STATE OF THE AQUIFER

2017 UPDATE

Long Island Commission for Aquifer Protection

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MESSAGE FROM THE CHAIRMAN

Stan Carey, Chairman, LICAP

In its five years of existence, the Long Island Commission for Aquifer Protection, now well known simply as "LICAP," has already taken tremendous strides toward its ultimate goal—the long-term preservation of the sole source underground aquifer system that provides 100% of Long Island's drinking water. It is no exaggeration to say that the achievement of this goal is absolutely essential to Long Island's continued prosperity.

The group of public water supply professionals, elected officials, environmental groups and representatives of agencies dedicated to the preservation of the environment and public health who joined together to form LICAP fully understand this imperative. As a result, the group was tasked with the development of a first-of-its-kind State of the Aquifer Report and a Groundwater Resources Management Plan, both of which have been accomplished and will be further developed and updated as needed and will provide a blueprint for the management and protection of our groundwater supplies.

But LICAP has actually outperformed its core mission in its first five years in a number of ways, primarily through the development of a groundbreaking, GIS-based water quality mapping and database system called WaterTraq that provides the public with a convenient means of checking the quality of drinking water in their neighborhood right from their home computer. The program, the first of its kind in New York, also helps public water suppliers track and share with regulators potential groundwater threats.

And this spring, LICAP orchestrated a comprehensive water conservation campaign designed to teach Long Islanders how to better conserve our precious groundwater supply. The campaign, which included print and radio ads as well as the promotion of smart lawn watering devices, was funded by New York State and will provide metrics that will help us make the case to the public that water conservation is not only the right thing to do, but also the economically sensible thing to do.

Conservation is one of the topics we cover in this update to the original State of the Aquifer Report. You'll also find vital information about geothermal heating and cooling systems which, though environmentally-friendly in many ways, also present challenges to both groundwater quality and quantity. And finally, we provide in this report the latest information about emerging contamination threats such as 1,4-dioxane and perfluorinated compounds and what is being done to make sure your drinking water supply continues to be completely safe to drink.

Stan Carey,

Chairman, Long Island Commission for Aquifer Protection

LICAP Members

VOTING MEMBERS AND THE ORGANIZATIONS OR OFFICES THEY REPRESENT

Stan Carey
Chairman
Nassau-Suffolk Water Commissioners Association

Jeffrey Szabo
Vice-Chairman
Suffolk County Water Authority

Frank Koch
Long Island Water Conference

Walter Dawydiak
Suffolk County Commissioner of Health

Don Irwin
Nassau County Commissioner of Health

Brian Schneider
Nassau County Executive

Dorian Dale
Suffolk County Executive

Chris Ostuni
Nassau County Legislature Presiding Officer

Michael White
Suffolk County Legislature Presiding Officer

EX-OFFICIO MEMBERS AND THE ORGANIZATIONS OR OFFICES THEY REPRESENT

Honorable Tom Cilmi
Suffolk County Legislature Minority Leader

Sarah Meyland
Nassau County Legislature Minority Leader

Jared Hershkowitz
Suffolk County Legislature Presiding Officer

Gilbert Anderson, P.E.
Suffolk County Commissioner of Public Works

Nick Gibbons
Suffolk County Commissioner of Parks,
Recreation and Conservation

Michael Comerford
Nassau County Commissioner of Parks

Satish Sood
Nassau County Planning Commission

Karen Gomez
New York State Department
of Environmental Conservation

Stephen Terracciano
U.S. Geological Survey Long Island Program Office

Henry Bokuniewicz
LIGRI (Long Island Groundwater Research Institute)

SUNY Stony Brook: School of Marine and Atmospheric
Sciences

LICAP FACTS

FOUNDED: By unanimous votes of the Suffolk County and Nassau County Legislatures in 2013.

MISSION: To advance a coordinated, regional approach to the protection of Long Island's sole source aquifer through the preparation of a State of the Aquifer Report, to be updated manually, and a Groundwater Resources Management Plan.

MEMBERS: LICAP has nine members. The Suffolk County Water Authority, the Long Island Water Conference, the Nassau-Suffolk Water Commissioners Association and the Nassau and Suffolk Departments of Health are permanent members. Additionally, the Nassau County and Suffolk County Executives each appoint one member as do the presiding officers of each county's Legislature. There are also 13 ex-officio members with no voting power.

COMMITTEE STRUCTURE: LICAP maintains two standing subcommittees: the 2040 Water Resources and Infrastructure Subcommittee will identify long-term risks to the water supply industry created by global climate change. The Water Resource Opportunities Subcommittee will identify and quantify short-term risks, if any, to groundwater resources.

MEETINGS: LICAP is required to meet at least quarterly and hold one public hearing in each county annually.

THE STATE OF THE AQUIFER: THE THREAT TO WATER QUALITY AND QUANTITY

This update to the original State of the Aquifer report focuses on emerging threats to both water quality and quantity on Long Island and what is being done to address each area of concern.

Long Island is extremely fortunate in that we possess an abundant water supply relative to other areas of the country. However, our resources are not unlimited, and thus LICAP supports and has led comprehensive public awareness efforts designed to educate the public about the importance of water conservation. Water conservation, and the impact of geothermal heating and cooling systems on groundwater supplies, is covered extensively in this update.

Regarding water quality, Long Island is experiencing emerging threats from a number of unregulated contaminants, including perfluorinated compounds and 1,4-dioxane. The potential impact of these contaminants and the actions being taken to remove them from groundwater supplies are addressed in this update.

