GROUNDWATER RESOURCES MANAGEMENT PLAN

DECEMBER 11
2019

LICAP
Long Island Commission for Aquifer Protection

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Message from the Chairman

As Chairman of the Long Island Commission for Aquifer Protection (LICAP), I'm delighted to present you with the following document, which completes a six-year initiative undertaken with the voluntary efforts of many groundwater professionals and others with expertise in various environmental fields to produce a working Groundwater Resources Management Plan for Long Island.

Jeffrey W. Szabo, 2019 Chairman LICAP

When LICAP was created, its primary mission was to establish a framework to manage the sole source aquifer that provides 100% of Long Island's drinking water in a coordinated, regional manner.
To do so, LICAP's members were charged with two primary deliverables: the creation and annual update of a State of the Aquifer report and development of a comprehensive Groundwater Resources Management Plan to provide a blueprint for municipalities to follow in ensuring Long Islanders will continue to enjoy a plentiful and clean drinking water supply for many generations to come.

The creation of the management plan came in two stages. We created an initial document released in 2017 focusing on the development of management strategies for topics including climate change, geothermal heating and cooling systems, water conservation and the regulation of the Lloyd aquifer. After its release, LICAP members decided it was important to assess, in a more granular fashion, four specific topics including the prevalence of private wells in the counties and options to provide public water to those residents relying on these wells, wastewater management, regulation of contaminants and issues relating to the use of New York City water supplies to provide additional supply to Western Nassau wells.

This month, we present the second component of the plan, and with the completion of the plan, the work of two original LICAP subcommittees—the 2040 Water Resource Infrastructure Subcommittee and the Water Resources Opportunities Subcommittee—is also complete (though two others, the Conservation Subcommittee and Long Island Nitrogen Action Plan Subcommittee, continue their work). Taken together, we feel we've provided a realistic management plan that Long Island's leaders of today and tomorrow can look to for guidance when it comes to the preservation and proper management of our greatest natural resource.

Jeffrey W. Szabo,

Chairman, Long Island Commission for Aquifer Protection

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CHAPTER 1:
INTRODUCTION AND EXECUTIVE SUMMARY

The aquifer system that underlies Long Island is the sole source of drinking water for Nassau and Suffolk Counties. Numerous reports and studies regarding this aquifer system have been prepared over the years, but due to the proliferation of local governmental entities and decentralized land use controls on Long Island, the need for addressing groundwater issues on a regional scale continues to be a challenge.

In 2013, Nassau County and Suffolk County established a bi-county entity called the Long Island Commission for Aquifer Protection (LICAP) to address and to advocate a coordinated approach to the groundwater issues facing the region. It was devised to build upon previous groundwater studies and reports, identify areas for further research, suggest programmatic opportunities for stemming further degradation of Long Island's sole-source aquifer and identify mechanisms, including land use controls, for improving the quality of water within the sole-source aquifer.

LICAP consists of nine voting members. Five entities have permanent membership positions: the Suffolk County Water Authority (SCWA), the Long Island Water Conference, the Nassau- Suffolk Water Commissioner's Association and the Nassau and Suffolk Health Departments. Four other members, two appointed from Nassau County and two appointed from Suffolk County, complete the voting membership. LICAP also includes 18 ex-officio, non-voting members. These ex-officio members include representatives from Nassau County, Suffolk County, the New York State Department of Environmental Conservation, the United States Geologic Survey and the Long Island Groundwater Research Institute.

LICAP's legislative mandate includes the creation of a Groundwater Resources Management Plan (GRMP). LICAP's members and ex-officio members have worked cooperatively during the past three years to compile the germane information. The GRMP must include, but is not limited to: (a) qualitative and quantitative groundwater data, (b) anthropogenic threats to groundwater quality and quantity, (c) existing regulatory groundwater management regimes,

(d) assessment of adequacy of existing groundwater management regulations, (e) management opportunities, (f) development recommendations, (g) methods for implementing the recommendations and proposed regulatory amendments, and (h) implementation program, including stakeholders, roles and responsibilities, prioritization of actions, schedules and costs.[1]

In order to address these issues, LICAP established a number of working groups to address particular topics. The full unedited reports are contained in a separate document (Appendix A). The GRMP contains ten reports[2] on aspects of Long Island's groundwater including a series of prioritized recommendations for future management actions. LICAP considered and prioritized the 15 original recommendations, along with five additional recommendations resulting from several meetings with Suffolk County Health Department and Executive representatives.[3]

[1] LICAP was required to provide notice to the public upon completion of a draft GRMP and to conduct at least one public hearing in both Nassau County and Suffolk County prior to the issuance of the issuance of the final GRMP.

[2] These reports are also available by going to the LICAP website http://www.liaquifercommission.com

[3] The Executive Summary, as approved by LICAP, lists 20 recommendations which are reflected in the attached document entitled "Recommendations and Implementation Planning". This matrix of recommendations includes suggested responsible stakeholders, milestones for tracking, horizons for implementation, a qualitative assessment of cost and criticality, suggested milestone reporting intervals, and a reference to the appropriate section in the GRMP. Additional short-term and long-term recommendations can also be found in Chapter 8 of the GRMP.

1. Investigate ways to further optimize pumping operations for wells located near shoreline areas to help minimize salt water intrusion.
2. Fund the development of a regional groundwater model to be used for planning purposes.
3. Implement conservation pricing at public water suppliers and include a full description of water conservation pricing in annual water quality reports issued by public water suppliers.
4. Establish guidelines for Best Management Practices to reduce peak demand for landscape irrigation.
5. Establish guidelines for use of water by geothermal systems.
6. Make the case against reactivation of public supply wells in Queens County that would impact negatively on Long Island's sole source of water supply.
7. Identify federal, state and local funding sources to conduct groundwater monitoring, plume identification and modeling.
8. Actively remediate or strategically contain groundwater contamination plumes, such as the Grumman/ Navy plume, to minimize and prevent potential impacts to public drinking water.
9. Maintain, update and utilize the existing Nassau County Department of Public Works (NCDPW) monitoring well network (599 total wells), including: 366 Upper Glacial Aquifer wells, 167 Magothy Aquifer wells and 66 Lloyd Aquifer wells.
10. Develop and expand WaterTraq for LICAP.
11. Require the notification of a public water supplier before a geothermal system is permitted in its service area.
12. Require the New York State Department of Environmental Conservation and the County Health Departments to review and provide comments on municipal planning board applications that may impact water resources through the State Environmental Quality Review Act process to identify and communicate potential groundwater issues to municipal planning boards.
13. Reauthorize LICAP in the Nassau and Suffolk County Legislatures.
14. Ensure that pumpage caps on public suppliers, if implemented in the future, are based upon sound scientific data.
15. Given the power to regulate and protect drinking water on a regional basis resides with the New York State Department of Health and the New York State Department of Environmental Conservation, creating other oversight entities is unnecessary.

16. Continue expanding programs in both Counties to upgrade wastewater treatment in currently unsewered areas, to restore integrity of surface waters while improving quality of drinking water.
17. Identify and promulgate funding sources to enable impacted or threatened private wells in both Counties to connect to public water including water main extensions and service line connections, where applicable, with a long-term goal of making public water available to all residents, to the extent practicable.
18. Identify opportunities to enhance monitoring and regulatory enforcement efforts to prevent VOC releases and mitigate impacts of revealed contamination.
19. Continue to expand monitoring capabilities under the NYSDEC Pesticide Monitoring Program for Long Island groundwatersand support the LI Pesticide Management Strategy and work collaboratively to minimize/eliminate excess pesticide via best management practices. Explore opportunities for intermunicipal agreements to enhance sampling via shared services.
20. Expand assessment/management programs for PCPPs Enhance monitoring for pharmaceutical and personal care products (PPCP), including 1,4-dioxane, near wastewater effluent discharges from sub-regional wastewater treatment plants and individual onsite wastewater treatment systems and identify wastewater treatment technologies that demonstrate PPCP reduction or removal. Continue to support local STOP programs to reduce improper disposal of PPCPs. Fund local laboratory capacity to analyze potential threats to public and private water supplies from emerging contaminants such as PFAS.

CHAPTER 1:
TOP 20 LICAP RECOMMENDATIONS

RECOMMENDATIONS AND IMPLEMENTATION PLANNING

	RECOMMENDATION	STAKEHOLDERS	INTERESTED PARTIES	SUGGESTED GOALS OR MILESTONES TO BE TRACKED FOR PROGRESS OR COMPLETION	TIME HORIZON	OBJECTIVE COSTS***/ CRITICALLY AT A MACRO LEVEL	REPORTING MILESTONE SCHEDULE (e.g. ANNUAL/ QUARTERLY/ETC.)	GRMP Section Referenced	CHALLENGES
1	Investigate ways to further optimize pumping operations for wells located near shoreline areas to help minimize saltwater intrusion	Public Water Suppliers; NYSDEC; County Health Dept.	USGS	Complete GW modeling and assessment of impacts and conditions in affected jurisdictions	Short-term	low/high	Bi-annual Review	Chapters 2,3	Funding for the completion of a GW model as a tool for assessment and planning is required. Management of pumping in areas susceptible to salt water intrusion should require very strict water usage rules, especially relative to lawn watering. (See Recommendations 3 and 4)
2	Fund the development of a regional groundwater model to be used for planning purposes	NYSDEC; County Legislatures (funding); USGS (model development underway)	Water Suppliers	Percent Completion of Modeling Project Effort	Immediate	mod/high	Quarterly	Chapters 4,6	Funding priorities for both counties and the water providers. Without a dedicated source of funding these important initiatives can lose momentum. The County Health Departments or the NYSDEC appear most logical repositories for this critical information. Model to be developed by USGS must be "open source", user friendly and training /availability must accommodate planning and decision-making needs at several agency levels.
3	Implement conservation strategies at public water suppliers, and include a full description of water conservation pricing in annual water quality reports issued by public water suppliers	Water Suppliers; PSC (rate structure approval for private utilities); NYSDEC; State Legislature (legal authority)	County Health Depts; County Execs; Public water customers	Percent Water Usage Reduction	medium	NA/moderate	Annual	Chapters 2,3	Strategies not limited to pricing approaches; includes communications and public outreach, LICAP PSAs initiated. Consistency of implementation across industry providers. Timing and other challenges with rate related matters provide opportunities for the efforts to stall. Needs to be driven by either County Level or State Level executive
4	Establish guidelines for Best Management Practices to reduce peak demand for landscape irrigation	Water Suppliers; building/plumbing departments	Designers and installers Water Suppliers; NYSDEC; County Health Depts	Schedule Compliance with Approved Project Plan	Immediate	low/low	Quarterly	Chapter 6	This measure closely coupled with conservation strategies including education and pricing. This issue continues to be one of enforcement of lawn watering. Irrigation controller technology development and reliability. Development of Pressures "brownouts" or managed pressure reductions could create potential public safety concerns relative particularly to fire protection.
5	Establish guidelines for use of water by geothermal systems; distinguish open loop geothermal systems using public supply from open and closed loop systems involving well installation.	Public Water Suppliers; Building Depts./ NYSDEC; State Legislature	County Health Dept; USGS; County Exec; State Legislature	Schedule Compliance with Approved Project Plan	medium	low/low	Quarterly	Chapter 4	This issue warrants greater study and consideration to evaluate the real impacts on drinking water supplies. Like many issues, this presents a case for competing interests, with drinking water safety on one side, potentially opposing sustainable practices, reductions of green house gases and cost efficiencies. Like many issues funding is a concern, particularly with the other many critical matters facing water suppliers. Developing a Risk Matrix for items like this would be useful. State, county or town legislation many to be needed to authorize regulatory control over various types of systems
6	Make the case against reactivation of public supply wells in Queens County that would potentially negatively impact Long Island's sole source of water supply	Water Suppliers; NYSDEC; Nassau County Health Department; NCDPW	County Execs; NYCDEP	Legislative Action Tracking	long	high/moderate		Chapter 4	While this issue has shifted focus for LICAP and the water providers, the continuing challenges remains the development of trust and cooperation between NYC and Long Island. Political detente would appear the biggest impediment to valuable relationships between both parties. The value of regional water sharing and agreements cannot be understated and the risks and benefits careful weighed, particularly in light of continued challenges with emerging contaminants and adequate supply. Need to work cooperatively with NYC to optimize L.I.'s water supply and minimize impacts from salt water intrusion and to further evaluate supply options for challenged western Nassau suppliers.
7	Identify federal, state and local funding sources to conduct groundwater monitoring, plume identification and modeling	County Execs; State Leg; NYSDEC; County Health Depts.	Public Water Suppliers; USGS; Federal Legislature (regarding continued cooperative USGS agreements)	Funding Legislation	medium	low/high	monthly	Chapter 3	Budget priorities and continued pressures on funding measures. The level of priority it receives legislation or approval, at any level of government needed is the most significant factor.
8	Actively remediate or strategically contain groundwater contamination plumes, such as the Grumman/Navy plume, to minimize and prevent potential impacts to public drinking water	Fed Leg; State Leg; County Execs; NYSDEC	Public water suppliers; drinking water regulatory agencies	Funding Legislation	medium	high/high	monthly	Chapter 4	Budget priorities and continued pressures on funding measures. The level of priority it receives legislation or approval, at any level of government needed is the most significant factor.
9	Maintain, update, and utilize the existing Nassau County Department of Public Works (NCDPW) monitoring well network.	NCDPW; Nassau Legislature	USGS; County Health	State Leg; County Exec; Federal Leg.; USGS	medium	moderate	Quarterly	Chapter 5	Budget and resources
10	Develop and expand WaterTraq for LICAP	Water Suppliers; Health Departments; Labs	All potential users	(ongoing activity)	long	moderate	(dependent on continued funding)	Chapter 7	Well underway; need funding source to continue. Need to coordinate with NYSDOH efforts to move forward with electronic data reporting by laboratories.

CHAPTER 1:
TOP 20 LICAP RECOMMENDATIONS

RECOMMENDATIONS AND IMPLEMENTATION PLANNING

11	Require the notification of a public water supplier before a geothermal system is permitted in its service area	Public water suppliers; county or state legislatures regarding creation of authority to regulate	State Leg; NYSDEC; County Health Depts;	Rule making or legislation	Immediate	low/low	Quarterly	Chapter 4	The challenge here would appear mostly political. Notification, without some enforcement and a rationale that supports such an enforcement pits sustainability goals against concern for damage to public water supplies. Increased study and engineering could provide greater guidance on this issue. Staff of regulatory agencies would require technical training to implement.
12	Require the New York State Department of Environmental Conservation and the County Health Departments to review and provide comments on municipal planning board applications that may impact water resources through the State Environmental Quality Review Act process to identify and communicate potential groundwater issues to municipal planning boards	County Execs; County Health Depts;	Local Govts; NYSDEC	Rule making or legislation	long	mod/moderate	Legislative Rulemaking Timeline	Chapter 3	Challenges are highly political and implementation and consistency of approach might pave the way for challenges in court, legal disagreements pitting local versus state and potentially local jurisdiction versus one another. This will require uniform political will and consensus
13	Reauthorize LICAP in the Nassau and Suffolk County Legislatures	State and County Legislatures	County Execs; State Leg; NYSDEC; County Health Depts; Water Suppliers	Legislative Action Tracking	Immediate	low/high	Quarterly	Chapters 4,5,7	Legislation reauthorizing LICAP has been enacted, but does not preclude other legislative action at State level. Need to monitor, and advocacy for continued role. No duplication of existing services is considered to be needed, with adequate funding, staffing and training provided. .
14	Ensure that pumpage caps on public suppliers, if implemented in the future, are based upon sound scientific data	NYSDEC; Public Water Suppliers	Public water customers	Annual reporting (currently required for Public Suppliers)	Immediate	low/moderate	Annual	Chapter 3	Evaluation of individual systems usage and needs, along with good GW modeling would seem to logically precede any rule making or enforcement. Agricultural, cooling water well metering must be implemented; permit renewals required.
15	Given the power to regulate and protect drinking water on a regional basis resides with the New York State Department of Health and the New York State Department of Environmental Conservation, creating other oversight entities is unnecessary.	Public water suppliers; NYSDEC; Health Depts.	County Execs; County Legislatures; State Legislature	NA	Immediate	low/high	NA	Chapter 5	Sustain legislative and funding commitments for existing resource protection programs; avoidance of unnecessary duplication of efforts and responsibilities
16	Continue expanding programs in both counties to upgrade wastewater treatment in currently unsewered areas to restore the integrity of surface waters while improving quality of drinking water	County Execs; County Health Depts; County Public Works Departments	County Legislatures; State Legislature; Public water suppliers	Annual reporting on County Subwatershed Plan outputs/outcomes	Short-term	high	Annual	Task 3A	Establishing a sewer district and recurring revenue stream
17	Identify and promulgate funding sources to enable impacted or threatened private wells in both counties to connect to public water including water main extensions and service line connections, where applicable, with a long-term goal of making public water available to all residents, to the extent practicable	NYS; Public Water Suppliers; Health Departments	County Health Departments; State Legislature	Annual SCWA report on PW connections, track WIIA grants	Short-term	high	Annual	Task 2	Public outreach & acceptance; enhancing existing funding sources/identification of additional funding sources
18	Identify opportunities to enhance monitoring and regulatory enforcement efforts to prevent VOC releases and mitigate impacts of revealed contamination	NYSDEC, Health Departments	Public water suppliers	Annual report for Suffolk County Comprehensive Water Resources Management Plan	Short-term	low	Annual	Task 3C	Maintain adequate staffing levels
19	Continue to expand monitoring capabilities under the NYSDEC Pesticide Monitoring Program for Long Island groundwaters, support the LI Pesticide Management Strategy, and work collaboratively to minimize/eliminate excess pesticide usage through best management practices. Explore opportunities for intermunicipal agreements to enhance sampling via shared services.	NYSDEC, Health Departments	Public water suppliers, Cornell Cooperative Extension, USGS, LI Farm Bureau	Continue to update NYSDEC and provide analytical data, meet periodically to review status	Short-term	low	Annual	Task 3C	Continue state funding
20	Expand assessment/management programs for pharmaceutical and personal care products (PPCPs). Enhance monitoring for PCPPs, 1,4-dioxane, near wastewater effluent discharges from subregional wastewater treatment plants and individual onsite wastewater treatment systems and identify wastewater treatment technologies that demonstrate PPCP reduction/removal. Continue to support local STOP programs to reduce improper disposal of PPCPs. Expand funding for local laboratory capacity to analyze potential threats to public and private water supplies from emerging contaminants such as PFAS.	NYS, NYSDEC, Health Departments, County Legislatures, Police Departments	USGS; County DPWs	Annual reporting on County Subwatershed Plan outputs/outcomes, PPCP STOP program outreach, Suffolk to develop in-house capability for PFAS analysis by 2021	Short-term	moderate	Annual	Task 2	Identification of funding

***Costs:

- Low:
  - Costs that would require marginal budget adjustments <$1.5M
- Mod:
  - Costs that would require considered investment and possibly funding or grant assistance >$1.5M -$10M
- High
  - Costs requiring significant investment and consideration, potentially requiring govt funding or grants >$10M

Criticality to Supply:

- Critical — Risk of immediate failure or impact requiring immediate response
- High — Significant risk requiring timely action plan and contingent planning
- Moderate — Risk requiring assessment, planning and periodic review prior to resolution
- Low — Risk that while identified does not require immediate action, but should wa

Introduction

Long Island is unique. Long Island's drinking water source is unique. The United States Environmental Protection Agency (USEPA) recognized the importance of the groundwater source of Long Island's water supply in 1978 by designating it a sole-source aquifer. Every day millions of Long Islanders live, work and play on the watershed which restores water to this aquifer system. This fact has created numerous challenges and opportunities for Long Islanders in managing their water resources. This section is devoted to providing foundational information about Long Islanders' water resources. Later sections will build on this foundation to discuss how Long Island water resources are managed, how they are challenged and what opportunities exist for protecting or preserving them.

All water used by Long Islanders for drinking and all other purposes comes from groundwater situated below the land surface. Groundwater is found virtually everywhere beneath Long Island, contained within naturally occurring geologic formations known as aquifers. Long Island's aquifers are underground sand or gravel formations that store and yield significant quantities of water. The water itself is found in the empty spaces, or voids, between the sand and gravel grains. Water within the aquifers behaves in a manner similar to an underground sponge filled with water. On Long Island, water initially enters these aquifers solely from precipitation (rain, snowmelt, sleet and hail) that falls to the ground and percolates vertically through Long Island's permeable soils until it reaches the aquifers. The "water table" represents the upper most part of groundwater stored in the aquifer system. Below the water table, the voids between the grains of sediment are completely saturated with groundwater. The water table lies just beneath the land surface at coastal locations. Beneath some hilly locations on central Long Island, the water table may be several hundred feet below the land surface.

Most parts of Long Island receive between 42-50 inches of precipitation per year (www.ny.water.usgs.gov/pubs/ wri014165/wrir01-4165.pdf, pp.8). Approximately half of this precipitation is lost to evaporation, the biological processes of plants (known as "transpiration"), or to surface waters ("runoff"). Approximately half of all precipitation enters the aquifer system ("recharge"). Recharge is far greater during the non-growing season (mid-September to mid-May) since evaporation and plant activity (together known as "evapotranspiration") occurs much less than during the warm months. Conversely, during the summer, very little recharge to the groundwater system occurs. The overall volume of precipitation that is recharged to the aquifer system, averaged all across Long Island and averaged throughout the year, amounts to approximately one million gallons per day (MGD) of recharge for every square mile of land on Long Island.

Once water enters the aquifer system, it moves from areas of higher elevation to areas of lower elevation. The average speed of groundwater flow is approximately 1 foot per day in the horizontal direction and approximately 1/10 of a foot per day vertically. The speed at which groundwater moves through the aquifers depends upon a number of factors. Some groundwater will flow naturally out of the aquifers (or "discharge") into surface waters, such as rivers, lakes and tidal waters (such as the Great South Bay). Discharge may take up to several thousand years under natural conditions. Some groundwater discharges by being pumped from a well. The pumping of wells can greatly accelerate this horizontal and vertical movement.

Using only the two-county land surface area [1,200 square miles (sq. mi.) of land mass] and using a conservative estimate of 1,000 feet (roughly 2/10th

of a mile) for its average thickness, this amounts to a volume of 240 cubic miles of saturated aquifer material beneath the two counties. Given the typical porosity of 25% for sand and gravel aquifers, it is estimated that Nassau and Suffolk Counties together have between 60-65 trillion gallons of groundwater stored within its aquifer system. However, only 5-10% of this volume is extractable from the aquifers, which limits the available volume of water to no more than 6.5 trillion gallons. Precipitation adds approximately 300 billion gallons of recharge to the aquifers annually. The total annual pumpage from the aquifers beneath Nassau and Suffolk Counties is approximately 150-200 billion gallons.

In addition to groundwater's importance as a critical resource for drinking and other purposes, virtually all surface water bodies on Long Island exist because of groundwater that naturally discharges into them. There are more than 100 stream channels on Long Island, typically less than 5 miles long, that flow to the tidewater that surrounds Long Island. The channels were formed by glacial melt water and, therefore, are more abundant along the southern shore than along the northern shore. Groundwater discharge to streams has a major effect on flow patterns within the groundwater system. Under natural conditions, approximately 90% of the flow of rivers and creeks is due to the contribution by groundwater discharging into them, while only about 10% of their flow is attributable to surface runoff. Therefore, all of Long Island's surface waters (rivers, lakes and estuaries, such as the Great South Bay) depend on groundwater in order to maintain their viability and health.

Water is always moving through the aquifers from the center of Long Island toward the shorelines. Under natural conditions, the amount of water entering the aquifers is in balance with the water leaving the aquifers. Any use of groundwater, and any change in surface activities will have some effect on the quantity and/or the quality of Long Island's groundwater.

Long Island's Aquifers

The three principal aquifers situated beneath Long Island are the Upper Glacial Aquifer, the Magothy Aquifer and the Lloyd Aquifer. The Upper Glacial Aquifer directly underlies the ground surface. It was formed during the last ice age (approximately 10,000 years ago), as large masses of ice, known as glaciers, covered a large portion of North America, including parts of Long Island. Wells that tap this aquifer are capable of producing very large quantities of water. However, because it is the shallowest and most permeable of Long Island's aquifers, it is also most prone to contamination from land-derived sources. The vast majority of wells that provide water to farms, golf courses and industry take water from the Upper Glacial Aquifer. Additionally, most private wells that serve individual homes draw from the Upper Glacial Aquifer. The Upper Glacial Aquifer is used for public supply purposes primarily on eastern Long Island, where the population is less dense and the threat of contamination is also reduced. Many of these public supply wells require some type of treatment for land-derived contaminants.

The Magothy Aquifer is the most extensive of Long Island's aquifers and was formed approximately 65 million years ago. Consisting of fine sand and silt deposits alternating with clay, it attains a maximum thickness of approximately 1,100 feet in southeastern Suffolk County. Water in the deepest portions of the Magothy Aquifer on Long Island can be as much as 800 years old. Though not as permeable as the Upper Glacial Aquifer, wells that draw from the Magothy Aquifer are still usually capable of pumping large quantities of water. The vast majority of Long Island's public supply wells take water from the Magothy Aquifer. A notable exception is on the north and south forks of eastern Suffolk County. In those areas, most of the Magothy Aquifer contains naturally salty groundwater and so public suppliers must utilize the Upper Glacial Aquifer. There are also areas on Long Island where the Magothy Aquifer is not present. Most of these areas are on the north shore, where the actions of the glaciers gouged out large sections of the Magothy Aquifer long after it was initially deposited.

The Raritan Formation underlies the Magothy Aquifer and was formed in a similar manner to the Magothy Aquifer. Its two primary units are an upper clay member (the Raritan Clay) and a lower sand member (the Lloyd Sand). The clay member is very impermeable in most areas and so helps to greatly reduce the movement of contaminants between the Magothy and Lloyd Aquifers. Geologists call formations such as the Raritan Clay a "confining unit." The lower sand unit of the Raritan Formation comprises the Lloyd Aquifer.

The Lloyd Aquifer is the deepest and oldest of Long Island's aquifers. It consists mostly of fine sand and silt and ranges from 0-500 feet thick. At its deepest, it is approximately 1,800 feet below the surface. The water contained in the Lloyd Aquifer can be as old as several thousand years. The Lloyd Aquifer is not used as extensively as the Magothy Aquifer, since the Magothy Aquifer is a highly productive aquifer and because of New York State Law imposing a moratorium on the construction of new Lloyd Aquifer wells in most areas enacted in1986. Due to its depth and degree of "confinement" by the overlying Raritan Clay, the Lloyd Aquifer is generally much less prone to contamination than either the Upper Glacial or the Magothy Aquifers. However, due to its lower permeability and its confined nature, it is not as productive as the other two aquifers. The Lloyd Aquifer is underlain by bedrock, which is not a source of water on Long Island. Several exploratory borings have been drilled through the full extent of the aquifer system and into the bedrock. However, these have been largely for academic studies rather than for the purpose of pumping water from them.

There are also several other geologic layers found beneath Long Island that are not water- bearing. They include the Gardiners Clay and the Monmouth Greensand. They are situated beneath the Upper Glacial Aquifer and above the Magothy Aquifer and are considered "confining units." These formations are typically found throughout the south shore of Long Island and are important on a local scale.

The three major aquifers, together with several minor aquifers that occur in portions of Nassau County, comprise what is known as the Long Island aquifer system. Since this aquifer system is the only source of drinking water for Nassau and Suffolk Counties, in 1978, the United States Environmental Protection Agency designated the Long Island aquifer system a "sole-source aquifer," thereby affording it a high degree of legal protection.

Groundwater as Long Island's Drinking Water Supply

The most significant use of groundwater on Long Island is for public drinking water supply. Between 1985 and 2005, it is estimated that approximately 70-80% of groundwater withdrawn from Long Island's aquifer system was used for this purpose. In 2014, Long Island's public water suppliers pumped an average of 413 MGD. In Suffolk County alone, the number of private wells is estimated at 47,000 (Suffolk County Comprehensive Plan, pp. 4-6), and they pump an estimated 15 MGD. Total water use for all purposes (potable, irrigation and commercial/industrial) on Long Island is estimated at 450-500 MGD. More than 75% of all groundwater withdrawals are from the Magothy Aquifer.

Residents of Nassau and Suffolk Counties obtain their public drinking water from a decentralized network of water supply wells located throughout both counties. These wells are located within the areas where the water that they pump is consumed. The development of public water infrastructure on Long Island tends to follow a pattern very similar to population trends. Where population density is greatest, such as in Nassau County, there tends to be more well fields per square mile and, therefore, more intensive water supply pumping. In total, there are approximately 1,200 community public supply wells throughout Nassau and Suffolk Counties. The aquifer system underlying some portions of Nassau County has experienced some degree of water quality degradation (particularly salt water intrusion) due to this intensive use in localized areas, and these topics are addressed in greater detail in this publication. While western Suffolk County exhibits water supply infrastructure trends similar to Nassau County, there have been no such water quality issues relating to overuse in that part of Suffolk County.

In stark contrast to Nassau County, there are large portions of eastern Suffolk County that have not been developed extensively (or at all) with public water supply infrastructure. As a result, numerous homes in eastern Suffolk County are not served by public water and continue to utilize individual private wells for their water supply. There are an estimated 47,000 private wells supplying drinking water to homes in Suffolk County. Seasonal use is a major factor in how much water is pumped and used on Long Island. During the past 30 years, there has been a marked increase in summertime water usage across Long Island. This is largely attributed to the increased use of underground sprinkler systems for lawn irrigation. Outdoor recreational activities and increased summertime population in some areas also contribute to increased water use. However, even in Nassau and western Suffolk Counties with minimal population increase in the past decades, per capita water usage has increased significantly due almost entirely to lawn watering with automatic sprinkler systems.

Records from the Suffolk County Water Authority (SCWA) for the year 2007 show that demand during a typical winter day in ranging from a low of approximately 20,000 gallons per minute (GPM) to a high of approximately 100,000 GPM. In stark contrast to this, water usage during a summer weekend day ranged from a low of approximately 200,000 GPM to a high of almost 500,000 GPM – almost 10 times the water use at the same time of day in the winter. This means that public water suppliers must provide sufficient well capacity and infrastructure to handle this additional water demand on peak summer days above and beyond what is necessary for "normal" usage, largely for the purpose of accommodating lawn watering. This trend continues.

These seasonal water use patterns point to the necessity for water suppliers throughout Nassau and Suffolk Counties to manage peak water demand in order to maximize water supply efficiency. Reducing summer peak pumpage "spikes" is an essential ingredient in such a strategy. From the SCWA example, a reduction in peak pumping of as little as little as 5% represents a savings of approximately 25,000 GPM or the equivalent of approximately 20 wells that would not have to be pumping at that time. Both fire protection and operational redundancy would be enhanced by having this extra well capacity in reserve. Additionally, the energy savings of this reduced pumping are significant. Should similar conservation-based demand reductions be realized throughout Nassau and Suffolk Counties, overall stresses on the aquifer system also could be reduced with obvious benefits to the aquifer system. A separate chapter of this publication discusses in detail opportunities to allow for the more efficient use of water.

Non-potable water uses are also significant in different portions of Long Island. Such uses include: golf course irrigation, water used for industrial processes, geothermal heating and air conditioning and, of course, agriculture. The vast majority of wells used for these purposes take water from the Upper Glacial Aquifer. Farms and golf courses pump

the largest volumes of non-potable water from the aquifer system. There are more than 200 wells supplying irrigation water to golf courses
throughout Long Island, while agricultural water use is quite extensive in eastern Suffolk County. Suffolk County has for many years been among the top three agricultural counties in New York State based on the dollar value of crops produced. These agricultural products all depend on the availability of groundwater for irrigation. A later chapter provides more information on water usage broken down by category.

Farms and golf courses use all of their water between mid-April and mid-October when public water suppliers also are struggling to keep up with consumer demand. This adds to the increased seasonal stress on the aquifer system during that time. If these seasonal stresses are significant enough, long-term impacts to both the quality and quantity of Long Island's groundwater can result.

Existing Conditions, Qualitative and Quantitative Groundwater Data

Long Island is entirely dependent on the underlying sole source aquifer system, which currently supplies more than 400 MGD of fresh water from more than 1,200 public-supply wells to more than 2.8 million people in Nassau and Suffolk Counties. As the name implies, Long Island's sole- source aquifer system is the only source of water available to meet the needs of Long Island's population.

In addition to its value for drinking and irrigation, groundwater is also the primary source of fresh water in streams, lakes and wetlands and maintains the saline balance of estuaries. When large volumes of groundwater are withdrawn, the water table is locally depressed; and this, in turn, reduces the quantity of groundwater available to discharge to streams and estuaries. Large-scale sewering practices also have reduced groundwater levels and discharge to surface receiving waters. In some areas of Long Island, groundwater pumping has resulted in salt water intrusion into the aquifer system and also has impacted streams, ponds and coastal areas that rely on groundwater discharge to sustain them. In addition to these quantity- related impacts, additional factors such as urban runoff and the widespread use of septic systems also have affected the water quality of the aquifer system. Therefore, development and use of groundwater on Long Island is constrained by ecohydrological (i.e., the interactions between groundwater and surface water ecosystems) and water quality concerns.

Water Suppliers and Drinking Water Consumption

Nassau County Public Water Suppliers

Nassau County's decentralized public water supply system includes numerous suppliers independently managed by either private or municipal entities [Nassau County Master Plan (NCMP), 2010]. According to United States Geological Society (USGS, 2015), "The responsibility of the water supply companies in Nassau and Suffolk Counties is shared between more than 50 supply companies who are members of the Long Island Water Conference (LIWC)." The LIWC companies utilized more than 1,100 large capacity wells to supply potable water to a population of more than 2.6 million and to light industries such as office parks and other commercial business.

Suffolk County Public Water Suppliers

Suffolk County's water supply is managed by 14 different water suppliers (USGS, 2015). An estimated 80% or 1.2 million people in Suffolk County are served by Suffolk County Water Authority. SCWA, for example, delivers 70 billion gallons of potable water each year through nearly 6,000 miles of pipe from 581 active wells and 234 pump stations [Suffolk County Department of Health

Services SCDHS), 2015]. Other water suppliers in Suffolk County include: South Huntington, Dix Hills, Riverhead and Hampton Bays Water Districts to name a few (LIWC, 2015).

Nassau County Public Water Demand

In Nassau County, encompassing 291 sq. mi. and with a population of 1.34 million people, the average daily withdrawal is 220-340 MGD in the summer months and 130-150 MGD in the winter months (USGS, 2015). Other sources may provide different data. For example, NYSDEC reports water supply pumpage rates for Nassau County. For the period from 2000-2014, the average day rate ranges from 175-205 MGD, with a mean of approximately 189 MGD; non-peak average day range from 139-149 MGD, with a mean of approximately 144 MGD; and a peak average day ranges from 231-288 MGD, with a mean of approximately 251 MGD (NYSDEC, 2016).

With roughly one-third of the land area, Nassau County's dense population consumes approximately the same volume of water as Suffolk County, which has land area that is two-thirds larger and a slightly greater population. The 2014 combined Suffolk and Nassau public water supply pumpage average day was approximately 425 MGD (NYSDEC, 2016).

Suffolk County Public Water Demand

In Suffolk County, encompassing 934 sq. mi. and with a population of 1.5 million people, the average daily withdrawal is 187 MGD with summer withdrawals of up to 360 MGD and winter withdrawals of 80-100 MGD (SCDHS, 2015). From 2005-2010, Nassau and Suffolk County's combined public water supply annual average daily withdrawal was approximately 380 MGD (USGS, 2015). Other sources may provide different data. For example, NYSDEC reports water supply pumpage rates for Suffolk County in 2014. The average day rate is approximately 222 MGD; the non-peak average day is approximately 132 MGD; and the peak average day is approximately 348 MGD on a peak average day (NYSDEC, 2016).

Defining the Amount of Water in Storage in Long Island's Aquifer System

Historical Studies

The Long Island aquifer system has been studied in some detail since the 1850s. Attention to the use of groundwater began in Brooklyn (Kings County) and then moved into Queens and Nassau Counties. The first comprehensive report on the Long Island aquifer system was prepared by C.V. Veatch et al in 1906 and published by the United States Geological Survey (USGS).

The groundwater system beneath Long Island is a combination of sand and gravel aquifers with interspersed layers of clay and sandy clay deposits. The Raritan Clay is the largest aquitard formation beneath Long Island. It separates the Magothy and Lloyd Aquifers and averages between 100-200 feet thick. Clay layers can have high porosity, but they do not function as aquifers because clay does not easily transmit or yield water. Groundwater is stored in the miniscule spaces between sand and gravel particles. The USGS publication Atlas of Long Island's Water Resources (1968) provides the following description of groundwater storage and availability (Cohen 1968, pp. 26-27):

A water-budget area was identified as the land mass from the Nassau-Queens boundary on the west to the eastern limits of Brookhaven Township and a part of Riverhead (excluding the forks). The total volume of material saturated with fresh ground water beneath Long Island … is nearly 300 cubic miles; the volume of fresh water beneath the water-budget areas is about 180 cubic miles. Assuming an average porosity of 30%, the amount of groundwater stored beneath the water budget area would be approximately 54 cubic miles or about 60 trillion gallons.

Cohen estimated specific yield of the Long Island aquifer system to be only 5-10%. (Specific yield indicates the total amount of water that can be removed from an aquifer.) More recently, Buxton and Smolensky (1999) analyzed the entire Long Island aquifer system (Kings, Queens, Nassau and Suffolk Counties, excluding the Forks) and estimated the specific yield for each aquifer. The yield ranged from a high average amount in the Upper Glacial Aquifer (25-30%) to a much lower average amount for the Magothy Aquifer (15%) and as little as 10% for the Lloyd Aquifer.

How an Aquifer Works

An aquifer system works on the principle of dynamic equilibrium that is described by the equation:

INFLOW = OUTFLOW +/- STORAGE

The process of analyzing a water budget requires that accurate quantitative values be provided for all factors in the equation. A comprehensive analysis of the water budget for the full Long Island aquifer system has never been conducted. The United States Geological Survey has begun to conduct research related to this topic in its Long Island Sustainability Study described in a later chapter.

Under natural conditions, over the long term, an aquifer system is in hydrologic equilibrium where the amount of water entering the system (inflow) is in balance with the amount of water leaving the system (outflow). As noted earlier, inflow represents water entering an aquifer system, mainly as precipitation, through the process of recharge. Other sources of inflow can include salt water intrusion or from various surface water features. Outflow represents water leaving the system naturally (prior to human activities). Processes involved in outflow are: groundwater discharge to streams, shallow discharge to coastal waters and deeper subsurface outflow, evapotranspiration and spring flow discharge.

For a groundwater system like Long Island's, the volume of recharge is equal to the volume of discharge, so there would be negligible changes in the amount of water in storage for long-term average pre-development conditions. Human activities such as groundwater pumping add an additional outflow component to the water budget equation. As the amount of groundwater pumpage increases, the additional loss of water can cause the equation to become out of balance and the aquifer system must adjust accordingly. We can observe such an adjustment in the aquifer system beneath Nassau County.

Buxton and Smolensky (1999) developed a water budget for pre-development conditions for the entire Long Island aquifer system. It showed that average recharge was about 1.1 billion/gal/day. The largest loss of water was outflow to the shore (525 MGD or 52%). The second largest loss was groundwater discharging to streams (460 MGD or 41%). The smallest outflow was to subsea coastal areas (81 MGD or 7%). Table 1 provides the details of groundwater flow prior to human impacts.

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Table 1
Pre-Development Water Budget for Long Island Aquifer System by County in MGD

COUNTY	RECHARGE	DISCHARGE		
	Precipitation (MGD)	Stream MGD	Shore MGD	Subsea MGD
Kings and Queens	160	58	96	10
Nassau	257	125	94	24
Western Suffolk	273	140	137	28
Eastern Suffolk	436	137	258	19
TOTAL (% of total)	1126	460 (41%)	585 (52%)	81 (7%)

Source: Buxton and Smolensky (1999, pp. 27)

Table 1 illustrates the dominance of groundwater processes in Suffolk County as compared to those in western Long Island (Nassau and Queens Counties and Brooklyn). Pre-development recharge was 709 MGD in Suffolk County compared to only 417 MGD for Brooklyn, Queens and Nassau Counties. Table 1 shows the system in hydrologic equilibrium. It does not quantify water loss from the system due to evaporation, evapotranspiration or runoff.

Table 2 provides additional detail to the recharge process for only Nassau and Suffolk Counties. Not all precipitation reaches the aquifers and precipitation rates are slightly different for the two counties. Nassau County receives, on average, just over 43 inches of rain per year, while Suffolk County receives more than 45 inches per year. When evaluating the fate of precipitation, recharge and evapotranspiration rates far exceed the amount of water lost to runoff.

Table 2
Comparison of Regional Groundwater Budget Components for Nassau and Suffolk Counties: Precipitation, Recharge, Evapotranspiration and Direct Runoff Rates

COMPONENT	NASSAU COUNTY	SUFFOLK COUNTY	LONG ISLAND
PRECIPITATION (inches)	43.3	45.9	45.2
RECHARGE			
Total (inches)	20.6	23.5	22.7
Percentage (%) of total precipitation	47.6	51.2	50.2
EVAPOTRANSPIRATION			
Total (inches)	21.8	22.1	22.1
Percentage (%) of total precipitation	50.3	48.1	48.8
DIRECT RUNOFF			
Total (inches)	0.9	0.3	0.4
Percentage (%) of total precipitation	2.1	0.7	1

Source: Paterson (1987, USGS)

More recently, studies by Nassau County (1998, Table 3) and Suffolk County (2015, Table 4) have described water budgets for each county. Nassau County's water budget does not identify groundwater flow lost to Queens County or inflow from Suffolk County. Suffolk County's water budget is in balance. However, changes in storage due to significant groundwater depletion or groundwater flow across county borders are not quantified. This missing piece of information should be included in future efforts to describe subregions of Long Island's water budget.

