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Long Island Commission
for Aquifer Protection

Water Supply Alternatives

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Abstract

The development of alternative water sources is an initiative to diversify supply. Diversification of water sources is an important tool to contend with future water demand while helping to build drought resilience and increasing water supply reliability. According to the Florida Department of Environmental Protection (FDEP), “Source diversification creates a water supply system that is more reliable than a system that relies on a single source of supply” (FDEP Fact Sheet Series, page 1, May 2014). In various parts of Long Island, both those that have the potential for population growth (especially seasonal population), as well as those with stressed aquifer conditions, water providers may be forced to consider alternative sources to meet future demands. Currently, areas of Nassau and Suffolk Counties where saltwater intrusion or upconing is occurring may have the greatest potential widespread use of water supply alternatives in the future. In addition to limitations on the groundwater resources in those areas, there is also the potential for regulatory limitations on new or replacement wells and for stricter conditions for obtaining or renewing groundwater-related permits. While these technologies are not in widespread use in the Long island area, they are common throughout the United States. Employing these technologies locally could reap enormous benefits in terms of future potable water savings.

Introduction

The utilization of alternative water sources and technologies could supplement or even replace a portion of traditional fresh groundwater sources and help to alleviate aquifer stresses resulting from overpumping and reduction in recharge. The most common examples of alternative water supplies are desalination and aquifer storage and recovery. These technologies are in widespread use throughout the United States and internationally, though they are not developed on Long Island. Alternative technologies are generally higher in cost and require more technical expertise than simply pumping a new source of fresh groundwater. However, as more complications arise that may inhibit conventional groundwater extraction, Aquifer Storage and Recovery (ASR) and desalination should be given additional consideration locally. Additional water resource alternatives include non-potable reuse or supplemental use from such sources as: rainwater from roofs; storm water collected from at- or below-grade surfaces, graywater and blackwater taken from the wastewater stream, water discharged from industrial processes, and even condensate water from air handling units. Some municipalities, particularly in drought prone areas in the western United States, have extensive reclaimed non-potable water programs. These will be discussed in the appropriate sections below.

Desalination

Desalination is the removal of salts or other dissolved substances from seawater and/or brackish groundwater to produce water that is suitable for potable water needs. In areas of the United States, the “drought resistant” nature of desalination makes it an attractive alternative to those water sources that rely on rainfall (FDEP, April 2010, p. i) or plentiful surface water supplies. Desalination technologies include reverse osmosis (RO), electrodialysis reversal (EDR), and thermal distillation (TD). The type of source water (surface or ground, salt or brackish), the desalination technology employed, and the concentrate management method used are significant factors affecting the environmental evaluation and regulation of these facilities. In addition, desalination technologies have greater energy consumption and associated greenhouse emissions compared to other traditional water supplies (FDEP, April 2010, p. ii). According the FDEP, “as the salt content of the source water increases from brackish water to seawater, there is a proportional increase in the energy usage and greenhouse gas emissions” (April 2010, p. ii).

Reverse Osmosis (RO): Reverse Osmosis uses pressure to force a solution through a membrane that will hold solute (waste concentrate) on one side while allowing solvent (potable water) to pass to the other side. Membranes used in this process are "semi-permeable," meaning the membrane will allow solvent (water) to pass, but not solutes such as salt ions. RO removes the broadest range of substances of the three technologies, but in general it has been energy intensive and involves costly operation and maintenance. Recent membrane improvements have lowered the costs and improved efficiency (FDEP, April 2010, p. 18).

Electrodialysis Reversal (EDR): EDR desalination is also a type of membrane process. An electric current draws dissolved salt ions through an electrodialysis stack consisting of alternating layers of cationic and anionic exchange membranes. The result is ion-charged salts and other chemicals are electrically pulled from the source water to produce the finished water. (FDEP, April 2010, p. 19). EDR has the lowest energy requirement of the three primary desalination technologies but it has inherent limitations. It works best at removing low molecular weight ionic components from a feed stream. Non-charged, higher molecular weight and less mobile ionic species often will not be removed. Also, in contrast to RO, EDR becomes less economical when extremely low salt concentrations in the finished water are required (FDEP, April 2010, p. 19).