GEOTHERMAL HEATING AND COOLING

Geothermal heating and cooling systems provide a sustainable, energy-efficient upgrade over conventional HVAC systems that rely exclusively on fossil fuels. These systems are often encouraged by utility companies because of their efficiency and ability to help reduce energy consumption. Long Island, with an abundance of groundwater with a temperature of 50 to 55 degrees Fahrenheit, is an ideal location for the use of geothermal systems. While use of these systems is gaining in popularity, there are negative aspects to their use that warrant additional consideration.

The use of groundwater for cooling and heating on Long Island dates to the 1930s (Boyce and Fitzsimmons, 2010). The earliest systems were used for cooling only, usually for large industrial or commercial operations. Given the minimal knowledge of groundwater flow on Long Island at that time, the operation of many of these systems resulted in significant groundwater contamination. Modern day geothermal systems have numerous safeguards to prevent the release of contaminants. However, operation of the systems can have the effect of disturbing legacy groundwater contamination. Despite these drawbacks, the energy savings and resulting lower cost and emissions have resulted in an increase in their popularity.

Unlike conventional systems, which require the burning of fossil fuels to provide the energy for heating or cooling, geothermal systems do not create heat. These systems exchange thermal energy stored in groundwater between the building being heated or cooled and the earth itself. While energy is required to move the heat exchanging fluid (usually, but not exclusively, groundwater) through the building, and to operate the mechanical components of the system, overall energy savings from geothermal systems are significant. As a result, the long-term costs to the consumer are greatly reduced. Geothermal systems also have some positive environmental effects--since these systems utilize 25% to 50% less electricity when compared to conventional heating or cooling systems, this translates into an emission reduction of between 44% and 72% (Englehardt, 2009).

The most common geothermal systems utilized on Long Island are known as either "open loop" or "closed loop" systems. The open loop system can be utilized in both large and small scale applications. Open loop systems typically include one or more supply wells (which pump groundwater into the building), and one or more diffusion, recharge, return or injection wells (which return the thermally altered water back into the aquifer). In an open loop geothermal well system, groundwater is withdrawn from an aquifer through the supply well and pumped to a heat exchange device where it acts as a heat source or sink in the heating or cooling process. A typical heat exchange device is a plate heat exchanger, in which a non-contact, non-consumptive process takes place between the groundwater and the building's internal circulation water. Heat is transferred between the two waters without ever physically coming into contact or mixing with one another.

Once the groundwater passes through the heat exchange device, it is returned to the aquifer through a diffusion well(s). The only difference between the supply and return water is the temperature; the return water temperature is typically 10-15 degrees Fahrenheit ("deg F") colder during winter heating, and 15-30 deg F warmer during summer cooling, than the ambient groundwater temperature. Knowledge of local hydrogeology is an important factor is designing an open loop geothermal system. Wells must be sized to supply and return to the ground a consistent 1.5 to 3 gallons per minute (gpm) per ton of cooling or heating load.

Closed loop ground source heat pump systems do not use wells that pump groundwater, but rather a series of boreholes (usually more than 300 feet deep) into which u-tube configurations of piping are inserted. The water (or water and antifreeze mixture) within the piping never physically contacts the groundwater, and groundwater is not withdrawn from or recharged to the aquifer. The water within the piping is circulated between the boreholes and the building's heat exchange device. The boreholes are drilled deep below the water table and rely on the combination of the soil mass of the earth materials and groundwater to act as the heat source or sink for the water being pumped through the piping within the boreholes. The only exchange between the water within the borehole tubes and the groundwater and soil mass is a thermal one. These systems are gaining popularity on Long Island due to their easy maintenance. The major drawback of this system is that a large number of boreholes are usually required and spacing between boreholes can vary between 10 to 15 feet, thus a large area of land is often necessary for a properly designed system (Boyce, 2010). Borehole depth can be independent of hydrogeologic factors (Rhyner, 2017).

Currently, there are an estimated 4,000 to 5,000 geothermal systems in Nassau and Suffolk Counties. It is estimated that 70% of these are open loop and 30% are closed loop. They represent less than 1% of all HVAC systems in use, but notably constitute as much as 50% to 70% of systems used in new home construction in some communities. In addition to the previously mentioned benefits to the homeowner, these systems also provide many benefits to Long Island as a whole, including:

1. Reduced summer peak load demand on the power plants and electric grid,
2. Reduced or eliminated need to construct new generation capacity,
3. Reduced utilization of inefficient peaking power plants and the purchase of more expensive off-grid power from outside vendors, and
4. Improved load factor of power plants in the winter when their current usage is otherwise low.

However, there are numerous potential drawbacks to the widespread and unregulated use of geothermal systems (Rhyner, 2017).

For example it has become common practice for some homeowners, primarily on the North and South Forks, to use their domestic potable water connection as the source water to their open loop system, instead of their own on-site water supply wells. This results in a constant demand of anywhere from five to 30 gpm of potable water from the public water supply for a non-potable use. This practice needs to be reviewed for its impacts on water resources in general, and on the water suppliers specifically. Since it places an additional burden on public water suppliers, the infrastructure requirements to supply this additional volume of water could become costly, and thus may not be permitted in the future. The Town of Shelter Island has recently imposed a moratorium on the construction of open loop geothermal systems due to the potential impacts of such systems on the town's limited groundwater resources. SCWA is currently working with both the New York State Department of Environmental Conservation and local governments in an attempt to minimize or eliminate this practice.

It is also possible to return groundwater to the aquifer via means other than return wells, such as via drywells or horizontal buried perforated pipes. As these methods can result in localized mounding of water or impact surface water bodies, and are clear attempts to circumvent existing rules and regulations, they should be banned. The NYSDEC should close the gap that allows permitting a new supply well(s) without an associated diffusion well(s). Additionally, involvement of local governments in permitting of new construction activities may need to be increased.