Changes in the Aquifer System Due to Pumping

Groundwater lost from the aquifers due to pumping comes from aquifer storage. If the groundwater loss is large enough, it can cause a number of changes in the aquifers as the system re-equilibrates. The observed changes can include:

- Lowering of water table levels.
- Reduction in stream flow.
- Loss of surface water features and ecosystems that depend on them.
- Reduction in coastal discharge.
- Change in bay salinity.
- Shifts in contaminant migration paths.
- A shift in the salt water interface and potential for salt water intrusion.
- Change in recharge zone boundaries and rate of groundwater flow.

All of these responses are considered undesirable changes in the groundwater system. In particular, salt water intrusion represents a system change that limits the supply of potable water in the coastal portions of the aquifers. Groundwater that discharges into coastal waters performs the essential function of holding out the ocean. When fresh groundwater is removed from storage due to excessive pumpage, less fresh water reaches the coastal margins. This result will allow the fresh water-salt water interface to move landward into the fresh water portions of the aquifers beneath the island, making the groundwater too saline for human consumption (Nassau County, 1998).

Competing Uses for Groundwater

Most studies of groundwater resources concentrate on human activities and needs. However, there are many important ecological and hydrologic aspects of the groundwater system beyond human considerations. From the human standpoint, the following sectors that need and use groundwater are:

- Public water supply: existing customers.
- New construction/letters of water availability.
- Irrigation.

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- Private water supply.
- Drinking water needs.
- Residential irrigation needs.
- Industrial water uses.
- Commercial water uses.
- Agricultural water needs.
- Recreation/golf course water.
- Housing/built - environment needs (heating, ventilation, air conditioning, HVAC).
- Groundwater-sourced geothermal systems.
- Contaminated site remediation.
- Dewatering activities around infrastructure.
- Waste assimilation.

The environmental and hydrologic need for groundwater includes the following considerations:

- Water table elevation to maintain groundwater discharge to surface water features (wetlands, ponds, lakes and streams) for habitat health and ecosystem balance.
- Groundwater discharge to coastal margins for salinity maintenance.
- Groundwater subsurface discharge to control salt water intrusion.
- Sufficient groundwater storage for drought and other extreme events.
- Sufficient head to support deep recharge processes.

Water Budgets for Each County

Nassau County

Nassau County developed water budgets in several studies between 1980-1998. In 1980, Nassau County set a limit of 180 MGD as the sustainable consumptive level of groundwater withdrawal for the county. However, due to reports that recharge increased due to recharge basins, Nassau County later increased its safe yield value to 185 MGD. In the 1998 Groundwater Study, Nassau County predicted that "average demand in 2010 ... would be 180 MGD, with about 161 MGD attributable to residential use and 19 MGD to commercial/industrial use" (pp. 3-4).The study also noted that, in years with hot, dry summers, annual demand could climb to more than 190 MGD. However, by 2000, Nassau County exceeded this prediction. The Nassau County Department of Public Works (NCDPW) reported that annual demand reached 203 MGD in 2001 and 200 MGD in 2002. During a hot summer, monthly water demand could exceed 300 MGD (Nassau County, 2005, pp. 8). Table 3 identifies the Nassau County Water Budget projected for 2010 conditions by the 1998 study.

Table 3
Present-Day Nassau County Water Budget - Year 2010

PROCESS		AMOUNT IN	TOTAL MGD
INFLOW			384
RECHARGE	From Precipitation	341	
	Recharge to Glacial Aquifer (341 MGD)		
	Recharge to Magothy Aquifer (260 MGD)		
	Recharge to Lloyd Aquifer (14 MGD)		
OTHER INFLOW			
	Saltwater Intrusion/Inflow from Suffolk County	43	
	Into Glacial Aquifer (21 MGD)		
	Into Magothy Aquifer (16 MGD)		
	Into Lloyd Aquifer (6 MGD)		
OUTFLOW			384
	Public Water Supply Pumpage	180	
	Pumpage from Glacial Aquifer (2 MGD)		
	Pumpage from Magothy Aquifer (166 MGD)		
	Pumpage from Lloyd Aquifer (12 MGD)		
	Discharge to Streams	35	
	Subsurface Flow	169	
	Subsurface Flow in Glacial Aquifer (90 MGD)		
	Subsurface Flow in Magothy Aquifer (73 MGD)		
	Subsurface Flow in Lloyd Aquifer (6 MGD)		

Source: Nassau County 1998 Groundwater Study (pp. 2-8)

Table 3 shows a current (2010) water budget for Nassau County that is in balance because the total amount of water coming into the system is balanced by the amount of water going out. But, the "balance" is dependent on extra inflow into all three aquifers totaling 43 MGD. The source of the inflow is not identified which makes the water budget incomplete. It could include the 9.2 MGD reported in the Suffolk County water budget plus salt water intrusion. Masterson et al (2016) has noted that groundwater flow between subregions can be an important component of regional water budgets. Since pre-development conditions, the aquifer system beneath Nassau County has substantially changed. Outflow to streams has declined 58%, from 84 MGD (pre- development) to 35 MGD (current conditions). This change is observed in the dramatic reduction in south shore stream flows and stream lengths.

Subsurface underflow of groundwater into the offshore portions of the aquifers declined from 332 MGD (pre-development) to 169 MGD (current conditions), a net change of 163 MGD or about a 50% reduction in subsurface discharge (Nassau County 1998 Groundwater Study, pp. 2-8). It should be noted that data for this analysis represent conditions from approximately 1995. This change is due to groundwater loss from

storage caused by pumping, thus no longer available to hold out the ocean.

In order to compensate for the large loss of groundwater due to pumping, the aquifers adjusted by discharging less water to the oceans. To replace the fresh water lost from the aquifers, salt water intrusion increased significantly over time (Nassau County, 1998, pp. 2-8 to 2-9). Public water supply pumpage now represents between 50-60% of the total recharge, depending on annual demand (and recharge rates).

Suffolk County

Suffolk County has developed water budgets for separate areas that cover different parts of the county: the main body, North Fork, South Fork and Shelter Island. Due to the large land area of Suffolk County, the groundwater system receives and discharges roughly three times more water than Nassau County. Suffolk County is surrounded by salt water on three sides, but, from a water budget standpoint, its system is less complicated than that of Nassau County, which has flow boundaries on its eastern and western borders as well as north and south shores. The most recent water budget analysis for Suffolk County (2015) includes all of the budget components needed for it to balance (Table 4).

Table 4
Suffolk County Water Budget - All of Suffolk County

PROCESSES		AMOUNT IN MGD	TOTAL MGD
INFLOW	Recharge from Precipitation		1367.3
OUTFLOW	Water Supply Withdrawals	196.7	
	Withdrawal from Glacial Aquifer (59.4 MGD)		
	Withdrawal from Magothy Aquifer (134.5 MGD)		
	Withdrawal from Lloyd Aquifer (2.8 MGD)		
	Discharge to Streams	506.2	
	Discharge to North Shore	304.6	
	Discharge to South Shore	233.5	
	Discharge to Peconic Bay	117.1	
	Discharge to Nassau County	9.2	
	TOTAL WATER LOST FROM THE SYSTEM		1367.3

Source: Suffolk County Comprehensive Water Resources Management Plan (2015, Executive Summary, pp. 40)

Table 4 reports present the total recharge (inflow) for Suffolk County, which is 1,367.3 MGD, based on:

- Main body: 1119.6 MGD
- South Fork: 178.4 MGD
- North Fork: 51.7 MGD
- Shelter Island: 17.6 MGD.

This total represents the average amount of water that replenishes the aquifers annually.

Overall, there is a large difference in the amount of water in storage between Nassau and Suffolk Counties. As Suffolk County moves to expand centralized sewer systems, less water will be returned to the aquifer from domestic septic systems. A similar loss of return flow due to sewering has had a substantial impact on the flow system in Nassau County, which is approximately 85% sewered. Currently, Suffolk County reports that water supply withdrawals represent approximately 4% of recharge (2015). In addition, with only 25% of the county sewered, large amounts of the pumped water is being returned to the aquifers through domestic septic systems.

Existing Groundwater Withdrawals

Regional Groundwater Withdrawals: USGS Data

The USGS has reported on Long Island water use in the completed North Atlantic Coastal Plain Study (NACP), 2010-present (Masterson et al, 2013, 2016). The USGS has reported on total groundwater pumpage per day by use. Pumpage is broken down for the following user groups:

- Agricultural use: 9 MGD.
- Commercial and industrial use: 68 MGD.
- Public and domestic water supply: 376 MGD.

The total annual average pumpage of 165.7 billion gallons of groundwater was reported. The same NACP Study found the daily total pumpage from the Long Island aquifers is 441 MGD. By specific aquifer, the totals are:

- Surficial Aquifer (Upper Glacial Aquifer): 82 MGD.
- Magothy Aquifer: 349 MGD.
- Lloyd Aquifer: 10 MGD.

When compared to all the other counties being studied in the NACP, Nassau and Suffolk Counties (2005 data) are the only two counties in the largest pumpage category (176-200 MGD) (Masterson. et al, 2013, 2016). Long Island groundwater pumpage is far beyond that of other communities elsewhere along the Atlantic coastal plain. Only Florida rivals New York in groundwater use.

Public Water Supply Pumpage

Public water supply pumpage varies by county and also changes with the seasons. The highest pumpage is in the summer (May-September), usually peaking in July and lowest is in the winter (October-April), especially from December-February.

The New York State Department of Environmental Conservation has summarized pumpage during the period 2000-2014. Table 5 documents pumpage by county for both average pumpage conditions and peak pumpage conditions. It shows a pumpage comparison for 2014 which was a reasonably average year.

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Table 5
Public Water Supply Withdrawal Trends by County from 2000-2014

PUMPAGE 2000-2014	NASSAU COUNTY MGD	SUFFOLK COUNTY, SCWA 2014 ONLY, MGD
2014 Pumpage Only		222
Peak Daily Average	261	
Non-Peak Daily Average	139	
2000-2014 Non-Peak Average Day		132
Low	139	
High	149	
Mean	143	
2000-2014 Peak Average Day		348
Low	231	
High	288	
Mean	251	

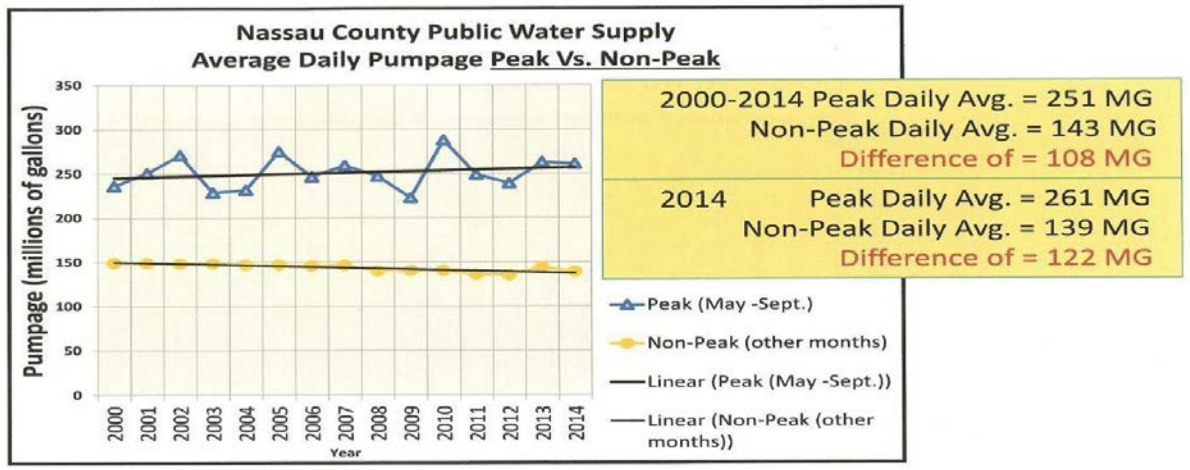
Source: Pilewski (NYSDEC, 2016)

Pumpage by the Suffolk County Water Authority can exceed pumpage in Nassau County (NC) during peak conditions (SCWA-348 MGD vs. NC-288 MGD). However, Nassau County water suppliers may supply more water than SCWA during average conditions in summer (NC-149 MGD vs. SCWA-132 MGD).

Nassau County Public Water Supplier Pumpage

The details of recent pumpage in Nassau County are shown in Figure 1.

Figure 1 Public Water Supply Withdrawal Summary for Nassau County, 2000-2014

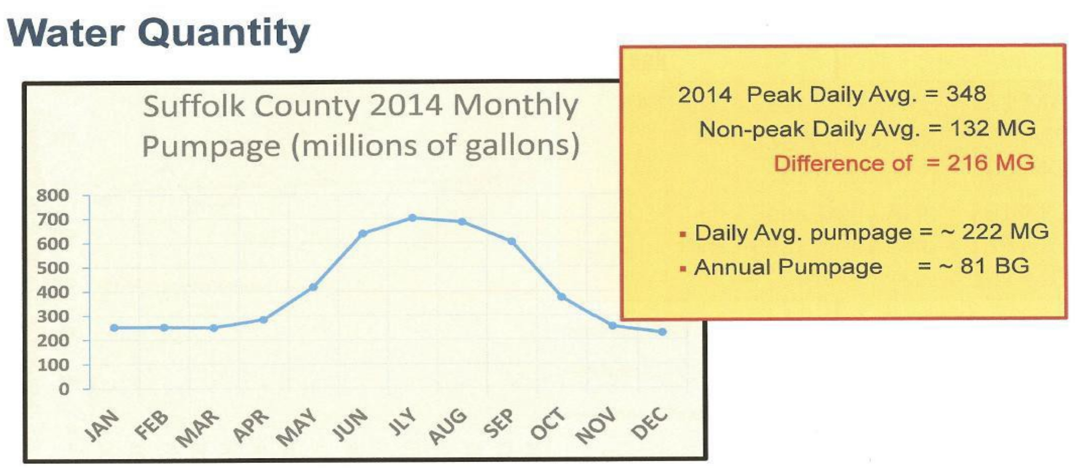


Source: NYSDEC (2015)

Suffolk County Water Authority Pumpage

Pumpage for SCWA, shown in Figure 2, shows a typical pattern of pumpage over the course of a year. It is typical of pumpage patterns for water suppliers in both counties. Low demand occurs in the winter and a 200-400% increase in demand occurs during summer months.

Figure 2 Public Water Supply Withdrawal for SCWA, 2014



Source: NYSDEC (2015)

The Suffolk County Comprehensive Water Resources Management Plan (2015) reported that total water supply pumpage for all ten towns would increase from 2008 to the planning year 2030. The total Suffolk County groundwater pumpage for 2013 was reported to be 228.3 MGD. The predicted pumpage for the county by 2030 is estimated to be 314.5 MGD (Suffolk County, 2015 pp. 4-3 and 4-4). An additional 100 public water supply wells, including all public water suppliers, may be needed by 2030.

Regional Groundwater Use (Brooklyn to Eastern Suffolk County) vs. North Atlantic Coast Plain Aquifers

When comparing all groundwater use on Long Island to groundwater use along the entire North Atlantic Coastal Plain, the USGS has found that the largest aquifer-specific withdrawals from major regional aquifer systems from North Carolina to Long Island have occurred in Long Island's Magothy Aquifer. Magothy Aquifer groundwater withdrawals represented 28% of all withdrawals in the NACP aquifer system (Matheson et al, pp. 28). Based on 2008 data only for Long Island, 72% of all water use on Long Island is derived from the Magothy Aquifer and 27% comes from the Upper Glacial Aquifer. (pp. 28). The same report found that the net volume of groundwater depletion on Long Island between 1900-2008 was 502,000 million gallons (Table 4).

How Long Island's Groundwater is Used

One important aspect of quantity management is how water is used and disposed of. In areas served by public sewer systems, where the wastewater is treated and discharged to coastal waters, all the wastewater effluent leaving the system is considered a consumptive use. It is permanently lost from the aquifer system. The sewers protect groundwater quality, while impacting groundwater quantity.

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Consumptive groundwater use is observed in Nassau County where the majority of all groundwater withdrawal is permanently removed from the aquifer system through evaporation of irrigation water or the coastal discharge of treated wastewater effluent. By comparison, on-site wastewater treatment systems return their waste discharge to groundwater, although the discharge is a pollutant that can impact groundwater quality. Examples of consumptive water use are:

- Central sewering with ocean outfall/discharge.
- Irrigation.
- Some remediation projects where remediated water is not recharged.
- Industrial/manufacturing water use in products, e.g., beverages.
- Some power production that uses groundwater for electricity generation.

Irrigation: Lawns, Landscape Plants, Farms and Golf Courses

Virtually all groundwater used for irrigation is a consumptive use. Water applied to the land during the growing season is lost from the aquifer system through evapotranspiration (taken up by plants and then lost) or through simple evaporation from the soil. It is a 100% consumptive use. The high-water demand experienced by water suppliers in the summer is driven by the 200-400% increase in seasonal water use mainly for lawn and landscape irrigation.

There are approximately 134 golf courses on Long Island. Some courses irrigate using water from local public supplies, but most have their own wells. A few courses use recycled water such as the Town of North Hempstead Links Golf Course in Port Washington that uses collected runoff and treated leachate from the nearby closed landfill. A Riverhead public golf course (Indian Island Country Club) is planning to use recycled water from a nearby sewage treatment plant. For nearly all other courses, groundwater is the ultimate source of irrigation water. An example of a large golf course using groundwater is the Bretton Woods course in Coram that used 71 million gallons of water in 2014 (Harrington, 2015). Golf course water use on Long Island has been calculated to be approximately 2 billion gallons of groundwater per year (Monti, 2015). Golf course irrigation is a significant factor affecting groundwater sustainability since it occurs in the high water-stress summer season.

Agricultural activity on Long Island is another category of consumptive use that is hard to track. The amount of acreage in agricultural use changes yearly. Total agricultural acreage in Suffolk County in 2012 was approximately 21,000 acres. In addition, there was 12 million sq. ft. of greenhouse space in use in 2012. Annual agricultural irrigation will change based on summer weather conditions. It has been estimated that, for 2012, agricultural water use was approximately
4.4 MGD, not including greenhouses (Monti, 2015). Other USGS estimates have agricultural water use as high as 9 MGD.

Per Capita Water Use

Long Island has some of the highest rates of per capita water use in the United States. The national average for per capita water use is generally reported to be 100 gallons per person per day (g/p/d) or less. The New

York City per capita water use is declining (approximately 125 g/p/d) and is now below that of Nassau County.

It is difficult to find specific data on per capita water use for Long Island. According to one estimate, average per capita water use during the winter on Long Island is 100 g/p/d. A yearly average water use per capita is approximately 145 g/p/day. Average summer use is estimated at 200 g/p/d and maximum daily use, mainly during peak summer demand, is 300 g/p/d or more (Granger, 2014). The Cleaner Greener Communities Sustainability Study (2013) found that, regionally, per capita water use is 135 gallons per day. For Nassau County, the per capita water use was set at 149 g/p/d. For Suffolk County, the per capita rate was 122 g/p/d (2013).

Large-Scale Water Consumers

While average water use levels describe how water is used in general on Long Island, there are also examples of sizeable water use by individual categories or individual customers. Newsday reported on the relationship between energy production and water use in 2015 (Harrington, 2015). Long Island power plant's use of groundwater for 2014 was documented. Nearly all the freshwater is used to produce steam to turn turbines for energy production.

Table 6
Groundwater Use for Power Generation on Long Island

NAME OF POWER PLANT	MEGAWATTS	GROUNDWATER USE MG/YR	PUBLIC WATER SUPPLY/ PRIVATE WELL	SALTWATER FOR COOLING
National Grid – Northport	1,580	95	SCWA	939 MG
National Grid – Island Park	391	81	Public Supply	294 MG
National Grid – Port Jefferson		53	SCWA + private well	
NYPA –Holtsville		230: (49.7 + 180.3)	SCWA + private well	
Pinelawn Power – Peaking Plant	79.9	32.4	SCWA	
Covanta – Huntington		30.3	SCWA	
Covanta - Babylon		25 + (300*)	SCWA + Treated Landfill Leachate* - not counted	None
Covanta - Hempstead	72	450	Public Supply	None
Caithness Plant I- Yaphank, Brookhaven	350	18.4	SCWA	None – air cooled system
Caithness Plant II – Proposed, Yaphank	(750) proposed	(52.6) proposed	Not included in total	
TOTAL GW/YR		906.7		

Source: Harrington (2015, Newsday)

Table 6 shows that nearly 1 billion gallons of groundwater per year is used in power production on Long Island. All of this water use is considered a consumptive use and is not returned to the aquifers. In addition, more than 1 billion gallons of salt water is used for cooling water by some of the power plants. Most of this water may be returned as heated water to coastal marine waters.
Another example of major groundwater use is for open-loop geothermal heating and cooling systems. Some of the larger homes on Long Island use in excess of 20 million gallons of potable

public water per year for geothermal and landscape irrigation. Since both of these uses do not require drinking quality water, some water suppliers are reviewing usage data in order to work with major users and get them to reduce their overall demand. Geothermal use is studied in greater detail in a later chapter.

New York State Department of Environmental Conservation - Water Conservation Policy

In January 2017, the NYSDEC notified all public water suppliers on Long Island of a new reporting and water conservation policy. Starting in 2017, the NYSDEC is asking Island water suppliers to prepare and implement a plan to reduce water use in the peak season by 15% over a three-year period or roughly 5% per year. A new reporting form was provided for suppliers to report their progress and document details about water use. The nine-page Water Conservation Reporting Form covers topics such as: water use (daily, annual, peak, etc.); use by sector; unaccounted for water; water bill rates; water meter programs; pipe replacement programs; leak detection; public education; tracking water use reductions; indoor and outdoor water use reductions; drought response and emergency planning; and funding sources to support water conservation.

Chloride Contamination in Nassau and Suffolk Counties, New York

Existing chloride contamination of Long Island aquifer system is examined in this section. Chloride concentrations can be a bellweather of salt water intrusion, perhaps related to excessive pumpage or changes in the aquifer system. Chlorides can also relate to land use within a specific well's zone of capture which is the surface area where groundwater recharge will eventually reach that well. The section presents a summary of chloride concentrations identified in potable supply wells operating within Nassau and Suffolk Counties during 2014, together with an assessment of potential sources of chloride contamination within the vicinity of affected public supply wells. Water quality data was assembled from existing public supply wells in both Nassau and Suffolk Counties for all three principal aquifers. The range of results and their distribution within each county are displayed in Table 7 and Table 8 of this report.

The data collected from potable supply wells during this period shows that mean chloride concentrations are significantly below the drinking water and groundwater standard of 250 parts per million (ppm); however, wells located near shoreline areas appear to be susceptible to chlorides via salt water intrusion and upconing. For example, the public supply wells that exceeded the drinking water and groundwater standard in Suffolk County were located within proximity to shoreline areas. In addition, the analytical results indicate that chloride concentrations in wells screened in the Glacial Aquifer are greater than chloride concentrations identified in deeper wells screened within the Magothy and Lloyd Aquifers, suggesting that various land uses and activities may be having a greater impact upon the shallower wells (e.g., road salting; institutional, commercial and residential developments; the operation of salt storage facilities; etc.).

Table 7
Summary of Chloride Concentrations:
Supply Wells in Suffolk County Operating During 2014

Suffolk County Public Supply Wells - Glacial Aquifer		
Number of Wells	Range of Chloride Concentrations	Percentage of Wells
401	0 - 50 ppm	81%
67	51 - 100 ppm	14%
19	101 - 250 ppm	4%
8	Exceeding 250 ppm	1%
Total = 495	Mean Concentration = 41 ppm	
Suffolk County Public Supply Wells - Magothy Aquifer		
Number of Wells	Range of Chloride Concentrations	Percentage of Wells
372	0 - 50 ppm	97%
9	51 - 100 ppm	2.5%
1	101 and 250 ppm	< 1%
Total = 383	Mean Concentration = 12 ppm	

Suffolk County Public Supply Wells - Lloyd Aquifer		
Number of Wells	Range of Chloride Concentrations	Percentage of Wells
5	0 - 50 ppm	100%
Total = 5	Mean Concentration = 8 ppm	
Suffolk County Public Supply Wells - Raritan Formation		
Number of Wells	Range of Chloride Concentrations	Percentage of Wells
3	0 - 50 ppm	100%
Total = 3	Mean Concentration = 11 ppm	
Suffolk County Private Wells - Glacial Aquifer		
Number of Wells	Range of Chloride Concentrations	Percentage of Wells
210	0 - 50 ppm	82%
26	51 - 100 ppm	10%
16	101 - 250 ppm	6%
5	Exceeding 250 ppm	2%
Total = 257	Mean Concentration = 41 ppm	

Introduction

The potential impact of chlorides upon Long Island aquifers and water resources is an ongoing concern, as the groundwater has been designated by the United States Environmental Protection Agency as a sole-source water supply. Chlorides can impact the Long Island groundwater and drinking water supply primarily through: salt water intrusion via lateral intrusion and upconing when operating supply wells in proximity to surface waters, road salting and runoff from improperly stored road salt

Table 8
Summary of Chloride Concentrations:
Supply Wells in Nassau County Operating During 2014

Nassau County Public Supply Wells - Glacial Aquifer		
Number of Wells	Range of Chloride Concentrations	Percentage of Wells
4	0 - 50 ppm	44%
5	51-100 ppm	56%
0	101-250 ppm	0%
Total = 9	Mean Concentration =46 ppm	
Nassau County Public Supply Wells - Magothy Aquifer		
Number of Wells	Range of Chloride Concentrations	Percentage of Wells
248	0 - 50 ppm	95%
14	51 - 100 ppm	5%
0	101 - 250 ppm	0%
Total = 33	Mean Concentration = 21 ppm	
Nassau County Public Supply Wells - Lloyd Aquifer		
Number of Wells	Range of Chloride Concentrations	Percentage of Wells
31	0 - 50 ppm	94%
2	51 - 100 ppm	6%
0	101 - 250 ppm	0%
Total = 33	Mean Concentration = 12 ppm	
Nassau County Public Supply Wells - Port Washington Magothy Aquifer		
1	0 - 50 ppm	%100
Total = 1	Mean Concentration = 50 ppm	

and deicing compounds. Other sources of chlorides include: effluent from sewage disposal systems, leachate from municipal landfills and infiltration of stormwater from recharge and drainage basins. Impacts of chlorides from lateral intrusion and upconing are particularly relevant with respect to areas on the North and South Forks of Suffolk County, Shelter Island and various coastal regions along the south shore of Long Island. In addition, several supply wells within areas of the Brookhaven and Islip Towns also have been affected with chlorides. In Nassau County, several public supply wells located in Great Neck, Manhasset Neck and Bayville were shut down due to salt water intrusion and overpumping. It should be noted that removal or treatment of excessive chloride contamination from drinking water supplies is typically not an option because of the difficulty and expense involved. For purposes of this report, drinking water wells that exhibit chloride concentrations exceeding 100 ppm are considered impacted or affected with chlorides.

Methods

A query of the Suffolk County Department of Health Services (SCDHS) database was performed to compile the chloride results of samples collected from potable supply wells during 2014 as part of the department's public water supply surveillance monitoring program and private well sampling program. All samples were analyzed by the SCDHS Public and Environmental Health Laboratory in accordance with USEPA's Method 300. Water quality results for wells operating in Nassau County were collected and analyzed by public water suppliers in Nassau County and compiled by the Nassau County Department of Health (NCDOH). Screening values for chlorides were compiled for ranges up to 50 ppm; between 50-100 ppm; from 100-250 ppm, and greater than 250 ppm. In addition, salt storage facilities located within the groundwater contributing areas of public supply wells operating within Suffolk County were identified to help with assessing possible sources of chloride contamination. A compilation of historical water quality results performed by the SCDHS from 1998 and through most of 2015 also was utilized to help identify chloride concentrations at public supply wells exhibiting concentrations that exceeded 100 ppm.

Discussion

Public supply wells serve both community water supply and non-community public water supply systems. Pursuant to the New York State Sanitary Code, public community water supply systems serve at least five service connections used by year round residents or regularly serve at least 25 year round residents. Non-community public water supply systems regularly serve at least 25 people a minimum of 60 days of the year. In general, supply wells serving community public water systems are much deeper than wells serving non-community systems and private wells. In addition, private wells typically serve single-family residences and are not regulated as public water systems.

Chloride Results from Public and Private Wells within Suffolk County

During 2014, the SCDHS collected a total of 1,458 samples for chloride analyses from public and private drinking water supply wells operating within Suffolk County as part of the department's routine surveillance monitoring programs (this total includes 1,099 samples from public wells and 359 samples from private wells). Test results show that 401 public supply wells (81%) screened within the Glacial Aquifer exhibited chloride concentrations below 50 ppm; 67 wells (14%) exhibited concentrations between 51-100 ppm; 19 wells (4%) exhibited chloride concentrations between 101-250 ppm; and eight wells (1%) exceeded the New York State Department of Health's (NYSDOH) drinking water standard and the New York State Department of Environmental Conservation's groundwater standard of 250 ppm (this includes one community supply well and seven non-community supply wells). The mean concentration was 41 ppm.

Analysis of public supply wells screened within the Magothy Aquifer show that 372 wells (97%) exhibited chloride concentrations below 50 ppm; nine wells (2.5%) exhibited chloride concentrations between 51- 100 ppm; only one well showed chlorides between 101-250 ppm and none exceeded 250 ppm. The mean concentration was 12 ppm. Chloride concentrations identified in all five wells screened in the Lloyd Aquifer were below 50 ppm, with a mean concentration of 8 ppm, while chloride concentrations in all three wells screened in the Raritan Formation also were below 50 ppm, with a mean value of 11 ppm. Samples collected from private wells within Suffolk County during 2014, showed that 210 wells (82%) exhibited chloride concentrations below 50 ppm; 26 wells (10%) exhibited chloride concentrations between 51-100 ppm; 16 wells (6%) exhibited concentrations between 101-250 ppm, and five wells exceeded the drinking water and groundwater standards of 250

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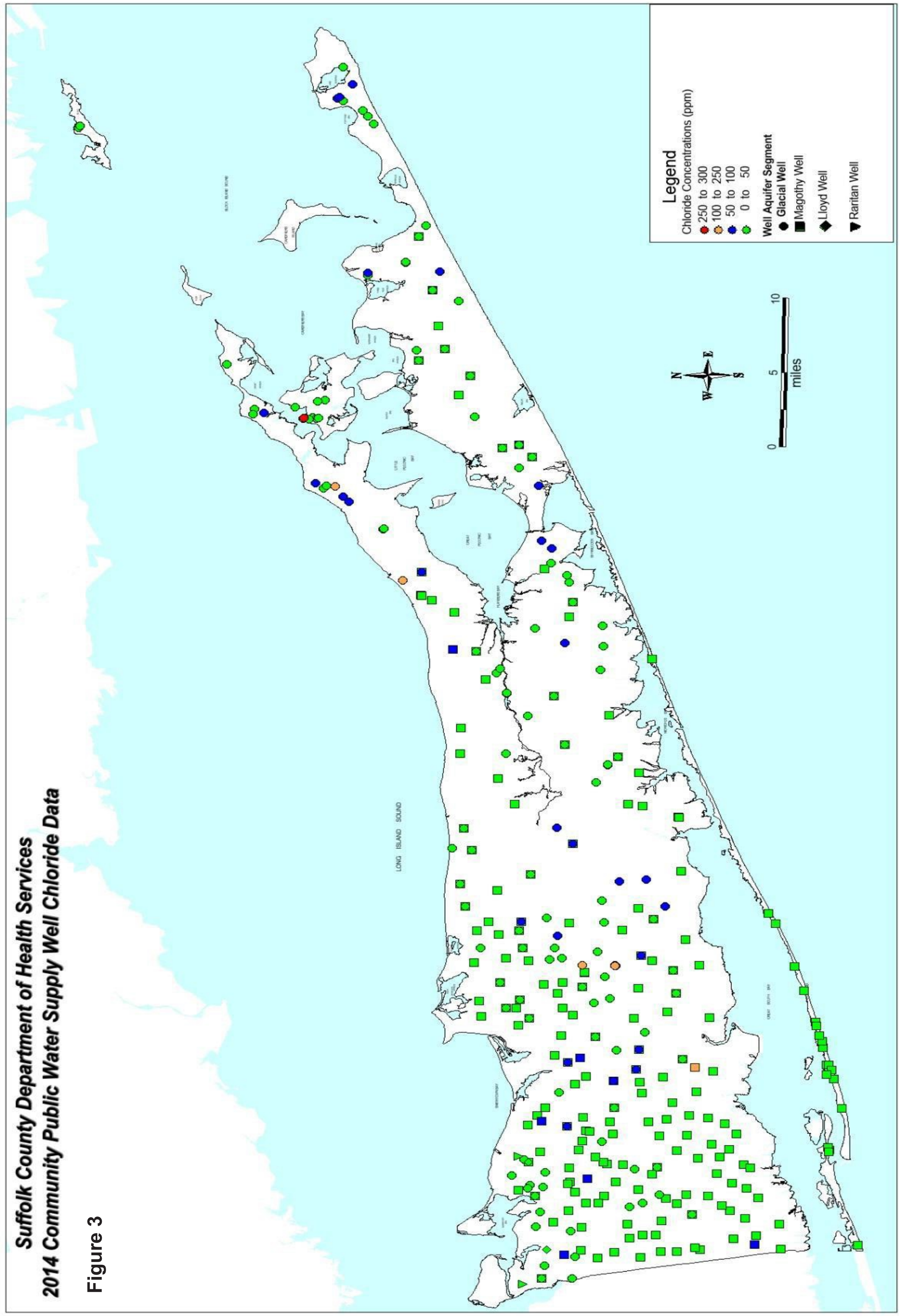
ppm. It should be noted that these results represent a small percentage of the estimated 45,000 private wells in Suffolk County.

The eight public supply wells that exceeded the drinking water standard noted above are located within the townships of Shelter Island, Southold and East Hampton and include one community supply well and seven non-community wells. The affected public water systems either: removed the impacted wells from service, provided the appropriate treatment devices or connected to a community water supply system. All of the private well owners were notified accordingly of their results by the SCDHS. Table 7 provides a summary of chloride concentrations identified in public and private supply wells sampled by the SCDHS during 2014. Figures 3, 4 and 5 illustrate the chloride detections identified in public community supply wells, non-community supply wells, and private wells operating within Suffolk County during 2014, respectively.

Chloride Results from Public Wells within Nassau County

Water quality results compiled by the NCDOH from 305 public supply wells during 2014 as part of their regulatory programs showed the following results: four wells (44%) screened within Glacial Aquifer exhibited chloride concentrations below 50 ppm, and five wells (56%) exhibited chloride concentrations between 51-100 ppm. The mean chloride concentration was 46 ppm. Public supply wells screened within the Magothy Aquifer showed that 248 wells (95%) had chloride concentrations below 50 ppm, and 14 wells (5%) had concentrations between 51-100 ppm. The mean concentration was 21 ppm. Public supply wells screened within the Lloyd Aquifer showed that 31 wells (94%) had concentrations of below 50 ppm while two wells exhibited chloride concentrations between 51-100 ppm. The mean chloride concentration was 12 ppm.

In addition, only one supply well screen within the Port Washington Magothy Aquifer exhibited a mean chloride concentration of 50 ppm. Table 8 includes a summary of the results, and Figure 6 shows the chloride concentrations from public supply wells operating within Nassau County during 2014.