Thermal Distillation (TD): The basic concept of thermal distillation is to heat a saline solution to generate water vapor and direct the vapor toward a cool surface where it will condense to liquid water. The condensate is mostly free of the salt. Thermal distillation is the oldest desalination method used and, until recently, provided the most worldwide production of water. According the 19th International Desalination Association plant inventory (GWI, 2006b), in 2006, thermal distillation technologies represented 43% of the total worldwide desalination capacity. Membrane technologies accounted for 56% of the capacity. However, it is very energy intensive and is less efficient at removing volatile substances such as VOCs or ammonia. It is most efficient when treating higher salinity source waters. With the cost of RO-produced water decreasing, the use of distillation technology is declining (FDEP, April 2010, p. 19).

Desalination Issues and Considerations

Disposal of waste brine. Desalination produces a salt concentrate. The concentration of the waste brine depends largely on the initial salinity of the raw water. Brackish ground and surface waters are preferred over seawater for this reason. If located near a seawater body, the concentration of the waste brine from brackish water desalination could closely match that of seawater, thereby minimizing the environmental impact of brine disposal**.**

Among the disposal methods in use are surface water discharge, discharge to sewers, deep well injection, land application, evaporation ponds/salt processing, and brine concentration. The brine disposal option used depends mostly on the plant location and desired efficiency. For inland brackish groundwater desalination plants, surface water discharge, sewer discharge, and land application can increase the salt load in the receiving waters and soils, which may contaminate water resources and reduce soil fertility. Evaporation ponds often require large land areas and are appropriate only in arid climates and, like other brine concentration techniques, they typically require impervious disposal areas to prevent contamination of freshwater supplies and soils.

Deep well injection is not permitted in many states. However if deep wells were to be allowed, it is likely that it would require permits, monitoring wells, and possibly completion of the wells in deep confined aquifers to protect freshwater supplies. The Safe Drinking Water Act of 1974 gave the United States Environmental Protection Agency authority to manage disposal and reuse of concentrates and brines resulting from the desalination of brackish groundwater through the Underground Injection Control (UIC) program.

High energy use/costs: Desalination processes require significant amounts of energy. Generally speaking, the higher the salinity and total dissolved solids (TDS) levels of the raw water, the higher the energy cost of the desalination process. The base cost of energy (along with the previously-mentioned costs associated with brine disposal) is a key factor in the relatively high total cost of desalination. In 2010, the United States average cost for treating 1,000 gallons of water was $2.00. Even though desalinated brackish groundwater is becoming increasingly cost-competitive, particularly in areas of the country such as the southwestern United States where water scarcity is a problem, desalination remains a more expensive process for producing potable water (National Ground Water Association (NGWA) Information Brief, Brackish Groundwater, 2010, pp. 2-3).

Desalination efficiency: According to the NGWA, desalination systems have recovery efficiencies of 60 to 85 percent for brackish groundwater, which means 15 to 40 percent of the available water is not used but is instead disposed of as a concentrate stream. Improving recovery efficiencies to 90 or 95 percent would significantly reduce concentrate disposal volumes, extend the supply of brackish resources, and potentially reduce overall desalination costs (NGWA Information Brief, Brackish Groundwater, 2010, pp. 2-3).

Case Study: Alameda County Water District, California

The Alameda County Water District (ACWD) is a major water supplier in the “East Bay” area of the San Francisco Metropolitan Region, including the cities of Fremont, Newark, and Union City. It has over 80,000 customers, and the total service area is over 100 square miles. The District has three main sources of supply, including the San Francisco (Hetch Hetchy) supply, the California State Water Project, and the Alameda Creek Watershed. Its average daily demand is approximately 34 million gallons per day (mgd), while its peak demand is over 52 mgd.