POTENTIAL IMPACTS TO LONG ISLAND'S GROUNDWATER RESOURCES

Geothermal systems have the potential to cause certain thermal, chemical, and hydraulic effects that need to be understood and controlled to protect the aquifers (Rhyner, 2017).

THERMAL EFFECTS

Geothermal systems seasonally increase the local groundwater temperature during the summer and decrease the temperature during the winter (one exception is a cooling-only open loop system in which the groundwater temperature is only increased during the cooling months). The thermal effect on the aquifer dissipates some distance from an operating system depending upon groundwater flow velocities and soil characteristics and varies between the different types of systems, as discussed below.

Open Loop Systems

For an open loop system, the thermal effect occurs around the diffusion wells where the thermally-altered water is injected into the aquifer. The effect is generally localized at the depth of the diffusion well screens. Since all groundwater flows, open loop geothermal systems cause seasonal thermal "pulses" of cool or warm water flowing away from the diffusion wells along the natural groundwater flow path. Each pulse dissipates as it moves away from the diffusion wells through mixing of the thermally-altered water with ambient temperature groundwater. The distance at which the natural groundwater temperatures are reestablished depends on several factors including the overall thermal load, aquifer properties and the groundwater flow velocity.

The long-term effect of these thermal pulses is different for a "cooling only" system and one used for both heating and cooling. The overall length of the thermal plume for a heating and cooling system will be shorter because the alternating seasonal warm and cool pulses mix and cancel each other out.

Closed Loop Systems

For a closed loop system, the thermal effect occurs within the volume of the aquifer material directly surrounding each closed loop. The heat is injected into or extracted from the interval lying between the surface and the completed depth of each borehole. The radial thermal effect around a closed loop or DX borehole is approximately 10-15 feet; thus much smaller than an equivalent capacity open loop system, since the thermal energy is spread out over a significantly thicker vertical depth interval.

The temperature is greatest within the center of a closed loop bore field and decreases outward, where the heat can dissipate by conduction to the surrounding aquifer materials. In the winter, the pattern is reversed. Temperatures within the "core" of the bore field are coolest as heat is extracted from the ground, and heat energy flows into the bore field from the surrounding aquifer that is at higher ambient temperatures.

Closed loop bore fields exhibit the same seasonal thermal "pulses" of cool or warm water as an open loop system and are controlled by the same factors.

The typical temperature of the fluid (water or water and antifreeze mixture) circulating in a closed loop bore field is as low as 30 deg F during heating (if antifreeze is used in the fluid) and as high as 90 deg F during cooling. The resulting temperatures in the surrounding aquifer between the boreholes do not reach these extremes due to the heat loss across the piping and grout. During the spring and fall, the residual heat or "cold" in the ground continues to flow through and beyond the boundaries of the bore field. When winter arrives, there is generally still some stored heat within the bore field left over from the previous summer season that can be extracted for heating. Similarly, when summer arrives there is generally still some stored "cold" from the previous heating season that can be used for cooling (Rhyner, 2017).

Conclusions on Potential Thermal Impacts

The thermal effect of large geothermal systems, either open or closed loop type, may extend beyond the property boundaries. Therefore, large systems could potentially alter the temperature of groundwater being extracted from nearby wells, and interfere thermally with other geothermal systems on adjoining and/or downgradient properties. Thermally-impacted groundwater could also discharge into downgradient surface water bodies or wetlands and result in ecological impacts and violations of NYSDEC limits. The current state policy of "first-come-first-served" for underground water rights may need to be re-assessed to address cumulative effects. In the meantime, a system of better tracking the installation of small open loop systems is warranted. Since existing NYSDEC permitting programs require a demonstration that there will be no thermal impact by large open loop systems on nearby drinking water supply wells, protection of public drinking water systems is therefore realized. However, areas served by private drinking water wells would be particularly susceptible to impacts from large geothermal system thermal plumes.

A high concentration of small open loop geothermal systems serving individual homes on small lots (particularly dense suburban areas of Nassau, western Suffolk, and much of the south shore) would result in some thermal interference between neighboring systems. A better understanding of thermal transport from large geothermal systems in Long Island's aquifers and potential impacts on ecological resources is therefore necessary. Regional modeling (building on the USGS groundwater model) could be performed to define the "safe" concentration of such systems that would prevent this from occurring, with appropriate limits enacted by either NYSDEC or the local municipalities. Regulations could then be enacted to minimize such impacts, including requiring modeling or other means to determine safe setbacks from these resources.

In addition, the cumulative thermal effect of large numbers of these systems could be to change the average groundwater temperature in the aquifer (most likely an increase since some percentage of such open loop systems are used for cooling only purposes). Thermally altered groundwater could result in water quality effects, altering the "normal" levels of dissolved solids in local groundwater. Additionally this altered temperature could affect chlorination and pH control practices instituted by public water suppliers. This may be of concern in areas within the capture zone of a drinking water supply well where the upper glacial aquifer is used for drinking water supply (most small open loop system wells are shallow and withdraw water from this aquifer).

With closed loop systems, the cumulative thermal effects should be much less than with open loop systems. The thermal effect around a residential closed loop system dissipates within 10-15 feet away, so possible thermal interference between neighboring systems in dense suburban areas is minimal. For the same reason, there would be no significant cumulative thermal effect on downstream ecological resources, drinking water supply wells or other groundwater users. Since closed loop systems must be used for both heating and cooling, this balances out the thermal effects on the groundwater.

CHEMICAL EFFECTS

Open Loop Systems

There are existing, older operating open loop systems that do not employ a heat exchanger and may presently be leaking refrigerants to the groundwater or could in the future. This has contaminated the aquifer at several locations in northern Nassau County. Modern heat exchanger technology provides an additional physical barrier that protects the aquifer from contamination by refrigerants. The return water of an open loop system that does not employ an intermediate heat exchanger could become contaminated by refrigerants (e.g., freon) and other chemicals used in the mechanical equipment should a breach occur in the heat pump or chiller coils.