Suffolk County Department of Health Services
2014 Community Public Water Supply Well Chloride Data

Figure 3

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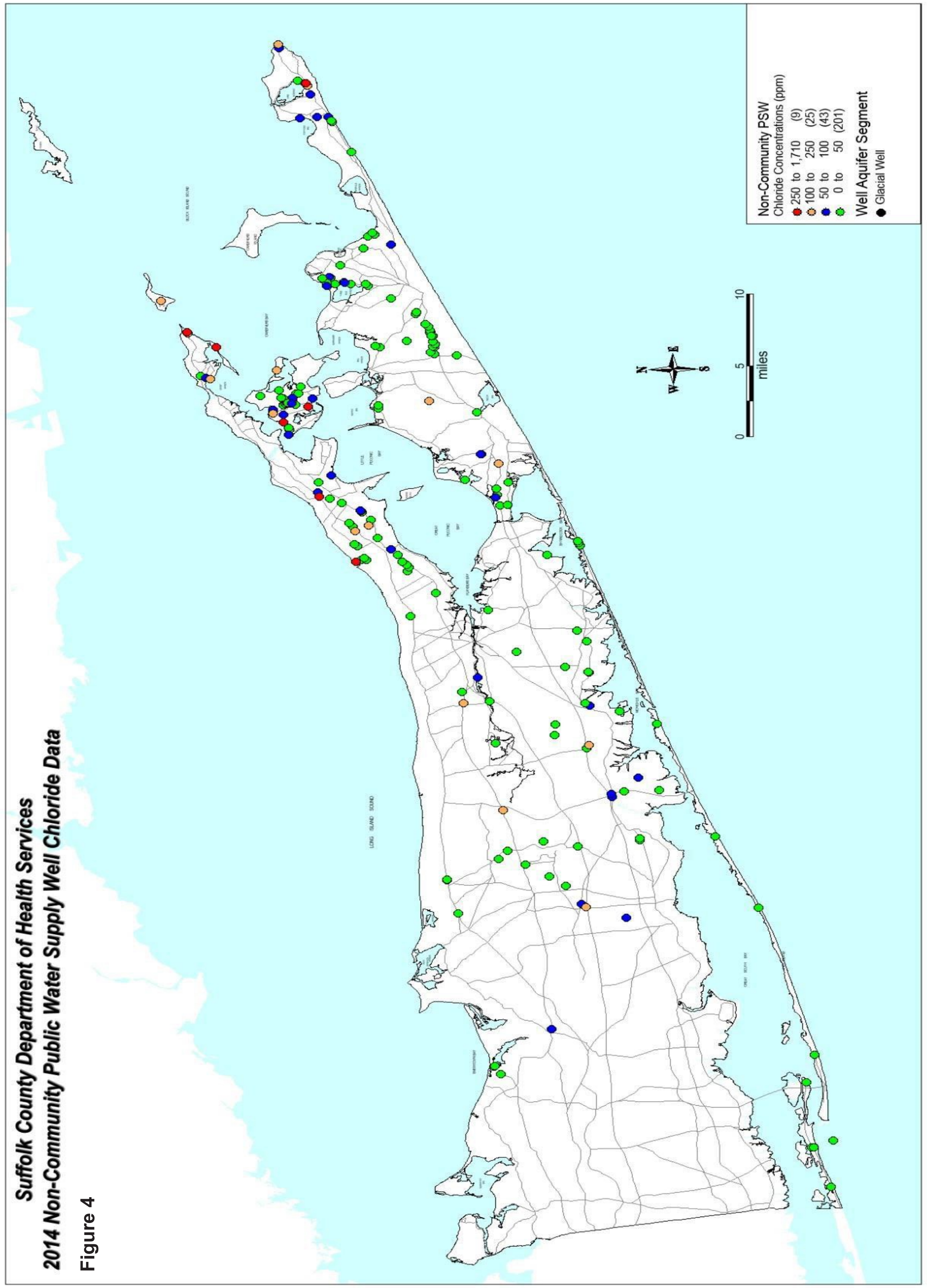

Suffolk County Department of Health Services
2014 Non-Community Public Water Supply Well Chloride Data

Figure 4

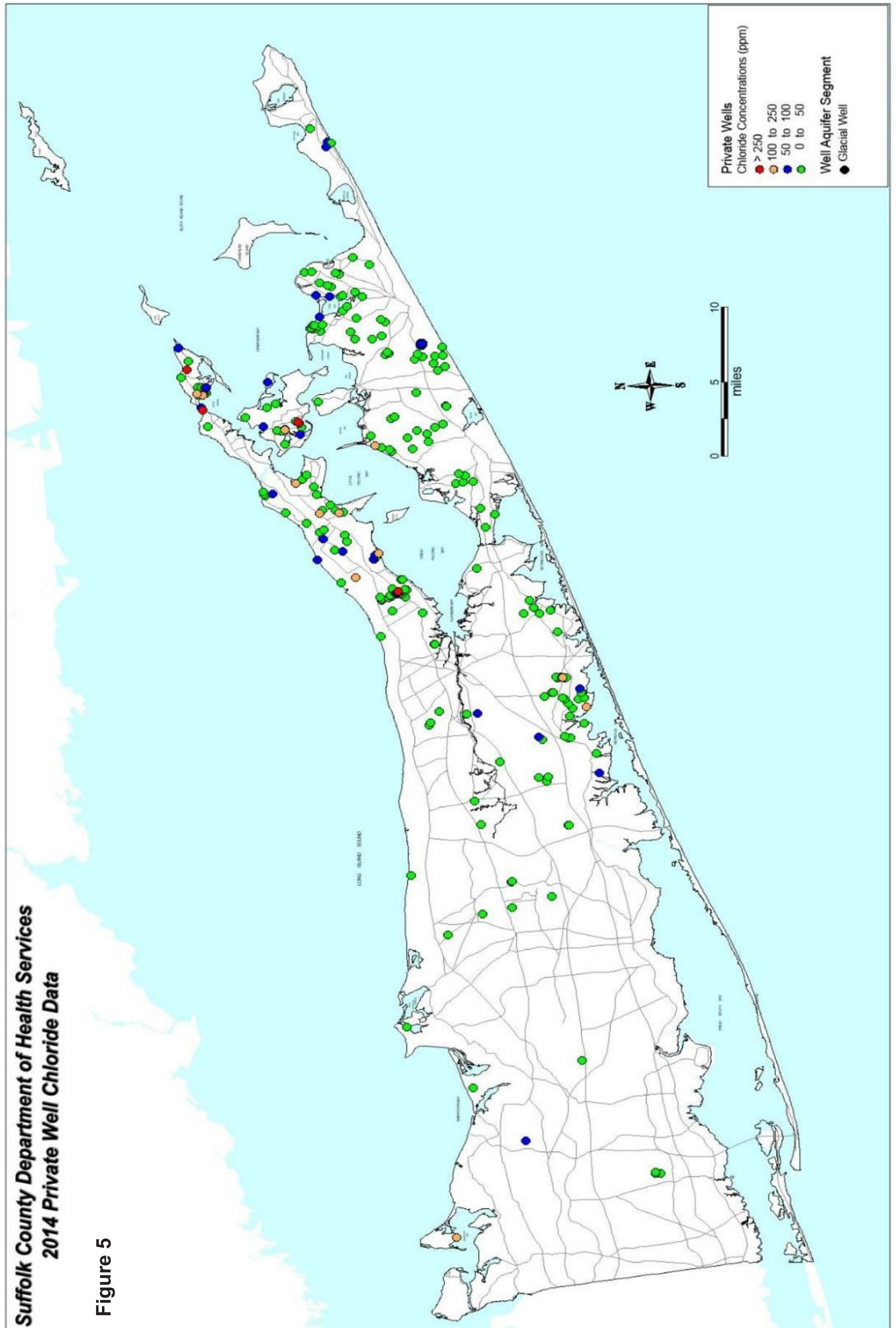

Figure 5

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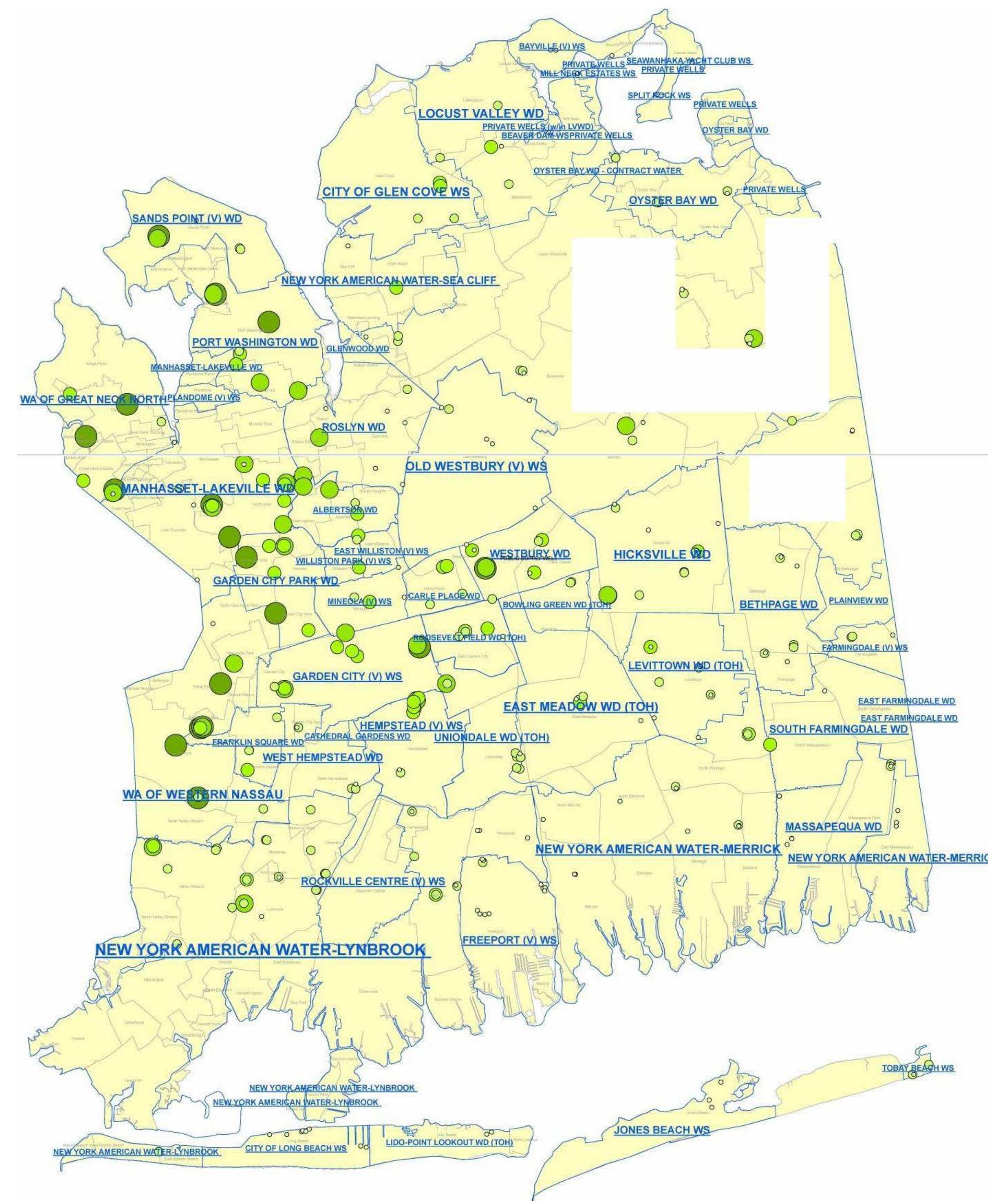
Figure 6 Chloride Concentrations, Nassau County Public Wells, 2014



Evaluation of Source Water Assessment Areas of Public Supply Wells Affected with Chlorides

To help evaluate potential sources of chloride contamination in public drinking supplies, supply wells with chloride concentrations greater than 100 ppm were evaluated in greater detail. Fifteen public supply wells in Suffolk County exhibited chloride concentrations exceeding 100 ppm (Table 9). Of these 15 wells, the groundwater contributing areas of 12 wells have been modeled by Camp, Dresser, and McKee (CDM) as part of the Suffolk County Comprehensive Water Resources Management Plan. A review of this information, as well as identifying potential sources of chlorides in the vicinity of the other three wells that exceeded 100 ppm, indicates that five of the wells are located near roadways that are possibly influenced by road salting; five wells are located in proximity to a salt water body such as the Long Island Sound; three wells are located in proximity to both salt storage facilities and roadways; and two wells are in the vicinity of both a salt water body and roadways (Table 10). This review indicates that there are multiple potential sources of chloride contamination at public supply wells with elevated chlorides.

As noted above, Table 10 provides a summary of potential sources of chloride contamination that exists within the vicinity of public supply wells where concentrations exceeded 100 ppm. Table 5 provides a list of public supply wells where salt storage facilities were identified within the groundwater contributing areas together with the respective trends in chloride concentrations.

In addition, a review of available information shows that approximately 29 road salt storage facilities are located within the groundwater contributing areas serving 33 public supply wells in Suffolk County. A compilation of water quality results obtained from these wells between 1998 through most of 2015 suggests that, overall, chloride concentrations generally increased in 12 of the 33 wells sampled during this period; however, chloride concentrations generally remained the same in 18 wells and decreased in three of the wells. Table 11 provides a list of public supply wells where salt storage facilities were identified within the source water contributing areas together with supporting data.

To help identify and monitor the fresh water-salt water interface near shoreline areas at select locations within Suffolk County, the SCDHS is in the process of installing monitoring wells near shoreline areas of the Southwest Sewer District; within the North and South Forks and at locations within Shelter Island. These monitoring wells will be utilized to measure the concentration and trend in chloride concentrations and to monitor the fresh water-salt water interface through the use of geophysical logging equipment and measuring other chemical parameters. Additional monitoring wells at other locations may be installed and monitored depending upon available resources.

Table 9
Concentration History: Public Community Supply Wells in Suffolk County Exhibiting Concentrations Exceeding 100 mg/L

S-Number	Date of 1st Sample	Date of Last Sample	Number of Samples	Min. Conc. mg/L	Max Conc. mg/L	Mean Conc. mg/L	1st Sample Conc. mg/L	Last Sample Conc. mg/L	Change in Conc. mg/L
S-00177	10/19/1998	10/14/2015	18	14	111	52	30	86	56
S-103522	12/15/1998	11/17/2015	19	29	134	89	29	91	62
S-121811	5/16/2005	2/3/2010	6	33	104	57	104	66	-38
S-124659	7/31/2007	9/9/2015	9	47	147	89	47	147	100
S-124789	10/29/2008	6/2/2015	6	171	198	181	172	198	26
S-126076	9/9/2008	8/21/2014	6	111	201	155	111	192	81
S-126912	8/12/2008	9/23/2015	8	17	296	112	17	197	180
S-129199	8/22/2011	7/14/2015	6	171	277	213	277	171	-106
S-130317	8/2/2011	5/18/2015	5	6	209	74	6	209	203
S-131612	6/27/2013	6/23/2015	3	67	137	99	67	137	70
S-29492	7/16/1998	7/1/2015	19	32	131	66	36	80	44
S-32552	7/16/1998	6/2/2015	20	60	196	121	81	171	90
S-33775	1/27/1999	6/3/2015	17	85	131	114	100	107	7
S-54473	9/29/1999	6/2/2015	18	38	128	69	38	128	90
S-66366	11/5/1998	6/18/2015	19	94	152	115	95	108	13

Table10
Potential Sources of Chloride Contamination within Source Water Assessment Areas or Within the Vicinity of Public Supply Wells in Suffolk County Exhibiting Chloride Concentrations Exceeding 100 ppm

S-Number	Location	Groundwater Contributing Area Available	Potential Sources within Source water assessment Area or Within Vicinity of Supply Well
S-00177	Shelter Island	Yes	Well is located within 800 feet of Dering harbor
S-103522	Southold	Yes	Well is located within 0.68 miles of the Long Island Sound; adjacent to County Road 48
S-121811	East Hampton Montauk	Yes	Well is adjacent to Montauk Hwy. and is situated near agricultural areas
S-124659	East Hampton	No	Well is located within 0.5 miles of the Atlantic Ocean and Lake Montauk
S-124789 S-32552 S-54473	Brookhaven Selden	Yes	Wells are located within the vicinity of a salt storage facility and are adjacent to Nicolls Road. Institutional and residential properties are also within the sources water assessment areas
S-126076	Southold	Yes	Well is located within 0.40 miles of the Long Island Sound
S-126912	Shelter Island Heights	No	Well is adjacent to Dering Harbor
S-129199	Islip Terrace	Yes	Well is located several hundred feet away from Southern State Parkway. A salt storage facility is also located over a mile away and is situated outside of the source water assessment area to the well.
S-130317	Riverhead	Yes	Well is adjacent to Northville Turnpike and is situated about 1.5 miles from the Long Island Sound.
S-131612	Southold	No	Well is located about 0.5 miles from the Long Island Sound.
S-29492	Brookhaven Medford	Yes	Well is located in the vicinity of Portion Road and Morris Avenue. Residential and commercial properties exist within the source water assessment area.
S-33775	Southold	Yes	Well is located within one mile of the Long Island Sound, and is within the vicinity of Old North Road.
S-66366	Huntington	Yes	Well is adjacent to Oakwood Road. Various residential, commercial, and industrial properties exist within the source water assessment area.

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Table11
Chloride Concentration History - Public Community Supply Wells in Suffolk County with Salt Storage Areas Located Within Source Water Assessment Areas

S-Number	Date of 1st Sample	Ending Date	Number of Samples	Min. Conc. mg/L	Max. Conc. mg/L	Mean Conc. mg/L	1st Sample Conc. mg/L	Last Sample Conc. mg/L	Change in Conc. mg/L
S-111777	4/3/2000	5/18/2015	17	3	6	4.9	5		0
S-113006	8/23/1999	1/22/2015	19	3	7	4.6	7		-2
S-113387	7/19/2001	6/23/2015	17	10	19	13	15	19	4
*S-117742	5/21/2003	6/23/2015	12	9	32	15	11	32	21
*S-118818	10/16/2003	8/25/2015	13	27	62	43	28	62	34
*S-120190	3/22/2005	2/4/2015	11	5	17	13	5	17	12
*S-124003	5/16/2006	10/6/2015	10	23	59	43	38	59	21
S-124088	11/28/2005	5/18/2015	11	17	23	20	18	22	4
S-125133	11/19/2007	6/23/2015	9	11	16	14	12	16	4
S-125797	7/8/2009	4/21/2015	7	7	9	7.7	8		0
S-17576	10/19/2004	10/20/2015	9	5	8	6.7	6		2
S-17577	10/19/2004	3/17/2010	4	6	9	7	6		1
*S-20318	6/30/1998	5/13/2015	18	15	28	21	17	28	11
S-22640	11/9/1998	5/12/2015	19	7	23.7	16	15	8	-7
S-24851	7/11/2001	8/18/2014	14	23	27	25	25	27	2
S-32412	6/30/1998	5/13/2015	18	3	5	4.1	3		2
*S-32552	7/16/1998	6/2/2015	20	38	196	119	81	171	90
S-33820	8/2/1999	7/29/2015	17	21	30	26	28	29	1
*S-36976	2/2/1999	10/13/2015	17	15	34	22	15	34	19
S-38784	4/19/1999	5/26/2015	18	7	10	8	8		1
S-39709	6/24/1998	3/3/2015	18	2	5	3.5	3		1
*S-42761	9/15/1999	6/25/2015	19	9	38	20	15	38	23
S-51673	5/25/1999	3/31/2015	17	2	4	3	3		1
*S-54473	9/29/1999	6/2/2015	19	38	128	70	38	128	90
S-66496	3/22/1999	6/25/2015	19	3	6	4.2	4		1
S-66685	9/1/1998	5/18/2015	19	15	29	21	20	24	4
*S-67925	12/3/1998	10/6/2015	20	12	28	17	15	28	13
S-71533	4/7/2008	7/1/2015	12	9	11	10	9	11	2
S-93701	7/7/1999	6/16/2015	15	8	43	16	9	16	7
S-96673	6/17/1999	10/20/2015	18	5	12	7.6	8	10	2
S-99130	9/8/1999	6/25/2015	18	3	6	4.6	5		-1
*X-00041	10/25/1999	5/11/2015	17	6	29	16	6	29	23
*X-00050	10/25/1999	9/29/2015	13	13	89	44	13	89	76

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Summary and Conclusions

Based upon the compilation and evaluation of the water quality results and other available information noted above, the following summary and general conclusions can be offered:

- Public supply wells operating within Suffolk County during 2014 revealed that 81% of the wells screened in the Glacial Aquifer exhibited chloride concentrations below 50 ppm; 14% of the wells exhibited chloride levels between 51-100 ppm; 4% exhibited chlorides concentrations between 101-250 ppm; and only 1% of the wells tested exceeded the drinking water and groundwater standard of 250 ppm. The mean concentration was 41 ppm. Public supply wells screened within the Magothy Aquifer revealed that 97% of the wells exhibited chloride concentrations below 50 ppm; 2.5% of wells exhibited chloride levels between 51- 100 ppm; less than 1% of the wells tested showed chloride concentrations between 100-250 ppm; and none exceeded 250 ppm. The mean chloride concentration was 12 ppm. All of the wells screened within the Lloyd Aquifer and Raritan Formation were significantly below 250 ppm, with mean values of 8 ppm and 11 ppm, respectively.

- Samples collected and analyzed by the SCDHS from private wells during 2014 revealed that 82% exhibited chloride concentrations below 50 ppm; 10% of the wells had chloride concentrations between 51-100 ppm; 6% of the wells sampled exhibited chloride concentrations between 101-250 ppm; and less than 2% of the wells tested exceeded 250 ppm. Also, a review the data suggests that chloride concentrations exceeding the drinking water standard in the eight public supply wells sampled in 2014 was likely caused by salt water intrusion and storm surges as these wells operated in proximity to surface waters. However, other sources of chlorides, such as road salting also may have contributed to the chloride levels identified in these wells.

- Water quality results compiled by the NCDOH from 305 public supply wells during 2014 showed the following results: four wells (44%) screened within Glacial Aquifer exhibited chloride concentrations below 50 ppm, and five of wells (56%) exhibited chloride concentrations between 51-100 ppm. The mean chloride concentration was 46 ppm. Public supply wells screened within the Magothy Aquifer showed that 248 wells (95%) had chloride concentrations below 50 ppm, and 14 wells (5%) had concentrations between 51-100 ppm. The mean concentration was 21 ppm. Public supply wells screened within the Lloyd Aquifer showed that 31 wells (94%) had concentrations of below 50 ppm, while two wells exhibited chloride concentrations between 51-100 ppm. The mean chloride concentration was 12 ppm. In addition, only one supply well screen within the PortWashington Magothy Aquifer exhibited a mean chloride concentration of 50 ppm.

- The data collected from potable supply wells during 2014 shows that mean chloride concentrations are significantly below the drinking water and groundwater standard of 250 ppm; however, wells located near shoreline areas can be susceptible to chlorides via salt water intrusion and upconing. In addition, the analytical results indicate that chloride concentrations in wells screened in the Glacial Aquifer are greater than chloride concentrations identified in deeper wells screened within the Magothy and Lloyd Aquifers, suggesting that various land uses and activities may be having a greater impact upon the shallower wells (e.g., from road salting, developed properties, salt storage facilities, etc.).

- A review of available information by the SCDHS shows that 29 salt storage facilities are located within the groundwater contributing areas of 33 public supply wells operating within Suffolk County. An evaluation of the water quality results obtained from these wells between 1998 and most of 2015 suggests that overall, chloride concentrations generally increased in 12 of the 33 wells sampled during this period; however, concentrations generally remained the same in 18 wells and decreased in three wells.

- It should be noted that this information includes test results from 2014 and represents only a limited data set. Supply wells that may have had chloride impacts that were taken out of service were not included.

- An evaluation of the source water assessment areas serving 15 public supply wells operating within Suffolk County exhibiting chlorides exceeding 100 ppm indicates that five of the wells are located near roadways; five wells are located in proximity to a salt water body, such as the Long Island Sound; three wells are located in proximity to salt storage facilities and roadways; and two wells are in the vicinity of both a salt water body and roadways (Table10). This information suggests that a variety of sources and activities could be contributing to the increase in chloride concentrations identified in some of the affected wells.

Existing Regulatory Regimes

The following is a chronological listing of many of the more significant milestones in Long Island water resource management and water supply planning. A brief description of several land preservation programs also is provided in a separate section devoted to Suffolk County's *2015 Comprehensive Water Resources Management Plan.* This listing is not an exhaustive bibliography. Brief descriptions are provided for some grounding as to the progression of our understanding of the Long Island aquifer system, water supply needs, wastewater management, land use and population issues. Individual issue topics, such as contamination occurrence, or water quality investigations relating to a specific contaminant or group of contaminants are not listed; however, they are often listed as information sources in the bibliographies that accompany many of these listed studies. Subregional studies are listed primarily when they were considered a part of a regional plan. Several reports were not readily available for summary.

1. 1956 and 1958, Greely and Hansen, Nassau County, *New York Report on Water Resources.* Three Parts: Part I – Water Requirements, Part 2 – Water Resources and Part 3 – Development of Resources.

2. 1957, T.H. Wiggin, *Report on a Comprehensive Plan for the Development and Distribution of the Available Water Supply of Suffolk County, Long Island, New York.* Report to the Suffolk County Water Authority (SCWA). Includes estimates on recharge adequate for five million people. Wiggin's report said to contain first reference of potentially using recharge basins for aquifer recharge purposes in Suffolk County, in use in Nassau County since 1935. Wiggin report citation in Regional Planning Board's *1968 Existing Land Use Report:* water supply is obtained entirely from groundwater; natural replenishment of this supply is derived solely from precipitation, i.e., rain, snow and sleet, which averages 42 inches per year. It estimates that approximately50% of the precipitation is lost due to evaporation, stream flowand other factors so that only about half of the precipitation reaches the water-bearing strata. On thebasis of past experience and engineering projections, the groundwater reservoir appears to be adequateto serve an estimated population of approximately 5 million persons in the two counties.

3. 1963, Greely and Hansen, Nassau County, New York, *Report on Water Supply.* The primary purpose of this study for Nassau County was to provide a comprehensive plan to avoid a critical water supply problem, which, in 1963, was predicted for 1987. The recommended plan included the following: installation of deep injection wells along the south shore using reclaimed wastewater for creating a fresh water barrier to retard salt water intrusion into the Magothy Aquifer, increasing the aquifer yield; spreading location of future wells throughout Nassau County; and recharging supplemental water into the central part of the county. The third step considered purchase of supplemental water from New York City or Suffolk County, seawater desalinization and (recommended in the final plan) use of reclaimed wastewater. These recommendations prompted the bench and pilot studies of tertiary treatment and barrier-recharge at the Bay Park Sewage Treatment Plant in the 1960s and 1970s, ultimately leading to the feasibility operational testing of recharge at the Cedar Creek plant from late 1979-1982.

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4. 1967, Malcolm Pirnie, *Town of Southold Investigation of Water Resources.*

5. *1968-1970, Suffolk County Comprehensive Public Water Supply Study* (CPWS- 24). A 50- year master plan for development of fresh water resources. Pursuant to Article 5, Part V-A of the Environmental Conservation Law. Projected population of 3.06 million by year 2020, county consumptive uses of 381 million gallons per day, assuming 100 percent sewered; localized deficits in the Towns of Riverhead, Southold, Babylon and Southampton (without the Shinnecock Reservation) in drought. 466 million gallons permissive sustained yield. Projected Nassau County deficits by 2010 might make consideration of export to Nassau County necessary, gradually declining as Suffolk County surpluses diminish. Extensive bibliography including the *1965-1967 Comprehensive Sewage Study of Five Western Towns.*

6. 1968-1970, Greeley and Hansen, *Nassau County Comprehensive Public Water Supply Study* (CPWS-60). Intended to be a flexible planning guide for 50 years. Population projections, per capita use and estimated consumption were projected to exceed the permissive sustained yield based on the range of estimated sustained yields reported in prior studies. A deficiency supply plan similar to that discussed in CPWS-24 was described and was proposed to be administered by aWater Resources Board. Population projections were, as was the case with the Suffolk County study, substantially higher than what eventually occurred – reaching 2.25 million by year 2020.

7. 1969, New York State Department of Health, Nassau County Department of Health, Suffolk County Department of Health Services, Suffolk County Water Authority, and R.H. Lauman, *Long Island Groundwater Pollution Study.* Funded in part by the United States Public Health Service. Extensive field study of on-site sewage disposal system capability for removal of detergent formulations and other domestic sewage contaminants; and use of tracers and test wells. Temporary State Commission on Water Resources Planning.

8. 1970, Nassau-Suffolk Regional Planning Board, *The Nassau-Suffolk Comprehensive Development Plan.*

9. 1978, Long Island Regional Planning Board, *Long Island Comprehensive Waste Treatment Management Plan* (L.I. 208 Study). Examined many aspects of surface and groundwater pollution on Long Island; established the need for regional management approaches; established eight hydrogeologic zones with differing recharge characteristics; established one-acre development as a level needed to keep groundwater impacts acceptable; and evaluated viral and other pathogenic contamination potential. Provided the basis for the Environmental Protection Agency Sole Source Aquifer designation for Nassau and Suffolk Counties. Management projects continued under the established 208 program structure yielding the *1984 Non-Point Source Management Handbook,* the Suffolk County Drinking Water Protection programs, which acquired critical areas utilizing a dedicated sales tax revenue source, and the Long Island landfill law in 1983.

10. 1980, H2M Corporation, *Nassau County Draft Master Plan.* Reworked population projections and consumption from the prior report, anticipating both numbers would peak in the early 1990s. Permissive sustained yield was estimated at 180 million gallons per day.

Existing Regulatory Regimes (cont'd)

11. 1983, ERM-Northeast/Camp, Dresser, & McKee, *North Fork Water Supply Plan.* Prepared for Suffolk County Department of Health Services. Encompassing the Towns of Riverhead and Southold, the study area was divided into five zones with permissive sustained yield assigned to each budget area. Domestic consumptive use and agricultural consumptive use was projected through the year 2000. Several zones were recognized to have critical supply conditions and extensive contamination largely due to agricultural activity was noted and expected to continue for many years. Five levels of supply alternatives were projected from individual home system treatment through neighborhood systems, through small community, subregional and regional system supply and treatment responses.

12. 1986, New York State Department of Environmental Conservation, *Long Island Groundwater Management Program.* Summarized quality and quantity problems, existing programs, program needs and actions to preserve and protect groundwater; provided a technical basis for withdrawal limitations in Nassau County.

13. 1986, Holzmacher, McLendon, & Murrell, *South Fork Supplemental Water Resources Study: Phase III Groundwater Modeling and Recommendations.* Utilized the Pindar finite-element model developed by Pindar for the 208 Study designed to assess the impacts of withdrawals on water table elevations and the position of the salt water interface. It showed that the effect of net withdrawals is overshadowed by extended droughts.

14. 1987, Dvirka & Bartilucci Consulting Engineers and Suffolk County Department of Health Services, *Suffolk County Comprehensive Water Resources Management Plan.* Primary objective was as an update of the Comprehensive Public Water Supply Study CPWS-24 through a planning period of 2020 and beyond. Addressed future land use and growth patterns, population, demands, treatment and water transmission needs, land use impacts on quality, hydrogeologic zone boundaries and critical recharge areas and potential land use impacts on water resource utilization. Structural and non-structural options considered. This resulted in establishment of population-related, nitrogen-based targets for management of non-sewered future developments in the various designated recharge areas. These advanced concepts developed in the *1978 208 Study* and provided the necessary technical support for the density based non-sewered allowances formalized in Article 6 of the Suffolk County Sanitary Code. Volume II of the *Report* developed detailed management options, recommendations and implementation measures to address nine specific groundwater quality, groundwater quantity and water supply problems.

15. 1988, New York State Department of Environmental Conservation, *Long Island Water Resources Management Study.* Following the 1984 passage of the Water Resources Management Strategy Act; first step state-wide to identify deficiencies, both existing and potential for Long Island through year 2030, the rest of New York through year 2000; 49 of 84 systems were surveyed; noted Long Island's well permit system provided more information than elsewhere in the state; Nassau County's current consumptive use near or above most estimates of permissive sustained yield, although exact quantification is not possible, while Suffolk County has adequate supply; noted local pumping along with costs, private wells and streamflow reductions; recognized federal, state and bi-county efforts since the 1970s. Mainly focused on quality. Noted permissive sustained yield as a matter of debate; streamflow reduction coupled with rising per capita use resulted in devising of allocation system or caps in Nassau County; noted need to continue and expand monitoring to adjust allocated pumpage as necessary. Noted need for $0.5 billion in infrastructure needs by year 2000, about one third of which in storage to provide one-day demand.

16. 1989-1990, Nassau County Department of Public Works, *Nassau County Comprehensive Water Management Plan, Volume I and II.* Described a series of developments related to the implementation of a number of the 1980 Master Plan recommendations and discussed the development and status of the Regional Groundwater Model (Volume III, Camp, Dresser, and McKee).

17. 1992, Long Island Regional Planning Board, *The Long Island Comprehensive Special Groundwater Protection Area Plan.* Study of large remaining undeveloped tracts on Long Island, made land use recommendations, defined as ecologically, geologically or hydrogeologically sensitive. Provided a technical basis for Central Pine Barrens designation and management.

18. 1992, Long Island Regional Planning Board, *The Long Island Segment of the Nationwide Urban Runoff Program.* One of the first 19 national studies of impact of urban runoff on water quality.

19. 1992, Long Island Regional Planning Board, *The Long Island Comprehensive Open Space Plan.*

20. 1993, Long Island Pine Barrens Protection Act and Amendments (LIPBA). The LIPBA established the Central Pine Barrens Joint Planning and Policy Commission (CPBJPPC) and empowered the Commission to regulate development activities within 105,492 acre within the Suffolk County towns of Brookhaven, Riverhead and Southampton. The LIPBA, among other things, describes the duties of the Commission, defines development and "non-development" activities in the Central Pine Barrens (CPB) and defines the boundaries of both the Core Preservation Area (Core) and Compatible Growth Areas (CGA) of the CPB. The Core contains 56,836 acres of area, and the CGA contains 48,656 acres. The main goals and objectives of the LIPBA Act are to: (a) protect the quality of surface water and groundwater in the CPB, and(b) protect, preserve and enhance the functional integrity of the Pine Barrens ecosystem and the significant natural resources, including plant and animal populations within it. In 1995, the CPBJPPC adopted the *CPB Comprehensive Land Use Plan* (CLUP). The CLUP outlines review procedures for development in the CPB, standards and guidelines for development in the CGA, and Pine Barrens Credit Program criteria for the transfer of development rights, as well as other duties of the Commission. The CLUP has been periodically amended, and the CPNJPPC is currently considering another set of amendments.

21. 2003, Camp, Dresser, & McKee, New York State Department of Health, *Long Island Source Water Assessment Summary Report.* The Nassau-Suffolk County assessments for 938 community and 418 non-community wells built on earlier resource/land use initiatives at state and county levels and incorporated groundwater modeling and geographic information system tools. Five existing CDM

21. groundwater models (the Nassau County Regional Model, the Suffolk County Main body flow model and three salt water intrusion models developed for the North and South Forks and for Shelter Island in Suffolk County) were refined and recalibrated for the purpose of the Source Water Assessment Plan (SWAP), with simulations of aquifer conditions resulting from long-term average precipitation, recharge and stormwater management for the SWAP delineations. As described in the New York State SWAP for wells on Long Island, the source water assessment for each well has three components: delineating the source water recharge area for the well, determining the prevalence of contaminants within the source water area and analyzing the susceptibility of the well to potential contamination. The major deliverable products for the Nassau-Suffolk County SWAP were assessment reports and geographic information system-based maps indicating sources of supply, the respective delineated source water areas, the land use coverages within the assessment area and discrete sources of contamination.

Land Preservation Programs

Special mention is made of existing land protection programs in the following section. Land preservation programs provide important opportunities to protect watershed areas from development. The following sections briefly describe some of the existing programs. When combined with the information developed under *The Long Island Comprehensive Special Groundwater Protection Area Plan,* land preservation purchases can protect lands with important recharge value attributes.

In Nassau County, more than 80% of the land area is suburbanized. However, over the last 10- 15 years, a number of land preservation programs have been established in Nassau County in order to attempt to preserve a significant portion of the remaining undeveloped land. Land preservation studies, entities and programs in Nassau County include, but are not limited to, the Nassau County Open Space Plan, Nassau County Open Space and Parks Advisory Committee, Open Space Acquisition Fund, 2004 and 2006 Environmental Bond Acts, Special Groundwater Protection Areas and site-specific preservation efforts (NCMP, 2010).

In 2004 and 2006, Nassau County Environmental Bond Acts acquired approximately 300 acres at an estimated cost of $100 million. The majority of properties acquired through Bond Act funds are located in the Oyster Bay Special Groundwater Protection Area (NCMP, 2010). The acquisitions were aimed at preserving open space, but indirectly served to protect groundwater resources by eliminating the possibility of development on land above the sole-source aquifer (Schneider, 2015). Another preservation effort targeted the Underhill Property, a 96-acre parcel in Jericho, which was a priority acquisition for government officials and organizations for many years. Maintaining this property as open space also was found to provide valuable area for recharge of the local groundwater supply (NCMPU, 2008).

The North Shore Land Alliance (NSLA), founded in 2003, has facilitated $225 million in municipal funding measures and more than $10 million in private funding to date to protect 560 acres of farmland and open space. As of 2014, the North Shore Land Alliance owns and/or manages 11 nature preserves totaling 210 acres. The NSLA also holds 16 conservation easements on 195 acres of privately held land. The NSLA has

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protected nearly 1,000 acres of land in Nassau County (NSLA, 2016). See Figure 1.

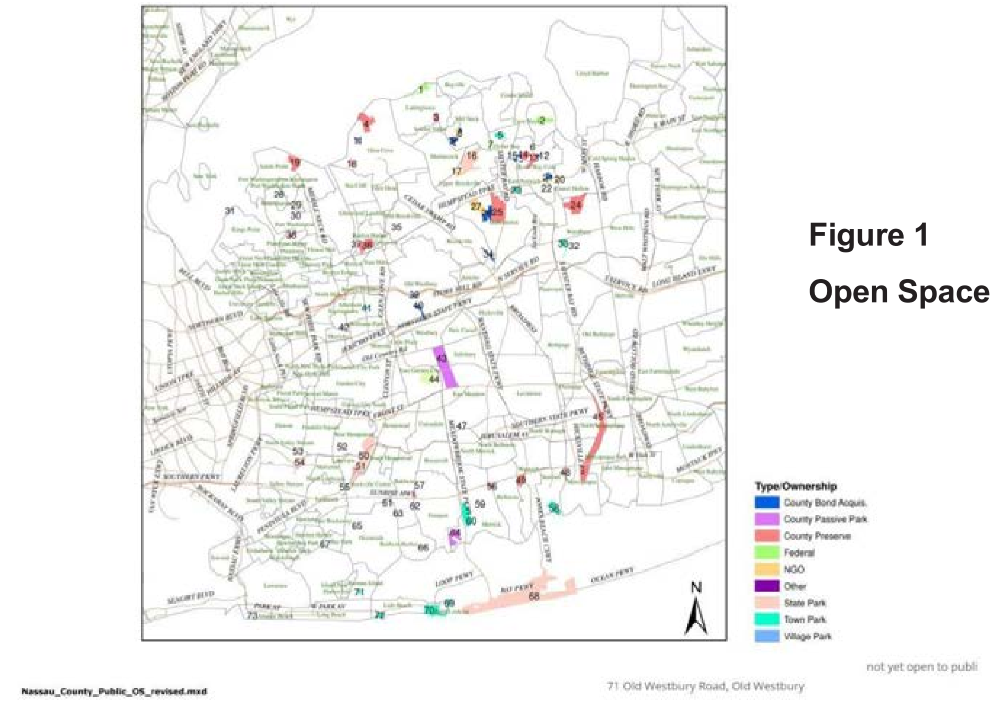
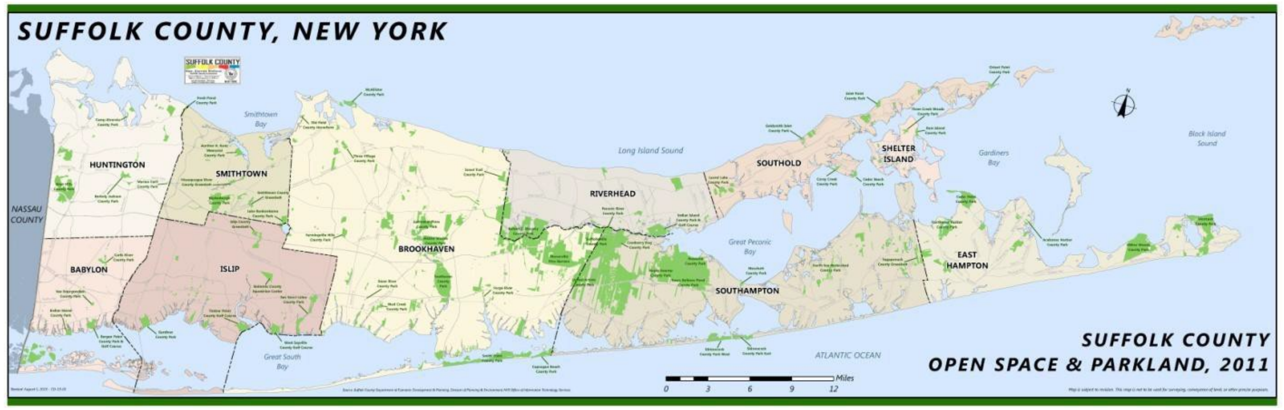


Figure 1

Open Space in Nassau County

According to the *Suffolk County Comp Plan,* Suffolk County has purchased more than 53,000 acres of land over the past six decades at a cost of more than $1 billion to preserve important environmental resources and significant ecological areas (SCDHS, 2015). See Figure 2. In addition, more than 10,745 acres of agricultural land has been protected for continued agricultural use. Suffolk County's purchase of development rights program to protect farmland was started in 1974 and is the oldest in the nation. In 2013, Suffolk County was the number one producer of agricultural products in New York State in terms of market value, with a market value generated of approximately $240 million ($273,693,592 in inflation-adjusted 2013 dollars) (SCDEDP, 2013). As of 2013, more than 162,500 acres or more than 25% of Suffolk County has been preserved, which includes 38,000 acres of the 55,000 acres of Core Preservation Area in the Central Pine Barrens (SCDHS, 2015).

Figure 2 Open Space in Suffolk County



Land preservation occurs in Suffolk County through a variety of programs, including transfer of development rights (TDR), the Suffolk County Drinking Water Protection Program (quarter percent sales tax program), other county-sponsored programs, municipal Community Preservation Fund (CPF), New York State programs, miscellaneous municipal programs and private preservation programs. An inventory of existing TDR programs in Suffolk County was prepared in a report by the Suffolk County Department of Economic Development and Planning in 2014 (Suffolk County, 2014). Some of the programs identified in the report include, but are not limited to, the Suffolk County Sanitary Credits program to protect the integrity of the groundwater in locations where wastewater is discharged through on-site disposal systems; the Purchase of Development Rights (PDR) program for farmland preservation, which is the oldest of its kind in the United States; and the Pine Barrens Credit Program, established as a result of the New York State Legislature's adoption of the Long Island Pine Barrens Protection Act of 1993 (the Act) and the subsequent adoption of the *Central Pine Barrens Comprehensive Land Use Plan* in 1995. The Pine Barrens Credit Program, managed by the Central Pine Barrens Joint Planning and Policy Commission, supports the preservation of groundwater and ecological resources that occur when a property owner of land in the Core Preservation Area records a conservation easement on their property and in return obtains Pine Barrens Credits to transfer development outside of the Core and/or outside of the Central Pine Barrens region.

In 1987, Suffolk County approved, by voter referendum, the Drinking Water Protection Program. It approved the use of one quarter of 1% of the sales tax to purchase and preserve land in critical watershed areas. As part of this program, the county acquires lands in mapped and designated Special Groundwater Protection Areas (SGPA's) most likely to have an impact on existing or future drinking water supplies (Jones and Corwin, 2010). Article XII of the Suffolk County Code (SC Code 2015) describes the program in which it states, "Suffolk County Drinking Water Protection Program designed to provide funding for sewer district tax rate stabilization, environmental protection and property tax mitigation is hereby extended in a modified form beginning on December 1, 2007 and ending on November 30, 2030" (SC Code, 2015).

According to the *Suffolk County Comprehensive Water Resources Management Plan* (2015), the Suffolk County Planning Division has identified the New Drinking Water Protection Program, the Multifaceted Land Preservation Program, the Save Open Space Program and the Environmental Legacy Program as the most significant county open space acquisition programs moving forward. The county's *2012 Comprehensive Master List Update* identified 86 proposed open space sites and assemblages, totaling 4,650 acres that are recommended for future open space acquisitions (SCDHS, 2015).

The Community Preservation Fund is derived from a 2% mortgage transfer tax and was established in 1998 by local voter referendum in the five East End Towns of Riverhead, Southampton, East Hampton, Shelter Island and Southold. The CPF also required authorization by the New York State Legislature. The CPF is administered by each of the five east end towns and has resulted in hundreds of millions of dollars in funding for open space preservation in these municipalities. In 2006, voters in all five towns approved a referendum to extend the collection of the tax through 2030 (PLT, 2015). In 2015, the CPF program was extended through 2050 and amended to allow 20% of funds to be used toward water quality improvement projects (NYS Legislature, 2015). It is important to note that CPF properties are not currently available to public water suppliers for wellfield development.

Other municipal programs can be found in central and western Suffolk County towns, which do not have a CPF. These towns have established alternative funding sources for acquisition and preservation of open space. Towns that have created significant programs include Brookhaven, whose program includes major preservation efforts in the Carmans River Watershed and Huntington. New York State also acquires and preserves open space primarily in Suffolk County. In the last 10-15 years, significant new state parks and open space areas have been acquired either wholly by the state or through joint funding with Suffolk County and its towns. These acquired and preserved properties are managed by the New York State Office of Parks, Recreation and Historic Preservation and the New York State Department of Environmental Conservation. Acquisitions have included areas of the Central Pine Barrens Core Preservation Area.

Finally, there are a number of private non-profit entities involved in land preservation and management on Long Island, which include, but are not limited to, Peconic Land Trust, the Nature Conservancy, North Shore Land Alliance, Friends of the New York State Environment, Land Trust Alliance and the Trust for Public Land. The Peconic Land Trust, for instance, a private, non-profit organization, has protected nearly 11,000 acres of land in eastern Suffolk County including farmland (PLT, 2015). The Nature Conservancy has acquired and manages more than 4,500 acres in Suffolk County (TNC, 2015).

Current Water Conservation and Efficiency Initiatives

Special mention also is given to efforts under way to curtail groundwater usage through the means identified in this section.

New York State Department of Environmental Conservation Pumpage Caps

During 1987, the New York State Department of Environmental Conservation (NYSDEC) imposed pumpage constrains, or "caps" on all Nassau County public water suppliers. The long-term preservation of Long Island's underground water supply by maintaining existing water levels was the basis for these caps. The caps were predicated on a then-current 5-year running average and a maximum volume in any 1 year, while still maintaining the 5-year average when developed in 1987. According to the NYSDEC, the caps have been maintained at their 1987 levels.