For much of the 20th century, part of its service area known as the Niles Cone Groundwater Basin was afflicted by seawater intrusion from overpumping by competing users and unregulated well construction and abandonment practices. Groundwater levels within the basin dropped below sea level, and sea water migrated landward into the basin, contaminating numerous wells. An Aquifer Reclamation Program (ARP) was started in 1974 to stop the spread of saltwater already in the groundwater basin. As part of this project, brackish, seawater-intruded groundwater was pumped from the basin and discharge in San Francisco Bay through a series of wells that removed this brackish water (approximate TDS range of 1,100 to 2,400 mg/L) from the basin.

This practice continued for over twenty years until an Integrated Resources Plan (IRP) was developed in the 1990s to optimize all sources of water available to the District. As part of this IRP, ACWD evaluated an extensive list of potential water supply alternatives, both supply-side (i.e., supplemental sources, facilities, and operational modifications) and demand-side (i.e., conservation). ACWD’s goal was to end up with a manageable number of the most effective resource options to implement over an extended period of time. Included within the potential supply-side alternatives was brackish groundwater desalination and seawater desalination. However, because of the high costs of seawater desalination and potential issues with concentrate disposal, the seawater desalination alternative was eliminated from further consideration. Due to TDS concentrations that are far lower than those of seawater, brackish groundwater desalination offered a more cost effective and environmentally friendly option.

On September 19, 2003, the ACWD dedicated the first brackish water desalination facility in northern California. The Newark Desalination Facility had an original production capacity of 5 mgd, which was expanded to 12.5 mgd in 2010. Brackish water from ARP wells is treated at the Newark Desalination Facility rather than being allowed to flow back into San Francisco Bay. The Newark Desalination Facility utilizes reverse osmosis to convert brackish water to potable water and provides the following water supply and water quality benefits:

Improved dry year water supply reliability: The District-adopted water management strategy includes conservation, reclamation, off-site groundwater banking as well as desalination. The desalination facility improves ACWD's dry year supply reliability by providing a drought-resistant source of potable supply for the service area.

Improved water system reliability and security: The Newark Desalination Facility provides ACWD with increased local production capacity, which is important in the event of temporary loss of imported water supplies or production facilities, since the ACWD service area is seismically active.

Increased water production capacity: The District's IRP also identified the need for additional water production capacity to meet peak summer demands. Although conservation (targeting outdoor use) and recycled water programs are helpful, additional localized production capacity was also needed. The Newark Desalination Facility provides this additional production capacity.

Improved water quality: Because the District's existing potable groundwater supplies are relatively high in hardness, the District blends these groundwater supplies with San Francisco Regional Water System supplies to reduce the overall hardness and improve water quality. Implementation of the desalination facility has allowed the District to further improve water quality for its customers.

Reduced future reliance on imported supplies: The Newark Desalination Facility allows ACWD to reclaim local, brackish groundwater for potable use, reducing the District's need for additional imported water supplies from outside the ACWD boundaries.

Groundwater basin protection and reclamation: Historically, ACWD has pumped the brackish groundwater out of the basin and disposed of it back to San Francisco Bay. However, the desalination facility now treats this brackish water and allows it to be used as a potable supply.

Aquifer Storage and Recovery (ASR) and Artificial Recharge (AR)

Aquifer Storage and Recovery and Artificial Recharge are processes that convey water underground. These processes replenish ground water stored in aquifers for beneficial purposes. Although the terms are often used interchangeably, they are separate processes with distinct objectives.

Aquifer storage and recovery (ASR) is a water resources management technique for actively storing water underground during wet or "off peak" periods and subsequently recovering it when needed, usually during dry or "peak" periods. The timeframe between water injection (or "storage") and pumping (or "recovery") cycles can range from months to decades. Intentional aquifer storage, with the intent of using the water later, has been used for hundreds of years, but is being further developed and refined as demand for fresh water threatens to exceed supply in California and many other parts of the world. Many states (including but not limited to Arizona, California, Florida, Nevada, and Texas) have ASR sites ranging from pilot projects to full operations.