Closed Loop Systems

If antifreeze is used in the fluid within a closed loop bore field and a leak or break occurs in the buried piping, antifreeze would be released to the aquifer. A concern would be what impact this could have on a nearby drinking water source and if remediation of such a situation is warranted. Neither NYSDEC nor USEPA have established groundwater quality or discharge standards or guidelines for any of the three commonly used refrigerant chemicals. However, antifreeze is not used at a full concentration in closed loop geothermal systems but mixed with water typically at a 20-25% mix or less. All three compounds biodegrade quickly in groundwater and none are presently designated carcinogens or mutagens. Nevertheless, all precautions should be taken to prevent a release of these compounds from a geothermal system, including strict pressure testing.

HYDROGEOLOGIC EFFECTS

Of the system types discussed in this report, only open loop systems affect the natural groundwater flow. However, there is no net effect on groundwater in storage since 100% of the extracted water is returned to the aquifer. The effect on groundwater levels is localized around the wells and when pumping stops, groundwater flow patterns return quickly to the natural non-pumping conditions.

As with thermal effects, hydrogeologic effects of a large operating open loop system may extend beneath an adjoining property or into nearby surface waters or wetlands. Water levels could be lowered or raised depending on the location of these resources relative to the supply or return wells. It is also possible that a large geothermal system could interfere hydrogeologically with another system or a water supply well on an adjoining property. Any such interference and potential impact of a large open loop geothermal system would need to be identified and addressed by NYSDEC as part of the permitting process.

The hydrogeologic effect around a small open loop system is not likely to extend beyond the property boundary. For most Long Island settings the maximum radius of either drawdown and mounding of the water table around the wells serving a typical residence would not exceed 1-2 feet during active system operation.

OTHER ISSUES AND SENSITIVE ENVIRONMENTS

Penetration of Major Confining Clay Units

An ungrouted borehole that penetrates a major confining clay unit represents a conduit for vertical migration of contamination in the shallow upper glacial aquifer into the deeper aquifers, and contamination of a shallow freshwater aquifer by saltwater present below the clay unit.

Alteration of Contaminated Groundwater Plumes

The extensive and sustained pumping and re-injection of pre-existing contaminated groundwater by commercial open loop air conditioning systems has distributed volatile organic compounds (VOCs) throughout the aquifer in some parts of Long Island. Under existing permitting programs, the NYSDEC now checks that proposed new water wells (including open loop geothermal system wells) will not alter the pathway of pre-existing legacy contamination plumes or impact groundwater remediation efforts at regulated contaminated sites.

Aquifers Most Susceptible to Geothermal System Impact

Aquifers most susceptible to the impact of geothermal systems exist beneath the Great Neck peninsula and portions of the Port Washington peninsula, Shelter Island, and portions of the North and South Forks, as these aquifers are limited in size and surrounded by salty groundwater. Geothermal systems may need to be curtailed or restricted in these areas.

Mitigation of Potential Impacts

While there are gaps in existing regulations, the following programs exist that protect Long Island's aquifers and regulated ecological resources:

- The NYSDEC and Suffolk County Department of Health Services have construction guidelines in place for open loop wells including grouting/sealing of the annular space, including through clay units that are penetrated.

- For open loop systems regulated under the existing LIWP program, the NYSDEC performs a rigorous review of potential impacts of a system on the groundwater, surface water and wetlands resources.

Activities within sensitive areas (e.g., flood zones, wetlands and surface water bodies) are regulated by other state and federal agencies. In addition, the following practices and programs are in place or in the planning stages with the goal to ensure quality of installations thus prevent impacts to groundwater and the environment:

- Current industry practice for commercial and large residential open loop geothermal systems is to separate/isolate the "well loop" from the building's HVAC equipment and distribution system with an intermediate heat exchanger to prevent contamination of the return water by refrigerants and other chemicals present in the mechanical equipment. Heat exchangers are made of material, e.g., stainless steel or titanium, deemed appropriate for the site's groundwater quality.

- Standard industry practices and guidelines for closed loop geothermal systems that use antifreeze include pressure testing of the loops and piping at multiple stages of installation to prevent leaks of antifreeze to the aquifers.

Additional best practices designed to protect Long Island's aquifers from potential impacts from geothermal systems have been implemented by Suffolk County and by municipalities that have adopted the Model Code. Those best practices include:

- Geothermal system inspector training programs have been developed by IGSHPA and NGWA, and LIGEO is developing a training program specifically for Long Island municipal building inspectors.

- The local geothermal industry is in discussion with NYS, IMC, and USEHC code officials about adopting the comprehensive ANSI/CSA standards into their respective code.