The caps program was designed to slowly bring down the average groundwater pumpage through gradual improvements in water use efficiency and water conservation. When begun, the 5-year average cap for the entire county was 188.5 MGD. This represented total pumpage between the years 1981-1985, divided by five. This approach allowed the highest pumpage to be offset by the lowest annual pumpage over a 5-year period. The annual cap was originally based on the highest yearly pumpage in 5-year blocks from 1976-1985 (e.g., 1976-1980, 1977-1981, 1978-1982, etc.) The highest amount for any 5-year block would represent the single highest pumpage of each supplier and would in effect simulate a "worst-case" peak demand. Over time, the 5-year cap and the annual cap would be adjusted as the program produced lower pumpage, thereby slowly bring down permitted withdrawals.

During the late 1980s, several water suppliers challenged the pumpage caps due to perceived inadequacies with the methodology utilized by the NYSDEC in developing the caps. These perceived shortcomings included: no allowance for water conservation programs that may have been implemented before the caps and no consideration of safe permissible yield and mathematical deficiency in the NYSDEC rules for calculating the current 5-year cap that existing regulatory and management regimes produces a "roller coaster" effect. Despite these perceived shortcomings, the regulatory initiative had one of its intended effects, namely of promoting water conservation awareness and the virtues of reducing waterwaste.

Based on prior legal challenges and the aforementioned inadequacies, the NYSDEC has authority to take enforcement action on the caps with the exception of the Village of Bayville. The agency recognizes the inadequacy of the current practice and cap calculation and will be looking in the future to formulate the caps in a way that can balance sustainable yield with the needs of the individual water suppliers. The NYSDEC plans to have a conservation plan template completed during 2016 (LO1). Discussions will ensue with each water supplier regarding overall conservation in general and its pumpage cap specifically.

After the NYSDEC lost litigation in the challenges to the caps, it stopped re-calculating new 5- year caps on a rolling 5-year average as the program was originally envisioned. It also stopped enforcing situations where a water supplier exceeded their caps. By the early 2000s, Nassau County saw annual pumpage reach 203 MGD (Nassau County, 2005).

Table 1
Public Water Supply Pumpage in Nassau County, 2000-2003

YEAR	WINTER LOW MGD	SUMMER HIGH MGD	ANNUAL MGD
2000	141 MGD - January	287 MGD - July	187
2001	134- February	296 - August	203
2002	128 - February	340 - July	200
2003	135 – December	293 - July	184
Four Year Average			193.5

Source: Nassau County (2005, Tables 4-12 to 4-15)

Between 1990-2003, the Nassau County Department of Public Works (NCDPW) reported that water supply pumpage had equaled or exceeded the county's updated safe withdrawal level of 185 MGD, in 12 of 14 years or 85% of the time (Nassau County, 2005). For all of the years analyzed, pumpage exceeded the 180 MGD goal originally used in the caps program. The recent analysis by the NYSDEC shows peak pumpage in Nassau County during 2000-2014 reached 251 MGD (see Figure 1, Chapter 2, page 14).

Well Permit Program on Long Island

The Long Island well permit program regulates any well or wells on any one property with a total pumping capacity of 45 gallons per minute (GPM) or more. The NYSDEC issues well permits that are valid for 10 years. The permit covers such issues as the rated capacity of the well (meaning how much water the well can produce) as well as the depth of the well. All permit holders must report their monthly pumpage to the NYSDEC.

In addition to public water suppliers, well permits are issued by the NYSDEC for a wide variety of operations. These include residential wells for irrigation, hospitals, private businesses, industry, golf courses, municipal parks and schools (for irrigation of recreation fields) as well as operations for remediation, dewatering and geothermal systems. To date, the program has not been a reliable source of information on water use and consumption for Nassau and Suffolk Counties. Personnel shortages and funding cutbacks have only exacerbated the problem.

Nassau County Water Conservation Ordinance (Ordinance 248-A-1987)

In 1987, a progressive water conservation ordinance was adopted by Nassau County (Ordinance 248-A-1987). The centerpiece of the ordinance involved strategies to reduce outdoor water use. In particular, lawn sprinkling is prohibited from the hours of 10:00 a.m.-4:00 p.m. and is limited during other hours to odd and even days corresponding to a resident's street address number. In addition, the ordinance also regulated outdoor water hose usage by requiring the use of a hand operated automatic-off nozzle valve. Furthermore, the hosing of driveways, sidewalks and streets is prohibited. Habitual violators of the county ordinance can be subject to a $50 fine from the local police department. Since the promulgation and enforcement of the lawn sprinkling regulation more than 27 years ago, many Nassau water purveyors have found the ordinance to be a valuable water resource management tool. It has been determined that outdoor water use is more uniformly distributed with the odd/even irrigation ordinance. This subsequently reduces peak water demand significantly, which results in far reaching environmental, financial and operational benefits for water suppliers and the community.

Presently Suffolk County has not adopted such an ordinance. In October 2015, the Town of Brookhaven adopted an ordinance requiring new in-ground irrigation systems to be equipped with a rain sensor. Rain sensors prevent an irrigation system from activating while it is raining or the lawn is still moist and watering is not needed.

NYSDEC Water Conservation Plans

In July 1988, the Governor of New York State signed legislation requiring a water conservation program as a condition of a water supply permit. To assist local governments in complying with this new requirement, the law directed the NYSDEC to develop a model water conservation plan, which includes beneficial short- and long-range water conservation procedures reflecting local water resource needs and conditions. This manual serves as a model to help advise local officials regarding water conservation techniques that individual suppliers may use to conserve water.

Current plans (submitted with water withdrawal permit applications) include an evaluation of existing information consisting of source water inventory, water usage, metering and rate structure, water supply auditing, leak detection and repair, and the review of current water conservation initiatives. Recommended water conservation polices evaluated reducing distribution system losses, leak detection, water efficient landscaping, water audits, and public awareness.

Recently, the NYSDEC has stressed that all water conservation plans must have measurable short-term objectives that will require an annual update. This includes a commitment to finance water conservation measures. The plan must provide time frames/schedules, discuss funding allocated or to be allocated for implementing water conservation measures and state a commitment to implement measurable objectives. Applicants must use the term "will implement" rather than "should implement."

A conservation plan must cover the following elements:

- Water rate structure – how often reviewed.
- Water meters – number of replaced, tested, calibrated and/or repaired per year.
- Top ten water users – have provisions to provide audits.
- Leak detection – miles of main surveyed.
- Water main replacement – 100-year replacement schedule.
- Measures to reduce unaccounted for water. (i.e., leak detection, main replacement and/or water meter replacement/calibration).
- Public outreach efforts – bill stuffers, newsletters, social media, news releases, etc. Must go beyond AnnualWater Quality Report (ADWQR).
- Flagging of high bills/potential leaks.
- Automatic irrigation – customer education and outreach.
- Reduce summer peaks associated with irrigation demand.
- Leak repairs – number of leaks, time to repair.

Most water suppliers have many of the above elements implemented, so the requested changes should not have a significant impact. The NYSDEC will be preparing a template in the near future.

2015 Suffolk County Comprehensive Water Resources Management Plan

The Suffolk County Comprehensive Water Resources Management Plan (Comp Plan) released in 2015 evaluated groundwater and surface water quality issues in Suffolk County. While the Comp Plan was broad in scope, specific contaminants were evaluated, including: nitrates, chlorinated solvents, methyl tertiary butyl ether (MTBE), pesticides and possible emerging contaminants. Due to its scope, it deserves special recognition.

The *Comp Plan* considered regional groundwater quantity needs and sea-level rise with an eye to the year 2030 for planning purposes. Surface water degradation and its correlation to coastal resiliency against storm damage, such as what was experienced during Superstorm Sandy in October 2012, also were discussed. The *Comp Plan's* first two sections covered the value of clean water globally and also outlined several possible policy and management initiatives for the county and others' consideration to finance, remedy and protect these vital water resources. Sections 3- 8 of the *Comp Plan* provided the then-current state of affairs and historical trends, where applicable, related to Suffolk County's groundwater quality/quantity, surface water, estuaries, coastal resiliency and wastewater management. Section 9 provided a road map for plan implementation listing numerous recommendations and assigning responsible agencies in a framework for implementing prioritized goals guiding future resource management. The following is a discussion of some of the key takeaways and goals of Suffolk County's *2015 Comprehensive Water Resources Management Plan.*

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Groundwater and Drinking Water

Public water supply in Suffolk County is extremely undervalued. The Suffolk County Water Authority, the largest water supply system in Suffolk County serving more than 80% of the county's population, charged $1.67 for 1,000 gallons of water at around the time the Comp Plan was written. At this price point, there is little incentive for consumers to conserve public water. Although Chapter 3 of the Comp Plan has estimates that indicate there is sufficient water in our groundwater aquifers to meet existing and projected demands, there are certain areas that are more sensitive to contamination, including chlorides due to over-pumping and salt water intrusion. As consumption increases, additional and expensive potable water supply infrastructure must be constructed, which can include:

- Property to be acquired at approximately $100,000-$400,000 per acre.
- New wells drilled at an estimated cost of $300,000-$500,000 each.
- New water treatment facilities with costs varying widely depending on the source water quality, costing $500,000-$3 million each.
- New bulk water storage tanks with an estimated cost of $500,000-$3 million each.
- New and/or larger water mains at about $150-$250 per foot including restoration.

One of the reasons drinking water in Suffolk County is so inexpensive is due to its high yield groundwater aquifers with generally very good groundwater quality. Suffolk County does contend with industrial, petroleum, defense industry and agricultural water quality issues, but fortunately to a lesser extent than they could be, due in large part to source water protection efforts, regulatory permitting/inspections/enforcement and effective planning. In 2015, approximately 24% of Suffolk's public water supply wells had treatment for volatile organic compounds or pesticides.

Monitoring, enforcement and voluntary restriction of select products have helped to reduce contamination of Suffolk County's sole-source aquifer. The county's bane remains a lack of sewering as there is an estimated 74% of the population that continues to discharge sanitary waste and chemicals into on-site cesspools and conventional wastewater systems with little to no reduction of the contaminants poured down the drain or being flushed. The *Comp Plan* evaluated a select group of contaminants of concern for trends from 1987-2013 in the county's monitoring program. Nitrate levels in the county's shallowest Upper Glacial Aquifer increased by an average of 1 milligram per Liter (mg/L) in the same set of wells over the 26-year period; and there was a similar increase of 0.76 mg/L in the same set of Magothy Aquifer wells, the next deepest aquifer. While the nitrate concentration in nearly all public supply wells was below the drinking water standard of 10 mg/L, this is a disturbing trend. Increased nitrate concentrations in groundwater also can have an indirect impact on our surface water quality as groundwaters migrate through our aquifers and upflow into streams, rivers and estuaries. Elevated nitrogen levels in surface waters can cause algal blooms, which may be harmful themselves but also can reduce oxygen levels and result in fish kills.

Volatile organic compounds (VOCs) include industrial and commercial cleaners, but they also include consumer products, such as paint, household cleaning agents, deodorants, adhesives and gasoline. The *Comp Plan* focused on three of the most commonly detected VOCs: the chlorinated solvents being tetrachloroethene (PCE), trichloroethene (TCE) and 1,1,1- trichloroethane (1,1,1-TCA) as well as a long-since banned but persistent gasoline additive, methyl tertiary butyl ether (MTBE). Water quality status and trends were evaluated for these contaminants between 1987-2013. Unfortunately, the total number of wells impacted by PCE doubled during this time frame (29 to 59), and the average concentrations in the Upper Glacial and Magothy Aquifers about doubled in a comparison of the same set of public supply wells. An evaluation of TCE showed similar results where the total number of impacted wells more than doubled (34 to 84). The average concentration of TCE in the same set of Upper Glacial and Magothy Aquifers nearly tripled in a same well comparison. On a positive note, chemical bans previously put in place for 1,1,1-TCA and MTBE appear to have been effective. Concentrations of 1,1,1-TCA have decreased in a same well comparison between 1987-2013 in the Upper Glacial Aquifer from 3.16 to 0.47 micrograms per Liter ug/L and the Magothy Aquifer from 0.57 to 0.47 ug/L. Similarly, MTBE saw a decrease in the number of public water supply wells with detections from 16% in 2005 to approximately 5% in 2013.

As one of the leading agricultural counties in New York State based on sales, Suffolk County has rich agricultural roots. In the United States Department of Agriculture's 2012 Census, Suffolk County was listed as having 604 farms over a total of 35,975 acres (www.agcensus.usda.gov/Publications/2012/Full_Report/Volume_1,_Chapter_2_ County_Level/New_York). An unfortunate byproduct of farming is the need to kill or control pests and nuisance vegetation using pesticides such as insecticides, herbicides and fungicides. Many similar, or the same products, are used by homeowners and commercial businesses either to maintain lush, green, weed-free lawns or to control insects such as termites, ants, grubs and ticks. Suffolk County Department of Health Services has implemented a widespread pesticide monitoring program to test for about 150 pesticides and their breakdown products to help inform the public, regulators, researchers and farmers of detections and potential health impacts.

Sampling efforts over the years from public and private drinking water wells and monitoring wells have identified more than 100 pesticide-related compounds. At least one pesticide compound was detected in about 20-25% of public community, non-community or private water supply wells sampled between 1997-2012. Of the 10 most frequently detected pesticides in private well samples, only simazine, metalaxyl, imidacloprid and atrazine were still registered for use on Long Island. Suffolk County continues to work with the New York State Department of Environmental Conservation, Cornell Cooperative Extension, the United States Geological Survey and others to monitor groundwater and surface water and advise policy makers on potential changes to be considered for pesticide regulations.

Several emerging contaminants were also discussed in Suffolk County's Comp Plan including a number of pharmaceutical and personal care products (PPCPs), 1,4-dioxane, chlorate and hexavalent chromium. While the majority of these are not specifically regulated by the federal or state government, it is essential to develop occurrence data to support the development of regulation by one or both of these agencies. Suffolk County continues to monitor and identify suspected sources of many of these contaminants through groundwater investigation work. This places Suffolk County ahead on the learning curve prior to anticipated regulation of these compounds and benefits the Suffolk County residents, visitors and environment by addressing contamination early on.

Section 3 and 4 of the *Suffolk County Comp Plan* discussed groundwater quantity in our aquifers. There is recognition of sanitary flow as a considerable source of water to the aquifers, albeit with the potential to contaminate said aquifers. This concept of indirect reuse of sanitary flows, although not highly publicized or savory, is a reality in the county's water cycle. The general public must be educated and understand that waste down the drain is likely to impact either a drinking water source (public or private supply well) or a surface water body on our island. In evaluating the alternative, Suffolk County also recognizes that discharging treated sanitary waste to surface waters will result in a net loss of groundwater to our aquifer. This may cause the elevation of groundwater to drop and can even result in streams drying up or the fresh water-salt water interface to move inland closer to existing groundwater wells, potentially contaminating them with high chloride levels. The good news is that water balances confirmed that the Suffolk County aquifer system, on a county-wide basis, is sustainable for projected groundwater pumping and that average pumping was only about 15% of the recharge rate.

Surface Water, Estuaries and Coastal Resiliency

Sections 5, 6 and 7 of the *Comp Plan* evaluate surface water quality, estuary programs and the county's coastal resiliency. The NYSDEC has identified more than 200 fresh water streams and ponds and regulate more than1,050 fresh water wetlands covering nearly 24,000 acres in Suffolk County. Several of these water bodies are on New York State's list of impaired waters caused by impairments such as pathogens, metals, phosphorous, ammonia, pesticides, silt/sediment and a lack of dissolved oxygen. Stormwater runoff has been identified as the primary source of these contaminants; however, contaminated groundwater also plays a role. Since the majority of the county's stream baseflow is from groundwater, fresh and coastal resources may become impacted by contaminated groundwater. Sampling streams can help determine if there are contamination sources in a watershed. This also can be a great tool in evaluating the impact of different land use types in resource management and planning around sensitive watersheds. The increased nutrient loads from groundwater discharge, especially nitrogen, to surface waters have caused algal blooms, resulting in a drop in the dissolved oxygen concentrations. These conditions can impair various ecosystems by reducing eelgrass beds, which are significant to the propagation of finfish and shellfish. These contaminants and conditions degrade the quality of Suffolk County's three major estuaries: the Long Island Sound, the South Shore Estuary and the Peconic Estuary. It is estimated that 80% of all fish and shellfish used estuaries as a primary habitat or as a spawning or nursery ground making them ecologically significant as well as a mainstay in Suffolk County's east end economy.

Modest sea-level rise predictions between 2015-2100 are on average between about 2-3 feet. This projected rise in sea level coupled with a major storm event such as Superstorm Sandy would devastate places such as Fire Island and Suffolk County's south shore. The National Resource Council identified a strategy to reduce the impact of flooding or waves for coastal resiliency. In addition to hard structures, nature-based risk reduction strategies to absorb floodwaters and wave energy included restoration or expansion of natural areas such as oyster reefs and salt marshes. Improved water quality is key to wetland enhancement and establishing oyster reefs and expanding clam beds. While these nature-based risk reduction strategies are not the only measures that should be evaluated to enhance resiliency against sea-level rise and large coastal storms, there are other indirect benefits to supporting these strategies.

Some of the recommendations identified to protect surface waters from degradation included: additional open space preservation, improved sanitary wastewater management practices – including a recommendation to require 1 acre density in hydrogeologic zones IV and VIII to protect surface water quality – , expansion of existing sewer districts, evaluation of alternative on-site sewage systems as part of a county-wide wastewater planning study and reducing the impacts of fertilizer on groundwater and surface water.

Wastewater Management

Section 8 of the Comp Plan provides a history of wastewater management efforts in Suffolk County, a review of feasibility studies for major county sewering projects, wastewater treatment technologies and a look at several innovative on-site wastewater treatment systems. This chapter also covers wastewater as a source of contaminants that can impact groundwater and surface waters, as previously mentioned. Pharmaceutical and personal care products; pathogens such as bacteria, viruses and protozoans; and other contaminants of emerging concern that can originate from wastewater are discussed. Suffolk County has implemented a monitoring program to evaluate and understand the potential impact from some of these compounds while discussing and evaluating research and efficacy of various treatment technologies. Understanding these potential impacts is paramount in the decision-making process of wastewater treatment technology selection and final treated discharge endpoint.

Plan Implementation

Section 9 is the culmination of the Comp Plan and provides the prioritized list of implementation strategies to meet Plan objectives. These are separated into seven separate, but often interrelated and overlapping categories, including: 1) nitrogen, 2) VOCs, 3) pesticides, 4) PPCPs, 5) potable supply, 6) project management and data collection and 7) coastal resiliency and surface water quality. The crux of this management framework is to collaboratively tackle big- picture planning and management initiatives with federal, state, county, town and non- governmental organizations.

Groundwater Quality Initiatives

During and since publication of the 2015 Comp Plan, Suffolk County and numerous stakeholders have embarked on several initiatives to address groundwater quality. Suffolk County has been extremely active in addressing high priority VOCs, pesticides, nitrates and emerging contaminants. A brief overview of some these contaminants and initiatives is provided below.

Volatile Organic Chemicals

The *Comp Plan* highlighted several areas where additional resources could be allocated to reverse the trend of VOCs increasing in groundwater, namely, chlorinated solvents and gasoline- related contaminants. Due to higher risk for environmental damage, gas stations and dry cleaners have the highest inspection priority and have been inspected annually under the *VOC Action Plan.* Compliance at gasoline stations has increased significantly since the Plan was adopted. The annual inspections of dry cleaners ensure that the sites are operated properly and that chlorinated solvent spills are kept in check. Another benefit of the *VOC Action Plan* is that it has allowed the office to increase the number of samples collected to more than 1,000/year vs. approximately 200/year before the program began. Below is a summary of the outputs and outcomes from implementing Suffolk County's *VOC Action Plan* and other enhanced Office of Pollution Control (OPC) activities in 2016.

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2016 Outputs

Tank Compliance Inspections

7,139 tanks inspected.
488 gasoline station facilities inspected.
61 gasoline station sites sampled.
0 gasoline station sites required remediation in 2016.

Dry Cleaner Inspections

283 facilities inspected.
42 facilities sampled.
3 chlorinated solvent remediations.
9 other chemical remediations (e.g., toluene).

Industrial State Pollutant Discharge Elimination System (SPDES) Inspections

62 facilities inspected.
1,118 industrial samples collected.

Environmental Assessment Report Reviews

390 reports reviewed.
99% resulted in remediations.

Sanitary Abandonment Reviews

120 facility reports. 30% resulted in remediations.

OPC Random Industrial Facility Sampling

100 facilities sampled.
30% resulted in remediations.

Environmental Enforcements

541 enforcement actions resulting in $400,000 in penalties

Gasoline Station Compliance

52% compliance for gasoline site inspections in 2015.
32% compliance for gasoline site inspections in 2016.
28% compliance for gasoline site inspections in 2017 (to date).

Environmental Remediations

222 remediations performed.
4,934 tons of contaminated soil removed from the environment.
871,650 gallons of contaminated liquid removed from the environment.
80 remediations to date are a direct result of the *VOC Action Plan.*

Reducing Toxics Study

The next phase of the *VOC Action Plan,* the Reducing Toxics Study, also is critically important. This study is intended to develop a method to control hazardous materials at industrial and commercial sites in Suffolk County that are not inspected on a regular basis. Random sampling performed at these sites shows that they are a threat to the environment. This study will look at data collected from such sites and suggest methods and practices to ensure that hazardous materials at the sites are properly controlled.

Nitrates

Suffolk County is pursuing proactive measures to reduce nitrogen pollution to its waters. The *Comp Plan* characterized negative trends in groundwater quality in the Upper Glacial and Magothy Aquifers in recent decades. The *Comp Plan* linked increasing nitrogen levels in groundwater to drinking water as well as surface waters, including significant impacts of nitrogen on dissolved oxygen (DO), harmful algal blooms (HABs), eelgrass and other submerged aquatic vegetation, wetlands, shellfish and, ultimately, coastal resiliency. For the first time, the Comp Plan established an integrated framework to address the legacy problem of on-site wastewater disposal systems, acknowledging that patchwork sewering is insufficient to solve the problem.

Subwatersheds Wastewater Plan

The Suffolk County *Subwatersheds Wastewater Plan* (SC SWP), an early action/initial step of the overall long-term *Long Island Nitrogen Action Plan* (LINAP) program, will provide a recommended wastewater management strategy to reduce nitrogen pollution from wastewater sources. The primary objective of the SC SWP will be to provide information regarding data gaps, areas requiring further study and, ultimately, to present data to support long-term LINAP scope refinement and focus on related initiatives throughout Suffolk (e.g., Long Island Sound Study, Peconic Estuary Program, South Shore Estuary Reserve and related town/village initiatives). Recommended wastewater upgrades will focus on the use of innovative alternative on-site wastewater treatment systems (I/A OWTS), sewering where existing feasibility studies indicate it is cost effective and the use of decentralized/clustered systems (e.g., small pre- packaged treatment plants or I/A OWTS that connect multiple tax lots or buildings). The SC SWP cost-benefit analysis will identify the criteria and locations where the use of decentralized/clustered systems represents the most cost-beneficial approach. In addition, the SC SWP will evaluate and provide preliminary recommendations on overcoming some of the challenges associated with implementing these systems (e.g., existing setback constraints, long-term O&M responsibility, approval process, etc.). Finally, an increase of the minimum lot size may be considered in select subwatersheds where sufficient undeveloped land exists to provide a meaningful environmental benefit.

Pesticides

Suffolk County has been a leader in water quality monitoring and assessment of pesticides working in close cooperation with the USGS, NYSDEC, New York State Department of Health (NYSDOH), Cornell Cooperative Extension and others. Pesticide monitoring and management is complicated as many pesticide compounds break down into other chemicals that leach through our sandy soils, are mobile in groundwater and may persist for decades. Over the 20 years since Suffolk initiated its pesticide program in 1997, the SCDHS has installed monitoring wells at nearly 70 different locations such as golf courses, greenhouses, nurseries, farms and vineyards. The results from this testing are used to advise the NYSDEC in its pesticide registration decisions, to support the Long Island Pesticide Pollution Prevention Strategy and to assess the status and trends of pesticide contamination in

groundwater, surface waters and drinking water wells. More than 100 pesticide-related compounds have been detected in groundwater since the program’s inception. Data collected between 1997-2012 from drinking water sources revealed the following results:

- At least one pesticide compound was detected in about 22% of the public community supply wells tested during this period (196 of 865 wells sampled).
- At least one compound was detected in about 25% of the public non-community supply wells sampled during this period (150 of 589 wells sampled).
- At least one compound was detected in about 23% of the private wells sampled during this period (2,300 of 9,900 wells sampled).

The SCDHS plans to continue to address pesticides and their potential impacts to groundwater, surface waters and drinking water supplies. Suffolk expects to continue to sample and monitor for a variety of pesticides and degradation products, to sample for pesticides as part of surveillance and self-monitoring programs, to expand the capabilities of the Suffolk County Public and Environmental Health Laboratory (PEHL) to detect pesticide compounds and degradation products and to identify commercial products that can impact water resources. Finally, as part of the NYSDEC’s Pesticide Pollution Prevention Strategy, stakeholders, regulators and agricultural communities will continue to work together to implement Best Management Practices (BMP) to help mitigate the impact of pesticide use on Long Island.

Emerging Contaminants such as 1,4-Dioxane and Perfluorinated Compounds (PFOS and PFOA)

Suffolk County has implemented a three-point approach to addressing emerging contaminants such as 1,4-dioxane and perfluorinated compounds. This includes: 1) facilitating and supporting maximum contaminant level (MCL) development by providing data from monitoring efforts to the NYSDOH and the NYSDEC, 2) encouraging public water supplymanagement to reduce exposure where possible and 3) providing public education and outreach. Following is an overview of Suffolk County’s efforts under this approach for 1,4-dioxane and the perfluorinated compounds perfluorooctanoic acid (PFOA) and perfluorooctane sulfonate (PFOS).

(1)) Support MCL Development

(a) 1,4-Dioxane

- The SCDHS PEHL has obtained the 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-December 2016:

  ◊~29% detection rate in community water supply wells tested.
  ◊~16% detection rate in non-community water supply wells tested.
  ◊~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 to test all non-community and community public supply wells by the end of 2017.

- Based upon 2015 and 2016 monitoring efforts by the SCDHS Office of Ecology, 1,4-dioxane was detected in six water bodies at levels as high as 9.65 parts per billion (ppb) (at Little Neck Run in Brookhaven). The goal is to sample all routinely monitored fresh water streams and tributaries again in 2017.
- The SCDHS Office of Pollution Control has sampled for 1,4-dioxane at various industries, including laundromats, dry cleaners, car washes, salons, etc. From January 2017-June 2017, 370 samples were collected at 89 facilities. Five detections from 5-12 ppb were observed in sludge and liquid samples.Sites found to exhibit 1,4-dioxane detections include a multi- tenant commercial center with a dry cleaner, a car wash and two laundromats. SCDHS OCP's goal is to collect approximately 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 collecting samples from several sewage treatment plant effluents in 2017.
- SCDHS Office of Water Resources is collecting samples from upgradient and downgradient monitoring wells near sewage treatment plant outfalls and also targeting groundwater investigations near five or more laundromats in 2017.

(a) Perfluorinated Compounds

- The SCDHS has leveraged resources with the SCWA's Laboratory and the NYSDOH's Wadsworth Laboratory to enable sampling and analysis of perfluorinated compound samples from public, private and groundwater samples near areas of known or suspected contamination.

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

(2) Encourage Public Water Supply Management to Reduce Exposure where Possible

(a) 1,4-Dioxane

Public Health Significance of Drinking Water Results to Date

1. The EPA lifetime health advisory level (HAL) is 200 ppb in drinking water.
2. There is no current federal or New York State drinking water standard specifically for 1,4-dioxane. It is currently regulated under a general 50 ppb standard for unspecified organic contaminants (UOC) in New York State.
3. The EPA 1 in 1 million cancer risk, assuming consumption of 2 liters of water per day for 70 years, is 0.35 ppb.
4. New Hampshire has created a drinking water standard around one in 100,000 cancer risk at 3 ppb.
5. While the majority of Suffolk County's detections are below 3 ppb, there have been at least four pump stations that have pumped water into the distribution system above 3.5 ppb (the highest was 12.5 ppb). The SCDHS has encouraged affected water suppliers to blend wells to reduce concentrations where possible, and Suffolk County is supporting the full- scale Advanced Oxidation Process (AOP) pilot program of the SCWA. This consists of hydrogen peroxide injection, ultraviolet reactor and granular activated carbon quenching of residual hydrogen peroxide at a site in Brentwood. This application was approved after review by the NYSDOH and the SCDHS. Construction of the pilot project was completed in July 2017 and is undergoing rigorous analytical testing during startup.

(b) Perfluorinated Compounds

Public Health Significance of Drinking Water Results to Date

1. EPA lifetime HAL for PFOS and/or PFOA is 70 parts per trillion.
2. There is no current federal or New York State drinking water standard specifically for PFOS and/or PFOA. They are currently regulated individually under a general 50 ppb standard for unspecified organic contaminants (UOC) in New York State.
3. As of September 2017, the SCDHS was aware of PFOS and/or PFOA detections in at least 24 community public water supply wells. All community public water supply wells with detections have either been voluntarily removed from service, provided with treatment or are blending to reduce concentrations below the HAL.

(c) Public Education and Outreach

1. The SCDHS has required large community public water suppliers to continue sampling for select emerging contaminants from the Unregulated Contaminant Monitoring Rule 3 (UCMR3) such as 1,4-dioxane, PFOS and PFOA in 2016 and 2017 where they have observed detections. These results must be reported in the public water suppliers' annual water quality reports that are provided to the public.
2. The SCDHS, in collaboration with the NYSDOH and NYSDEC, has developed a 1,4- dioxane fact sheet and frequently asked questions for perfluorinated compounds tailored specifically to Suffolk County. This information on emerging contaminants is posted on the County's website:
https://suffolkcountyny.gov/Departments/Health-Services/Environmental-Quality/EmergingContaminants

Regulatory Framework for Groundwater Management on Long Island

The sole-source aquifer system serving businesses and homes where the 2.9 million residents of Nassau and Suffolk live, and work requires a complex and interrelated regulatory structure in order to assure that it is properly protected and sustainably utilized to meet public needs. Various existing federal, state and county regulations address the many aspects of the management, protection and utilization of the aquifer system for Long Island. Such regulations and programs focus broadly on water resource management and protection and some are specifically directed toward the Long Island aquifer system.

Federal Regulations

Sole-Source Aquifer Designation

The United States Environmental Protection Agency defines such a sole- source aquifer as one supplying at least 50% of the drinking water for its service area and where no reasonably available drinking water source would be available should the aquifer become contaminated. Nassau and Suffolk Counties were so designated in 1978, Kings and Queens Counties followed in 1984.While the designation is significant regarding community planning and awareness, the power designated to the EPA regarding SSAs is limited. The Safe Drinking Water Act (SDWA) requires that the EPA administrator determine that a project incorporating federal financial assistance (through a grant, contract, loan guarantee or otherwise) will not result in a significant public health hazard through recharge zone contamination of a SSA. Measures to mitigate contamination can be incorporated into project planning.

Water Pollution Control Act and Clean Water Act (CWA) – National Pollution Discharge Elimination System (NPDES) Permit System

The regulation of pollutant discharges began with the FederalWater Pollution Control Act in 1948. This Act was significantly reworked in 1972 as the Clean Water Act. CWA authority is statutorily limited to navigable waters. The CWA regulates discharges through a permitting process known as the National Pollution Discharge Elimination System. NPDES authority is substantially delegated to New York State Department of Environmental Conservation, which, under the State Environmental Conservation Law (ECL), greatly broadened its scope to include groundwater discharges.

Resource Conservation and Recovery Act (RCRA)

The Resource Conservation and Recovery Act established a system for the environmentally responsible management of hazardous and non-hazardous wastes from point of origin to final disposal point – most commonly referred to as “cradle to grave.” Aspects of RCRA regarding waste tracking (manifesting and labeling) and solid waste disposal do facilitate groundwater protection measures and activities. Four federal agencies, the EPA and the Departments of Commerce, Interior and Energy, have specific responsibilities under RCRA, including the promotion of research, regulations for waste management and disposal and financial aid to states to manage their programs.

RCRA delegates states to develop and enforce their own hazardous waste programs in place of the implementation elements assigned to EPA. The delegated program in New York State includes a requirement that all large and small quantity generators over sole-source aquifers that store greater than 185 gallons of liquid hazardous wastes at one time have secondary containment for this storage. In addition, large quantity generators of liquid hazardous wastes must have a closure plan and close the storage areas in compliance with this plan. Federal regulations for underground storage tanks (discussed subsequently) are authorized by RCRA.

Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)

The Comprehensive Environmental Response, Compensation, and Liability Act established broad EPA response authority over releases of hazardous substances that may endanger public health or the environment. CERCLA accomplished several objectives: 1) it established requirements concerning closed and abandoned hazardous waste sites; 2) it placed liability on those responsible for releases of hazardous waste at these sites; and 3) it provided a cleanup mechanism (through a trust fund) when a responsible party could not be identified. CERCLA response authority includes short-term actions requiring immediate response as well as remedial actions to reduce dangers that are more significant in the long term. This latter authority is limited to sites placed on the National Priorities List (NPL), commonly referred to as the Superfund List. The NPL was amended in 1986 [Superfund Amendments and Reauthorization Act (SARA)] to work out some of the complexities of the original Act and to broaden public participation in the cleanup decision-making process.

Underground Storage Tank (UST) Laws and Regulations – 40 Code of Federal Regulations (CFR) 280 and 281

Nationally, problems involving leaking underground storage tanks (LUSTs), primarily those holding petrochemicals, became groundwater contamination issues in the mid-1980s. Initially, federal efforts were directed at cleanups, through existing Superfund authority. Initial regulations were published in 1988. In 2005, Congress directed the EPA to establish a spectrum of operational, training and facility requirements. Nassau and Suffolk County and New York State UST requirements predate these federal requirements and, in some respects, are more restrictive. The state has not sought federal delegation authority; however, DEC implements all aspects of the program. Nassau and Suffolk Counties are two of five New York counties for which DEC delegated authority for petroleum bulk storage (PBS) management. LUSTs were long recognized as significant groundwater contamination issues well before national regulations came forward; state and local (county) UST management is discussed later.

Underground Injection Wells – SDWA Authority

As defined by the EPA, an injection well is generally any hole that is deeper than it is wide and is used to emplace fluids underground. The Underground Injection Control (UIC) Program was created pursuant to the SDWA in 1974 to establish control over five classes of injection wells. Under the SDWA regulations, the EPA added a sixth class, geological sequestration wells, in 2010 to address emerging issues relating to the potential subsurface disposal of carbon dioxide to reduce industrial air emissions. On Long Island, Class V injection wells are most common – generally shallow waste disposal wells, septic systems, storm water and agricultural drainage systems or other devices used to release fluids either directly into underground sources of drinking water or into the shallow subsurface that overlies such sources. In order to qualify as a Class V injection well, the fluids released cannot be a hazardous waste as defined under RCRA.

Under the UIC program regulations, Class V injection wells are “authorized by rule,” meaning that Class V injection wells do not (under federal rules) require a permit if they do not endanger underground sources of drinking water and comply with other UIC program requirements – the foremost of which is the submission of basic inventory information. The EPA

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authorized a Class V Underground Injection Control Study (EPA/816-R- 99-014, September 1999) that summarizes the occurrence and numbers of Class V injection wells of each type and also covers what is being injected into these wells and how states regulate them. The Class V Report contains sections on six other subcategories of wells: storm water drainage wells, special drainage wells (examples include swimming pool drainage and construction dewatering injection wells), aquifer remediation wells, non-contact cooling water wells, geothermal direct heat wells, heat pump/ air-conditioning- return flow wells and agricultural drainage and food processing wells.

Two specific types of Class V injection wells – motor vehicle waste disposal wells and large capacity cesspools – were banned under the Class V Rule promulgated in December of 1999 because these wells posed the highest risk to underground sources of drinking water (USDW). On June 7, 2002, the EPA published its Final Determination that existing federal UIC regulations were adequate to prevent Class V injection wells from endangering USDW and additional federal requirements were not needed. In addition, the Suffolk County Department of Health Services considers the groundwater-contributing areas to public supply wells in review of new discharges for two injection well subcategories: sewage treatment effluent wells and large-capacity septic systems.

Source Water Assessment Program – SDWA Authority

The NYSDOH worked with the Nassau and Suffolk County Health Departments and other interested parties to develop a specific approach appropriate for Long Island. The Long Island Source Water Assessment Program (SWAP) noted that the regional aquifer systems on Long Island had been extensively investigated and assessed and that extensive groundwater resource management and protection efforts have evolved related to Long Island's unique regional setting and hydrogeological characteristics. Camp, Dresser, and McKee (CDM) completed the initial source water assessments for public water systems in Nassau and Suffolk Counties, which included: review of aspects of historical and ongoing ground water management programs; evaluation of emerging contaminant issues, relevant well data, inventory of specific contaminant sources and land use within a well's recharge area; delineation of source water assessment and well recharge areas utilizing a refined Nassau-Suffolk groundwater model determining each well's susceptibility to contamination; and source water assessments for each well, digital GIS contaminant source and land use information. Past updates to the SWAP had not been done as no further federal funding had been provided. In Suffolk County, the assessments were subsequently updated as part of the recent Suffolk County Comprehensive Water Resource Management Plan, adding newly constructed wells and updating contaminant inventory information. Full digital format groundwater contributing area information is forthcoming.

Federal Insecticide, Fungicide and Rodenticide Act (FIFRA)

FIFRA requires the EPA to register a pesticide if it meets certain specific conditions: labelling and application material must be complete and conform to FIFRA requirements and it will work as intended without unreasonable human health or environmental effects. In the United States, no pesticide can be sold or distributed that is not registered under FIFRA. FIFRA allows the EPA to delegate limited powers to the states. For example, states may issue permits to sell and use or control pesticide labelling to the extent that it does not conflict with FIFRA. This provision does not bar ordinances that restrict application or which require pesticide applicators to post notices informing the public of a pesticide application. FIFRA permits State laws such as California Proposition 65, which requires manufacturers and distributors to inform the public that a given product contains a chemical that the State of California has determined causes cancer or birth defects. Under delegated authority, FIFRA encourages and historically has provided limited funding for groundwater state management plans. The NYSDEC requests additional information on chemical properties of proposed pesticides and has limited use permits with objectives of protecting the state's water resources.

State Regulations

State Pollution Discharge Elimination System (SPDES)

SPDES regulations are more extensive than the NPDES requirements in that they control point- source discharges to groundwater as well as the surface water pollution sources authorized by the federal CWA. Like the CWA, the permit system is directed at maintaining water quality to permit its best use. Under that system, groundwater and surface waters are classified. All fresh groundwater in New York State is classified as GA. The NYSDEC document, Ambient Water Quality Standards and Guidance Values and Groundwater Effluent Limitations [Division of Water Technical and Operational Guidance Series (1.1.1, October 22, 1993, Reissued Date: June 1998)] helps regulators respond to a number of emerging contaminant issues. For many of these contaminants, values were developed utilizing the NYSDOH's drinking water standards for two broad organic contaminant groups, known as principal organic contaminants and unspecified organic contaminants.

State Superfund Program

New York State cooperates with both Nassau and Suffolk Counties in their efforts to obtain voluntary remediation at sites with contamination issues that may not rise to the level of qualifying under State Superfund.

State Brownfield Program

The State Brownfield Cleanup Program, as administered by the NYSDEC, provides a process for voluntary cleanup of sites contaminated with hazardous waste or petroleum. In exchange for the cleanups, the law provides the applicant with a liability release and tax incentives. Three types of costs can qualify for tax incentives: site preparation costs, tangible property costs and ongoing on-site water treatment costs for five years.

Watershed Rules and Regulations

Article 11 of the Public Health Law authorizes the NYSDOH to adopt rules and regulations for watersheds within the state. This authorization dates back to 1885, predating the NYSDOH (which was not created until 1900).Watershed rules and regulations are considered largely outdated and effectively replaced by other regulations with two notable exceptions: New York City and the City of Syracuse. Both were substantially updated as part of filtration avoidance determinations pursuant to the EPA's surface water treatment rule.

State Pesticide Program

Under FIFRA, the NYSDEC has been assigned limited authority in the regulation of pesticides. Every pesticide product used, distributed, sold or offered for sale in New York State must be registered with the NYSDEC Bureau of Pest Management. The New York State pesticide product registration procedures informs potential registrants with the guidelines for product registration submission. The registration period is two years. Prior to registration, products must provide "an overview of the potential for the pesticide product to contaminate groundwater from normal labelled use in New York State (including Nassau and Suffolk Counties) conditions." Given prevailing subsurface conditions, Long Island is usually considered a worst-case scenario for potential groundwater contamination.

The procedures explain a labelling provision known as a Long Island restriction (prohibition), which reflects the NYSDEC's evaluation that use of the pesticide, as labelled, would pose an unacceptable risk to Long Island's sole-source aquifer.

In the NYSDEC's New York State pesticide administration database (NYSPAD), 527 product names are listed indicating product labelling not for use, sale and/or distribution on Long Island (including statewide limitations). The current NYSDEC groundwater management approach to address low detections of pesticide-related compounds is the Long Island pesticide pollution prevention strategy (LIPPPS), which lists 61 pesticide related chemicals detected in Long Island groundwater at least once between 1996-2010 and associated with 47 active ingredients currently registered for use in Nassau and Suffolk Counties. LIPPPS outlines a process to prioritize and evaluate the 47 active ingredients detected in groundwater during this period by the Suffolk County Department of Health Services. An additional 56 pesticide related compounds associated with 35 active ingredients are restricted from further use and continue to be monitored. LIPPPS is one of the ways in which pesticides are evaluated as potential emerging contaminants in the NYSDOH/NYSDEC collaborative efforts in the New York Ocean Action Plan. It also incorporates ongoing workplan activities conducted under the NYSDEC contract with SCDHS, which cover sampling activities in both Nassau and Suffolk Counties, water analyses completed by the Suffolk County Public and Environmental Health Laboratory (SCPEHL) and monitoring well installations by the SCDHS Bureau of Groundwater Investigation.