As population centers grow, some of the water resources historically used for irrigated agriculture shifts to urban uses, suggesting that additional storage in and near urban areas may be needed. With limited space in urban settings, underground water storage through artificial recharge is an increasingly attractive option. Long term pumping rates in excess of recharge can have adverse hydrogeologic effects, such as reducing aquifer potentiometric pressures, lowering water tables, causing land subsidence and infrastructure damage, impairment of water quality, and significantly increasing pumping costs. Pumping this water is similar to mining a non-renewable resource, a practice called "overdrafting." To control or even reverse the adverse effects of overdrafting, artificial recharge can be employed. Many coastal aquifers have been overdrafted for decades. One of the results has been a reversal of ground water flow, causing seawater to be drawn inland through the aquifer, making water in affected aquifers unsuitable for most uses.

Although ASR has been used for a long time, the development of ASR facilities in an area with complex water management demands and practices (such as California) requires comprehensive information on the physical and chemical characteristics of the recharged geologic formations and the quality of recharge water. In addition, ASR facilities must be integrated with local and regional water distribution systems to allow optimal use of available water resources, legal control of stored and recovered water needs to be established, and potential off-site effects should be identified and evaluated to avoid unintended consequences.

Historically and currently, spreading basins are the primary technique used for artificial recharge. Ideally, basins are located in or adjacent to natural streams, have sand or gravel beds, and good hydrologic connection to a well-defined, high storage capacity aquifer. However, such ideal conditions are rare. Techniques continue to develop and evolve, enabling water managers to recharge water at higher rates in areas with geologic materials that do inhibit relatively rapid recharge. At the opposite end of the AR spectrum from spreading basins are aquifer injection wells that are designed to place recharge water directly into an aquifer. The same wells may be used for recovery. In general, water quality requirements are much more stringent for aquifer injection vs. surface disposal.

The quality of water used for ASR purposes should be consistent with existing and anticipated ground water uses. This can mean that stored water must meet drinking water standards prior to storage. The USEPA sets maximum contaminant levels for trace elements, different types of organic carbon, microbial (biological) contaminants, trihalomethanes (THMs), and many other potential contaminants to ensure that the water is safe for human consumption. THMs are disinfection by-products formed by the reaction of dissolved organic carbon in water that has been chlorinated to meet microbial drinking water standards. Water may also be chlorinated prior to injection to control "biofouling" or plugging of wells by bacterial growth. The injection of treated surface water has resulted in the recovery of water with concentrations of THMs that exceed drinking water standards. One of the most common water quality problems associated with ASR projects is elevated concentrations of dissolved solids, or salts. The major soluble cations (calcium, magnesium, and sodium) and anions (sulfate, chloride, and bicarbonate) are often higher in recharge water than in native ground water. This is usually not a health issue, but changes in taste, scaling in household appliances, and "hardness" may cause complaints from water users.

Chemical reactions between ground water and recharge water can create other problems such as mineral precipitation and mobilization of trace elements. Mineral precipitation can be sometimes avoided by adjusting pH or other properties of the recharge water. Study of the aquifer system matrix materials and water can identify trace elements or other contaminants that might be mobilized by ASR processes. Knowledge of the presence and distribution of anthropogenic and natural contaminants in an AR project area is needed to avoid mobilization of contaminants. In Yucca Valley, California, a potential source of nitrate contamination of an aquifer was shown to occur from septic tank seepage. Seepage can cause high nitrate levels in the unsaturated soils between the septic systems and the water table. When ASR was used in the Yucca Valley ground-water basin, rising water intercepted the nitrates, in some cases causing nitrate levels to exceed the USEPA's maximum contaminant level.

Physical, biological, and chemical clogging of infiltrating surfaces and injection wells with the resulting reduction in infiltration rates is perhaps the most obvious problem in ASR systems. Although spreading basins are less prone to serious plugging than injection wells, recharge water should be of an adequate quality to avoid clogging the infiltrating surface. Clogging can be caused by precipitation of minerals on and in the soil, entrapment of gases in the soil, formation of biofilms and biomass on and in the soil, and by deposition and accumulation of suspended algae and sediment. Pretreatment of the water can greatly reduce suspended solids and nutrients, but the infiltrating surfaces usually require periodic cleaning to maintain infiltration rates.