CONSERVATION

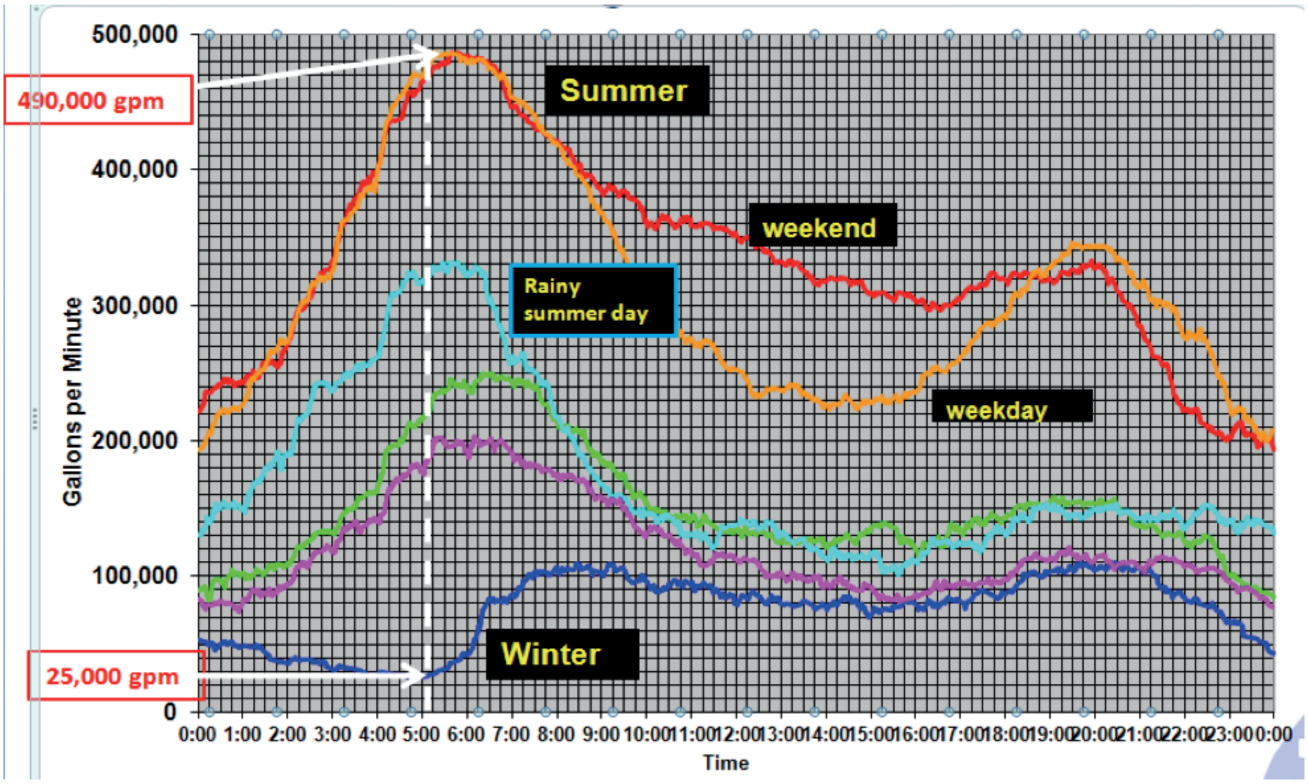
In most of the United States, water conservation has become synonymous with limiting consumption and minimizing depletion of a limited resource. Arid areas of the western United States, especially those that have seen significant population increases, are in serious danger of severe water shortages without extreme water conservation measures to minimize consumption. In contrast, most of Long Island receives from 42 to 50 inches of rainfall annually, about half of which recharges the aquifers. This amounts to approximately one million gallons of recharge per day per square mile of land throughout the course of an average year. While Long Island has a relatively abundant supply of groundwater, over pumping in many areas has impacted local groundwater quality and has also impacted surface waters (such as lakes and streams) in some areas.

Here on Long Island, our primary focus regarding water conservation isn't a matter of preserving a limited quantity, but rather maximizing efficiency, optimizing system operations and educating the public on proper water usage. Conservation here is more about optimal infrastructure management – reducing pumpage, especially during peak demand periods, so that water supply needs can be met with fewer wells and pumps running. Conservation will result in collateral water resource management improvements, however, and those should not be overlooked.

Seasonal water use is the primary factor driving the need for water conservation on Long Island. There has been a significant increase in summer water usage throughout Nassau and Suffolk Counties during the past thirty years. As an example, from 1988 to 2009, summer pumpage in Nassau County averaged between 220 and 340 million gallons per day (mgd), while winter pumpage averaged 130 to 150 mgd. Suffolk County has experienced a similar increase in the magnitude of summer pumpage vs. winter. This doubling of daily pumpage is largely attributable to the use of lawn irrigation systems (although in parts of eastern Suffolk County, some of this increase is attributable to increased summer population). For this reason, wise and efficient irrigation practices are essential to conservation efforts throughout Long Island.

The graph on the following page depicts instantaneous water usage within the Suffolk County Water Authority distribution system throughout the day for six specific days in 2007. The dark blue line represents water usage for a typical winter day. Note that at 5:00 a.m., system wide water usage totals approximately 25,000 gpm. In contrast, the red and yellow lines show water usage during peak summer days. Note that at 5 a.m. on these days, system wide water usage totals more than 490,000 gpm. This drastic increase in water usage is almost entirely due to lawn watering from automatic sprinkler systems and amounts to virtually the entire capacity of all SCWA wells. It is also interesting to note that the light blue line on the graph, which represents a rainy summer day, shows that the system wide SCWA pumpage at 5 a.m. is still more than300,000 gpm. This graph demonstrates clearly that reducing summer peak pumpage spikes is essential to any conservation strategy.

If SCWA could reduce peak pumpage by as little as 5%, this would amount to a reduction of almost 25,000 gpm. This represents the capacity of approximately 20 wells that would not need to be pumping at that time, and could be available for emergencies, such as a major fire. It also means that 20 electric pumps and motors in those wells would not have to be running, which represents a significant energy savings.



Should similar peak demand reduction be realized throughout Nassau and Suffolk Counties, a reduction in overall stresses on the aquifer system would result, and the water resource impacts from pumping would thereby be minimized. In order for this reduction in demand to happen, a long-term commitment to conservation must be made by both water suppliers and consumers.

There are a number of immediate measures that the average consumer can take to reduce water use around the house and thereby assist in conservation efforts. For instance, switching to so-called "odd-even" lawn watering, whereby addresses that begin with an odd number water their lawn on odd numbered days and addresses that begin with an even number water on even numbered days. If implemented properly, the reduction in peak demand pumpage due to lawn irrigation could be significant.