Long Island Landfill Law

The Long Island landfill law codified in the environmental conservation law, effectively closed all solid waste disposal by 1990 with six current operating landfills left on Long Island, two of which are ash monofills. Landfills or expansions are permitted if located outside the deep-flow recharge area. These facilities can accept material that is the product of resource recovery, incineration, composting and downtime waste and untreatable waste. These landfills require a double- composite liner system with a primary and secondary leachate collection and removal system. Any new landfill or expansion, located within the deep-flow recharge area, can accept only clean fill and must have, at a minimum, a double liner system consisting of an upper geomembrane and a lower composite liner system with a primary and secondary leachate collection and removal system. Clean fill landfills outside the deep-flow recharge area must have a single composite liner system with a provision for leachate collection and removal.

Spill Response Program

Under this program, DEC responds to and manages real time emergency spills of petroleum, hazardous materials and non-hazardous materials that range from several gallons to several thousand gallons and oversees all petroleum subsurface investigation and remediation projects by responsible parties or contractors hired with spill fund monies.

Major Oil Storage Facility (MOSF)

In 1978, the state established regulations under the navigation law for the safe transfer and storage of petroleum at MOSFs. The MOSF program applies to facilities that store a total of 400,000 gallons or more of petroleum in aboveground and underground storage tanks. Facilities must be licensed by the DEC and managed in compliance with applicable regulations for the storage and handling of petroleum. On Long Island, this includes groundwater monitoring at all facilities.

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Petroleum Bulk Storage (PBS)

The state PBS program applies to facilities that store more than 1,100 gallons of petroleum in aboveground and larger than 110 gallons in underground tanks. All tanks (except in delegated counties) for the storage of petroleum at facilities must be registered with the DEC and managed in compliance with applicable regulations for the storage and handling of petroleum. In October 2015, DEC modified the regulations to consolidate and increase consistency with updated federal regulations. With the modification, the counties must implement changes to their codes to continue with delegation.

Chemical Bulk Storage (CBS)

In 1994, the state established regulations under the ECL listing hazardous substances subject to handling, storage, and release reporting requirements. The CBS program applies to facilities that store a listed "hazardous substance" in an aboveground storage tank larger than 185 gallons, any size underground storage tank and some non-stationary tanks. All regulated tanks at facilities must be registered with the DEC and managed in compliance with applicable regulations for the storage and handling of hazardous substances. Unlike the PBS program, CBS authority is not delegated to any local entity and many of the county regulations have been superseded.

Nassau and Suffolk Counties Regulations

The most significant and innovative county regulations date to the Long Island 208 Plan in 1978.

These new regulatory measures primarily built on the 208 Study's development of hydrogeological zones that opened up regulatory approaches which would cross municipal boundaries and could better accommodate and respond to innovative land use approaches such as clustering and transfer of development rights. In addition to the Long Island 208 Plan, the Long Island Regional Planning Board completed a Special Groundwater Protection Area (SGPA) Study in 1992. The nine SGPAs consisted of large fairly continuous undeveloped tracts – two in Nassau County and seven in Suffolk County – and received additional planning recommendations.

Chemical Storage Tank Approaches

Suffolk County regulations specifying storage and handling requirements for defined toxic and hazardous materials under the authority of the Suffolk County Sanitary Code (SCSC) Article 12 (initially adopted in 1979). These regulations cover both new and existing aboveground, inground and indoor storage installations; permitting; inspectional right of access; standards for tanks; associated piping and spill containment; tank testing and tester qualifications; spill reporting; and seizure authority. Compliance timetables were established based on the age of the existing tanks and addressed upgrading spill containment, and monitoring systems were similarly phased in as standards were revised. Tank removal required inspection; if evidence of failure or spills was observed NYSDEC would be notified and would require remediation. Article XI of the Nassau County Public Health Ordinance is structurally identical to SCSC Article 12. The Nassau County Fire Marshall regulates flammable material storage. With the establishment of New York State chemical bulk CBS) (non-petroleum) requirements, many of the county regulations have been superseded, except for certain chemicals that fell outside the state regulation.

SCSC Article 7 (initially adopted in 1985) provides additional protection to designated deep groundwater recharge and water supply sensitive areas by restricting the quantities of defined toxic and hazardous materials that can be stored in these areas. The intent is to minimize the impact of spills and discharges in these areas.

Wastewater Management Approaches

SCSC Article 6 (1980) ties communal sewering requirements to SCDHS standards which limit nitrogen contribution for non-sewered developments to the equivalent of two single-family units per 40,000 sq. ft. in groundwater management zones (GMZs) III, V or VI, and one single-family unit per 40,000 sq. ft. in all other GMZs. For other than single-family homes, the SCDHS has provided Article 6 density design loading rates for a range of common commercial facilities and other residential applications. A 1995 Article 6 amendment included provisions to permit the transfer of the appropriate density equivalent from existing undeveloped open space controlled by the applicant to land proposed for development. Article 6 empowers SCDHS to adopt standards for on-site sewage disposal systems (OSSDS).

Nassau County Article X (1985) focuses on new subdivisions and a limited range of property redevelopments in un-sewered areas countywide and in the two SGPAs designated in Nassau. The approach is similar to that in Suffolk County – aimed at limiting OSSDS to 40,000 sq. ft. lot developments with an additional sewage design flow equivalency approach to non-residential developments.

Groundwater Resource Monitoring Activities

Article 4 of the SCSC authorizes the commissioner to collect and analyze appropriate water, soil and geological information to determine if water quality is being maintained. It also authorizes the commissioner to prepare and review comprehensive water supply plans and prepare necessary water resources management as well as numerous other resource management tasks. The Commissioner additionally is authorized to take appropriate legal action, which may include fines for failure to comply with the intent of this Article. It allowed investigation of groundwater impacts from activities within the county and monitoring of private wells. Private well survey work initially uncovered groundwater contamination from chlorinated solvents in the mid-1970s, water soluble pesticides beginning with aldicarb in 1979, methyl tert-butyl ether (MTBE) in 1990s and pharmaceuticals in the first decade of this century. Suffolk maintains drilling equipment for wells up to 300 feet deep. The county's ready access to public rights of way allows the department to investigate suspected contamination sources for code implementation or formal Superfund applications to state or federal agencies, augmenting on-site inspections as needed. Nassau County Department of Health maintains a private well program and enforces well construction standards authorized by Article IV of the County Public Health Ordinance.

Open Space, Farmland Acquisition and Transfer of Development Rights Programs

The *208 Study* prioritized actions in the designated deep recharge groundwater management zones. In the late 1970s and early 1980s, nearly every town with large tracts in the designated deep recharge zones selected residential areas for less-intensive uses, redesignated industrial areas for low-density residential uses and made undeveloped industrially zoned lands subject to additional requirements involving storage of toxic and hazardous materials. Water recharge overlay districts were incorporated into zoning categories in Southampton, East Hampton, North Hempstead and Oyster Bay. A program for outright purchases of areas of critical environmental significance set water supply facilities as a designated use and several Suffolk County Water Authority wells have been sited in lands acquired under this program. New York State's Long Island Pine Barrens Protection Act, which affected nearly 100,000 acres, added 20,000 acres to 30,000 public domain acres to form a Pine Barrens Core in which no development would be allowed. The remainder acres, designated a compatible growth area, received the cooperation of individual towns in

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the development of compatible land use.

Source Water Withdrawal Regulations

Permits for public water withdrawal are currently issued by the NYSDEC and are required for any potable and non-potable water withdrawal system having the capacity to withdraw 100,000 gallons per day (gpd) or more of surface water, groundwater or combination thereof. The Long Island Well Permit Program, addressing water withdrawals exceeding 45 gallons per minute, was established to regulate most non- public water withdrawals in the four designated counties composing Long Island and includes relatively short-term withdrawals exceeding that rate such as dewatering activities. A state well driller certification program for Long Island requires filing of preliminary and well completion reports and certain operational reporting requirements for permittees. Permits for public water withdrawal on Long Island are now issued for a maximum period of ten years, allowing for their modification.

Permits often contain site-specific special conditions, general conditions relevant to water withdrawals and general conditions applicable to all ECL-authorized permits. ECL Section 15-1527 amendments directed that the department undertake, as part of the permit renewal process, categorization of areas of all Long Island groundwater that are exhibiting stress with respect to quality or quantity. The amendments directed the NYSDEC to re-open, review, modify or delete permit conditions as necessary to reduce consumption in overstressed areas. Resulting permit modifications imposed annual pumpage caps on 41 public water suppliers in Nassau County.

By amendment of the ECL, a moratorium was established on the "granting of new permits to drill public water supply, private water supply or industrial wells into the Lloyd Sands or to permit new withdrawals of water from the Lloyd Sands." The moratorium applies "to all areas that are not coastal communities" and requires the NYSDEC to identify which areas of Long Island are to be considered coastal communities. ECL Section 1502 defines coastal communities as "those areas of Long Island where the Magothy Aquifer is either absent or contaminated with chlorides." Exemptions to non-coastal communities can be granted "upon finding of just cause and extreme hardship." A later amendment bans without exemption "the storage or pumping of water into the Lloyd Sands," which applies to both coastal and non-coastal communities. Nassau County controls private well water systems under Article IV of the Public Health Ordinance, while Suffolk's control is under Article 6 of its Sanitary Code; both codes serve to limit proliferation of private potable residential and non-residential wells.

Public Water Supply Regulations

Prior to the SDWA (1974), federal jurisdiction over public water suppliers was limited to only water supply systems involved in water transmission across state lines or via modes of interstate transportation through standards developed by the United States Public Health Service (USPHS). The USPHS standards for drinking water originally regulated 28 contaminants, many which are still used today. Beginning in 1969, USPHS and the EPA raised awareness of volatile organics and trihalomethane (THM) disinfectant by-products as emerging contaminants and surveys were done of local suppliers, initially for six halogenated volatile organic compounds. In 1987, the EPA proposed its first "Phase I" VOC maximum contaminant levels (MCLs) for seven organic contaminants ranging from 2 ppb for vinyl chloride to 200 ppb for trichloroethane.

In 1989, the NYSDOH exercised its right under the SDWA to set MCLs that were more restrictive than those promulgated by the EPA and created two broad regulated contaminant groups of organic compounds known as principal organic compounds and unspecified organic compounds (POCs and UOCS, with individual MCLs of 5 and 50 ppb, respectively, and 100 ppb for the total of all POCs and UOCs). The POC definition has an enforceable standard for trichloroethane of 5 ppb (as an MCL), substantially lower than the 300 ppb federal limit. By early 1989, 36 Long Island public wells out of nearly 900 wells tested were restricted voluntarily. The POC and UOC contaminant definitions and MCLs brought to light occurrence of other contaminants (e.g. MTBE and freons) that would remain unregulated nationally after their initial detection on Long Island or not regulated or receive EPA health advisories for some time (e.g., tetrachloroethylene, dichloropropane and dacthal).

Later SDWA amendments addressed specific issues, such as: provisions banning lead solder and revising "lead-free" definitions for plumbing fittings; requirements for public water supplier vulnerability assessments and emergency response plans; transparency and public accountability; revision of the public notification process associated with regulated contaminants, and consumer confidence reports beginning in 2000.

Primacy under the SDWA

The EPA delegates primary enforcement responsibility (primacy) for public water systems to states and Indian tribes if they meet certain requirements:

- Have regulations for contaminants no less stringent than the EPA's.
- Have adopted and be implementing procedures for enforcement.
- Maintain an inventory of public water systems.
- Have a program to conduct sanitary surveys.
- Have a program to certify laboratories for regulated water sample analyses.
- Have a laboratory that will serve as the state's "principal" lab that is certified by the EPA.
- Have a program for new/modified systems to have capacity for regulatory compliance.
- Have adequate enforcement authority to compel water systems to comply, to sue in court, to enter and inspect water system facilities, to require systems to keep records and release them to the state, to require systems to notify the public of any system violation of the state requirements and to assess civil or criminal penalties for violations.
- Have adequate recordkeeping and reporting requirements.
- Have adequate variance and exemption requirements as stringent as the EPA's.
- Have a plan to provide for safe drinking water in emergencies like a natural disaster.
- Have adopted authority to assess administrative penalties for violations.

A state can take up to two years to adopt a new rule while, concurrently, the EPA can choose to directly enforce its requirements. The NYSDOH historically has selected a process of formally adopting new EPA regulations into its code; other states have adopted some or all EPA SDWA regulations "by reference."

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SDWA Drinking Water Standard Setting

The three criteria for a contaminant to become regulated are: it must have an adverse health effect; it must be known to occur in distributed public water as a health concern; and its regulation would present a health risk reduction nationally. The SDWA requires that EPA simultaneously propose an MCL (the enforceable maximum contaminant level) and an MCLG (maximum contaminant level goal) and that the MCLs are set as close to the MCLGs as possible based on use of best available technology (BAT) and cost. The process is addressed by three operations occurring in overlapping five-year cycles: contaminant candidate lists (CCL), unregulated contaminant monitoring rules (UCMR) and regulatory determinations (RD).

The CCL process has been to add contaminant nominees to the prior list, removing only those that have had formal prior RDs. The current CCL4 includes 100 chemicals or chemical groups and 12 microbial contaminants that are known or expected to possibly occur in public water systems. The UCMR requires public water systems serving more than 10,000 people to sample entry points (after treatment) for no more than 30 suspected contaminants in each UCMR cycle (three years). However, UCMR data, gathered post-treatment, inadequately reflects water supply source waters contaminant occurrence and concentrations. UCMRs do provide opportunities for new analytical methods to be evaluated.

The EPA must make RDs every five years for a minimum of five contaminants. In three successive actions since 2003, EPA determined not to regulate a total of 24 contaminants and to regulate one contaminant (strontium). Many emerging contaminants have significant exposure routes besides drinking water. Assigning a "relative source contribution" for such a drinking water contaminant is challenging, particularly for one with cancer risks demonstrated through limited animal studies. The slow evaluation process for perchlorate has been a recent challenge illustrating this issue.

The 1996 Amendments required the EPA to review all existing contaminant regulations every six years and to determine if there is a need to revise existing regulations. One contaminant, coliform, has received a revised regulation (revised Rule effective April 1, 2016). The EPA is in the process of developing revised regulations for two of the most commonly found chlorinated solvents: trichloroethylene and tetrachloroethylene. Contaminant studies have reinforced previous conclusions on health effects, detection limits have been lowered and BAT systems are attaining excellent reliability.

EPA's New Regulation Strategy and Possible VOC Group Regulation

In 2010, the EPA began a public process of a new strategy for contaminant regulation, focusing on contaminants as a group based on: similar health effects or endpoints, removal by common control or treatment processes, common analytical methods and known or likely co-occurrence. Approximately 16 volatile organics (eight currently with EPA individual MCLs) were the most viable group to meet these criteria.

Emerging Contaminants and Risk Communication

There is a growing list of "emerging contaminants" and an increasing number of contaminant detections due to improved analytical methods with lower detection limits. The challenges facing state agencies and public water suppliers are risk communication and public perception, including the required public disclosure of detections of "new" contaminants in the most recent UCMR3 monitoring program. States have promulgated their own regulations, based on the current state of knowledge, leading to many differing approaches and MCLs for contaminants and differing targets for contaminants of concern at Superfund remediation sites. Conflicts in New York and several other states arise from dramatic changes in EPA advisory approaches to findings of two unregulated perfluorinated organic compounds PFOS and PFOA.

On Long Island, the contaminant in question is 1,4-dioxane. Although detected nationally in 22% of public suppliers in the UCMR sampling, only 7% of suppliers (336 suppliers) detected levels within an EPA range of levels of concern in at least one sample. Twenty-seven of these 336 suppliers are on Long Island.

State and County Sanitary Codes

NYSDOH has adopted the new EPA/SDWA-derived rules into the NYS Sanitary Code as they are developed and has delegated to Nassau and Suffolk County health departments a broad range of public water supply regulatory responsibilities. State requirements for publication and public comment are slow and can miss EPA's rule implementation deadlines. On occasion, this has resulted in compliance issues often relating to water suppliers' lack of awareness of the effective date of a federal rule. Most recently, the NYSDOH has shouldered compliance issues associated with the April 1, 2016 revised total coliform rule (RTCR) implementation date, although part 5 incorporation of RTCR has not yet run its course.

The NYSDOH has formally adopted some MCLs for contaminants that are not regulated by EPA and also has the POC/UOC definition for state regulation of organic chemical groups. Part 5 establishes discretionary authority allowing monitoring of contaminants and at set frequencies which can differ from that adopted in federal rules. Part 5 also addresses issues of plan approval, completed works approval and design standards that are not for the most part addressed in federal rules. Part 5 incorporates recommended standards for water works as the basis for approval of public water systems. The Sanitary Code also incorporates standards for water well construction. Although cross-connections have been documented as sources of waterborne disease outbreaks, there are no implicit federal requirements for cross connection control.

NYSDOH codified operator certification requirements in 2001, and subpart 5-4 of the NYSSC was amended to formalize certain operator certification baseline standards established by EPA pursuant to the 1996 SDWA amendments. Suffolk County Sanitary Code Article 4 addresses both public and private water supply systems. Nassau County Public Health Ordinance Article VI was last revised in 1987 and contains a number of specific operational requirements for public suppliers. Proliferation of private potable wells in areas served by public water is discouraged by these regulations. Both counties require monitoring programs exceeding the minimum requirements of the NYSSC, but enforceable through the part 5 discretionary authority in monitoring and regulatory reporting requirements.

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Conclusion and Recommendations

Existing federal, state and county requirements constitute an effective watershed rule and regulation matrix equivalent to and often exceeding the regulatory controls exercised over water resources elsewhere in the country. Strong levels of communication, regulatory compliance and cooperation between regulatory agencies and among water suppliers are necessary in achieving common goals. There has been an ongoing commitment to expanding knowledge of the water resource, emerging contaminant research and advancement of water supply and treatment technology. However, funding limitations have slowly eroded the overall level of commitment in these areas, most notably seen in overall staff reduction and a loss of institutional knowledge and capacity due to ageing-out and retirements of specialized staff.

Many of the contaminant occurrence problems experienced by public suppliers reflect legacy contamination by industries that are no longer active or involve chemical storage and use practices that have been curtailed or changed. New problems will be found due to newer developed chemicals that escaped notice of the regulatory agencies or as the result of lower limits of analytical detection.

The following actions are recommended for future consideration. It should be noted that much of this framework has already been initiated in Suffolk County as many of the same or similar recommendations were identified in their 2015 Comprehensive Water Resources Management Plan:

1. Restore and expand existing analytical capabilities at local health department laboratories such as aquifer evaluation, emerging contaminant studies, development of new analytical procedures and support of groundwater investigation and increased monitoring.
2. Expand and enhance public water suppliers' self-monitoring activities, recognizing the need for additional monitoring commitments.
3. Support local laboratory and trained staff response capabilities to meet the objectives of the New York State Water Quality Rapid Response Task Force currently under development.
4. Restore and expand existing county level test well drilling capabilities.
5. Expand and assess a cooperative relationship with the USGS to optimize the strength of local capabilities.
6. Restore health department industrial waste inspections to previous levels.
7. Develop and expand the new GIS-based water quality database developed by Suffolk County Water Authority for the Long Island Commission for Aquifer Protection (LICAP).
8. Commit to continued bi-county updates of water resource management plans and update existing SWAPs to also include GIS output.
9. The NYSDEC and the county health departments must review and provide comments on village and town planning board applications that may impact water resources. Through the State Environmental Quality Review Act (SEQRA) process, these agencies shall identify and communicate any potential issues to the planning boards regarding conservation measures and possible aquifer contamination. Likewise, planning boards must work closely with water suppliers to mandate conditions for the sustainability and protection of water resources prior to approving site plans.

Groundwater threats can be generalized as to being a regional threat or a local threat. Regional threats are pervasive issues that may impact, to different degrees, all geographic areas of the Long Island aquifer system. For example, nonpoint source contamination impact is a regional threat. Conversely, discrete impacts resulting from a site-specific land use practice is considered for the purpose of this publication a localized threat. These definitions are broad, and some local threats may become so large as to be a regional threat. This chapter analyzes several types of threats in each category.

Regional Threats

Threats to Groundwater Quality

Emerging Contaminants

Several emerging contaminants were discussed in the Suffolk County Comp Plan, including a number of pharmaceutical and personal care products (PPCPs), 1,4-dioxane, chlorate and hexavalent chromium. While the majority of these are not regulated by the federal or state government, it is essential to develop occurrence data to support the development of regulation by one or both of these agencies. Suffolk County continues to monitor and identify suspected sources of these contaminants through groundwater investigations. This places Suffolk County in a good position prior to regulation of these compounds and benefits the county's residents, visitors and environment by addressing contamination early.

Nitrate

Monitoring, enforcement and voluntary restriction of select products have helped to reduce contamination of Suffolk County's sole-source aquifer. An estimated 74% of the population continues to discharge sanitary waste and chemicals into on-site cesspools and conventional wastewater systems with little to no reduction of the contaminants. The Comp Plan evaluated a select group of contaminants for trends from 1987-2013 in the county's monitoring program. Nitrate levels in the county's Upper Glacial Aquifer increased by an average of 1 milligram per Liter (mg/L) in the same set of wells over the 26-year period. There was a similar increase of 0.76 mg/L in the same set of Magothy Aquifer wells. Increased nitrate concentrations in groundwater also can have an indirect impact on our surface water quality as groundwater migrates through our aquifers and into streams, rivers and estuaries. Elevated nitrogen levels in surface waters can cause algal blooms, which may be harmful themselves, but also can reduce oxygen levels and result in fish kills.

Volatile Organic Compounds

Volatile organic compounds (VOCs) include industrial and commercial cleaners as well as consumer products such as paint, household cleaning agents, deodorants, adhesives and gasoline. The Comp Plan focused on three of the most commonly detected VOCs: tetrachloroethene (PCE), trichloroethene (TCE) and 1,1,1-trichloroethane (1,1,1-TCA) as well as methyl tertiary butyl ether (MTBE). Water quality status and trends were evaluated for these contaminants between 1987-2013. Unfortunately, the total number of wells impacted by PCE doubled (29 to 59), and the average concentrations in the Upper Glacial and Magothy Aquifers were similar in comparison of the same set of public supply wells. An evaluation of TCE showed similar results. The total number of impacted wells more than doubled (34 to 84). The average concentration of TCE in the same set of Glacial and Magothy Aquifer wells nearly tripled in the same well comparison. Chemical bans previously put in place for 1,1,1-TCA and MTBE appear to have been effective. Concentrations of 1,1,1-TCA have decreased in a same well comparison between 1987-2013 in the Upper Glacial Aquifer from 3.16 to 0.47 micrograms per liter (ug/L) and the Magothy Aquifer from 0.57 to 0.47 ug/L. Similarly, MTBE saw a decrease in the number of public water supply wells with detections from 16% in 2005 to approximately 5% in 2013.

Pesticides

As one of the leading agricultural counties in New York State based on sales, Suffolk County has rich agricultural roots. In the United States Department of Agriculture's 2012 Census, Suffolk County was listed as having 604 farms over a total of 35,975 acres/www.agcensus.usda.gov/Publications/2012/Full_Report/Volume_1,_Chapter_2_County_Level/ New_York/). An unfortunate byproduct of farming is the need to kill or control pests and nuisance vegetation using pesticides, herbicides and fungicides. Many similar products are used by homeowners and commercial businesses to maintain lush, green, weed-free lawns or to control insects. The Suffolk County Department of Health Services (SCDHS) has implemented a pesticide monitoring program to test for about 150 pesticides and breakdown products to help inform the public, regulators, researchers and farmers of detections and potential health impacts. Sampling efforts over the years from drinking water and monitoring wells have identified more than 100 pesticide-related compounds. At least one pesticide compound was detected in about 20-25% of public community, non-community or private water supply wells sampled between 1997-2012. Of the 10 most frequently detected pesticides in private well samples, only simazine, metalaxyl, imidicloprid and atrazine were still registered for use on Long Island. Suffolk County continues to work with the New York State Department of Environmental Conservation (NYSDEC), Cornell Cooperative Extension, the United States Geological Survey (USGS) and others to monitor ground and surface water and advise policy makers on potential changes to be considered for pesticide regulations.

Climate Change Impacts

Climate change will present numerous challenges to water suppliers in the next decades. In addition to infrastructure-related issues, aquifer conditions will change in response to future weather variables, including sea-level rise, increased temperature and precipitation and increased occurrence of weather extremes. The United States Environmental Protection Agency (USEPA) defines climate change as any significant change in the measures of climate such as temperature, precipitation and other effects that last for an extended period of time (USEPA, http://www3.epa.gov/climatechange/basics/). It can be identified from changes in, "the average state or the variability of weather and can refer to the effects of 1) persistent human caused changes in the composition of the atmosphere and/or land use, or 2) natural processes, such as volcanic eruptions and Earth's orbital variations" (IPCC, 2007a, pp. 8).

The anticipated aquifer conditions resulting from climate change include: elevated water table, increased streamflow and both vertical and lateral migration of the salt water interface. Impacts to both the quantity and quality of surface water features such as lakes, streams and estuaries are predicted as well, and elevated water tables also are anticipated to affect wastewater disposal practices in coastal areas. The Suffolk County groundwater model has been utilized to help analyze and quantify these anticipated conditions on the aquifer system in Suffolk County. Responses by water suppliers and regulatory bodies to these new conditions should include such actions as: development of a user-friendly, Island-wide groundwater flow model as is currently underway as part of the Long Island Groundwater Sustainability Project, regional water quality and quantity monitoring, longer distance transmission of water from central Long Island toward the coastal communities, changes to water withdrawal permit conditions to adapt to changing aquifer characteristics (both quality and quantity) and reduced reliance on on-site sewage disposal systems in coastal areas. These potential challenges will be addressed through the prism of what may best be described as "new normal" conditions. As climate change conditions increasingly deviate from current conditions, water suppliers will be required to reevaluate both water resource and facilities management responses and also contend with potential policy and regulatory changes.

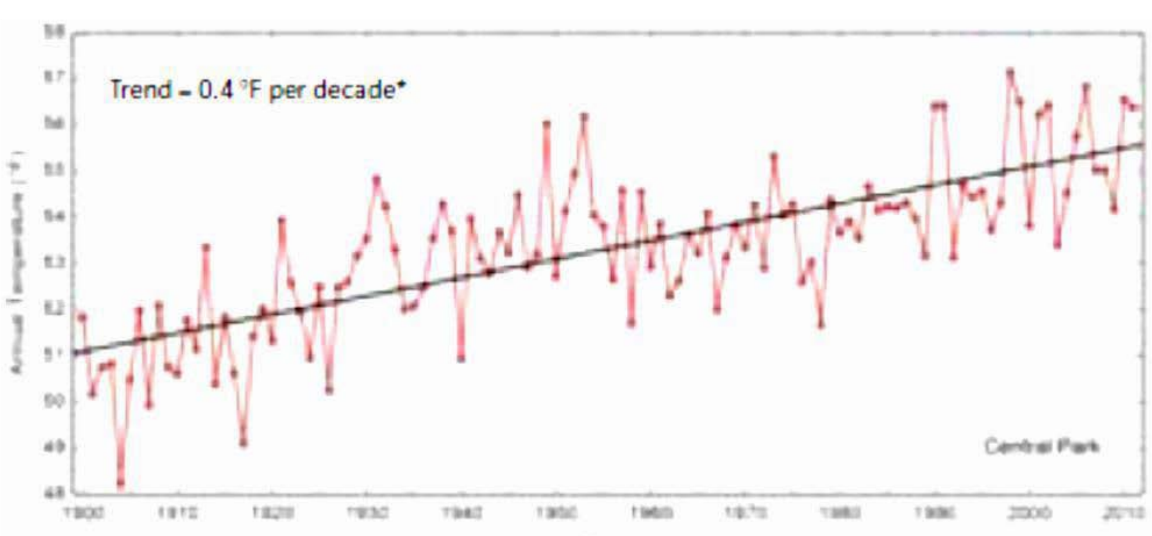
Climate Change Characteristics, Impacts and Projections

Temperature rise, extreme temperature and heat waves, hot and cold weather events, precipitation patterns, extreme storm events and sea-level rise are measurable parameters of climate change; and the impacts of these attributes will, individually and collectively, negatively impact Long Island water resources and water supply.

Temperature Rise

The mean annual temperature in Nassau and Suffolk has increased 5 degrees Fahrenheit (F) between 1900 and 2010. The likely future warming is predicted to be approximately 5.4 degrees F additional by 2050 (Zhang, et al, 2014). In addition to general rise in temperature, the frequency, intensity and length of heat waves are expected to increase as well. The impacts of warming trends will cause changes in seasonal water demand from public water suppliers as well as agricultural and recreational (particularly golf course) water users. According to the EPA, the northeast region of the United States, between 1895 and 2011, temperatures rose by approximately 2 degrees F. EPA projections show that the warming trend will continue through the foreseeable future with temperatures rising on average of 4.5-10 degrees F by the 2080s (Source: USEPA, http://www3.epa.gov/climatechange/impacts/northeast.html).

Figure 1 Observed Annual Temperature in New York City (NPCC Climate Risk Information 2013: Observations, Climate Change Projections and Maps pp. 12)



Observed annual temperature in Central Park (1900 - 2011). Data are from the National Oceanic and Atmospheric Administration (NOAA) National Climatic Data Center (NCDC) United States Historical Climatology Network (USHCNv2) (Menne et al., 2009). Trend is significant at the 99 percent level.

CHAPTER 4:
GROUNDWATER QUALITY AND QUANTITY THREATS

Extreme Temperature and Heat Waves

The NPCC CLIMATE RISK INFORMATION 2013 Report defines extreme temperature events using daily data from Central Park since 1900 using the following metrics:

- Individual days with maximum temperatures at or above 90 degrees F.
- Individual days with maximum temperatures at or above 100 degrees F.
- Heat waves, defined as three consecutive days with maximum temperatures at or above 90 degrees F.
- Individual days with minimum temperatures at or below 32 degrees F.

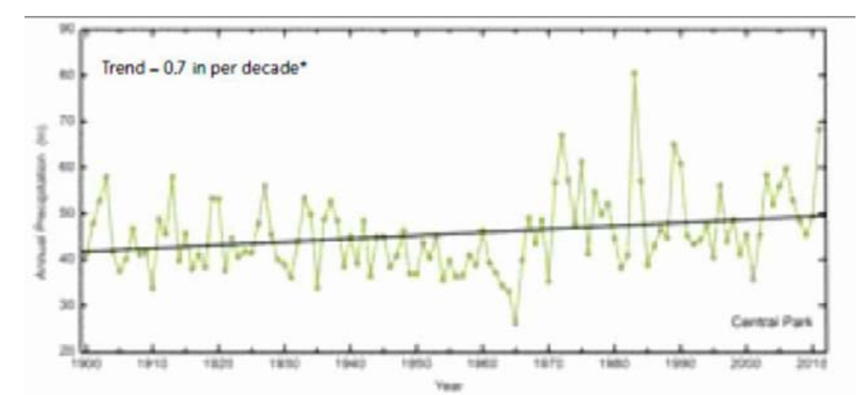
(*NPCC CLIMATE RISK INFORMATION 2013:* Observations, Climate Change Projections, and Maps pp. 12).

According to the National Panel Climate Change, "[t]he total number of hot days, defined as days with a maximum temperature at or above 90 and 100 degrees F, is expected to increase as the 21st century progresses. By the 2020s, the frequency of days at or above 90 degrees F may increase by more than 50 percent relative to the 1971-2000 base period; by the 2050s, the frequency may more than double. While 100 degrees F days are expected to remain relatively rare, the percentage increase in their frequency of occurrence may exceed the percent change in days at or above 90 degrees F. The frequency and duration of heat waves, defined as three or more consecutive days with maximum temperatures at or above 90 degrees F, are very likely to increase. In contrast, extreme cold events, defined as the number of days per year with minimum temperature at or below 32 degrees F, are expected to become more infrequent, with a 25%decrease projected by the 2020s and more than a 33% decrease by the 2050s." (NPCC CLIMATE RISK INFORMATION 2013: Observations, Climate Change Projections, and Maps pp. 20).

Precipitation Patterns

Climate change has the potential to affect the precipitation patterns. Both the total amount of precipitation and the frequency of heavy precipitation events have been rising. Between 1958 and 2012, the northeast saw more than a 70% increase in the amount of rainfall measured during heavy precipitation events, more than in any other region in the United States (http://www3.epa.gov/climatechange/impacts/northeast.html). Total annual precipitation is predicted to be anywhere from 10-25% higher by the end of the 21st century (Zhang, 2014). Excessive precipitation could influence the groundwater system by elevating the water table due to increased recharge. Increased water quality and quantity monitoring would likely be necessary in order to accurately track these changing hydrogeologic conditions. The development of and increased reliance on regional groundwater models to help interpret changing conditions in the groundwater system is recommended.

Figure 2 Observed Annual Precipitation in New York City (NPCC Climate Risk Information 2013: Observations, Climate Change Projections, and Maps, pp. 12)

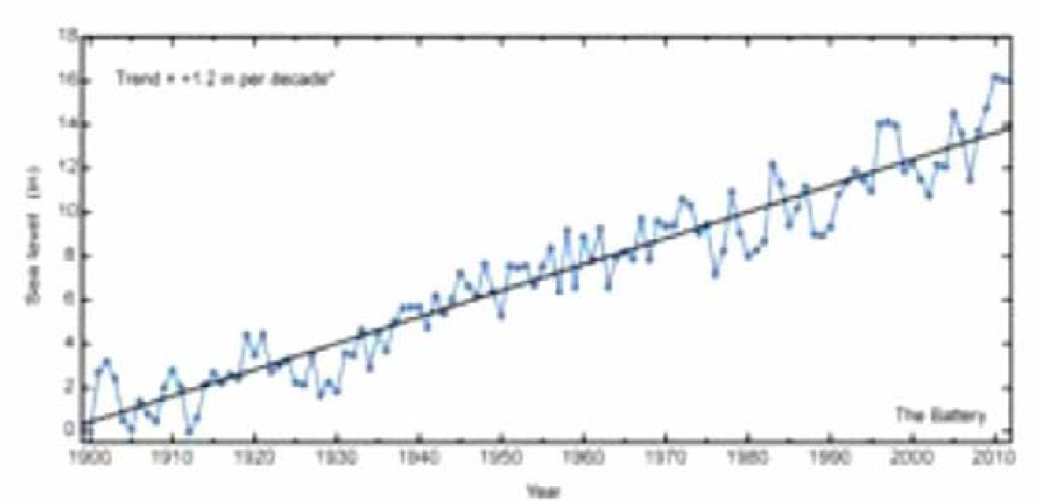


Observed annual precipitation in Central Park (1900 - 2011). Data are from the National Oceanic and Atmospheric Administration (NOAA) National Climatic Data Center (NCDC) United States Historical Climatology Network (USHCNv2) (Menne et al., 2009). Trend is significant at the 99 percent level.

The effects of excessive flooding can negatively impact water quality and can damage water supply infrastructure such as distribution mains and well fields (www3.epa.gov/climatechange/impacts/water.html). These impacts will likely require changes in regional sewering vs. on-site sewage disposal due to rising groundwater levels. Impacts on aquatic habitat also will occur due to changes in streamflow, which also will affect salinity of bays and estuaries and possibly inundate marginal areas. Projections indicate continuing increases in precipitation, especially in winter and spring, and changes in the timing of winter and spring precipitation could lead to drought conditions in summer as warmer temperatures increase evaporation and accelerate snow melt (http://www3.epa.gov/climatechange/impacts/northeast.html). The impact of precipitation timing would directly influence seasonal water demand needs with regard to public supply, agricultural and recreational (i.e. golf course irrigation).

Sea-Level Rise

In addition to climate change, sea-level rise is a threat to Long Island. According to the Climate Risk Report for Nassau and Suffolk County, TR-014-01, the sea level is projected to rise 34.0 inches by the end of the 21st century. Aquifers face risks from sea-level rise because as the sea rises, salt water moves into fresh water areas, laterally constricting the transition zones and pushing the water table up. According to the USEPA, in the northeast, sea level has risen by approximately 1 foot since 1900, which has caused more frequent flooding of coastal areas (http://www3.epa.gov/climatechange/impacts/northeast.html).



Observed annual mean sea level (in) at the Battery, New York City, relative to the year 1900. Data are from the Permanent Service for Mean Sea Level (PSMSL). Trend is significant at the 99 percent level.

Figure 3 Observed Sea Level in New York City (NPCC Climate Risk Information 2013: Observations, Climate Change Projections, and Maps pp. 12)

Extreme Storm Events

"Hurricane Sandy has focused attention on the significant effects that extreme climate events have on New York City. Other recent events in the United States, such as the widespread drought of 2012, also have raised awareness of the impacts of weather and climate extremes. While it is not possible to attribute any single extreme event such as Superstorm Sandy to climate change, sea-level rise already occurring in the New York City area, in part related to climate change, increased the extent and magnitude of coastal flooding during the storm." (NPCC CLIMATE RISK INFORMATION 2013: Observations, Climate Change Projections, and Maps pp. 7).

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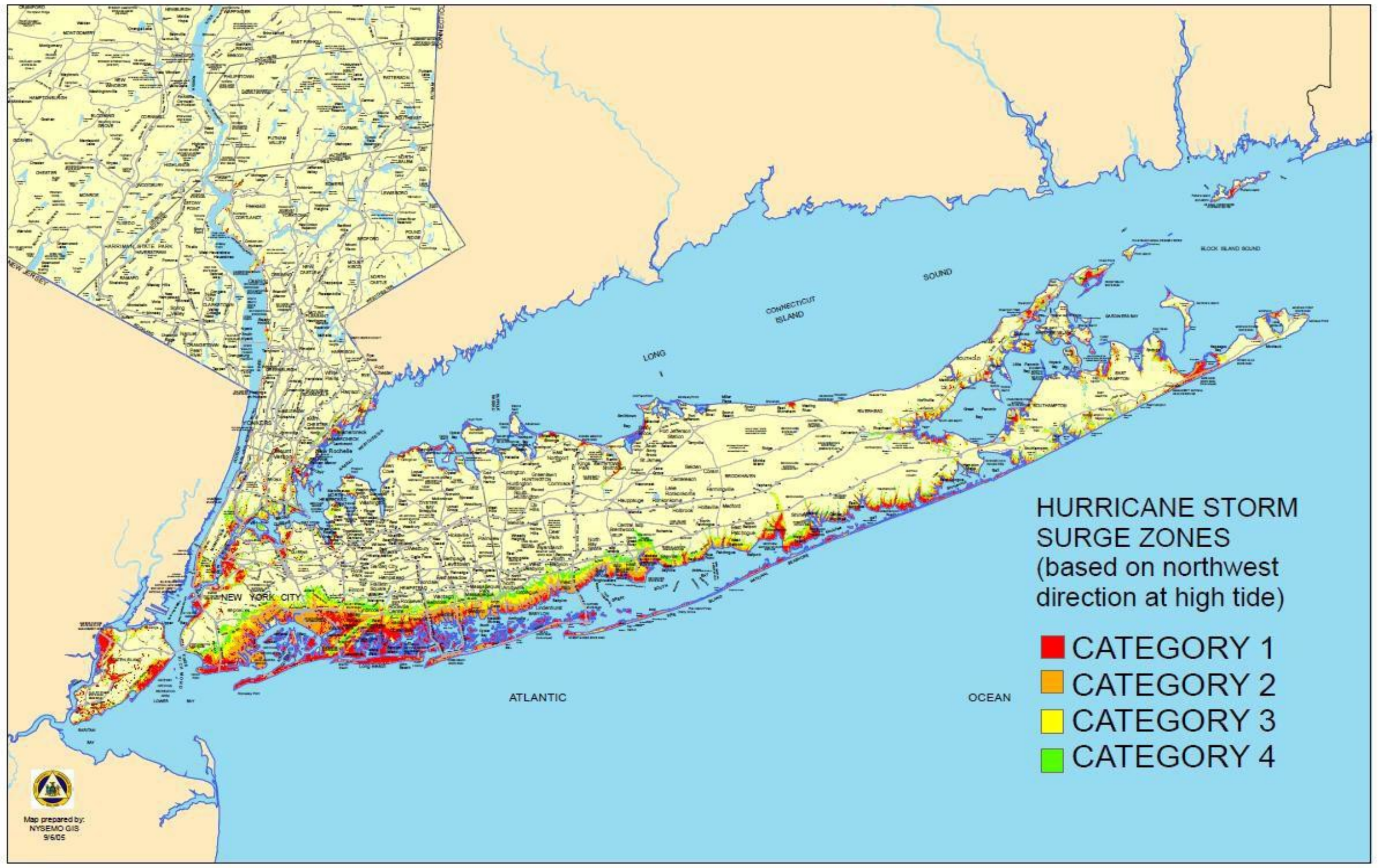
The "New Normal"

The northeast is experiencing warming temperatures and a large increase in the amount of rainfall measured during heavy precipitation events. Sea-level rise and more frequent heavy rains are expected to increase flooding and storm surge, threatening infrastructure. The Climate Risk Report for Nassau and Suffolk County, TR-014-01 examined two different scenarios for climate change based upon different predictions for future global greenhouse gas emissions: a scenario wherein future emissions are mitigated aggressively, and a "business as usual" scenario, with minimal mitigation of future greenhouse gas emissions. Values from this latter scenario will be utilized for purposes of this report. Issues that Long Island's public water suppliers will have to contend with under this new normal scenario include, but are not limited to, the following:

- Changes in "safe yield" of aquifer.
- Increased recharge from precipitation.
- Changes in seasonal water demand-public supply, agricultural, recreational (golf course) from longer growing season.
- Increased upconing (east end) and lateral salt water intrusion (Nassau).
- Increase in water table elevation and resulting changes to aquatic habitat.