Surface infiltration systems require permeable soils and relatively thick unsaturated zones to get water into the aquifer. Aquifers recharged from infiltration basins must be unconfined and have sufficient transmissivity to allow lateral flow of the water away from the infiltration sites to prevent excessive ground water mounding. Soils, unsaturated zones, and aquifers should be free of significant contamination. Locations that do not have sufficiently permeable soils and/or available land area may be able to recharge ground water through vertical infiltration systems (trenches, ditches, wells) in the unsaturated zone. For direct injection through wells, water is pumped or gravity-fed into confined and unconfined aquifers. Clay lenses, faults, and other features that can significantly retard the movement of recharged ground water can render a seemingly straightforward ASR project only marginally effective or worse.

A potential hazard that can occur from ASR/AR is liquefaction, caused by creating a very shallow water table in poorly consolidated geologic materials that is subsequently shaken by an earthquake of sufficient magnitude. San Francisco's Marina District was a well-publicized example of liquefaction immediately following the 1989 Loma Prieta Earthquake, where structures were shaken off their foundations. Such areas are often popular building sites because they tend to be fairly level and may have readily available ground water supplies.

A primary issue of importance for water managers is water supply reliability. The relationship between using ASR with related management strategies, and increased effective total water supply, has been a theme of this overview. Another aspect of reliability is the physical proximity of stored water to users of that water. In southern California and many other urbanized areas, there is a heavy dependence on aqueducts hundreds of miles long to maintain water supplies. Aqueducts and their support facilities are subject to damage and potentially extended periods of service interruptions by natural hazards such as earthquakes, landslides and even floods. They are also potential terrorist targets. The extensive use of ASR in urban areas can mitigate the effects of interrupted water import capacity by increasing the volume of water stored near users.

Artificial Recharge (AR) Issues

AR is used solely to replenish water in aquifers. Water used for artificial recharge can come from a variety of sources, including: perennial and intermittent streams, water imported through aqueducts and pipelines, storm runoff from urban, suburban, and agricultural areas, irrigation districts, and drinking water and wastewater treatment plants. On Long Island, a form of AR has been practiced for many years by conveying precipitation and resulting runoff into recharge basins, or “sumps” for recharge. These basins are located within existing development and the recharge they provide has offset some of the water table declines resulting from regional sewering.

Elsewhere, reclaimed water is becoming an important resource that can be treated and processed to meet or exceed standards and, in some instances, is the highest quality water available for artificial recharge. If AR is used for recharge without sufficient understanding of the hydrogeologic conditions and near surface saturation occurs, an earthquake of sufficient magnitude can destabilize foundations and destroy buildings and with loss of many lives. In California, earthquakes are an everyday occurrence and this is a significant risk.

In addition to intensively managed artificial recharge programs, there are a number of land use practices that can increase water recharge:

Enhanced recharge through vegetation management: Replacement of deep-rooted vegetation, like trees, with plants with shallow root systems can increase recharge rates. However, there may be unintended consequences such as habitat destruction, increased surface water temperatures, and sedimentation of streams and reservoirs.

Induced recharge: The alteration of groundwater flow patterns (or “gradients”), which will induce water movement from streams to adjacent ground water systems, is a common result of ground water pumping. This may be a deliberate management technique or an unintended consequence of pumping. The natural filtration provided by the sediments in the vicinity of the surface water body can be used to "pretreat" water as it moves through stream bank and channel bottom sediments before recovery and treatment to use in public water supplies.

Incidental recharge: Surface water management may result in additional recharged water, but recharge was not an original objective. Urbanization, with land covered with impermeable surfaces, produces more runoff and has less evapotranspiration than comparable un-urbanized areas. Urban runoff can be collected and stored in holding ponds for flood control or, increasingly, to help meet Total Maximum Daily Load (TMDL) requirements in streams. There are inherent conflicts in the management of storm runoff water. For some managers, there is a need to retain "first flush" waters with relatively high contaminant levels to meet water quality standards in receiving streams. Others want to have the "first flush" discharged to allow the capture of subsequent cleaner water for artificial recharge operations. Resolution of these kinds of competing objectives is an ongoing process. Other activities contributing to incidental recharge include deep percolation of irrigation water (to prevent salt accumulation in the root zone), and wastewater discharge from septic tanks (Aquifer Storage and Recovery, United States Department of the Interior, United States Geological Survey, URL: http://ca.water.usgs.gov/misc/asr/index.html.).