Another simple measure to decrease peak water usage would be to reduce the time for each lawn watering zone by just two minutes. This practice has been implemented in the Roslyn Water District. The "Save 2 Minutes" initiative recognizes the average duration of irrigation per zone is 20 minutes. By reducing the timing in each zone by two minutes, the homeowner can reduce their irrigation consumption by up to 10%. Irrigation specialists have indicated that this two-minute reduction should not negatively impact the lawns or gardens of Long Island residents. District officials anticipate savings of up to 60 million gallons of water annually as a result of the "Save 2 Minutes" program. This program is outlined in greater detail on the district's website (http://www.roslynwater.org/conservation.html).

Installation of rain sensors on irrigation systems can significantly reduce irrigation demand, especially on days when lawn irrigation may not be called for (as shown in the graph above). Rain sensors will act to automatically turn off a sprinkler system when the sensor is filled with water. This simple but effective device can greatly reduce water use on marginal weather days.

Indoor water use can be significantly reduced by utilizing a number of simple technologies. Low flow shower heads can save a family more than 2,000 gallons of water per year. These devices also help the homeowner save energy by reducing the volume of hot water used during a shower. Shortening showers to five minutes or less can save a typical family as much as 1,000 gallons per month. Similarly, low flow faucets can save more than 900 gallons per year.

The Massapequa Water District's Board of Commissioners recently adopted several new requirements to improve district-wide water conservation efforts. The new measures are the first of their kind by a Nassau County water provider and are a major step forward in conserving water.

Construction projects for new and refurbished homes, as well as the development of subdivided lots, require a series of permits before construction can begin. As part of the permitting process within the Town of Oyster Bay or Village of Massapequa Park, a water availability letter is required from the water district. In order for a new construction project to be issued a water availability letter from the Massapequa Water District, the following parameters must be followed:

- Mandatory usage of water efficient plumbing fixtures and appliances
- Approval by the District for underground irrigation systems
- Backflow prevention devices must be installed
- Smart irrigation controller technology and rain sensors must be used on all underground irrigation systems
- Compliance with Nassau County's water restrictions (odd/even and time-of-day water schedules)
- Low moisture landscaping and turf lawns are highly recommended but not required

Enforcement of water-saving mandates can be difficult, but the protocols put in place by the Massapequa Water District are designed to help ensure compliance. Prior to setting up a new water meter or activating a new service line, district personnel will verify the conditions of the new regulations are met. Additional information about these new regulations is available at www.massapequawater.org.

The Suffolk County Water Authority has begun an initiative (known as the "Water Wise Club") under which consumers can receive credits on their water bill for the purchase of the above-mentioned water conserving devices. SCWA also offers free "Water Wise Checkups" in which consumers can have a representative from SCWA inspect their home and identify possible areas for both indoor and outdoor water savings. With this in mind, SCWA will contract with irrigation professionals to evaluate large irrigation systems and recommend water-saving changes. This service will be free as long as those changes are implemented. SCWA has also instituted a program of making targeted phone calls to those who use high quantities of water users during peak demand periods in an effort to reduce peak pumpage.

Long Island, in comparison with other parts of the country, has an abundant supply of groundwater, but conservation measures should nonetheless be encouraged for a variety of reasons, paramount among them the great expenses incurred by public water suppliers in providing ample water pressure during times of peak demand. Such peaks typically occur during the early morning hours when residential lawn watering is most common. Extreme spikes in water use during such peak periods can necessitate expensive infrastructure upgrades to meet demand. All Long Island residents need to become stewards of the aquifer system to ensure its continued vitality into the future.

The New York State Department of Environmental Conservation has called for a 15% pumpage reduction by public water suppliers over a five-year period, and it is incumbent upon all public water suppliers on Long Island to heed the call and engage in coordinated public education campaigns to encourage conservation. Such campaigns should demonstrate measures that can be taken at home, such as the installation of rain sensors and the use of water-saving household devices, to reduce overall water usage.

1,4-DIOXANE

1,4-dioxane is a synthetic organic chemical that has been used as a solvent and a solvent stabilizer for industrial chemicals. In addition, it is used in inks and adhesives, as well as in some consumer products such as cosmetics, shampoos, detergents and deodorants. It has been characterized as a likely carcinogen by the U. S. Environmental Protection Agency and has been found in groundwater at numerous sites throughout the United States and on Long Island. (USEPA, 2014). 1,4-dioxane moves easily through soil and completely mixes with groundwater.

In addition to the potential cancer risk, 1,4-dioxane has been associated with a variety of other illnesses. Exposure may cause damage to the central nervous system, liver and kidneys. However, most of what we know about the chemical's health effects is derived from studies in occupational settings, where people have been exposed to much higher levels than would be expected from consumption through public drinking water.

The Suffolk County Water Authority conducts quarterly sampling of its more than 600 wells for 1,4-dioxane. Approximately 275 wells that have tested "positive" for 1,4-dioxane.. Wells with the highest concentrations are sampled on a monthly basis. The remaining SCWA wells are sampled bi-annually. SCWA also conducts distribution sample station testing twice per year at each of its 79 distribution system sampling stations. According to these sample results, levels of 1,4-dioxane do not appear to be increasing.

There is currently no specific federal maximum contaminant level (MCL) for 1,4-dioxane in drinking water. The USEPA has set a health advisory of 200 parts per billion (ppb) for lifetime exposure. The New York State Department of Health (NYSDOH) regulates 1,4-dioxane as an unspecified organic contaminant with a maximum contaminant level of 50 parts per billion (ppb).. The USEPA has estimated that a person consuming two liters of water with 0.35 parts per billion of 1,4-dioxane every day for 70 years would have a one-in-million increased cancer risk. According to the USEPA, several states have set their own guidelines for 1,4-dioxane, as follows:

- Colorado has established an interim groundwater cleanup standard of 0.35 ppb.
- California has established a notification level of 1 ppb for drinking water.
- New Hampshire has established a reporting limit of 0.25 ppb for public water supplies.
- Massachusetts has established a drinking water guideline level of 0.30 ppb.