Figure 4 **Sea, Lake and Overland Surges from Hurricanes (SLOSH) – NYSEMO GIS**



In addition to the above issues, which will result in changes to Long Island's water resources as a whole, the increased frequency of extreme weather events such as heavy downpours, hurricanes or nor'easters could impact operations and infrastructure in low-lying or coastal areas of Long Island. Due to threats of intensity, duration and frequency of these events, and the associated impacts such as inundation, wind damage and storm surge damage may cause water suppliers to abandon or relocate assets. In addition, if inundations become permanent, the relocation of populations out of at-risk areas will be necessary. Populations moving in-land will require water suppliers to create additional infrastructure (out of at-risk areas) to supply newly settled regions. When the draft 2010 Suffolk County Comprehensive Water Resources Management Plan was developed, global climate models at that time projected the following increases in sea-level elevation in the New York City area:

Decade Increase

- 2020s, 2-5 inches
- 2050s, 7-12 inches
- 2080s, 12-23 inches

Newer data suggests that higher sea levels are extremely likely by mid-century. Projections for sea-level rise in New York City are as follows:

- By the 2020s, the middle range of projections is 4-8 inches, and the high estimate is 11 inches.
- By the 2050s, the middle range of projections is 11-24 inches, and the high estimate is 31 inches.

The USEPA states that in the northeast, even higher sea-level rise is possible due to the combined effects of warming waters and local land subsidence. The rate of sea-level rise has been increasing, with average sea-level rise since 1900 now at 1.2 inches/decade. Global warming is predicted to further accelerate the rate of rising sea level, both as a result of the expansion of the warming oceans and as a result of ice melt. (Suffolk County Comprehensive Groundwater Resources Management Plan, pp. 3-118).

Suffolk County Groundwater Model Projections

The effects of sea-level rise on groundwater resources have been studied extensively as part of the Suffolk County Comprehensive Groundwater Resources Management Plan (SCCGRMP). A portion of this Plan was devoted to utilizing the Suffolk County groundwater model to investigate the effects of various sea-level rise scenarios on the groundwater resources of the main body of Suffolk as well as the north and south forks. As a conservative approach, the mean sea-level rise projection under the "business as usual" case as presented in Zhang et al (2014) was utilized, projecting an increase in sea level of 34 inches. For consistency purposes, a baseline value of 0.5 feet was used as the beginning mean sea level in all model simulations.

These simulation results were used to assess the potential impact to on-site sewage disposal systems, as discussed in Chapter 8. Model simulations were run through 2099 assuming an increase in sea level of 34 inches.

Assuming a 34-inch rise in sea level, the change in water level varies from 2.8 feet to less than
1.25 feet, with most of the model area showing an increase of 1 foot or less. Similar to the original sea-level rise scenarios (Task 4.4 SCCGRMP), the predicted change in water level is much lower along the south shore, compared to the north shore, because increases in stream baseflow limit the water level rise in the vicinity of

the non-tidal portion of the south shore streams (simulated to increase by approximately 48% in response to a 34-inch rise in sea level).

Over most of the north fork, the change in water level varies from 1-2 feet. Short, non-tidal segments of streams along the southern shore of the north fork locally limit the water level increase because of increases in stream baseflow. The simulated fresh water-salt water interface position following a 34-inch rise in sea level is shown in cross section on Figure 3-39 SCCGRMP in black. The simulation suggests that the interface moves inland by approximately 800 feet.

Over most of the south fork, the simulated change in water level varies from 1-2 feet. The simulated interface migrates approximately 1,000 feet inland in the shallow aquifer along portions of the south shore.

Flow models used in the Comp Plan confirm that Suffolk County's aquifer system can continue to meet current and projected rates of water supply pumping on a county-wide basis. Nevertheless, as water supply pumping increases in the future and becomes a larger percentage of the overall water budget on Long Island, fresh groundwater supplies and surface water bodies will most likely become more limited in many areas, particularly the north and south forks. The water balances also identify the net loss of baseflow to area streams and to coastal areas in those parts of the county where water supply pumping is not returned to the aquifer, i.e., sewer district areas with tidal water discharge (Southwest Sewer District and others).

This report recommends the utilization of a similar type of model to investigate the effects of various sea-level rise scenarios on the groundwater resource in Nassau County.

Impacts on Wastewater Treatment Practices in Suffolk County

Pre-1972 Suffolk County standards identified a minimum distance of 1 foot from the bottom of a cesspool to groundwater (providing 9 feet from ground surface to the water table).

Current standards identify a minimum distance of 3 feet (providing 11 feet from ground surface to the water table). There are many areas along the coast that currently are developed where the existing depth to groundwater is less than 10 feet below grade. These areas also generally correspond with areas that are projected to be further impacted by rising sea level. It is possible that many of the systems within these areas are currently just above the seasonal high water table and may become flooded as sea-level rises in the future. This would not only reduce treatment capability of existing on-site treatment systems, but could completely eliminate the functionality of the system(s). At greatest risk to elevated sea level are the communities along the south shore barrier island. Not only does the water table rise significantly, but much of the land area becomes flooded, similar to a wetland as the groundwater system adjusts to the rising sea level.

As part of the Suffolk County Comp Study, the number of unsewered parcels in Suffolk County where the depth to groundwater is less than 10 feet were estimated based on the 2013 simulated water table. On a county-wide basis, it is estimated that more than 80,000 of the existing 360,000 unsewered parcels, or more than 20%, are currently located in areas where groundwater is less than 10 feet below grade. These areas should be prioritized for evaluation of appropriate wastewater management alternatives. Shallow depth to groundwater that potentially compromises septic system effectiveness will be exacerbated with increasing sea-level rise. Based on recent mid-range projections of sea-level rise, it is projected that more than 10,000 additional unsewered parcels (total of more than 90,000 parcels) may be located in areas where the depth to groundwater will be less than 10 feet by the turn of the century.

Regional Groundwater Threats

In addition to the generalized threats posed by holistic challenges such as climate change, regional threats also impact groundwater quality. This section discusses three such threats: the potential that NYSDEC public water supply permits originally issued to the Jamaica Water Supply Company will be renewed and issued to the City of New York; localized legacy contamination sites and the impacts associated with geothermal heating, ventilation and cooling systems, in depth.

Reactivation of Public Water Supply Wells in Queens County, New York

A system of groundwater pumping wells located in southeastern Queens and southwestern Nassau Counties was owned and operated by the Jamaica Water Supply Company (JWSC) between the years of 1887 and 1996. In 1996, New York City (NYC) purchased and operated the Queens County groundwater well system, supplying drinking water to a roughly 5.5 square mile (sq. mi.)area of NYC until 2007. Although the system has not operated since 2007 and an earlier NYC plan to reactivate the wells has been abandoned, NYC is seeking to reapply for groundwater use permits (which expire in 2017) through the New York State Department of Environmental Conservation for the 68 wells that make up the groundwater supply system in the Queens County area. According to NYC, the reissuance of the permits are necessary in case an emergency condition in some other area of NYC's distribution system occurs, requiring NYC to pump groundwater to make up for the deficiency. Although NYC has no plans to activate any of the wells within the system in the immediate future, the reissuance of the permits alone is cause for concern to all in Nassau County as any withdrawals from southeastern Queens County could have far-reaching impacts on water quantity and water quality in Nassau County.

NYC supplies more than 1 billion gallons of fresh water each day from large upstate reservoirs – some located more than 125 miles from City Hall – to the taps of 9 million customers. Figure 5 depicts the NYC Water Supply System.

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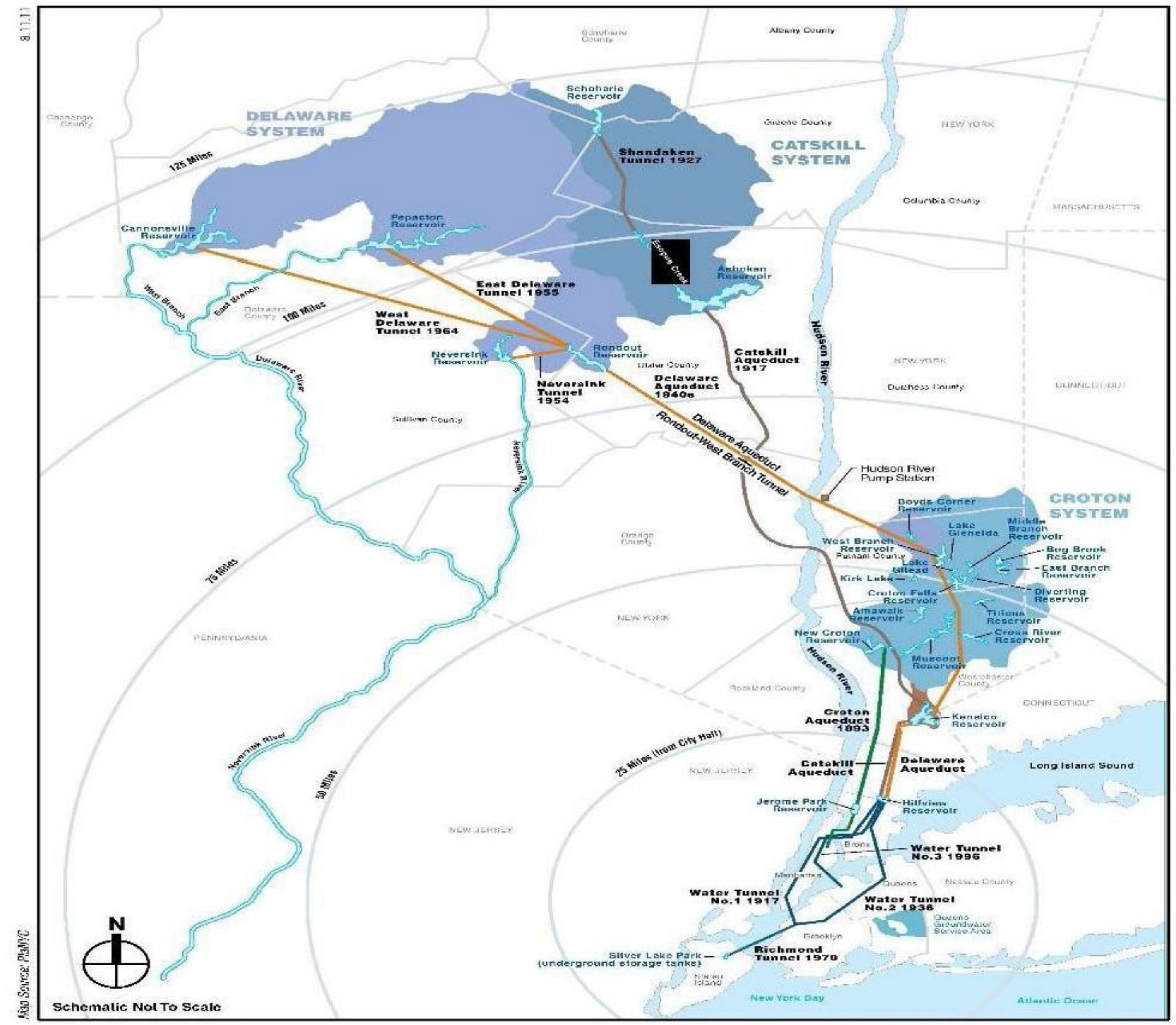
Figure 5 - New York City Water Supply System



A small area of southeastern Queens and Nassau Counties was serviced by a system of 68 groundwater wells at 44 well stations and several water storage tanks between the years of 1887 and 1996 by the Jamaica Water Supply Company.

Figure 6 - NYC Queens Groundwater System

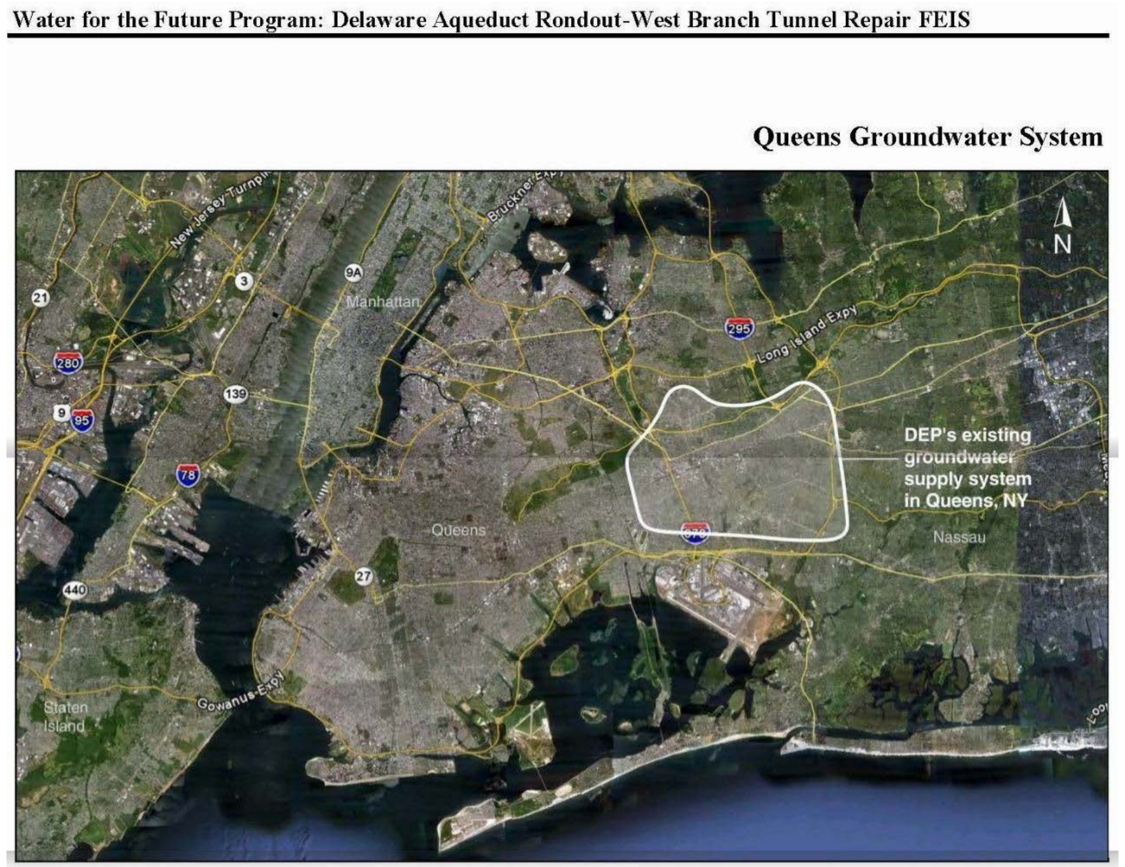
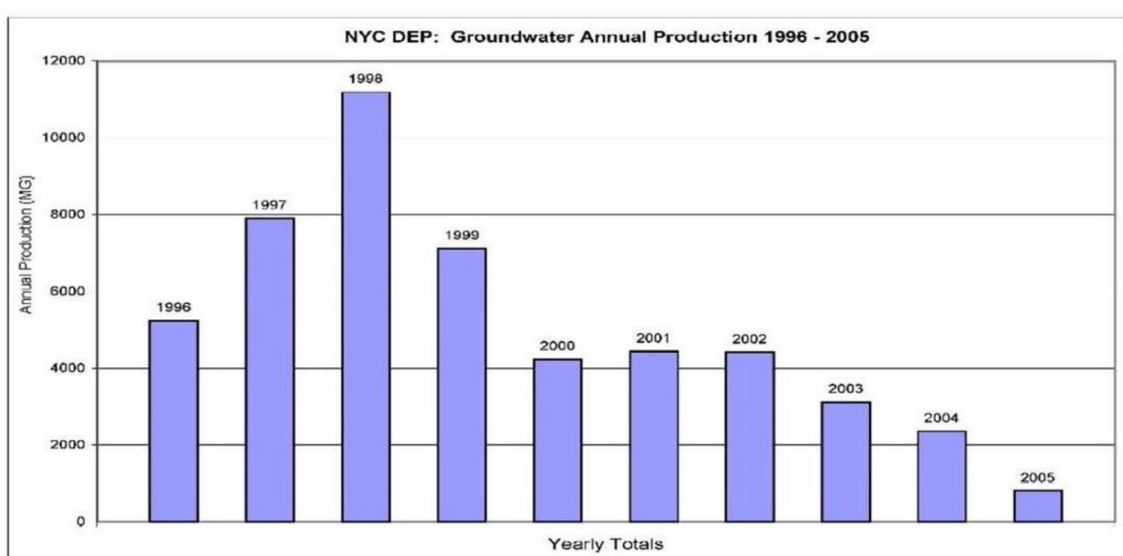


Figure 7 - NYC Groundwater System Annual Production 1998-2005



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Since the 1990s, NYC has been monitoring leaks in the Delaware Aqueduct reservoir and tunnel system where as much as 35 million gallons per day (MGD) has been leaking from the system. A series of repairs was proposed to be conducted by NYC between the years of 2013-2020 that would result in the construction of a bypass tunnel combined with other system components and initiatives to account for the 500 MGD necessary to make up the difference while the portion of the Delaware Aqueduct system was shut down and repaired. One of the proposed components was the reactivation of the Queens County groundwater well system. The proposal included reactivating 23 wells at 20 well stations in order to provide 33 MGD with a total capacity of 40 MGD to include redundancy. The wells would pump from the Glacial (two stations), Magothy (16 stations), Jameco (one station) and Lloyd (four stations) Aquifers. NYC has indicated that, from an economic and volumetric perspective, it would have to invest more than $200 million in order to restore enough wells and well stations to provide 40 MGD.

As discussions of the plans for the reactivation of the Queens County groundwater well system and the potential for negative impacts to Nassau County's water resources became more publicized, NYC was made aware of Nassau County's opposition and significant concerns. In June 2015, NYC decided to abandon the concept of utilizing the Queens County groundwater well system to supplement the reservoir system during the Delaware Aqueduct repair and will utilize other means to make up the water shortage. Although NYC has abandoned the groundwater withdrawal proposal from the overall plan to repair the Delaware Aqueduct system, NYC is still seeking to have the NYSDEC reissue the well permits in case future emergency conditions warrant the reactivation of the groundwater well system in any fashion.

There have been a number of studies conducted over the last 50 plus years examining the use, impacts and potential reuse of the groundwater aquifer system beneath Queens County. The theme of these studies have concluded that, without stringent management, the resource could become useless due to salt water encroachment or other type of contamination. There is particular sensitivity toward the use of the Lloyd Aquifer, the deepest confined aquifer and only source of fresh water for the barrier beach communities around Long Beach in southwest Nassau County. Similarly, concerns raised from the northwestern Nassau County water suppliers on Manhasset Neck and the Port Washington peninsulas have publicized the importance of further study and evaluation of the impacts of re-energizing the Queens County groundwater well system. Historically, measured groundwater elevations have shown that significant cones of depression develop during periods of groundwater pumping from eastern Queens County wells. These cones of depression, as much as 40 feet below sea level, can cause changes in groundwater flow direction, rate of movement and salt-water intrusion potential as well as changing known groundwater contamination plume migration. Although the wells have not pumped since 2007, and the consideration to reactivate the wells during a perceived emergency has been removed for now, NYC is moving forward with a plan to have all the well permits reissued. NYC currently is developing a scope for a Draft Environmental Impact Statement (DEIS) for the reissuance of the well permits. There is serious concern that, without updated hydrogeological framework information, the same assumptions will be made when utilizing and running a groundwater flow model to determine impacts of groundwater withdrawals. Without even a basic acknowledgment of where the current position of the fresh water-salt water interface is in the various aquifers, it would be highly unlikely that a groundwater flow model can accurately predict how and where it will move.

The United States Geological Survey has proposed a project to evaluate the hydrogeologic framework, groundwater availability and water supply sustainability in western Long Island. The need for further study, including the installation of additional monitoring wells drilled to bedrock, before allowing the well permits in Queens County to be reissued, is paramount and needs to be conducted as soon as possible. Recent developments regarding funding this study to be conducted by the USGS have been made public through a February 21, 2016 announcement by the New York State Governor's Office. The announcement detailed the allocation of $6 million toward the study of Long Island's aquifer system. Specific details on how the funds will be distributed between several projects have not been made available yet, but funding the additional study of water availability and impact of groundwater withdrawals from the Queens County groundwater wells is of the utmost importance.

The reissuance of these permits requires the preparation of a DEIS, which is currently in the scoping phase. Given the uncertainty of a number of key parameters needed in order to make the proper decisions regarding the operation and use of the Queens County groundwater well system, further study of the hydrogeologic framework and position of the fresh water-salt water interface, including the development of a groundwater model that will predict its movements in response to groundwater withdrawals, must be conducted immediately. Regardless of the outcome of the study, the protection of the Lloyd Aquifer must be further enhanced by eliminating the potential for any additional withdrawals of water from the Queens County groundwater well system going forward.

The reactivation of NYC Lloyd Aquifer supply wells, which have not been used for extended periods in areas where other cost-effective sources of water supply are available, will promote increased salt water intrusion. This will be the case in Queens County if the NYCDEP reactivates four Lloyd Aquifer public supply wells that pumped an average of 4.1 MGD of water from 1920-1995 (for a total withdrawal of 112 billion gallons) and where a 20 foot depression in the potentiometric surface of the aquifer resulted (Cartwright, 2002). This depression extended into western Nassau and eastern Kings Counties. This over-pumping occurred in Queens County where there are combined sewers that discharge stormwater and sewage to treatment plants with outfalls to the surrounding water bodies. In these areas, groundwater recharge by precipitation is vastly reduced and the major source of recharge water to the aquifer is leakage from water supply and sewer lines (Buxton and Smolensky, 1998).

Regional Contamination Threats

These types of challenges are largely influenced by historic land use, development and industrialization. More than 250 hazardous waste sites have been identified on Long Island. The United States Environmental Protection Agency and the New York State Department of Environmental Conservation have identified approximately 145 inactive hazardous waste sites in Nassau County and 109 sites in Suffolk County.

Many of the sites can be considered legacy sites where soil and groundwater contamination related to former industrial activities have been affecting the environment for more than 75 years. Many of the older sites and their associated contaminants have become well known to local governments, water suppliers and regulatory agencies. These sites have been listed and studied to varying degrees over the years.

The historic and current formation of groundwater contamination plumes associated with these sites and their movement within Long Island's aquifer system have impacted both public and private drinking water wells and continue to present a significant threat to many of Long Island's public water supplies. The contamination of drinking water supply wells results in greater risk to public health, increased cost to produce potable water and lower consumer confidence that the tap water is safe to use. Proper assessment and remediation of this threat requires increased monitoring of groundwater quality and pumpage from

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all sources. This information, in turn, can be used to expand the effective use of state-of-the-art modeling techniques currently under development by the United States Geological Survey and others.

Nassau County

Regional groundwater contamination in Nassau County has been well documented in recent years. More than 145 inactive hazardous waste sites are known to exist on both the federal National Priorities List (NPL) and New York State Superfund lists. Although there are many smaller sites that have been documented and, in some cases remediated, a significant regional threat to local groundwater and public supply comes from long-lived legacy sites. These sites contaminated soil and groundwater as part of industrial activities related to war time production and post-war expansion and commercialization within Nassau County. Historic contamination began at many of these sites due in large part to the lack of public sanitary sewer systems in place at the time of operational discharges associated with production and manufacturing. In most cases, the utilization of on-site sanitary and drainage systems, coupled with prolonged, unregulated discharges of significant quantities of volatile organic and inorganic contaminants, resulted in the discharge of these contaminants into on-site sanitary systems and the ultimate migration of these contaminants once they reached the groundwater table. The resulting contamination caused the formation of groundwater plumes, which developed first in the Upper Glacial Aquifer and then migrated horizontally and vertically (dependent on chemical properties of specific contaminants) to deeper portions of the Magothy Aquifer. Groundwater plumes on Long Island have been documented at depths of greater than 500 feet and have achieved lengths greater than a mile in the direction of groundwater flow.

In many cases these historical or legacy sites and their associated source areas and contaminants are known. However, the full extent of the problem often is not. These sources have manifested for decades, even after discharges have ceased. Plumes that have been mapped during early stages of most remedial investigations (RI) are continuously modified by the effects of natural groundwater flow and, more significantly, groundwater pumpage, primarily driven by summer water demand for irrigation. The depth and area impacted can change significantly even through the preparation of site feasibility studies (FS), the issuance of records of decision (RODs) and, finally, the construction and implementation of remedial actions.

The location and extent of these contaminants are routinely influenced or altered by pumping of nearby industrial, cooling and public water supply (PWS) wells. The ever-increasing density of these wells in Nassau County, a function of population density, makes this problem particularly acute when compared to Suffolk County, a county of equivalent population having a land area that is three times the size of Nassau County. Currently, there are six large legacy sites in Nassau County, which are undergoing further study and ongoing remediation of soil, soil vapor and groundwater. They include the following sites and the agencies responsible for their remediation:

- Old Roosevelt Field (USEPA).
- Grumman Corporation/United States Navy at Bethpage (NYSDEC).
- Fulton Avenue Industrial Area at Garden City Park (USEPA).
- New Cassel Industrial Area (USEPA).
- Lockheed Martin at Lake Success (NYSDEC).
- Old Bethpage Industrial Area (USEPA and NYSDEC).

Suffolk County

Regional groundwater contamination in Suffolk County also has been influenced by land use and development but, to a much lesser degree, by industrial activity. An agrarian-based economy lasted much longer in Suffolk County well into the late 1960s and 1970s. Contamination related to farming, specifically the presence of pesticides and herbicides in soil and groundwater, was common on the east end of the county in the early to mid-1980s (when the first pesticide detected, aldicarb, was documented to cause contamination of groundwater and private wells). Contamination related to the construction of new homes and associated cesspool effluent has led to regional issues involving nitrogen pollution and the spread of nitrates in shallow groundwater and estuarine environments in Suffolk County (and, to a lesser extent, in some of the shorefront communities that remain unsewered along the north shore of Nassau County).

Discussion and Status of Nassau County Legacy Sites

The first major effort at identifying contaminated aquifer segments in Nassau County was undertaken as a collaborative effort between the Nassau County Department of Health (NCDOH) and the Nassau County Department of Public Works (NCDPW) under a contract with Dvirka and Bartilucci Consulting Engineers. This effort ultimately produced a June 1986 report titled, Investigation of Contaminated Aquifer Segments – Nassau County, New York. In this report, five separate and distinct areas of volatile organic compound contamination were identified conclusively in the aquifers beneath New Hyde Park, Garden City Park, New Cassel (Westbury) and the west and north Hicksville areas. This was in addition to the Old Roosevelt Field site, the Grumman Corporation/United States Navy and Ruco site and the former Sperry/Unisys/Lockheed Martin sites that were already known to have significant VOC contamination in groundwater beneath those sites. Based on this report, the NYSDEC conducted multiple preliminary site investigations in each of the areas identified and listed many sites that were subsequently included in their "Registry of Inactive Hazardous Waste Disposal Sites in New York State":

Old Roosevelt Field (USEPA) – Site No. NYSFN0204234

The USGS, the NCDOH and the NCDPW collaborated on the investigation of this site during the early 1980s subsequent to the identification of VOC contamination in several private wells located in this area. The USEPA initiated the most recent investigation of subsurface conditions in 2010. This investigation resulted in the mapping of new portions of a deeper Magothy Aquifer plume and the installation of a small treatment plant to address additional source area contamination along the western edge of the current Roosevelt Field Mall complex. This location is considered to be the area of that site with the highest remaining levels of groundwater contamination by VOCs, primarily trichloroethene (TCE). Additional contamination was discovered further down- gradient and is suspected to be the source of TCE contamination impacting the Village of Hempstead PWS wells. Portions of the aquifer located east of this primary source area are still under investigation. The NCDPW and the NCDOH have supported this additional investigation and strongly agree with the need for additional wells to further define the vertical and horizontal extent of contamination emanating from other unknown sources located on the Old Roosevelt Field property.

The long travel time (60-70 years) associated with any potential releases from the Old Roosevelt Field site, coupled with the intensive and varied groundwater pumpage (public supply, heating and cooling, industrial and remedial) in the area, has the potential to move and distribute VOC contaminants throughout large portions of the Magothy Aquifer. Water suppliers impacted by this groundwater contaminant plume include the Village of Garden CityWater Department, the Village of Hempstead Water Department and the Town of Hempstead Water Department (Uniondale). A repository of information relative to this investigation can be found at www.cumulis.epa.gov/supercpad/cursites/csitinfo.cfm?id=0204234.

Grumman Corporation/United States Navy at Bethpage (NYSDEC) – Inactive Hazardous Waste Site No. 130003

Nassau County was one of the first areas in the United States to study the presence of VOCs in groundwater. In the early 1970s, employees at the Grumman Aerospace and Naval Weapons Industrial Reserve Plant (NWIRP) in Bethpage, New York noticed an unusual taste and odor emanating from water faucets located on the site. At this time, Grumman operated its own water supply system and was not connected to the Bethpage Water District. The taste and odor condition was reported to the New York State and Nassau County Health Departments. Testing by Grumman and these health agencies confirmed that the Grumman water well system was contaminated by trichloroethene (TCE). In 1976, Grumman then asked the Bethpage Water District to permit connection to the public water supply. After 1976, the Grumman on-site water supply wells were no longer used for potable supply, but continued to be used for industrial and cooling purposes. All potable water use at the Grumman facility was then connected to the Bethpage Water District.

Following the initial discovery of the problem in the 1970s, the site was subsequently listed in the Registry of Inactive Hazardous Waste Sites in New York State in 1983. The original Site No. 130003, as defined, did not include Bethpage Community Park (a donated section of the Grumman Corporation property). Subsequently, on March 10, 1993, the Grumman Aerospace Bethpage Facility Site (#130003) was acquired by and divided into the Northrop Grumman- Bethpage Facility Site (#130003A) and the Naval Weapons Industrial Reserve Plant Site (#130003B). During the early 1990s, many portions of the Northrop Grumman-Bethpage Facility Site (#130003A) were delisted as the investigation of area was completed. However, soil vapor issues were not studied at these formerly delisted areas until the NYSDEC addressed these issues under a legacy site policy directive in 2006. This directive required the NYSDEC to investigate previously delisted sites that did not address the soil vapor intrusion pathway of possible human health exposure.

Since the mid-1970s, the original groundwater contamination plume emanating from the site has plagued and threatened the sole-source aquifer system that provides water for nearly a quarter of a million people in southeastern Nassau County. Two separate plumes of VOC contamination and at least one groundwater hotspot release from the source area have resulted in the formation of a significant larger off-site groundwater plume that has impacted both the Upper Glacial and Magothy Aquifers. These two contamination plumes have become co-mingled south of the Grumman Corporation site. Some of the contamination extends to a depth of 550 feet below grade and appears to be approaching the BethpageWater District No. 4 well field.

One of the largest and most complicated and concentrated groundwater contamination plumes in the country, the NWIRP plume has grown to 4 miles long, 2 miles wide and 800 feet deep over the past 30 plus years. Additional groundwater investigations currently are underway to help determine both the lateral and vertical extent of contamination, but years of exhaustive studies have done little to mitigate and remediate this massive plume. Clearly, the current regulatory framework is insufficient in marshalling the resources necessary to compel the responsible parties to resolve this environmental disaster. The consequence has been an admittance that treating the contaminated water at the drinking water wellhead was the preferred approach to protecting public health. Preventing the contamination from getting to the wellhead has been routinely dismissed in the regulatory process. This regulatory approach to responding to groundwater contamination must end. Wellhead treatment must be an action of last resort. If not, the protection of public health will always be at risk as the contamination was permitted through the regulatory process to reach the wellhead and only a water treatment barrier exists as the measure between public health protection and public health crisis.

The NWIRP groundwater contamination plume, as well as all other contamination plumes that impact the sole-source aquifer on Long Island, must be remediated to lessen the impact to already impacted public supply wells and protect against the impact to currently unimpacted supply wells. Regulations must be put in place to make wellhead treatment an option of last resort and strengthen the regulatory enforcement capability to make the responsible parties fully responsible, and if improper action is taken, allow the state to take action and the costs fully borne by the responsible parties. Therefore, LICAP fully supports the strategic containment of this massive groundwater plume to minimize future impacts to public supply wells.

Water suppliers impacted by this groundwater contaminant plume include the Bethpage Water District, the South Farmingdale Water District, the Town of Hempstead Water Department (Levittown) and New York American Water (Seamans Neck well field). Additionally, this plume of contamination is threatening, but has not yet impacted the Massapequa Water District, based on its southerly migration pathway and data that confirms the plume is approaching Massapequa. A repository of information relative to this investigation can be found at www.epa.gov/region02/waste/fsgrumm.htm,www.dec.ny.gov/press/ 101689.html, and www.dec.ny.gov/chemical/8431.html.

Fulton Avenue Industrial Area at Garden City Park (USEPA) – Site No. NY0000110247

The Fulton Avenue site (150 Fulton Avenue, Garden City Park) is a former fabric cutting mill that operated from 1965-1974. Discharges from this operation resulted in both soil and groundwater contamination. Soil contamination at the site has been addressed through excavation, removal and treatment of contaminated soils in the vicinity of an on-site drywell. Following excavation, any remaining soil contamination was addressed using an interim remedial measure (IRM). Thismeasure involved the use of an air sparging/soil vapor extraction (AS/SVE) system that operated from October 1998-November 2001. In early 2004, a sub-slab ventilation system was installed beneath the building as a protective measure to remove any remaining VOC-enriched soil gas.

The primary groundwater contaminant in this plume contaminant was tetrachloroethylene or perchloroethylene. This contamination is subject to additional source control that will be provided by in-situ chemical oxidation and a groundwater extraction and treatment system. A second plume of VOCs, primarily composed of trichloroethene and not associated with activities at this site, was subsequently discovered. The control of on-site groundwater contamination and the investigation of the second plume of trichloroethene is the focus of additional investigation and remediation. The Village of Garden City Water Department, the Franklin Square Water District, the Water Authority of Western Nassau and the Village of Mineola Water Department all are affected by this groundwater contaminant plume. A repository of information relative to this investigation can be found at www.cumulis.epa.gov/supercpad/cursites/csitinfo.cfm?id=0203853&msspp=med.

New Cassel Industrial Area (USEPA) – Site No. NY0001095363

The New Cassel Industrial Area was first identified as a source of VOC contamination of soil and groundwater as part of the 1986 joint Contaminated Aquifer Segment (CAS) Study. The results of the 1986 study determined that the New Cassel Industrial Area had “extensive and substantial” contamination of groundwater. Total volatile organic compound (TVOC) contamination in groundwater collected from the 35 wells installed during the investigation ranged from 1,000- 10,000 parts per billion. Sampling results obtained from up-gradient monitoring wells appeared to isolate the industrial area located south of the Long Island Rail Road (LIRR) and north of Old Country Road as a potential source area for the detected organic compounds. The VOCs associated with this industrial source were detected within the Magothy Aquifer at depths greater than 250 feet. A potential threat to the Bowling Green Estates public supply wells (part of the Town of Hempstead Water Department) was recognized at the completion of the study, and the wells were subsequently found to be contaminated and require treatment to meet drinking water standards.

In 2010, the NYSDEC requested that the USEPA list the site on the federal Superfund NPL and it was listed subsequently in September 2011. After the listing, site investigations to determine the nature and extent of contamination and to identify and evaluate possible remedial alternatives resumed. The New Cassel/Hicksville groundwater contamination site continues to be an area of widespread groundwater contamination in the Towns of North Hempstead, Hempstead and Oyster Bay. Sampling of public supply wells identified contaminants in four Town of Hempstead PSW, six Hicksville Water District PSW and one Village of Westbury Water Department PSW. The primary contaminants observed in groundwater at the site include PCE, TCE and other VOCs. Consistent with the federal Safe Drinking Water Act that protects public water supplies throughout the nation, public water suppliers in the area of the New Cassel site monitor water quality regularly and have installed treatment systems to remove VOCs from the groundwater. A repository of information relative to this investigation can be found at www.epa.gov/Region2/superfund/npl/newcassel/index.html.

Lockheed Martin (former Unisys site) at Lake Success (NYSDEC) – Inactive Hazardous Waste Site No. 130045

The former Unisys site is located in the Village of Lake Success. The 94-acre site is bounded by Marcus Avenue to the north, Union Turnpike to the south, Lakeville Road to the west and The Triad Office Park to the east. This facility was an active aerospace and defense systems manufacturing facility from its start-up in 1941 until approximately 1995, when most manufacturing activities ceased. However, some limited production activities continued at the facility until 1999. Groundwater had been used for non-contact cooling purposes since the facility was constructed. The non-contact cooling water system consisted of three extraction wells and four diffusion wells that were located to the north and south of the main manufacturing building, respectively.

Past manufacturing processes include casting, etching, degreasing, plating, machining and assembly. Chemicals used during manufacturing at the facility included halogenated solvents, cutting oils, paints, fuel oils, plating compounds and associated metals. The facility had five drywells located near the southeast corner of the main building. These drywells were used to dispose of water containing solvents and oils from approximately 1941-1978. Additionally, on-site recharge basins also were contaminated with plating solutions that contained metals but which were mostly filtered out by soils in those basins.

A ROD was issued for the site in March 1997 and groundwater treatment was initiated in 2002. The treatment plant consists of three groundwater extraction wells operating at a combined flow rate of approximately 725 gallons per minute (GPM). Additional investigation and treatment of the off-site area beyond the property boundary where contaminants and groundwater have migrated was required. Eleven active PSWs are located off-site, nine which draw water from the Magothy Aquifer and two which draw from the Lloyd Aquifer. Four inactive PSWs also are located off-site in the plume vicinity as are six active irrigation wells. Generally, groundwater flow in this area is north-northwest; however, public supply and irrigation wells operating in the area have altered local groundwater flow direction.

The primary site-related groundwater contaminants of concern are numerous VOCs including Freon 113. Another groundwater plume originating from the nearby 400 Lakeville Road site (Site No. 130176) is known to contain Freon 22 and co-mingles with the Unisys groundwater plume. During the remedial investigation of the off-site plume, it became apparent that VOCs in the groundwater north of the former Unisys site were present at a location and depth where a large portion of the contaminants could be removed by an additional IRM. An IRM groundwater treatment plant was designed and constructed and began operation in 2006.

Groundwater migration from this site has resulted in a significant off-site groundwater plume that has impacted both the Upper Glacial and Magothy Aquifers and has affected nearby public supply and golf course irrigation wells. The Lloyd Aquifer has not been impacted. Several of these public supply wells have treatment systems in place to assure that the supplied water meets all drinking water standards.

Recent activities at the site during July 2014 call for an amendment to the original site remedy prepared in 1997 and the development of a proposed remedial action plan (PRAP). The final remedy proposed for the off-site groundwater contamination that has migrated from the site included:

- The continued operation of the existing 500 GPM IRM groundwater extraction and treatment system.
- Upgrading the current 730 GPM groundwater remediation system by the installation of a new 120 GPM extraction well to collect and treat an additional volume of groundwater to bring the total system up to 850 GPM.
- Implementation of a Public Water Supply Protection and Mitigation Program that includes:
  - ◊ An installation, operation and maintenance plan for PWS wellhead treatment systems on wells affected by site-related contamination, now or in the future, to assure that drinking water standards are achieved.
  - ◊ A response plan that will be implemented if site-related contaminant concentration(s) in the sentinel well(s) approach or exceed site-specific action levels.
  - ◊ Development of a site management plan approved by the NYSDEC and operation of a treatment system on the Lake Success irrigation well should it be used again.

Water suppliers impacted by this groundwater contaminant plume include the Manhasset/Lakeville Water District and the Water Authority of Great Neck North. A repository of information relative to this investigation can be found at www.lockheedmartin.com/content/dam/lockheed/data/corporate/documents/remediation/great- ne ck/fact-sheet-june2014.pdf.

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Old Bethpage Industrial Area (USEPA and NYSDEC) – Inactive Hazardous Waste Site No. 1-30-171

The site is located in both the Town of Oyster Bay in Nassau County and the Town of Huntington in Suffolk County. The Nassau-Suffolk County boundary bisects the site in a north-south direction. Of the 33 commercial properties that comprise the site, 17 are in Nassau County and the remaining 16 are in Suffolk County. Most of the properties are located along Bethpage-Sweet Hollow Road, Spagnoli Road, Winding Road and Hub Drive. The site is located in a mixed commercial and industrial area and is approximately 230 acres. Most of the buildings on the Nassau County side were built between 1963-1973, while the structures on the Suffolk County side were constructed between 1969-1979.

In January 2006, at the seventh year of operating the groundwater treatment system (more than 1,362,111,408 gallons of contaminated groundwater treated) for the remediation of the VOC related to operations at the Nassau County Fire Service Academy (Nassau County Fireman's Training Center, FTC), NCDPW concluded that four of the seven operating FTC off-site recovery wells had been impacted by sources other than the FTC. These wells were located in the eastern portion of the recovery well network and exhibited the following characteristics: they were not hydraulically downgradient of the FTC, and influent from these recovery wells regularly contained VOCs that were not common to the FTC plume.

As a result, the commercial/industrial properties located in the Old Bethpage Industrial Area were investigated as potential up-gradient sources. Following a cooperative review of existing NCDOH records, it was determined that six properties on the Nassau County side of the site had stored and used halogenated solvents. A record search and site reconnaissance, conducted by Malcom Pirnie, Inc. on behalf of the NYSDEC in 2008, revealed that 11 companies had used similar compounds on the Suffolk County side of the site.