Case Study: South Carolina

The Beaufort Jasper Water and Sewer Authority (BJWSA), located in southeastern South Carolina, serves a population of approximately 170,000 and covers an area of 1,300 square miles. Its average demand in winter is approximately 15 mgd, which increases to over 30 mgd in summer. The BJWSA operates a large ASR system to supplement its conventional supply during times of peak demand. The ASR system also provides needed storage to support this peak season pumpage.

The principal supply for the BJWSA is from the Savannah River. The ASR wells allow for treated surface water from the river to be stored in the Floridan Aquifer during the off season (October to April), and recovered by pumping during the peak season (May to September) when needed to meet peak demand. Each ASR well can recharge and store 200 to 500 million gallons of water throughout the off season and pump at approximately 1,700 gallons per minute when needed during summertime peaks. The ASR wells add approximately 7 mgd of pumping capacity to the BJWSA system during the summer. The cost of the ASR wells and associated facilities is a fraction of the cost of constructing appropriately sized above ground storage facilities. Fortunately, the hydrogeologic characteristics of the Floridan Aquifer are conducive to such a high volume operation and no negative effects to the Floridan Aquifer have been observed. Three additional ASR facilities are planned for the BJWSA.

Other Alternative Water Uses

Buildings often may have water uses that can be met with non-potable water from alternative water sources. Alternative water sources are those not supplied from fresh surface water or potable groundwater and that offset the demand for freshwater. Examples of alternative water sources include harvested rainwater from roofs, onsite storm water, graywater, discharged water from water purification processes, on-site reclaimed wastewater, and captured condensate from air handling units. Though there may be some water quality requirements for non-potable supplemental water, such alternative water is usually not treated to potable standards and is therefore not safe for human consumption. Common uses of alternative water include landscape irrigation, ornamental pond and fountain filling, cooling tower make-up, and toilet and urinal flushing.

Rainwater harvesting is the collection of rainwater from rooftops that is then diverted and stored for later use. Captured rainwater is often used to irrigate landscaping because the water is free of salts and other harmful minerals and typically requires only minimal treatment. Other uses include ornamental pond and fountain filling, cooling tower make-up, and toilet and urinal flushing. Rainwater harvesting can help to manage storm water by reducing the amount of runoff, which eases flooding and erosion, and by allowing it to soak into the ground, turning storm water problems into water supply assets. Less runoff also means less contamination of surface water from sediment, fertilizers, pesticides, and other pollutants that might be transported in rainfall runoff.

The major components of a rainwater harvesting system include:

- Roof surface
- Gutters and downspouts to carry the water to storage
- Leaf screens to remove debris
- First-flush diverter that prevents the system from collecting the initial flow of rainwater
- Cisterns/storage tanks to store the harvested rainwater
- Conveyances to deliver the stored water either by gravity or pump
- Water treatment system to settle, filter, and disinfect the water, if required.

The level of treatment required for harvested rainwater depends on how the water will be used. Minimal treatment is required for irrigation uses. However, at a minimum, a rainwater harvesting system should have a leaf screen and a method to settle out suspended solids.

Rainwater collection and distribution systems can be incorporated into almost any site, although it is easier to incorporate them into new construction. Rainwater harvesting systems may require a permit from local or state government. According to The Texas Manual on Rainwater Harvesting, 620 gallons of water can be collected per inch of rain per 1,000 square feet of catchment area. All rainwater systems require some degree of maintenance, which should include monitoring collection tank levels, periodic cleaning of system parts including gutters and first-flush diverter, monitoring for leaks, maintaining treatment systems (including filter replacement) and disinfection equipment, and testing for water quality.

