water quality standards for industrial reuse between the five states chosen for this discussion.

Table 2

Reclaimed water quality and treatment requirements for industrial reuse

	Arizona	California	Florida	Georgia	Alabama
Treatment	NR	Oxidized and disinfected	Secondary treatment, and basic disinfection	NR	NR
BOD	NR	NS	20 mg/l	NR	NR
TSS	NR	NS	20 mg/l	NR	NR
Turbidity	NR	NS	NS	NR	NR
Coliform	NR	**Total**	**Fecal**	NR	NR
		23/100 ml (Avg)	200/100 ml (Avg)		
		240/100 ml (Max in 30 days)	800/100 ml (Max)		

NS – Not specified by state regulations
NR – Not regulated by the state

Process water requirements for water quality vary depending on the industry. The computer and electronics industry require water that is close to distilled water while the petroleum and coal industry has relatively low standards for water quality. Pulp and paper mills and textile plants have water quality requirements somewhere in between those two industries. Petroleum and coal production can usually use low quality water with a pH range of 6 to 9 and a TSS of no greater than 10 mg/l (EPA, 2004). The reason industrial use is not more prevalent in the rest of the United States is that it takes a great deal of money to build a treatment plant and distribution system for industrial uses which drives up the initial price of reclaimed water for municipalities. Another reason is that industry demands a constant non-interrupted flow of reclaimed water throughout the day but the inflow of wastewater is not constant throughout the day therefore storage facilities must be built along with the reuse treatment facility and distribution system which drives the costs up for the municipality. On the other hand, it is not so critical that urban reuse applications have a constant uninterruptable flow and usually reuse plants can easily meet their demand.

Agricultural Reuse on Food Crops

One of the biggest and longest users of reclaimed water for agricultural is California. As early at 1890, California was using wastewater for agricultural irrigation albeit it was untreated raw sewage back then. By 1952, over 107 communities were using recycled water for agriculture. (California, 2003). "Agricultural irrigation is estimated to represent 40 percent of the total water demand nationwide (Solley et al, 1998). Agriculture irrigation makes up 48% of the water reuse in California and 19% in Florida. Recycled water is used on "at least 20 varieties of food crops" in California (California, 2003). The regulations for reclaimed water quality for Arizona, California, and Florida are the same for Unrestricted Urban Reuse. Georgia and Alabama have no regulations addresses using reclaimed water for irrigation of food crops. Table 3 shows the comparison of treatment and water quality standards for reuse on food crops between the five states chosen for this discussion.

Table 3

Reclaimed water quality and treatment requirements for agricultural reuse on food crops

	Arizona	**California**	**Florida**	**Georgia**	**Alabama**
Treatment	Secondary treatment, filtration, and disinfection	Oxidized, coagulated, filtered, and disinfected	Secondary treatment, filtration, and high-level disinfection	NR	NR
BOD	NS	NS	20 mg/l $CBOD_5$	NR	NR
TSS	NS	NS	5 mg/l	NR	NR
Turbidity	2 NTU (Avg)	2 NTU (Avg)	NS	NR	NR
	5 NTU (Max)	5 NTU (Max)			
Coliform	**Fecal**	**Total**	**Fecal**	NR	NR
	None detectable (Avg)	2.2/100 ml (Avg)	75% of samples below detection		
	23/100 ml (Avg)	23/100 ml (Max in 30 days)	25/100 ml (Max)		

NS – Not specified by state regulations
NR – Not regulated by the state

Regulations for irrigation of food crops vary greatly from an all-out prohibition on food crops to using reclaimed water only on crops that will be processed and not eaten raw to allowing irrigation on all food crops. In any case, most states required a high level of treatment before reclaimed water can be used for food crop irrigation. Reclaimed water quality is a major concern with agricultural irrigation. States carefully monitor salinity, trace elements such as heavy metals, and chlorine residue to protect the food crops and the soil as well as surrounding water bodies (Prieto, 2008).