Malcolm Pirnie, Inc. conducted a full investigation of environmental conditions in the industrial area, including analysis of soil, soil vapor and groundwater and completed a Site Characterization Report – Old Bethpage Industrial Area Plume Trackdown, Oyster Bay and Huntington NY, Site #1-30-171, September 2009. Volatile organic compounds were detected in soil gas and groundwater samples at multiple locations. These compounds included, but were not limited to, PCE, TCE and chlorofluorocarbon (CFC-113). However, many of the detected compounds were found at levels below applicable standards in groundwater.

The investigation resulted in the listing of one site – American Louvre, Inc., 301 Winding Road, Old Bethpage. The site was found to have elevated levels of halogenated compounds, including TCE and PCE in both soil and groundwater. A ROD was issued for onsite contamination in March 2013. The selected treatment technologies include: soil removal, in-situ thermal treatment, air sparging and soil vapor extraction. Subsequent investigation of groundwater conditions in the area indicates that the groundwater plume of organic compounds emanating from the American Louvre site is not the source of volatile organic compounds previously observed in both Town of Oyster Bay and NCDPW recovery wells. These organics are from an unknown source(s) located to the east and north of the former Claremont Polychemical site, Old Bethpage Solid Waste Disposal Complex (Town of Oyster Bay landfill) and the Nassau County Fire Service Academy, and form a plume that extends more than 5,000 feet in length. This plume is still being investigated as it presents a potential threat to the Village of Farmingdale public supply wells. A repository of information relative to this investigation can be found at: https://nepis.epa.gov/Exe/ZyPURL.cgi?Dockey=P1000YCG.txt.I

Localized Groundwater Threats

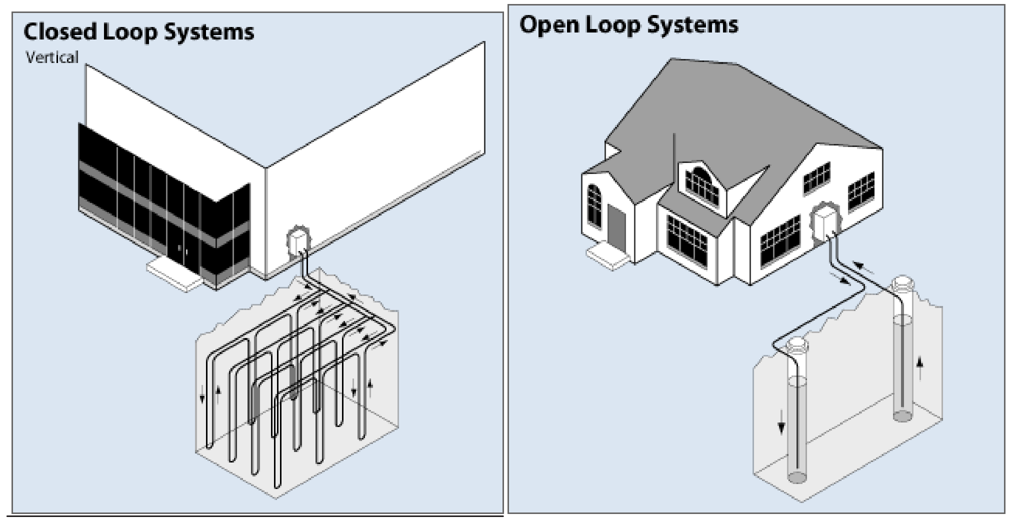
Geothermal Heating, Ventilation and Air Conditioning Systems

Geothermal heating, ventilation and air conditioning systems utilize geothermal heat pumps (GHPs) that tap into its cool naturally occurring ground temperatures for energy-efficient space heating and cooling. GHP systems represent less than 1% of all the heating, ventilation and air conditioning (HVAC) systems in use on Long Island, although they are expected to grow in the future. They presently make up a high percentage of the HVAC systems installed in new homes in some communities (Southampton and Laurel Hollow, for example). These systems pose localized groundwater quantity and quality threats, and this section provides a general description of the technology, presents the major questions and concerns and provides recommendations to addresses the risks, raise awareness and improve understanding by the stakeholder community.

Background Information

Geothermal is a technology that taps into the cool naturally occurring ground temperatures that exist in Long Island's aquifers for energy-efficient heating and cooling and, in some instances, domestic hot water heating. Utilizing this technology for HVAC systems provides an alternative to conventional fossil-fuel based furnaces used for heating as well as chillers, cooling towers and window air conditioning units used for conventional cooling systems. The primary difference between a GHP system and a conventional HVAC system is the use of two distinct components: 1) one or more GHPs are installed inside the building, and 2) a ground coupling, or ground heat exchanger (GHE) is installed in the ground next to the building. Mechanical piping and ductwork inside the building are like a conventional HVAC system. A GHP system essentially couples the building's HVAC system to the ground. Groundwater temperatures on Long Island range between 50-55 degrees F and provide a consistent and moderate temperature source of energy for heating and an energy sink for cooling. The two main types of GHEs in use on Long Island utilize either standard water wells (open loop system) or high-density polyethylene (HDPE) plastic loops (closed loop system). Both are routinely installed to depths of up to hundreds of feet deep in vertical drilled boreholes. Another type of GHE known as a direct exchange (DX) system is used but is uncommon on Long Island.

Figure 8 - Types of Geothermal Systems



There is a general lack of understanding about how GHP systems work and are installed and operated. There also have been instances in which GHP systems have failed or locally impacted the aquifers on Long Island, which has resulted in a general concern of local municipal and regulatory agency staff, members of the public and some members of the Long Island Commission for Aquifer Protection over their use. This report addresses the major questions and concerns, which include:

- Gaps in regulatory and inspection responsibility for certain aspects and types of systems. For example, closed loop systems are largely unregulated in New York State, including Long Island.
- Lack of documentation of locations of some type/size systems.
- Potential impacts on other groundwater users, ecological resources, surface water bodies and wetlands and on the groundwater resource, in general.
- Aggregate hydraulic and thermal effects on the aquifers from high concentration of many small GHP systems installed near each other, e.g., suburban environments.
- Increases in regional groundwater temperatures from extended operation of large air conditioning-only facilities (e.g., Roosevelt Field Mall/Mitchell Field complex).
- Potential cross contamination of aquifers by pesticides, herbicides and any other contaminant spilled on or in the general vicinity of the property during drilling through confining clay units.
- Potential contamination of the aquifer from return water in open loop systems containing refrigerants (e.g., Freon contamination in northern Nassau County).
- Potential contamination of groundwater by the working fluid in closed loop boreholes from leaks in the plastic piping.

State of the Geothermal Industry on Long Island

On Long Island, open loop GHP systems have been used for over a century for air conditioning and industrial and municipal process water cooling uses. The advent of the reversible heat pump in the 1960s allowed for the combined heating and cooling of buildings employing open loop wells and, more recently, closed loop GHEs.

There are roughly 4,000-5,000 operating GHP systems in use in Nassau and Suffolk Counties, with roughly 70% open loop and 30% closed loop. Figure 9 shows the locations of systems that have received Public Service Enterprise Group (PSEG) rebates (both open and closed loops) and open loop systems permitted by New York State Department of Environmental Conservation under the Long IslandWell Permit (LIWP) program in Suffolk County GHP systems represent less than 1% of all the HVAC systems in use on Long Island. However, in certain communities (Southampton and Laurel Hollow, for example) GHP systems may represent 50-70% of the HVAC systems installed in new home construction.

GHP systems offer numerous benefits to Long Island residents and business owners. Despite their higher first cost compared to conventional HVAC systems, the GHP market on Long Island is expected to grow in the future. Various levels of state government, including the New York State Energy Research and Development

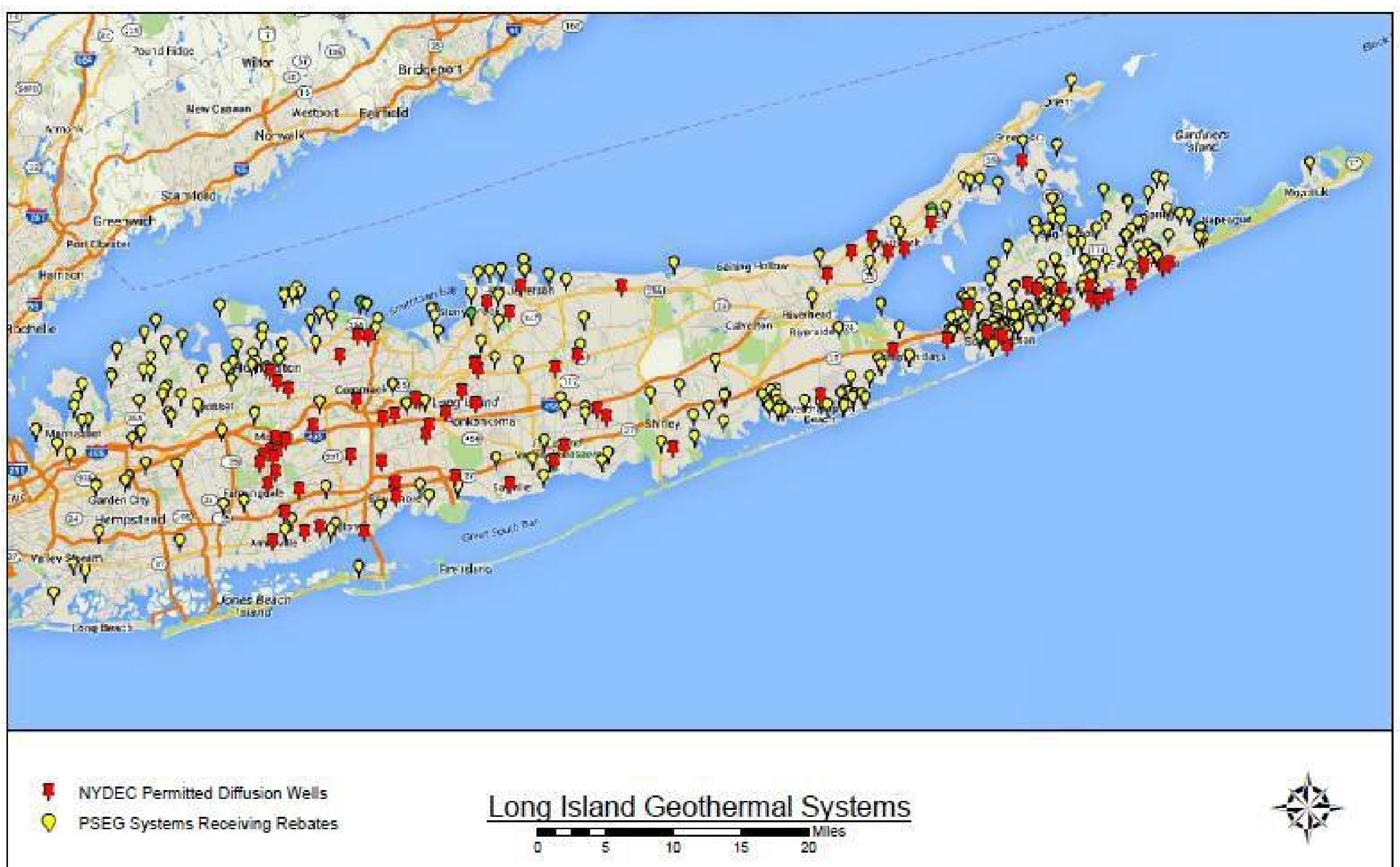
Authority (NYSERDA), the New York State (NYS) Governor's Office and the Public Service Commission (PSC), PSEG, the NYS Legislature and Suffolk County have recognized that GHPs can play an important role in the state's goal to increase building efficiency and reduce energy consumption and greenhouse gas (GHG) emissions. On a local level, GHPs are the preferred alternative to oil and electric resistance heating in the Cleaner Greener Long Island Regional Sustainability Plan.

More widespread adoption of GHP systems benefits Long Island's electric provider, PSEG, in numerous ways, which translate to lower electric costs to ratepayers, including:

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

However, as noted above, there are numerous potential risks to the groundwater system that can result from widespread and unregulated use of geothermal systems. These potential risks are discussed in this report.

Figure 9 - Map of GHP Systems on Long Island



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LICAP Long Island Commission for Aquifer Protection

Geothermal Heat Pump System Components

Geothermal heat pumps are mechanical devices that transfer heat between the GHE and the building spaces to be conditioned. A GHP is essentially a reversible chiller that can both cool and heat a building. Being all electric systems, GHPs eliminate the use of fossil fuel-based boilers and the particulates and GHGs they emit. The two main types of GHPs are water-to-air and water-to- water heat pumps. A water-to-air heat pump heats or cools air that is ducted to and from the interior spaces. Water-to-water heat pumps produce chilled or hot water that is circulated to fan coil units for cooling or to radiant floor systems or fan coils for heating. A device called a de- superheater or dedicated GHPs can be utilized to heat domestic hot water.

Ground heat exchangers (GHE) are the in-ground, buried part of a GHP system where heat is transferred between a circulating heat transfer fluid (HTF) and the ground by the difference in temperature between the fluid and the ground. Depending on system type, the HTF is groundwater, fresh water, a fresh water/ antifreeze mixture or refrigerant.

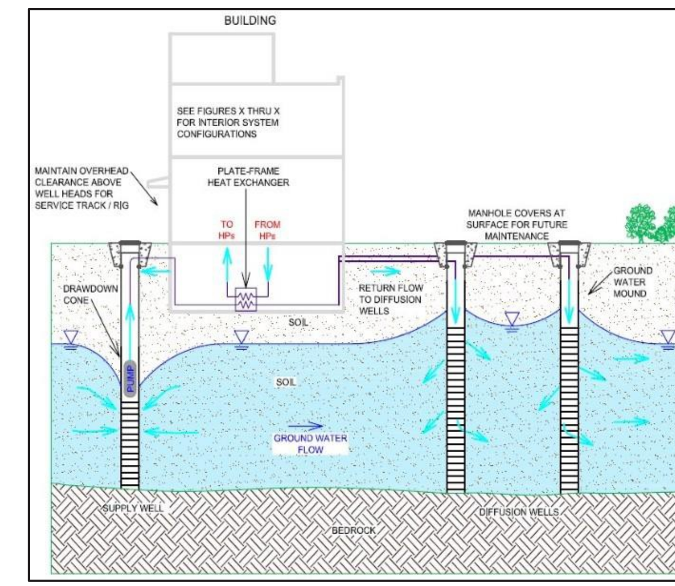
GHP Types

The predominant types of GHEs in use on Long Island are vertical closed loop boreholes and open loop systems, as described in the following.

Open Loop Systems

Open loop systems withdraw ambient temperature groundwater from a standard supply well(s), passes the groundwater directly through the GHPs and returns the temperature-altered water back into the aquifer via a return, or diffusion, well(s). Some system designers add an intermediate plate-frame heat exchanger (HX) to separate the building piping system and components from the groundwater (Figure 10). The open loop system is one of the more common systems found on Long Island due to the highly productive aquifers. Well depths depend on the local hydrogeology. Wells must be sized to supply and return to the ground a consistent 1.5-3 GPM per ton of cooling or heating load (Note: a ton equals 12,000 British thermal units or BTUs per hour of heating and cooling demand).

Figure 10 - Open Loop System



Despite misperceptions to the contrary, the daily and seasonal temperature range of the circulating HTF used in GHP systems is not constant, but varies by system type. An open loop system operates by pumping groundwater at its stable natural temperature. However, the return water temperature is typically 10-15 degrees F colder during winter heating and 15-30 degrees. F warmer during summer cooling than the ambient groundwater temperature (see Table 1). The groundwater passes once through the system.

For large open loop systems, research of local hydrogeology and groundwater testing are advisable to select well depths and gather data for proper well design. For systems requiring a LIWP (pumping rate >45 GPM; see Open Loop Systems under Chemical Effects), the NYSDEC reviews the site relative to the presence of and potential impacts to wells on adjoining properties, nearby ecological resources, groundwater contaminant plumes or the fresh water-salt water interface (coastal sites). In certain cases, the NYSDEC may require site testing, which could include a test well, pumping test and appropriate hydrogeologic analysis and/or groundwater modeling as part of the permitting process to demonstrate that there will be no impacts to these resources.

Table 1
Typical Temperatures of Heat Transfer Fluid

GHE	Heat Transfer Fluid	Summer Operation Temperature Range	Winter Operation Temperature Range	Remarks
Closed Loop	Water or water and antifreeze mixture	60-90 deg. F	30-45 deg. F	Typical ΔT between supply and return water is 5-10 deg. F. Antifreeze is required if winter operating temperatures will drop below 32 d
Open Loop	Groundwater	50-55 deg. F from supply well (ambient), 65-80 deg. F to diffusion wells	50-55 deg. F from supply well, 40-45 deg. F to diffusion wells	Constant supply well groundwater temperature; return temperature to diffusion wells depends on ΔT preference of designer

Notes: ΔT = delta T or difference in

Other unconventional open loop systems, described in the following, are in use on Long Island. Although believed to be limited in number, it is recommended that these types of systems are disallowed except under the conditions noted. One option to prevent their use would be for the NYSDEC to require that dedicated supply and return wells are in use for all open loop GHP systems when renewing an existing permit or permitting new well installations. This is currently the case for systems governed under the LIWP program. However, smaller systems not regulated under the LIWP program (flow rate <45 GPM) only require filing of a preliminary report on proposed well form (PRPW). Technically, PRPWs must be filed only for new wells for consumptive use. Based on discussions with the NYSDEC, there may be instances where a permit to drill a new diffusion well(s) is issued without an associated supply well(s) and vice versa.

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Closed Loop Systems

Closed loop systems circulate either water (or a water and antifreeze mix) as the HTF through a series of HDPE plastic loops installed horizontally in trenches or, more routinely, vertically in drilled boreholes. Unlike an open loop system, a closed loop GHE does not involve pumping and re-injection of groundwater and the plastic piping isolates the HTF from the aquifer. Heat exchange occurs by conduction between the circulating fluid and the ground across the plastic piping.

Each loop consists of two pipes, ¾-1.25 inches in diameter and connected at the bottom with a 180-degree "U" fitting as shown in Figure 11. The loop assembly is lowered to the bottom of the borehole and the space between the borehole wall and the closed loop piping (the annulus) is filled with a thermally-enhanced grout, which is a low-permeability clay, water and sand mixture. The main purpose of the grout is to prevent migration of contamination from the surface into the aquifer or between multiple aquifers. The grout also provides a thermal bridge between the loop and the ground.

Figure 11 U-Bend Fitting

The loops are connected using horizontal HDPE piping. For larger systems, the loops are grouped into "circuits" of typically four to ten loops, as illustrated in Figure 12. The individual circuits are connected to supply and return mains that lead to a manifold in the mechanical room. The HDPE is joined together using a heat-fuse welding method. The HTF is circulated through the borefield and the GHPs using circulator pumps located in the mechanical room. The HDPE piping is comparable to piping used in the natural gas industry and is warrantied for 50 years by the manufacturers.

The operating temperature of the HTF in a closed loop system varies daily and seasonally. At the start of a season, the temperature of the HTF may start at about the ground's natural temperature. However, its temperature will generally increase over the summer and decrease over the winter as more and more heat energy builds up or is depleted from the ground around the borefield, respectively (see Table 1).

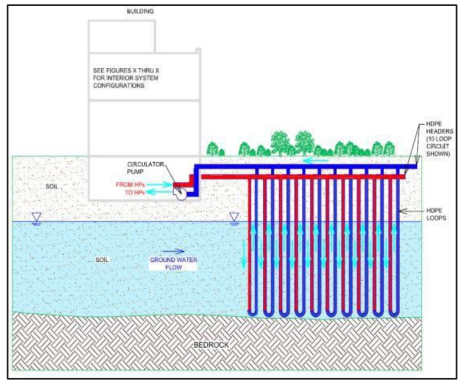

Figure 12 Closed Loop System

For larger closed loop systems, a test closed loop is typically installed and a thermal conductivity test performed to confirm the geologic conditions and develop the data needed for borefield sizing and design. The piping also can be laid out horizontally in an open excavation in coils or in straight runs of piping in trenches and backfilled.

HDPE coils also can be emplaced in an open water body (for example, a lake, marine bay or river) and used for heat exchange if the water body meets certain minimum volume, depth and quality criteria depending on the building's thermal load profile. Approval also may be necessary from the appropriate agencies as environmental impacts could occur from altering the temperature of the water body.

The closed loop piping undergoes multiple stages of pressure testing during construction to make sure there are no breaks and the joints are tight. Individual loops and circuits are pressure tested prior to backfilling. Finally, the entire system gets pressure tested after the circuits are connected to the main supply and return lines. The NYS Mechanical Code, under which most municipal agencies on Long Island operate, requires pressure testing of the piping system for closed loop GHP systems.

If the piping were to leak, and the HTF contained an antifreeze, this would result in a release of antifreeze into the groundwater (see Closed Loop Systems under Chemical Effects). Fortunately, leaks in the HDPE piping network are rare, and when they occur it is usually by an excavator breaking a line. A leak can be detected by a loss of pressure in the working fluid across a loop or circuit. A loop or circuit with a leak can be repaired or isolated from the rest of the system and decommissioned. It is important to plot the locations of the individual loops and horizontal connector piping on a plot plan for future reference to prevent excavation and damage to the piping during future building maintenance or expansion. When ownership of the home or facility changes, transferal of this information to the new owner is critical.

Direct exchange systems are a type of closed loop system with the following major differences:
1) the GHE is copper tubing, not HDPE pipe, and 2) the HTF is refrigerant (R-410A). Some configurations of a "DX-to-Ground Contact" DX system are shown in Figure 13. The copper tubing is installed in a vertical drilled borehole and grouted like an HDPE closed loop or buried in trenches in a horizontal configuration.

The copper tubing assembly is pressure tested prior to introducing refrigerant. DX systems must be protected against corrosion of the copper by using sacrificial anodes or other means of cathodic protection.

Figure 13 DX-to-Ground Contact Systems

A version of a DX system, the GeoColumn(c) (Figure 14), submerges the copper tubing in an enclosed HDPE plastic cylinder filled with water that isolates the tubing from contact with the soil and aquifer. The GeoColumn(c) is typically installed to a depth of 25 feet or less. Because of their shallow installation depth and the physical containment provided by the HDPE cylinder, these GHEs are not grouted.

Pressure testing, potential for leaks and the need for adequate documentation of the buried piping are the same as the closed loop system.

Figure 14 GeoColumn(c) DX-to-Water Contact System

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Standards, Guidelines and Regulations

Federal and State Regulations

Presently, comprehensive regulations covering all types of GHP systems do not exist and standards and guidelines that do exist are not consistently applied on Long Island. Therefore, impacts to the aquifers beneath Long Island from widespread unregulated use of GHP systems are possible. There are ongoing efforts by the GHP industry throughout the state to put into effect uniform design, installation and maintenance standards and code to address concerns over potential environmental impacts of GHP systems. Depending on the outcome of these efforts, formal regulationsmay need to be enacted to safeguard Long Island's aquifers from such impacts.

National design and installation standards and guidelines exist for GHP systems and have been published by the following organizations: American Society for Testing and Materials (ASTM), American National Standards Institute (ANSI), American Society of Mechanical Engineers (ASME), American Society of Heating, Refrigeration, and Air Conditioning Engineers (ASHRAE), Air-Conditioning and Refrigeration Institute (ARI), Air Conditioning Contractors Association (ACCA) and the refrigeration section of the International Building Code. The following additional standards and guidelines apply for specific GHP system types:

- Open loop systems: National Ground Water Association (NGWA) and American Water Works Association (AWWA) water well construction guidelines.
- Closed loop systems: International Ground Source Heat Pump Association (IGSHPA) installation guidelines.
- DX systems: Canadian Standards Association (CSA) and National Association of Corrosion Engineers (NACE).

IGSHPA certifies geothermal drilling contractors for closed loop borehole drilling and installation; and IGSHPA and the HDPE manufacturers certify the piping installation contractors for heat-fuse welding. The equipment and materials manufacturers also recommend that their guidelines, methods and specifications are followed. Recently, IGSHPA and NGWA also have developed GHP system inspector training programs that are being offered to the public.

Most recently, the CSA, in conjunction with ANSI, published C448 Series-16, a comprehensive set of standards for the installation, testing, operation and maintenance of all types of GHP systems. These standards were developed by a bi-national (United States and Canada) working group of industry representatives and trade groups including IGSHPA and NGWA.

Most Long Island municipalities have adopted or otherwise defer to the NYS Mechanical Code (NYSMC) for building HVAC design and construction requirements, which, in turn, has adopted the International Mechanical Code (IMC). Section 1210 of the IMC covers certain aspects of closed loop GHP systems, including pressure testing and flushing requirements for the piping and the HTF. Local GHP industry representatives are in discussion with NYSMC officials and representatives of the IMC, as well as the Uniform Solar Energy and

Hydronics Code (USEHC) – the competing code to the IMC – about adopting the C448 Series-16 standards into their respective codes. To that end, the USEHC committee has proposed to add a reference to the CSA standards into its next code revision in 2018.

Another means to address concerns over GHP systems that the local GHP industry is undertaking is to tie utility rebates to adherence to strict quality control measures. The NYS Governor has released an "emergency" rebate program for GHP installations to offset loss of the federal tax credits that expired at the end of 2016. As part of that program, NYSERDA will issue rigorous quality control measures that must be followed to earn the rebates. Local GHP representatives are in discussion with PSEG to consider issuing similar measures as part of PSEG's rebate program.

As discussed previously, the NYSDEC requires that a PRPW is filed before drilling for any planned new water well (including open loop GHP wells) with its Region 1 Division of Water in Stony Brook, New York. Further, any proposed well(s) with a rated pumping capacity greater than 45 GPM or 64,800 gallons per day (or if there are existing wells on the property, then the combined pumping rate for the existing and proposed wells if exceeding 45 GPM) is regulated under the NYSDEC LIWP program. This 45 GPM threshold equates to up to approximately 25 tons of peak heating or cooling capacity (2 GPM/ton). All open loop wells must be installed by a NYSDEC-registered well driller and the submersible pump must be installed and the system started up by a NYSDEC- registered water well driller. Hydrogeologic calculations and details on the well design, use and construction must be provided with the LIWP application. As noted earlier, the NYSDEC reviews the site relative to potential impacts to other nearby groundwater users, public drinking water wells, surface waters, wetlands and ecological resources, contaminated groundwater remedial systems and the fresh water-salt water interface at coastal sites. In some instances, the NYSDEC will require that a more detailed engineering report be prepared and submitted with the LIWP application. Among other items, the engineering report involves more in-depth hydrogeological analysis, potentially along with groundwater testing and modeling to demonstrate no impact to these resources.

The NYSDEC regulations do not specify either upper or lower limits on the temperature of the return water, although regulations do state that the discharge must not prevent others from being able to use the groundwater for its best intended usage. As with any water supply well, an open loop well system may be designated a Class I Action under the State Environmental Quality Review Act by the NYSDEC if its rated pumping capacity exceeds 2 million gpd (or 1,388 GPM), thus triggering a SEQRA review.

The United States Environmental Protection Agency must be notified of all return wells of an open loop system, as these wells are designated Beneficial Re-Use Class V wells in the federal Underground Injection Control (UIC) regulations under the Safe Drinking Water Act. USEPA can authorize operation of such wells "by rule" pursuant to the regulations.

NYSDEC presently does not regulate closed loop or DX systems with the exception that a permit is required from the NYSDEC Division of Mineral Resources (DMN) if drilling will be deeper than 500 feet, which is an uncommon practice in the industry on Long Island.
Because the fluid within a closed loop/DX GHE does not directly contact the environment, it is not considered

a Class V well under the federal UIC regulations. Therefore, the USEPA has no jurisdiction over these GHEs.

Any size or type of GHE intended to be installed in or within a regulated distance from a wetland, floodplain, pond, lake, river or coastal erosion hazard area requires state and/or federal environmental agency approval. Additionally, if the return water from an open loop system is intended to be discharged into a regulated wetland or surface water body, state and/or federal permits are required.

County and Local Codes and Guidelines

Nassau County claims no jurisdiction and defers regulatory authority for GHP systems to the NYSDEC and the local towns and villages.

Suffolk County through its Department of Health Services regulates GHP systems that are proposed to be installed in conjunction with a proposed wastewater and/or water supply system. The SCDHS requirements are contained within its General Guidance Memorandum #25. The major requirements relate to setbacks for open loop wells and closed loop boreholes from public and private water supply wells, sanitary and stormwater system structures and piping, property lines and other utilities. The SCDHS guidelines also stipulate that there shall be no cross- connection between the GHP system and domestic water supply system. Memo #25 was recently revised to incorporate in its entirety the Model Geothermal Code developed by the Suffolk County Planning Commission (see next section). SCDHS requires that the proposed geothermal wells or borehole locations and piping routes are shown on the site plan with the proposed sanitary and storm drainage structures and submitted to SCDHS for approval prior to construction.

In 2014, Suffolk County adopted the Suffolk County Uniform Model Geothermal Code (Model Code), developed by the SCPC in association with the local GHP trade organization the Long Island Geothermal Energy Organization (LI-GEO). Input to the Code was provided by key stakeholders including the NYSDEC, SCDHS, SCWA, the Suffolk County Legislature and the NYS Department of State's Division of Building Standards and Codes. The main objectives of the Model Code were to address concerns that local municipalities have about GHP systems, provide a uniform filing process for the typical GHP systems that are being installed on Long Island and in the process facilitate more widespread acceptance and deployment of systems. The Model Code identifies standards, best practices and environmental protections specifically for systems proposed to be installed in "non-sensitive areas," which comprise most GHP systems. The Model Code also requires well drilling contractors to notify the SCWA of the location of open loop wells installed within SCWA's service area. The Model Code provides a basic working framework for local jurisdictions to incorporate into their existing code or simply be issued as guidelines to its building inspectors.

Some local municipalities disallow certain types or any GHP system installations for various reasons. Specifically, the villages that are serviced by the Water Authority of Great Neck North (WAGNN) and the Village of Sands Point Water Department and the Town of Shelter Island disallow GHP systems over concerns on impacts on the stressed aquifers upon which these locales rely for drinking water. The Town of Oyster Bay has issued a referendum on new GHP systems until a suitable process is established. Otherwise, the filing and permitting process within jurisdictions that allow GHP systems varies widely. The Towns of North Hempstead and Hempstead allow closed loop systems but not open loop systems. The Town of North Hempstead is required by its own statute to review and discuss with the WAGNN any application for any new well within the WAGNN's service area.

The towns, cities and villages on Long Island have not readily adopted Suffolk's Model Code, partly due to confusion over professional sign-off responsibility of the in-ground portion of the system. Two exceptions are the Towns of Smithtown and Brookhaven that have adopted the Model Code into their administrative framework, requiring sign-off by a professional engineer for the design, installation and as-built drawings. Other municipalities not mentioned above allow and permit new GHP systems within their jurisdictions under their existing building department code.

Potential Groundwater Impacts

It is a practice for some homeowners, primarily on the north and south forks, to use their domestic potable water connection as the source water to the system in place of the standard approach to use on-site water supply wells. This practice should be disallowed, since it places an undue burden on public water suppliers and is an inappropriate use of potable water. The NYSDEC should close the gap that allows permitting a new diffusion well(s) without an associated supply well(s).

Groundwater Return through Infiltration Devices other than Wells

It is possible to return groundwater to the aquifer through means other than return wells, such as a drywell, horizontal buried perforated pipe or other means. This practice should be disallowed except where the supply well(s) taps the upper/first aquifer, such that return through the infiltration device is back to that same aquifer. The NYSDEC should close the gap that allows permitting a new supply well(s) without an associated diffusion well(s).

Groundwater Return through Infiltration through the Ground Surface

This practice is not presently regulated by NYSDEC, but there have been reported instances of discharge water overflowing the property line and entering adjoining regulated water bodies and wetlands in violation of NYSDEC wetlands regulations. Further, this practice has created nuisance conditions such as soil erosion, sedimentation, freezing and migration onto adjacent private properties and public roadways. As such, this practice should be disallowed and the NYSDEC should close the gap that allows permitting a new supply well(s) without an associated diffusion well(s).

Groundwater Return to a Surface Water Body or Wetlands

The NYSDEC regulates all discharges to regulated surface water bodies and wetlands on Long Island. A State Pollutant Discharge Elimination System (SPDES) permit would be required and temperature limits apply to the discharge water. The NYSDEC should disallow this practice to avoid unintended impacts to these resources.

Dual Use Wells

Open loop system supply wells conceivably can be used for other purposes besides heating and cooling, for example, irrigation and drinking water. Where public water is not available, this practice should be allowed with approval of the local authorities. The Suffolk County Department of Health Services General Guidance Memorandum #25 prohibits cross connections between a potable water supply system and geothermal wells where a GHP system is proposed for a project with a new wastewater and/or water supply system (see County Codes and Guidelines, Suffolk County section). Otherwise, standards

for acceptable design and installation of dual use (geothermal, potable water) wells are provided in the NYS Mechanical Code.

Typical GHE Depths

Table 2 presents the typical install depths for GHEs. DX boreholes/loops are installed to the shallowest depths of all the GHEs. In virtually all cases, GeoColumns(c) would terminate above or slightly into the Upper Glacial Aquifer where the depth to the water table lies less than about 25 feet deep. With a typical depth of up to 100 feet, DX-to-Ground Contact DX systems would terminate in the Upper Glacial Aquifer or potentially into the top of the Magothy Aquifer where it may be shallower than 100 feet (most of Nassau County and the extreme west end of Suffolk County).

Most open loop wells terminate at relatively shallow depths in the Upper Glacial Aquifer to keep drilling costs down. Approximately 89% of Nassau County's public drinking water supply wells are screened in the Magothy Aquifer (Long Island Regional Planning Board, 1993), and, therefore, would not be impacted by open loop GHP systems. This percentage is significantly higher in Suffolk County – per the Suffolk County Water Authority's website (SCWA, 2015), approximately 45% of its wells are installed in the Upper Glacial aquifer. If a proposed GHP system must be permitted under the NYSDEC LIWP program (flow rate >45 GPM) and is located within the capture zone of an existing public supply well field, the NYSDEC should require the owner of the system to perform the appropriate aquifer testing and modeling to assess the potential impact to the

Table 2
Typical Installed Depths of GHEs

GHP System Type/GHE	Typical Depth (feet below ground surface)	Remarks
Open Loop Supply and Diffusion Wells	Variable; dependent on depth to water table and suitable aquifer conditions	Generally constructed in Upper Glacial Aquifer to minimize cost, with suitable thickness and water quality
Closed Loop Vertical Boreholes	200-500 feet deep	Depth depends on available land to drill and driller capabilities, not aquifer conditions; avoid thick clay, if possible
Closed Loop Horizontal	4-10 feet deep	Where sufficient land area exists; typically not installed below the water table
“DX to Ground“ Vertical	100 feet deep	Depth depends on available land to drill and driller capabilities, not aquifer conditions
“DX to Ground“ Horizontal	4-10 feet deep	Where sufficient land area exists; typically not installed below the water table
“DX to Water“ (“GeoColumn©”)	<25 feet deep	Water containment device is standard 20 feet long

well field to the satisfaction of the water supplier. Smaller proposed GHP systems that are not regulated under the NYSDEC LIWP program can be addressed as discussed in future report sections.

Closed loop borehole depths vary depending on subsurface conditions, driller preference and size of the property. Their depths are not usually dependent on hydrogeology. Although clay has a low thermal conductivity, more loops drilled to a shallower depth and terminated above a major clay unit might be a preferred option for a GHP system designer.

Comparison to other Groundwater Uses

Heating and cooling with a GHP system is just one of the many uses of Long Island's groundwater resources. Factors that distinguish a GHP system from other uses are:

- It is a non-consumptive use of groundwater.
- The temperature of the groundwater is altered, either increased or decreased on a seasonal basis.
- For an open loop GHP system, the groundwater is injected back into the aquifer after it is used.

These processes have the potential to cause certain thermal, chemical and hydraulic effects that need to be understood and controlled to protect the aquifers. Each of these potential effects are discussed in this section along with other significant issues and conditions relevant to aquifer protection.

Thermal Effects

GHP 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 where only the groundwater temperature is 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 in the following.

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. The affected distance around the wells will depend on the thermal load imposed on the aquifer, which is determined by the injection flow rate, injection water temperature and duration. Since all groundwater flows, albeit slowly, open loop GHP 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 the processes of conduction, advection and mixing of the thermally altered water with ambient temperature groundwater. The distance where the natural groundwater temperatures are re- established depends on the thermal load, aquifer properties and the groundwater flow velocity.

The long-term effect of these thermal pulses varies between 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. An example of such

a system is shown in Figure 15, illustrating the effect after operating a large open loop geothermal system for heating and cooling for 20 years. The system heats for seven months each year with a return water flow rate of 275 GPM at a temperature of 41 degrees F. The system cools for the other five months with a return water flow rate of 430 GPM at a temperature of 71 degrees F. There are numerous public water supply well fields located within 1-2 miles from the diffusion wells. Public supply well fields located downgradient of the diffusion wells were modeled to pump continuously over the 20-year period at a flow rate of 900 GPM each. Based on numerical model simulation, the thermal effect on the aquifer dissipates within a significantly shorter distance than the groundwater flows over the same duration, because of the mixing of the seasonal warm and cool pulses (1,200 feet vs. 2,550 feet). Therefore, there will be no effect from this system on the temperature of the groundwater drawn from the public supply wells.

Figure 15
Twenty-Year Simulation of Large Open Loop GHP System (Heating and Cooling

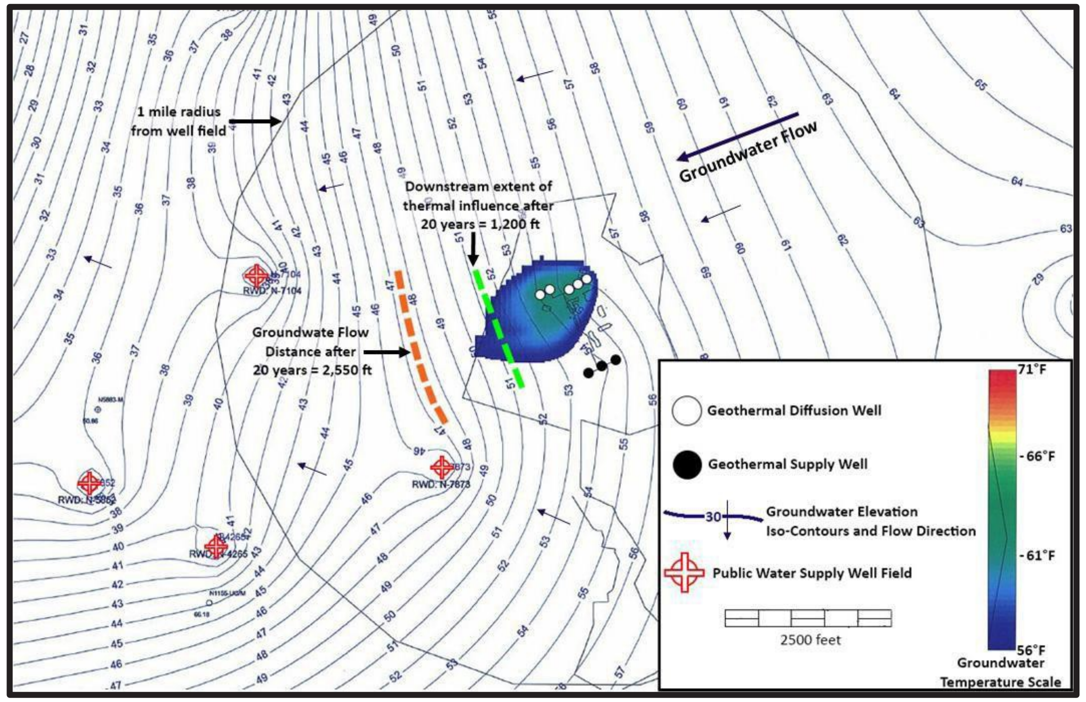
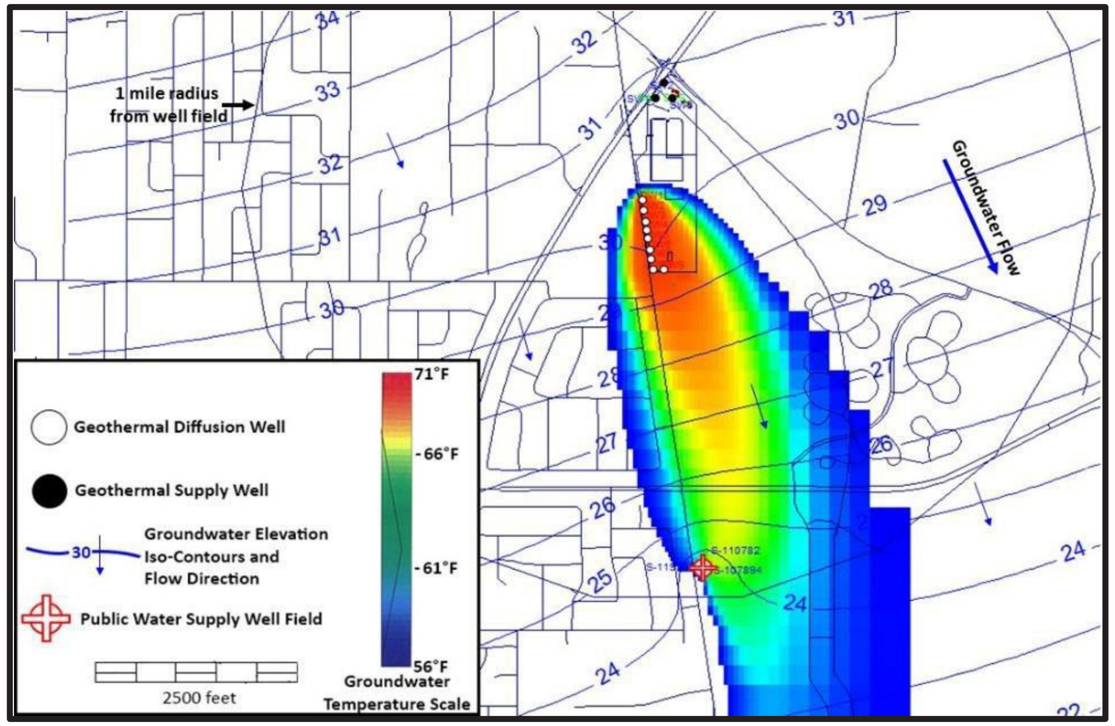


Figure 16 is an example showing the results from a numerical model simulation of an extreme case of a large cooling only open loop system after operating for 30 years. A public water supply well field is located approximately 3,500 feet directly downgradient of the diffusion wells. The GHP system is simulated to pump and recharge continuously at the peak design flow rate of 3,600 GPM. The public supply well field has three wells that are simulated to pump continuously over the 30-year period at a combined flow rate of 1,200 GPM. The return water temperature to the aquifer is 10 degrees F warmer than ambient conditions or approximately 65 degrees F. The return water cools via advection, conduction and blending with cooler surrounding groundwater as it moves along the natural groundwater flow path. After 30 years, the temperature of the water reaching the wellfield from the diffusion wells is approximately 2-3 degrees F warmer than the natural groundwater temperature. However, because the public supply wells draw in water radially from all sides, besides groundwater originating at the diffusion wells, there will be no measurable effect on the public supply wells water temperature.