Storm Water

Storm water is precipitation runoff over at-or below-grade surfaces that does not soak into the ground but has not entered a waterway such as a stream or lake. Much like rainwater described in the section above, storm water can be harvested and reused for irrigation, wash applications, cooling tower make-up or process water, dust suppression, backup fire protection, vehicle washing, and other non-potable uses. Storm water harvesting differs from rainwater harvesting in that runoff is collected from ground-level hard surfaces such as sidewalks, streets, and parking lots rather than from roofs. The characteristics of storm water harvesting and reuse systems vary considerably by project, but most include collection and storage (temporarily in dams or tanks awaiting use in non-potable applications), treatment, and distribution. The benefits of storm water harvesting include reduction of pollutants and potential flooding from large water events that flow to surface water. Other benefits include reduction of stream bank erosion, sewer overflows, and infrastructure damage.

Captured storm water normally requires more treatment than captured rainwater because it is exposed to additional pollutants from drainage systems and surfaces that may have hydrocarbons or other miscellaneous debris. Treatment options to reduce pathogens and pollution levels include the use of constructed wetlands, sand filters and membrane filters, and disinfection techniques including chlorination and ultraviolet radiation. The degree of treatment required depends on the proposed use and the level of public exposure.

Successful storm water harvesting and reuse plans need specialist input from a number of areas, including storm water management, water supply management, environmental management, and public health. There may also be local limitations on the storage and reuse of stormwater and/or there may be permit requirements from local or state governments. Stormwater systems require monitoring and maintenance similar to rainwater collection system as mentioned above. Potential limitations and disadvantages of stormwater harvesting include variable and unreliable rainfall patterns, environmental/land use impacts of storage facilities, and potential health risks.

Reclaimed Wastewater

Reclaimed wastewater is water that is discharged from buildings and processes, and then reused in non-potable applications such as irrigation and industrial processes. It is becoming more common for local municipalities to reclaim wastewater to help lower the community's demand for freshwater. This water is often available at a significantly lower cost than potable water.

Reclaimed wastewater likely needs secondary treatment such as additional filtration and disinfection to further remove contaminants and particulates to ensure the water is safe for non-potable applications. An efficient and successful reclaimed water project requires a reliable source of wastewater of adequate quantity and quality to meet non-potable water needs. These projects may be more economically viable when the cost of freshwater is high and there is a lack of high-quality freshwater or there are future supply risks due to conditions such as drought. Methodology for Use of Reclaimed Water at Federal Locations provides a step-by-step process on developing on-site reclaimed wastewater projects.

Implementation Considerations

State and local governments regulate the use of reclaimed wastewater and the associated water quality requirements. To minimize cross-connection problems, reclaimed water pipes must be color coded with purple tags or tape according to standards set by the American Water Works Association. Signs should be used to indicate that reclaimed water is non-potable. Place these signs in public places such as in front of a fountain and on valves, meters, and fixtures. To avoid accidental cross-connection, keep the pressure of reclaimed water 10 psi lower than potable water mains to prevent backflow and siphonage. Run reclaimed water mains at least 12 inches lower in elevation than potable water mains and horizontally at least five feet away. Review the quality of reclaimed water to minimize the potential for harmful effects from long-term use, such as salt buildup.

Captured Air Handling Condensate

Water condenses on air handling units (AHUs) and cooling coils when humid air contacts these cool surfaces. A large amount of condensate can form on cooling equipment in areas with hot, humid summers such as the southeastern United States. Water that collects on the AHUs and cooling coils must be drained to prevent damage to the equipment or building from water build-up. Typically, the condensate is collected in a central location and discharged to a sewer drain. In a condensate capturing system, the condensate is directed to a central storage tank or basin and then distributed for reuse.

Make-up water for cooling towers can be an ideal use of captured air handler condensate. Cooling tower make-up water is needed the most during the hot summer months, when the largest amount of air handler condensate can be collected. By nature this water is very pure with very low dissolved mineral content, which is ideal for cooling towers. However, condensate can potentially grow bacteria during the storage phase, requiring disinfection to avoid introducing bacteria-contaminated water to the cooling tower system. Condensate can also contain heavy metals because of contact with cooling coils. Treatment to remove these heavy metals may be required. (Energy.gov, http://energy.gov/eere/femp/best-management-practice-14-alternative-water-sources, retrieved from the internet August 16, 2016).