Agricultural Reuse on Non-Food Crops

Since these crops are not meant for human consumption, the regulations are less stringent. Most states just require secondary treatment and disinfection. Common non-food crops reclaimed water is used on are sod, feed, fiber and seed, nursery, pasture, orchards and vineyards (Prieto, 2008). Forty states have some sort of regulations or guidelines allowing use of reclaimed water on non-food crops. Most of reclaimed water used in agriculture is used on non-food crops as shown in Figure 4 (California, 2003).

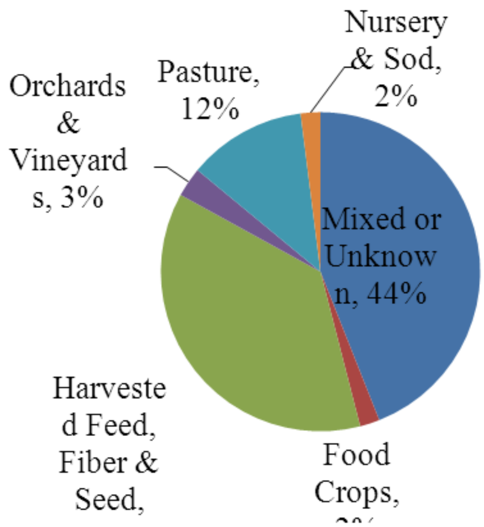

Figure 4: California breakdown of reclaimed water usage for agricultural irrigation

Groundwater Recharge and Stream Augmentation

The objectives of using reuse water for groundwater recharge are to establish saltwater intrusion barriers in coastal aquifers, to augment aquifers, to provide storage of reclaimed water for subsequent reuse and to control and prevent ground subsidence (Prieto, 2008). Only five states have regulations or guidelines governing the use of reclaimed water for groundwater recharge. Most of them only require minimum standards of treatment for this purpose such as secondary treatment standards and basic disinfection. Most municipalities build infiltration or percolation lakes to allow the reclaimed water to naturally percolate into the soil and back into the surficial aquifer. This allows the ground and soil to naturally filter the reclaimed water before going back into the aquifer. Special care must be taken to properly characterize the subsurface geology and depth to groundwater so not to contaminate existing groundwater used for potable water sources. Some states pump reclaimed water into the aquifer to replace the potable water being pumped out to prevent land subsidence. Florida uses injection wells on the coast to inject reclaimed water into the aquifer to protect inland potable water aquifers from saltwater intrusion due to Florida's karst geology. Florida also uses direct injection of reclaimed water into the aquifer for storage of that water for future use eliminating the need to build expensive water storage tanks and the land needed for those tanks. ASR systems were favorable for water storage since there is very little lost water unlike surface water reservoirs that lose a lot of water due to evapotranspiration. These systems are called Aquifer storage and recovery (ASR) systems. Early ASR test wells ran into problems with water chemistry and the chemistry of the karst geology of Florida. It was found that in early ASR test wells, when the stored reclaimed water was pumped back out for use, there were high levels of arsenic in the water. This was traced by to the chemistry of the reclaimed water interacting with the limestone in the Floridian aquifer to release high amounts of arsenic from the rock. This was solved by controlling the oxygen and chlorine content of the reclaimed water before injecting it into the aquifer for storage (SFWMD, 2010).

The main concern for any reclaimed water recharge system is to protect the existing pristine potable water source from contamination. Surface water recharge basins are easier to monitor for water quality but subsurface recharge of aquifers are harder to monitor due to unknown chemical or biological processes that might happen while reclaimed water is stored in the aquifer.

Stream augmentation differs from surface water discharge in which stream augmentation is meant to maintain flow in a stream to protect wildlife and habitat in and along that stream during periods of drought or to make up the difference of heavy potable water intakes downstream. San Antonio, Texas releases high quality reuse water to maintain water flow and water level of the San Antonio River through its city park and downtown river walk (EPA, 2004).

Conclusion

With over 10 years of case studies and data from reuse water systems, the lowering cost of reuse systems and updated regulations and guidelines, there is very little reason for the United States to not use reclaimed water as part of an overall water resource management plan. The only way to meet the demands of a growing population and support the economic growth of the region is to implement reuse water systems sooner than later.

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