The SCWA has tested a pilot program to remove 1,4-dioxane from groundwater. With this Advanced Oxidation Process (AOP) system, water containing 1,4-dioxane passes through a reactor, where hydrogen peroxide and ultraviolet light destroys the chemical. SCWA ran a small scale (200 gallons per minute) pilot test five years ago and discovered that AOP is successful in removing 1,4-dioxane from water.

Based upon this pilot test, a full scale AOP system has been installed at SCWA's Commercial Blvd. well field in Central Islip. This well field has had some of the highest 1,4-dioxane concentrations of any SCWA well, and the full-scale AOP system should remove at least 97% of the 1,4-dioxane from groundwater. Any remaining organic contamination will be removed by the existing Granular Activated Carbon (GAC) adsorption system. It is hoped that Long Island's other water suppliers will be able to utilize the experience gained at the SCWA and employ this technology in the future for their wells affected by 1,4-dioxane contamination.

If an MCL is eventually established for 1,4-dioxane at the 0.35 ppb level, removal of this chemical from drinking water will require that water suppliers spend several hundred million dollars to construct, and maintain of AOP systems at all affected well fields. Federal and state financial assistance will undoubtedly be required in order to defray these costs.

Suffolk County Monitoring Efforts

The SCDHS Laboratory has obtained Environmental Laboratory Approval Program (ELAP) approval for analysis of 1,4-dioxane in drinking water (March 2015) and high-level soils, low-level soils, and non-potable liquids (November 2016). 1,678 drinking water samples were analyzed by the PEHL from SCDHS Office of Water Resources samples collected April 2015 to December 2016, with the following results:

1. 29% detection rate in community water supply wells tested
2. 16% detection rate in non-community water supply wells tested
3. 7% detection rate in private wells tested

1,4-dioxane appears to be much more prevalent in deeper wells, which would strongly suggest that its presence in groundwater may be associated with historic releases, not recent discharges. The Office of Water Resources has a goal test all non-community and community public supply wells by the end of 2017. The environmental presence of 1,4-dioxane is also noteworthy. Based upon 2015 and 2016 monitoring efforts by the SCDHS Office of Ecology, 1,4-dioxane was detected in 6 water bodies at levels as high as 9.65 ppb (Little Neck Run in Brookhaven). The goal is to sample all routinely monitored freshwater streams and tributaries again in 2017.

The SCDHS OPC has sampled for 1,4-dioxane at various industries including laundromats, dry cleaners, car washes, salons, etc. Beginning January 2017 through June 2017, 370 samples were collected at 89 facilities. Five detections from 5 ppb to 12 ppb were observed in sludge and liquid samples. Sites found to exhibit 1,4-dioxane detections include a multi-tenant commercial center with dry cleaner, a dry cleaner, a car wash, and two laundromats. The SCDHS OPC goal is to collect about 500 samples in 2017 at high-risk facilities and at random sites. High risk facilities to be considered include: laundromats, wet cleaners, dry cleaners, car washes, wineries/breweries, power plants, airports, auto repair shops, and junkyards (1,4-dioxane may be present in auto coolants and deicing fluids). The SCDHS and NYSDEC are conducting a collaborative sampling effort evaluating laundromat SPDES discharges and existing treatment effectiveness in 2017. The SCDHS Office of Wastewater Management is also collecting samples from several sewage treatment plant effluents in 2017.

1,4-Dioxane in Nassau County

Water quality sampling data for public supply distribution systems indicates the following spread of 1,4-dioxane concentrations. There were 135 "entry points" (each roughly equivalent to two wells) that had 1,4-dioxane levels of 0.35 ppb to 3.5 ppb (this represents the equivalent of 270 wells). There were 15 entry points (equivalent to 30 wells) with levels between 3.5 and 35 ppb. Some details of where water suppliers are with plans for wellhead treatment is as follows.

In the Hicksville Water District, Well No. 4-2 has seen a maximum 1,4-dioxane concentration of 34 ppb. The district has completed an AOP bench test pilot and engineering report that was submitted to the Nassau County Department of Health (NCDH) and NYSDOH. The district is awaiting comments from NCHD and anticipates that an on-site pilot test will be required before design and construction.

In the Bethpage Water District, Plant No. 6 has been tested and has 1,4-dioxane levels up to 8.4 ppb. The district completed an on-site pilot test, and the engineering report for AOP is being finalized.

The Water Authority of Western Nassau County Station No. 57 has been tested and has 1,4-dioxane levels of up to 10 ppb. The Board has just authorized a bench test pilot, then an on-site pilot followed by full design and construction of an AOP system.

The Garden City Park Water District Well No. 8 has 1,4-dioxane levels of 3.9 ppb. The district is considering the installation of a full scale AOP with a capacity to treat 1,200 gpm. A bench test report has already been completed.

Stony Brook CCWT RFP program

In 2015, the New York State Center for Clean Water Technology (CCWT) was founded at Stony Brook University and is supported through funding from the NYSDEC NYSDOH, NYS Environmental Facilities Corporation, and the Bloomberg Foundation. One of the primary goals of the CCWT is to develop and commercialize affordable, high performance water quality protection and restoration technologies that are suitable for widespread deployment. Toward this end, the center is focusing on developing and evaluating methods to remove emerging contaminants from drinking water supplies, with an initial focus on 1,4-dioxane. The CCWT is soliciting proposals from water providers in NYS to install and test pilot-scale, advanced water treatment technologies to remove 1,4-dioxane from drinking water.