Case Study: San Francisco, California

Potable water for the San Francisco area is provided principally from surface water sources. The San Francisco Public Utilities Commission Regional Water System utilizes a series of surface impoundments and long distance transmission mains to supply water to approximately 2.6 million people in the city and surrounding metropolitan and suburban areas. San Francisco's Local Water Program attempts to optimize water resources by recognizing four broad categories of water uses and savings, including: conservation, recycled water for irrigation, local potable groundwater, and non-potable water for uses within buildings. In September 2012, the City and County of San Francisco adopted the Onsite Water Reuse for Commercial, Multi-Family, and Mixed Use Development Ordinance, commonly known as the Non-Potable Water Ordinance, allowing for the collection, treatment, and use of alternate water sources for non-potable applications. In October 2013, the ordinance was amended to allow district-scale water systems consisting of two or more buildings sharing non-potable water (http://sfwater.org/index.)

Non-potable water sources include the following:
Blackwater: wastewater from toilets, dishwashers, and kitchen and utility sinks
Graywater: wastewater from clothes dryers, bathtubs, showers, and bathroom sinks
Rainwater: precipitation collected from roofs and above-grade surfaces
Stormwater: precipitation collected at or below grade
Nuisance groundwater: collected from drainage and dewatering operations.

Up to 50% of water demand in multifamily residential buildings and 95% of water demand in commercial buildings is satisfied by non-potable sources. Numerous regulatory agencies provide oversight and management of non-potable water use, including system design, water quality standards, and monitoring and reporting requirements. By 2015, such non-potable water systems became mandatory for projects over 250,000 square feet.

Alternative Water Supply Options on Long Island

Desalination - Brackish Water: The desalination of brackish groundwater may be an alternative worthy of consideration in some coastal communities on Long Island. Using a brackish source reduces the cost of water production. As with any water supply alternative, an evaluation of sustainability will be required prior to implementation. An increase in salinity will have a profound effect on the cost and feasibility of a source. The disposal of the concentrate brine waste will require regulatory approval unless a municipal sewer system capable of receiving it is available.

Desalination - Seawater: Although more costly than the brackish groundwater alternative, the desalination of seawater is feasible in Long Island coastal communities. The disposal of the brine waste will be a similar issue in any case. As discussed in the body of this report, this technology has successfully been implemented in the United States and globally.

Artificial Recharge (AR): Opportunities for AR on Long Island will include the use of treated wastewater and water imported from New York City. Proximity to a high-quality treated effluent and adequate space for recharge will play a critical role.   Additionally, geological conditions must be suitable to receive the water. Given the need for space, it is most likely that the best opportunities will be in Suffolk County.

Wastewater Reuse for Irrigation: A precedent for this alternative has been established at the Indian Island Golf Course in Riverhead, Long Island. Treated wastewater is being stored in a tank and used for irrigation of the golf course. It is likely that other similar opportunities exist throughout Long Island. While this alternative does not directly provide a potable drinking water supply, it can reduce withdrawals form a viable aquifer, conserving the supply. In these cases, the implementation of treated wastewater for irrigation can provide a net gain in potable water supply.

Conclusion

Aquifer storage and recovery (ASR), artificial recharge (AR), desalination, and related water management practices are evolving rapidly to help meet present and future demands for supplemental water supplies. There is great potential for ASR, used in conjunction with other water management techniques, to make more efficient use of existing water resources and to reuse more water now discarded after a single use.

To be effective, increasingly intensive management of water resources requires more a greater knowledge and understanding of the hydrologic and geologic characteristics of formations used for water storage. Much of the water used in ASR operations will be used for public water supply. Meeting drinking water standards and the aesthetic expectations of water users requires that water managers evaluate both the quality of recharge waters and the contaminant conditions of the receiving aquifers (Aquifer Storage and Recovery. U.S. Department of the Interior, USGS, URL: http://ca.water.usgs.gov/misc/asr/index.html.

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