A total of 39 water districts and/or distribution areas in Long Island had detections of 1,4-dioxane greater than the EPA's cancer risk guideline level of 0.35 μg L. In order to large scale treatment systems for 1,4-dioxane, an in-depth understanding of the system performance, optimum conditions, source water quality impacts, potential degradation pathways of 1,4- dioxane, and by-product formation is needed. In addition to the previously-mentioned system in use at the SCWA, other advanced/alternative treatment techniques for removal of 1,4-dioxane may also be considered under this RFP. The ultimate goal is to identify systems and operating conditions that are effective in removing 1,4-dioxane to levels lower than the U.S. EPA cancer risk guideline (0.35 ppb) in treated drinking waters.

The CCWT will appoint a Technical Advisory Committee (TAC) to review and evaluate proposals submitted by water utilities responding to this RFP. The TAC will consist of experts in the field, CCWT Executive Directors and Research Scientists, and a representative from the NYS Department of Health.

The project period is expected to begin between March 1, 2018 and April 1, 2018, and duration is up to 18 months from the start date. Awardees will be required to submit a final report upon conclusion of the project. As of this writing, the Port Washington Water District, in partnership with D and B Engineers and Calgon Corporation, has expressed its intention to submit a proposal under this program.

Perfluorooctane Sulfonate (PFOS) and Perfluorooctanoic Acid (PFOA)

PERFLUORINATED COMPOUNDS: PFOS AND PFOA

Perfluorooctane Sulfonate (PFOS) and Perfluorooctanoic Acid (PFOA) are fully fluorinated organic compounds and are the two perfluorinated chemicals (PFCs) that have been produced in the largest amounts within the United States (ATSDR 2009; EFSA 2008). Fully fluorinated compounds are man-made substances not naturally found in the environment. They are used in numerous products such as firefighting foams and cleaning products. They are readily absorbed after oral exposure and accumulate primarily in the serum, kidney and liver.

PFOS is a perfluoralkyl sulfonate that is commonly used as a simple salt (such as potassium, sodium or ammonium) or is incorporated into larger polymers (EFSA 2008; EPA 2009c). PFOA is a perfluoralkyl carboxylate that is produced synthetically as a salt. Ammonium salt is the most widely produced form (EFSA 2008; EPA 2009c). PFOS and PFOA are extremely persistent in the environment and resistant to typical environmental degradation processes. As a result, they are widely distributed in soil, air and groundwater at sites across the United States. The toxicity, mobility and bioaccumulation potential of PFOS and PFOA pose potential adverse effects for the environment and human health.

Analysis of U.S. National Health and Nutrition Examination Survey representative study samples indicate that higher concentrations of serum PFOA and PFOS are associated with thyroid disease in the U.S. general adult population. Further analysis is needed to identify the mechanisms underlying this association (Melzer and others 2010). Epidemiologic studies have shown an association between PFOS exposure and bladder cancer; however, further research and analysis are needed to understand this association (Alexander and others 2004; Lau and others 2007).

PFOS chemicals are no longer manufactured in the United States. However, EPA rules allow for the continuation of a few, limited, highly technical applications of PFOS- related substances where no known alternatives are available. In addition, existing stocks of PFC- based chemicals that were previously manufactured or imported into the United States can still be used (EPA 2009c, 2013a). In addition to their potential to contaminate groundwater and drinking water, PFCs also pose an environmental threat. The wide distribution of PFCs increases the potential for bioaccumulation and bioconcentration as they are transferred from low to higher level organisms. Because of their persistence and long-term accumulation, wildlife such as fish, certain birds, and other biota can continue to be exposed to PFOS and PFOA (EPA 2006a; UNEP 2006).

At this time, there are no federal drinking water standards for PFNA, PFOA or PFOS; however in 2009 the United State Environmental Protection Agency (USEPA, 2009) established a Provisional Health Advisory (PHA) level of 0.4 μg/L for PFOA and 0.2 μg/L PHA for PFOS for short-term exposure.

PFOA and PFOS can be removed from water using a variety of treatment techniques. Granular Activated Carbon (GAC) is the most common treatment method for PFC removal, and has proven to be an effective treatment technique in water systems located throughout the eastern U.S. and in the Netherlands. However, competition for adsorption with other contaminants can reduce effectiveness.

The Suffolk County Department of Health Services has leveraged resources with the SCWA Laboratory and the NYSDOH's Wadsworth Laboratory to enable sampling and analysis of perfluorinated compound samples from public and private wells and groundwater samples near areas of known or suspected contamination.

The SCDHS Office of Water Resources has collected samples from over 150 public and private drinking water wells between July 2016 and September 2016. Of these, about 29 samples were above the United States Environmental Protection Agency's (USEPA) health advisory level of 70 parts per trillion and an additional 44 samples had detections below the USEPA's health advisory level (HAL). Approximately 45 groundwater monitoring wells have also been installed and sampled by the SCDHS at various locations near known or suspected sources of perfluorinated compounds in Suffolk County. Of these, 22 wells had detections above the health advisory level and 14 wells had detections below the health advisory level. The goal of the SCDHS is to continue sampling at locations suspected to have stored or released perfluorinated compound containing products in consultation with local, state, and federal agencies.

CONCLUDING THOUGHTS

Much progress has been made in LICAP's first five years of existence in addressing groundwater quality and quantity threats in a regional manner. However, much work remains. Stakeholders, including the general public, will need to remain actively involved in protecting our sole source aquifer system.

It is our hope that the publication of the original State of the Aquifer Report, this update to that document, and the Groundwater Resources Management Plan will provide a foundation that can be used by all to protect our water supply, the greatest natural resource we have on Long Island.

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