Figure 16
Thirty-Year Simulation of Large Open Loop GHP System (Cooling Only)



For a closed loop or DX system, the thermal effect occurs within the volume of the aquifer material directly surrounding each closed loop or DX borehole. 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 on the order of 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 or DX borefield and decreases outward where the heat can dissipate by conduction to the surrounding ambient temperature aquifer materials. In the winter, the pattern is reversed. Temperatures within the “core” of the borefield are coolest as heat is extracted from the ground and heat energy flows into the borefield from the surrounding aquifer that is at higher ambient temperatures.

Closed loop and DX borefields exhibit the same seasonal thermal “pulses” of cool or warm water flowing away from the borefield as an open loop system and are controlled by the same factors as described above. The long-term effect of thermal pulses from closed loop and DX borefields used for both heating and cooling will be like an open loop system as described above. The borefield temperatures are at their highest in late summer and lowest in late winter. As presented in Table 1, the typical temperature of the HTF circulating in a closed loop borefield is as low as 30 degrees F during heating (if antifreeze is used in the HTF) and as high as 90

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degrees 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 HDPE 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 borefield with the natural groundwater flow. Due to the slow flow rate of groundwater, when winter arrives, there is normally still some stored heat within the borefield left over from the previous summer season that can be extracted for heating. Similarly, when summer arrives, there is normally still some stored cold from the previous heating season that can be used for cooling.

The thermal effect of large GHP 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 GHP systems on adjoining and/or downgradient properties. Thermally impacted groundwater also could discharge into downgradient surface water bodies or wetlands and result in ecological impacts and violations of NYSDEC limits.

A better understanding of thermal transport from large GHP systems in Long Island’s aquifers and potential impacts on ecological resources is necessary. Regulations should be enacted to prevent such impacts, including requiring modeling or other means to determine “safe” setbacks from these resources. Areas served by small private drinking water wells would be particularly susceptible to impacts from large GHP system thermal plumes. As noted previously, under the LIWP program, the NYSDEC requires demonstration that there will be no thermal impact by large open loop systems on nearby drinking water supply wells, thus offers protection of public drinking water systems.

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. The current state policy of first-come-first-served for underground water rights may need to be reassessed to address cumulative effects. In the meantime, a system of better tracking the installation of small open loop systems (not regulated under the LIWP) is warranted; for example, modifying the SCPC code to require drilling contractors and the NYSDEC to notify not only the SCWA but all public drinking water suppliers.

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Because the thermal effect around a residential closed loop system dissipates within 10-15 feet away, there would be no or only insignificant thermal interference between neighboring systems in dense suburban areas. For the same reason, there would be no significant cumulative thermal effect on downstream ecological resources, drinking water supply wells or other groundwater users. Unlike open loop systems, closed loop systems must be used for heating and cooling, which balances out the thermal effect on the ground. Nevertheless, it would be prudent to track the installation of small closed loop systems as recommended above for small open loop systems.

Historically, the aquifer below the Roosevelt Field Mall/ Mitchell Field complex has become thermally impacted (overheated) from extended operation of numerous large, commercial open loop type air conditioning systems. It is presumed that the systems' wells were permitted before NYSDEC established the LIWP or became aware of the potential for overheating of the aquifers by air conditioning systems. The increased groundwater temperatures have resulted in lowered system efficiencies and abandonment of some of these systems.

Chemical Effects

The return water of an open loop system that does not employ an intermediate HX 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. This has contaminated the aquifer at several locations in northern Nassau County. In addition, there are existing, older operating open loop systems that do not employ HXs and may presently be leaking refrigerants to the groundwater or could in the future. Modern HX technology provides an additional physical barrier that protects the aquifer from contamination by refrigerants.

If an antifreeze is used in the HTF of a closed loop borefield and a leak or break occurs in the buried HDPE piping, antifreeze would be released to the aquifer. A concern would be what impact this could have on the drinking water source and if remediation of such a situation is warranted. The three main antifreezes used in the industry are methanol, propylene glycol and ethanol (ethyl alcohol). Neither the NYSDEC nor the USEPA have established groundwater quality or discharge standards or guidelines for any of these three chemicals. Methanol is the most common antifreeze and is the same product also used in windshield washer fluid. Besides being used as an antifreeze, propylene glycol is also a common additive to food products. Methanol and ethanol are highly volatile and flammable liquids in their raw form and are toxic to humans if ingested at high concentrations. However, antifreeze is not used at a full concentration in closed loop GHP 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 as carcinogens or mutagens. Nevertheless, all precautions should be taken to prevent a release of these compounds from a GHP system, including enforcing strict pressure testing as discussed earlier and other best practices described throughout this report.

If a leak occurred in the buried copper piping of a DX-to-ground contact loop, refrigerant could be released to the surrounding aquifer. Refrigerants are regulated by both the NYSDEC and the USEPA. Concerns related to these types of DX systems are that there are no regulations for monitoring, reporting or mitigating a release of refrigerants nor for checking and replacing the sacrificial anodes and cathodes when depleted. If a leak occurred in the copper piping submerged in the water containment of a DX-to-water contact loop [GeoColumn(c)], the leak would be contained within the containment device and not be released to the surrounding soil or aquifer. Refrigerant could leak to the ground through the horizontal piping, thus double-wall piping should be required.

Hydrogeologic Effects

Of the three GHP system types discussed in this report, only open loop systems affect the natural groundwater flow. The water table around a pumping supply well is drawn down in the shape of a cone and mounds up around the return wells as shown in Figure 10. The extent of these areas is a function of the pumping and diffusion rates and the hydraulic conductivity of the surrounding geologic materials. However, there is no net effect on groundwater in storage since 100% of the extracted water is returned to the aquifer. The effect

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on groundwater levels is localized around the wells and, when pumping stops, groundwater flow patterns return quickly to the natural non- pumping conditions.

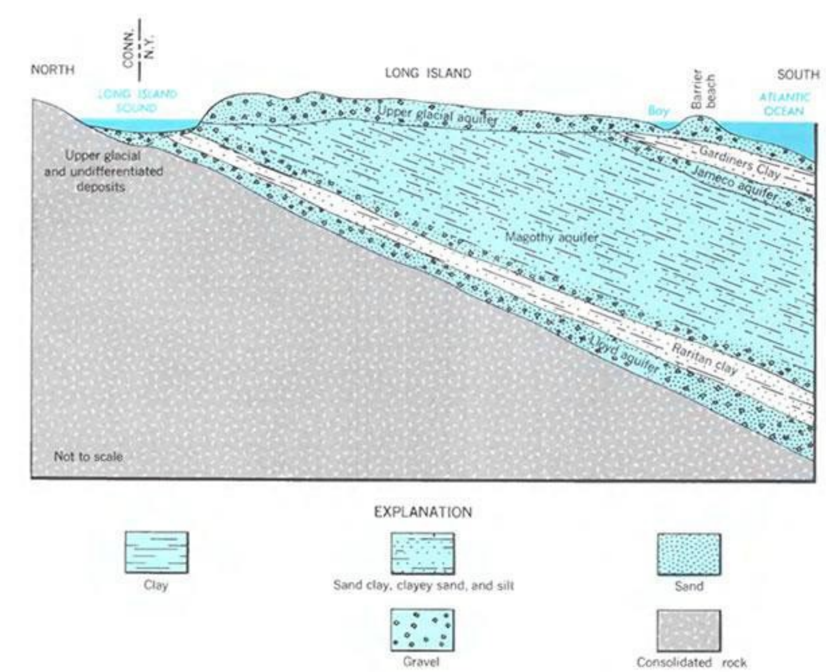
Like the thermal effects discussed previously, the hydrogeologic effect of a large operating open loop GHP system may extend beneath an adjoining property or into a nearby surface water body or wetland. The water levels could be lowered or raised depending on the location of these resources relative to, respectively, the supply or return wells. It is also possible that a large GHP system could interfere hydrogeologically with another GHP system or other water supply well on an adjoining property. The effect would be greatest during the peak heating and cooling seasons. In any case, any such interference and potential impact of a large open loop GHP system would be identified and addressed by the NYSDEC as part of the LIWP process as is the case for all new water supply well applications.

The hydrogeologic effect around a small open loop system is much more localized and less likely to extend beyond the property boundary or potentially impact a nearby natural resource. Given Long Island's prolific aquifers, the maximum amount of drawdown and mounding of the water table around the wells serving a typical residence (2-3 ton cooling or heating demand or approximately 4-6 GPM peak flow) would not exceed 1-2 feet and is temporary during system operation only. The same would be true for a high density of small GHP systems as the drawdown and mounding effects offset one another.

Other Issues and Sensitive Environments

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 fresh water aquifer by salt water present below the clay unit. The locations of major confining clay units on Long Island are shown on Figure 17 (below).

Figure 17
Generalized cross section of Long Island showing the main aquifers and confining units (Cohen and others, 1968)(Public domain.)



The thermally impacted aquifer beneath the Roosevelt Field Mall/Mitchell Field complex discussed earlier also was impacted by the release of volatile organic compounds from the prior industrial usage of some of the properties. The extensive and sustained pumping and re-injection of contaminated groundwater by commercial open loop air conditioning systems has distributed VOCs throughout the aquifer. As noted previously, this practice may have preceded close regulation of water supply wells under the NYSDEC LIWP program. The NYSDEC now checks under the LIWP program that proposed new water wells (including open loop GHP system wells) will not alter the pathway of pre-existing legacy contamination plumes or impact groundwater remediation efforts at regulated contaminated sites.

Sensitive aquifers exist beneath the Great Neck peninsula and portions of the Port Washington peninsula, Shelter Island and portions of the north and south forks. These aquifers are limited in size as they are surrounded by salty groundwater, thus they are particularly susceptible to the potential impacts from GHP systems discussed previously. GHP systems may need to be curtailed or restricted in these areas due to their sensitive nature.

The NYSDEC disallows the installation of open loop geothermal wells in the Lloyd Aquifer. Because closed loops are not pumping wells, neither the current NYSDEC regulations nor Lloyd Aquifer moratorium exclude closed loops from being drilled and installed into the Lloyd Aquifer, although the authors are not aware of any such systems installed in this manner.

Mitigation of Potential Impacts

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

- The NYSDEC and the SCDHS have construction guidelines in place for open loop wells, such as grouting/sealing of the annular space, including through clay units that are penetrated.
- For open loop systems regulated under the LIWP program, the NYSDEC performs a rigorous review of potential impacts of a system on the groundwater, surface water and wetlands resources. This includes a search for sites of environmental concern within the area of influence of the system and an evaluation of the potential thermal and hydraulic effects on neighboring systems and other groundwater users.
- Activities within sensitive areas (e.g., flood zones, wetlands and surface water bodies) are regulated by several other state and federal agencies.

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In addition, the following local GHP industry practices and programs are in place or in the planning stages with the goal to ensure quality of installations and thus prevent impacts to groundwater and the environment:

- The current industry practice for commercial and large residential open loop GHP systems is to separate/isolate the well loop from the building's HVAC equipment and distribution system with an intermediate HX to prevent contamination of the return water by refrigerants and other chemicals present in the mechanical equipment. The HXs are made of appropriate material, e.g., stainless steel or titanium, for the site groundwater quality.
- Standard industry practices and guidelines for closed loop GHP systems that use antifreeze in the HTF 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 GHP systems have been implemented by Suffolk County through Memo #25 and by municipalities that have adopted the Model Code.
- GHP system inspector training programs have been developed by IGSHPA and NGWA, and LI-GEO is developing a training program specifically for Long Island municipal building inspectors.
- The local GHP industry is in discussion with NYS, IMC and USEHC code officials about adopting the comprehensive ANSI/CSA standards into their respective code.
- Quality control and contractor certification requirements are being developed that must be met for owners to receive rebates from PSEG for GHP systems.

In this chapter, three issues highlighting two significant mechanisms for affecting groundwater and surface are addressed. The first concerns how Long Island treats its wastewater. Broadly, there are two ways of disposing wastewater, on-site or in an off-site treatment facility. Long Islanders have tried both, Nassau treats the majority of its wastewater in off-site facilities, while in Suffolk, the majority of wastewater is treated on-site. Each method has its advantages and disadvantages.

The second topic addresses how much water can be withdrawn from Long Island's aquifer system without causing undesirable impacts to the system.

The third topic presents a discussion on the Lloyd Aquifer, including the amount of water recharged to it, the amount of water withdrawn from it, the quality of the water withdrawn and the legal protections afforded to it.

Wastewater Management in Nassau and Suffolk Counties, New York

Wastewater treatment on Long Island is essentially "A Tale of Two Counties." Nassau County is approximately 85% sewered (though large stretches of the north shore of Nassau County, approximately 50,000 houses, utilize cesspools or septic tanks), while only 26% of Suffolk County is connected to sewers. Nassau County's largest sewage treatment plant, in Bay Park, handling 40% of the County wastewater, has been discharging effluent that has only gone through secondary treatment prior to discharge into Nassau County's south shore embayment. About 74% of Suffolk County's wastewater is released essentially untreated and ultimately finds its way into ground and surface waters. About 360,000 houses in Suffolk County currently utilize non- performing cesspools or septic systems. As a result of these contrasting sewage treatment practices, each county has its own set of water quality and quantity issues.

Potential climate change effects are also a compounding consideration regarding sewage treatment practices in each county. While the Bay Park treatment plant was significantly damaged in Superstorm Sandy, Suffolk County's principle wastewater treatment plant at Bergen Point barely escaped unscathed. Options are being examined to pipe Bay Park's discharge out into the ocean, while the portion of Bergen Point's ocean outflow pipe running through the Great South Bay is being replaced to avoid catastrophic failure. Diverting wastewater into the ocean rather than recharging to ground raises concerns about the water budget in Long Island's sole-source aquifer and poses the tradeoff between water quality and water quantity. Other issues associated with ocean discharge include coping with future sea level rise and the resulting impacts on coastal infrastructure, declining groundwater levels and the potential for salt water intrusion.

History

The Long Island Sanitary Commission (which included Robert Moses) was appointed by New York Governor Franklin D. Roosevelt on March 10, 1930 to "investigate the problem of developing a scientific administration and control over the disposal of sewage and garbage in Nassau and western Suffolk Counties. ... The commission recommends that, pending the adoption of its plan by the county supervisors, no municipal sewage project shall proceed without approval ... and that the commission provide and operate trunks

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or outlet sewers and sewage treatment plants wherever such facilities are required." The cost would be financed by county bonds to be paid by the county as a whole or paid by assessments on the benefitted properties.

Reportedly, there were 13 systems at this point, covering about 25% of the residents. Earlier in the century, the principle sewage treatment plants were opened in Garden City (1908), Hempstead (1911), Freeport (1920), Glen Cove (1920s), Mineola (1928), Rockville Centre (1928) and Mitchel Field (1920s). With a population of 300,000, Nassau County was the fastest growing county in the country. The first priority was "to maintain the purity of the water of the Long Island Sound, the Atlantic Ocean and the numerous bays and inland streams. ... The greatest asset of Nassau County, and one of the greatest assets to the metropolitan community, is the shore front. Pollution of these waters is inevitable unless the problem of waste disposal is properly solved." (*The New York Times,* May 15, 1931, page 20).

By 1957, Nassau County's census population was 1,178,075. In reporting to the Commissioner of Public Works (May 1958) relative to trunk sewers and sewage treatment plants for proposed Sewage Disposal District (SDD) No. 3, the engineering firm of Lockwood, Kessler, & Bartlett (LKB) estimated the cost at $227 million. LKB recommended "complete biological treatment by the 'activated sludge' process, chlorination and disposal of clear, disinfected, inoffensive effluent into one of the major boat channels of the bay waters." Such treatment removes 90-95% of biochemical oxygen demand and suspended solids with the bacteria count kept below 50 coliforms per 100 cubic centimeter. There was no mention of nitrogen loading. The report further noted that, "Our hydrographic studies indicate that all the major boat channels provide sufficient dilution of waters and dispersion currents for disposal of the treated effluent." These conclusions were subject to completed improvements to Jones Inlet, Long Creek and Fire Island Inlet.

The Bay Park Sewage Treatment Plant was placed into operation in 1950 with a design capacity of 27 million gallons per day (MGD) with only primary treatment. The plant expanded in the 1960s to 60 MGD with secondary treatment. A major upgrade in the 1980s brought capacity to 70 MGD, servicing an area of approximately 70 square miles (sq. mi.) with a population of 550,000. The Cedar Creek Water Pollution Control Plant was placed into operation in 1974 with a design capacity of 45 MGD. It was expanded in the 1980s to 72 MGD, servicing approximately 105 sq. mi. with a population of 600,000.

A 1972 report from the United States Environmental Protection Agency (USEPA) on the Environmental Impact Statement on Wastewater Facilities Construction Grants for Nassau and Suffolk Counties, New York offered a "general description of 'secondary' treatment plants. ... Nitrogen removal data is not given because the references cited did not give it. We know, however, that none of the processes described removes more than 30-50% of the effluent nitrogen (Eliasen and Tchobanoglous, 1969). ... While the physical-chemical scheme described removes more phosphorous than conventional secondary treatment, it removes less nitrogen since biological growth which assimilates soluble is not promoted." As for recharging, "The Bay Park experiments so far have shown it is possible to recharge to the Magothy Aquifer with reclaimed sewage through the use of injection wells. However, the assessment of economic practicality must await better definition of (1) the rates and causes of injection-well clogging and (2) the geochemical stability and long-term character of the injected water."

Among other concerns raised by the 1972 EPA report were algal blooms, which would create an anoxic environment detrimental to all oxygen dependent organisms. Loss of coastal wetland had adversely impacted the biota and increased the impact of severe coastal storms. The concept of oceans as an infinite sink was rejected, since there had been no impact assessment of large inputs of trace materials in sewage effluent into coastal waters. Concern was expressed over the decline of groundwater levels resulting from discharge of treated sewage effluent into Long Island Sound and the Atlantic Ocean, especially regarding the "sacrificing" of water quantity to water quality. A cautionary note was sounded over the installation of community sewering capable of supporting higher density, the counter being control of zoning practices.

In 1961, a feasibility study was conducted to explore the construction of public sewers within Suffolk County. In 1965, Suffolk County established the County Sewer Agency, which was responsible for sewage collection, conveyance, treatment and disposal. By 1970, the county acquired its first sewage treatment plant in the already constructed 1.5 MGD plant, located in Port Jefferson and known as Suffolk County Sewer District #1.

In an article titled "U.S. Warns Suffolk It May Act on Sewers," Alan Eysen reported in Newsday on April 24, 1969: "Murray Stein, assistant commissioner for enforcement for the U.S. Water Pollution Control Administration, told a water pollution conference here that the federal government would join with the state in seeking development of a regional sewage collection and treatment system if the County of Suffolk fails to take action." More specifically, there was a call for duck farmers to install pollution treatment facilities.

In a *Newsday* article dated September 26, 1969, "Sewers Needed Now, Suffolk Warned," Earl Lane wrote, "Mention Long Island to some people in Bangalore, India or Tashkent, USSR, and they might wrinkle their noses and ask, 'Isn't that where they have cesspools'? Recounting his travels through India, Russia and other countries, Dwight Metzler, New York State's deputy health commissioner for environmental services, said, "Long Island is the outstanding example in the world where a major population discharges sewage in groundwaters. Even people in underdeveloped countries tell me they can't understand it."

In 1969, according to "Utilities Inventory & Analysis" by the Nassau-Suffolk Regional Planning Board, "More than 50% of Nassau's homes and 98% of Suffolk's homes are still served by cesspools and septic tanks. ... The critical need for sewage collection and treatment is a direct outgrowth of the inadequacies and failures of disposal by septic tanks and cesspools. In the past ten years these failures have become more obvious. Some of the resultant effects are as follows:

- Pollution of the shallow fresh groundwater supply.
- The possibility of the rapid spread of intestinal disease caused by overflowing cesspools has increased.
- A slow but steady pollution of recreational waters has been produced.

The Report of the Suffolk County Sewer Agency to the Suffolk County Board of Supervisors (March 21, 1969) provided background on the Southwest Sewer District (SWSD) plans and cost estimates in preparation for the general election referendum authorizing the funding and construction of the SWSD on November 4, 1969. Total construction costs and interest over 40 years were projected at about $522 million. The project included the Bergen Point Sewage Treatment Plant (STP) (30.5 MGD capacity) with 71 miles of interceptor lines, 817 miles of lateral, main and trunk lines, 14 pump stations and a four-mile ocean outfall. Construction was slated to occur in stages over ten years. The *Long Island Comprehensive Waste Treatment Management Plan* (LICWTMP) prepared by the Board of Supervisors in 1978 indicated that, by 1976, 101 public and private sewage treatment plants were operating in Suffolk County with a total average discharge of 14.26 MGD.

In the late 1970s and 1980s, the SWSD, also known as Sewer District #3 (SD3), was created and the Bergen Point STP was built utilizing funding from the federal government and New York State. Bergen Point went online in October 1981. The SD3 is the largest sewer district in Suffolk County, consisting of an area of 57 sq. mi. with 950 miles of sewer lines, 14 remote pumping stations and serving an estimated population of 340,000. Evidence has shown that sewering can help reduce nitrogen loads to both ground and surface waters. For example, the average nitrogen level in the Carlls River in the 1970s was 3.2 milligrams per Liter (mg/L). By the 2000s, this level was reduced to 1.8 mg/L.

There is, however, a "flip side" to this scenario relating to stream flow and water quantity. Base flow in the Carlls River dropped from a 27.3 cubic feet per second (cfs) flow during predevelopment times, to 20.5 cfs during the 1968-1983 period. Furthermore, the United States Geological Survey (USGS) predicts that flow will decline to 11.9 cfs by 2020, a 50% loss of more than 50% of its pre-development base flow. Similarly, East Meadow Brook in Nassau County is predicted to go to 0 cfs stream flow in 2020 (Buxton and Smolensky, 1999). Other surface water features in Nassau and western Suffolk Counties have seen similar declines in base flow accompanying an improvement in nitrate levels. A larger discussion of this topic is detailed in the *2016 State of the Aquifer Report* (SOTA).

An outgrowth of the SD3 undertaking was the SWSD corruption case. It involved substantial delays and cost overruns. When started in 1969, the budget for construction was $315 million. By the time the first homes were hooked up in 1981, the cost of the project had ballooned to more than $900 million. Additionally, a project director and lawyers for the company that built the system had been convicted of conspiracy and racketeering. No public officials were convicted of criminal charges but several were assessed damages in civil suits filed by the county. As a result, no other major sewer projects were pursued in the ensuing 40 years.

Wastewater Treatment in Nassau County

The Nassau County Department of PublicWorks is responsible for the operation and maintenance of the county's three sewage facilities, which include the Bay Park Sewage Treatment Plant, the Cedar Creek Water Pollution Control Plant and the Glen Cove Wastewater Treatment Plant. The Glen Cove plant has been recently upgraded to meet the requirements associated with protecting the Long Island Sound from hypoxia or low dissolved oxygen. This plant currently treats approximately three MGD, leaving a surplus capacity of more than 2.5 MGD, which could be used to sewer some of the communities in the north shore that are currently served by cesspools. In addition to the sewage collection systems operated by the county, there are six village-owned and operated collection systems in the county that discharge to the county's sewage collection system.

The villages are: Freeport, Garden City, Hempstead, Mineola, Rockville Centre and Roslyn.

The county recently completed a joint project with the Villages of Cedarhurst and Lawrence to construct the infrastructure necessary to divert wastewater flows from the antiquated village sewage treatment plants to the county's Bay Park STP. The county assumed ownership of the villages' sanitary sewer collection systems and is currently undertaking the decommissioning and demolition of the former villages' sewage treatment plants. Excess treatment plant property will be returned to the villages for their use.

Eight other independent treatment facilities operate within the county, including the City of Long Beach, Jones Beach, the Village of Great Neck, the Port Washington Water Pollution Control District, the Belgrave Water Pollution Control District, the Great Neck Water Pollution Control District, the Greater Atlantic Beach Water Reclamation District and the Oyster Bay Sewer District. Together, these ten facilities process 15% of the county's effluent.

Nassau County also operates 57 sewage pump stations and approximately 3,000 miles of sewer main. The Bay Park STP collects wastewater from an area of approximately 70 sq. mi. in the western portion of Nassau County. It serves an estimated population of 524,000. The majority of the sanitary flow is from residential with the remainder from commercial establishments. Only about 1.5% of the flow to Bay Park is from industrial facilities..

The Bay Park STP was originally constructed in the late 1940s and was placed into operation in 1950. It was initially permitted for the treatment of 27 MGD of municipal sanitary waste. The plant was first expanded in 1960 to provide secondary treatment and increase its capacity to 60 MGD. Beginning in the mid-1980s, the plant was expanded again to increase its capacity to achieve secondary treatment of an average daily flow of 70 MGD. The plant currently treats on average 50 MGD of wastewater. The plant discharges its treated effluent into Reynolds Channel through an 84-inch diameter outfall pipe, which is approximately 2.3 miles long.

The Cedar Creek Water Pollution Control Plant (WPCP) collects wastewater from an area of approximately 105 sq. mi. in the eastern portion of Nassau County and serves an estimated population of 600,000. Similar to Bay Park, the majority of the sanitary flow is from residential and commercial areas with minimal industrial flows (1.5%). The Cedar Creek WPCP was originally constructed in the early 1970s and was placed into operation in 1974. It was initially permitted for the treatment of 45 MGD of municipal sanitary waste and complied with secondary treatment standards through the utilization of the activated sludge process. The plant was expanded as part of a capital improvements program in the mid-1980s through the early 1990s to achieve secondary treatment of an average daily flow of 72 MGD. The plant currently treats on average 55 MGD of wastewater. The plant discharges its treated effluent into the Atlantic Ocean through an 84-inch diameter outfall pipe approximately 2.5 miles off the shore of Jones Beach.

The Glen Cove Wastewater Treatment Plant (WWTP) serves an area of approximately 19 sq. mi. in the northern portion of the county with an estimated population of approximately 27,000. All of the sanitary flow is from residential and commercial areas. The Glen Cove WWTP was originally constructed in the 1920s with only primary treatment and chlorine disinfection. Beginning in 1950, the plant was upgraded to secondary treatment with the addition of trickling filters and secondary clarifiers. In 1980, a new plant was constructed that utilized the activated sludge process for secondary treatment. The old trickling filter plant was decommissioned

and demolished. In 2002, the plant was upgraded to include processes for nitrogen removal from the wastewater. The plant is currently permitted for an average daily flow of 5.5 MGD. The plant actually treats approximately 3 MGD of wastewater. The plant discharges its treated effluent into Glen Cove Creek.

transport sanitary wastes where gravity is not a viable transport option. There are 25 pump stations that serve the collection system delivering sanitary wastes to the Bay Park STP, 15 pump stations that help deliver sanitary wastes to the Cedar Creek WPCP and 17 pump stations that are tributary to the Glen Cove WWTP. The wastewater collection system operated by the county is comprised of approximately 3,000 miles of sanitary sewers (ranging in size from 8-108 inches in diameter), 64,000 manholes and 300,000 individual service connections. The sewer maintenance program is designed to annually inspect and clean a portion of the sewers and manholes within the system. This program includes visual inspection, remote video inspection, power flushing, biological treatments (grease control) and herbicide treatments (root control).

The wastewater treatment plants' operations are regulated by the Clean Water Act under the direction of the United States Environmental Protection Agency (EPA). The EPA has delegated permitting authority to the New York State Department of Environmental Conservation (NYSDEC), which administers the State Pollution Discharge Elimination System (SPDES).

Wastewater Treatment in Suffolk County

In contrast to Nassau County, only 26% of Suffolk County is connected to a community sewage collection and treatment system capable of reducing nitrogen. The remaining 74% of the county utilizes on-site sewage disposal systems to meet their sewage disposal needs. These on-site sewage disposal systems are either systems consisting of cesspools (also known as leaching pools) or a combination of a septic tank and leaching pool (conventional on-site sewage disposal system). These systems typically have little nitrogen reduction capabilities. The wastewater effluent from these on-site sewage disposal systems discharges into the ground eventually impacting ground and surface water resources. Suffolk County contains the highest density of on-site septic systems within the Tri-State area with approximately 360,000 homes currently utilizing on-site sewage disposal systems. Of particular concern are the on-site septic systems located in the groundwater-contributing areas of potable supply wells and estuarine surface waters.

Suffolk County witnessed a population explosion between the 1950s and 1960s. According to United States Census data, the population of Suffolk County increased from approximately 276,000 in 1950 to more than 1,127,000 by 1970 -- an increase of more than 300%. Since that time, Suffolk County's population has grown at a much more modest pace (i.e., a population growth of 5.2% between 2000 and 2010). From 2010 through 2015, Suffolk County gained a mere 8,296 people bringing the total to 1,501,587. The population of Suffolk County is projected to grow modestly through 2035 ultimately reaching a population of approximately 1.77 million.

Fueled by national housing and transportation policies that favored suburban tract development, the landscape of the county began to be transformed as the population of Suffolk County increased. By 1970, the number of housing units within Suffolk County was just above 325,000. From 1970 to 2013, the number of housing units grew to more than 568,000. Currently, approximately 360,000 housing units use on-site sewage disposal systems that have limited nitrogen-reducing capabilities. The remaining units are connected to a community wastewater treatment system.

With population growth came an increased need for potable water and wastewater infrastructure to serve the needs of the people. A study was performed by the Suffolk County Department of Health Services (SCDHS) beginning in the early 1970s (known as the 208 Study) to determine the effects of building density on groundwater quality. The LICWTMP was based on the results of the 208 Study. Eight Groundwater Management Zones (GMZs), each with differing recharge characteristics, were identified. The 208 Study showed that one-acre zoning was needed to keep nitrate in groundwater impacts acceptable while allowing development utilizing on-site wastewater disposal systems to proceed. As a result, Article 6 was added to the Suffolk County Sanitary Code in 1981, which defined the means and methods for wastewater treatment in Suffolk County. Based on differences in regional hydrogeological and groundwater quality conditions, Article 6 delineated boundaries of the 8 GWMZs for protection of groundwater quality. The goal of creating the GWMZs was to limit groundwater nitrogen to 4 mg/L in GWMZs III, V and VI and to 6 mg/L in the remaining zones.

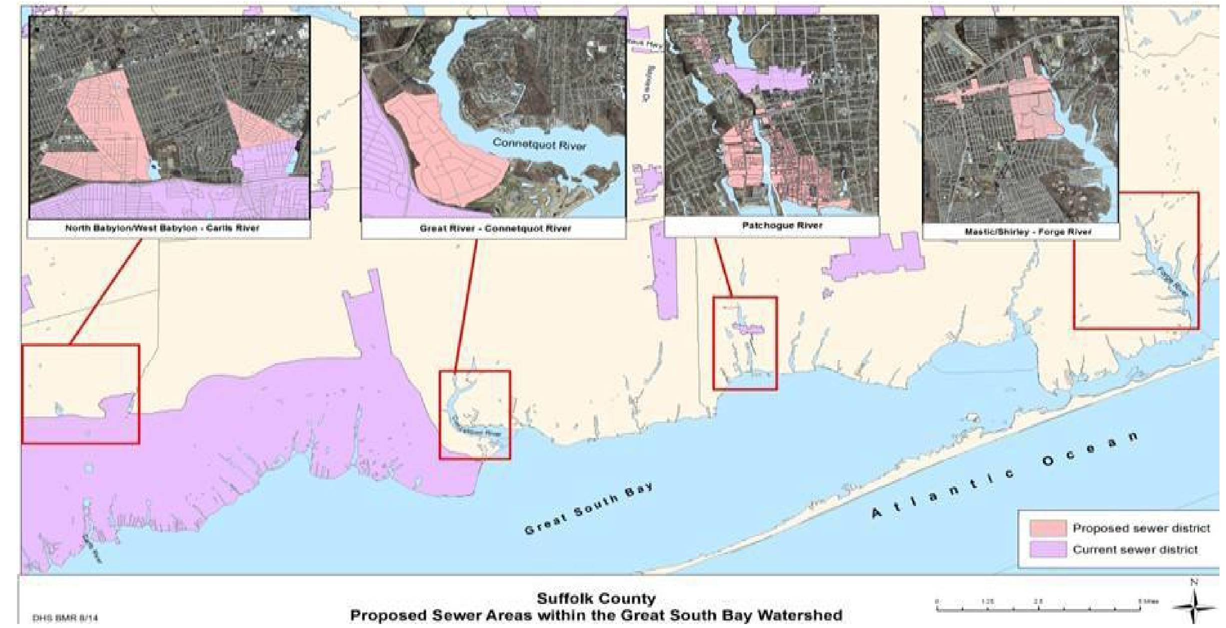
In order to facilitate reaching these nitrogen goals, residential properties located within GWMZs III, V and VI were required to have a minimum lot size of 40,000 square feet (sq. ft.) if using a conventional on-site sewage disposal system and either public water or private wells. Residential properties located in the remaining zones are required to have a minimum 20,000 sq. ft. of land when utilizing conventional on-site sewage disposal systems and public water or 40,000 sq. ft. with private wells. Commercial/industrial properties located in GWMZs III, V and VI were limited to a total discharge of 300 gallons per day (GPD) per acre when using a conventional on-site sewage disposal system and a public water or private well. The remaining zones were allowed 600 GPD per acre with public water or 300 GPD per acre with a private well. Exemptions from these guidelines were permitted for lots that existed prior to 1981, which allowed for higher densities in certain areas. Projects that exceed the density requirements as stated in Article 6 of the Suffolk County Sanitary Code and do not meet one of the exemptions are required to provide advanced treatment capable of reducing effluent nitrogen to 10 mg/L. This is accomplished by connecting the site to an existing or proposed community sewage treatment plant. However, many areas of Suffolk County were built before the Article 6 density restrictions or prior to conventional treatment system requirements. The Suffolk County Department of Economic Development and Planning estimated that more than 60% of the residential parcels in Suffolk County (more than 372,000) are less than or equal to one half acre. Of these, more than 257,000 (52.9%) are not sewered.

Additionally, there are more than 214,000 residential parcels less than one quarter acre, of which 26.7% are not sewered. As of 2017, changes were being considered to Article 6 that would require innovative/advanced on-site wastewater treatment systems (I/A OWTS) for new construction, modification of "grandfathering" provisions for commercial properties and establishing requirements for the replacement of conventional cesspools and septic systems.

Recent Developments in Suffolk County

Suffolk County has recently started to evaluate the feasibility of sewering various areas throughout the county. In 2008, the Suffolk County Sewer District/Wastewater Treatment Task Force was established by the Suffolk County Legislature. The goals of the Task Force were, among others, to evaluate Suffolk County's existing wastewater treatment infrastructure and to seek out public and private funding sources in order to expand its wastewater treatment facilities to additional areas within the county.

Figure 1 Suffolk County: Proposed Sewer Areas with the Great South Bay



In 2014, Suffolk County was awarded $383 million of Superstorm Sandy Recovery funds from New York State to install sewers and connect approximately 10,000 properties to sewage collection and treatment systems. This will be the first major sewering based project within Suffolk County in more than 30 years. The goal of the project is to reduce nitrogen pollution to ground and surface waters and to improve coastal resiliency against future storm events. The areas to be sewered are listed below:

- Mastic: Parcels in the Forge River area will be connected to a new wastewater treatment plant located near the Brookhaven Town Airport.
- North Babylon, West Babylon and Wyandanch: Parcels in the Carlls River area will be connected to the SWSD.
- Great River: Parcels in the Connetquot River and Nicolls Bay area will be connected to the SWSD.
- Patchogue: Parcels in the Patchogue River area will be connected to the Patchogue Sewer District.

Without extensive federal support, sewering has become prohibitively expensive. As an example, the 465 sewer connections proposed for Great River (number three above), which would be financed with a low 2% interest loan from the Environmental Facilities Corporation and involves simply connecting to an existing Bergen Point STP interceptor beneath nearby Heckscher Parkway, would cost an estimated $3,000 per year per parcel. A recent estimate from D&B Engineering and Architects, P.C. for connecting 5,600 Nassau County north shore properties to sewers came in at $120,000 per parcel.

Figure 2 May 2014 Feasibility Study

Annual Costs for Typical Property Owners (Sayville Sewer District Created)						
Property Type	"Typical " Assessed Value ($)	Annual Debt Service (Sewer Assessment)	Annual Electricity Cost & Service Contract	Annual O&M	Village of Patchogue Sewer User Fee	Total Annual Amount
Sayville Commercial Property	$45,000	$4,677	$1,850	$1,500	$8,270	$16,297
Sayville Residential Property	$45,000	$4,677	$375	$150	$745	$5,947

Existing Sewage Treatment Plants and Sewering in Suffolk County

As of 2013, Suffolk County has 197 operational STPs, 171 of which are designed to remove nitrogen from the wastewater with typical effluent total nitrogen of 10 mg/L or less. These types of plants are considered tertiary plants. The remaining 26 STPs are considered secondary plants, capable of reducing biochemical oxygen demand (BOD5) and suspended solids (SS). Of the 197 STPs, 15 discharge directly to surface waters. The 2013 average effluent total nitrogen for the tertiary plants in Suffolk County was 8.7 mg/L, which is less than the maximum allowed of 10 mg/L per SPDES permits.

The STPs in Suffolk County can be categorized as either centralized or decentralized. Centralized systems involve advanced processes that collect, convey, treat and discharge large quantities of wastewater. Municipalities usually own the centralized STPs. There are approximately 23 centralized STPs located in Suffolk County. Some of the major centralized sewer districts in the county include Bergen Point (Sewer District #3) and Selden (Sewer District #11), owned and operated by Suffolk County and the Town of Riverhead and Village of Patchogue STPs, which are operated by those municipalities. Bergen Point STP is the largest treatment plant in Suffolk County with an operating capacity of 30 MGD and is currently under construction to expand the plant to 40 MGD. Bergen Point STP is a secondary plant that discharges treated effluent two miles offshore into the Atlantic Ocean.

Sewer collection systems in Suffolk County consist mainly of gravity sewer lines with remote pump stations. In certain cases, low-pressure force mains have been utilized. The Village of Patchogue Sewer District has been expanding in recent years through the use of low-pressure force mains with pumping systems. The advantage of installing low-pressure force mains is the cost. They reduce the number of remote pump stations required, reduce the need for costly deep excavations to install gravity sewers and lower dewatering costs. Conversely, gravity sewers may be more expensive for developers or municipalities to install in certain cases but are less expensive for homeowners since the homeowner does not have to maintain and operate their own low-pressure pump station located on their property.

Unsewered Areas in Suffolk County

Most of the STPs located within Suffolk County are considered decentralized. Decentralized STPs are designed to operate on a smaller scale than centralized STPs and do not require multiple remote pump stations to convey sewage to the plant. The historical use of decentralized STPs in the county has been to serve single lots containing condominium complexes, apartment complexes, hotels or industrial or commercial buildings. The SCDHS has been actively requiring older plants that are under-performing and/or lack nitrogen removal capability to be renovated or replaced. During the past 15 years, 100 new STPs were constructed, 20 of which replaced existing facilities whose physical conditions and/or treatment capability had deteriorated. For example, the Kings Park STP, located on the grounds of the former Kings Park Psychiatric Center, was built in 1935, rehabilitated in 1960 and upgraded again in 2004.

Types of decentralized STPs in use throughout Suffolk County include rotating biological contactors (RBCs), sequence batch reactors (SBRs), extended aeration systems with a denitrification filter, membrane bioreactors (MBRs) and biologically engineered single sludge treatment (BESST) processes. All of these tertiary treatment plants are designed specifically to remove nitrogen. With the recent concerns regarding emerging contaminants [such as pharmaceuticals and personal care products (PPCPs)], some modifications may be required to some of the plants in order to remove these types of contaminants in the future.

As stated previously, 74% of Suffolk County residences use on-site sewage disposal systems. The effluent from on-site sewage disposal systems is discharged into the ground. The sands, silts, gravels and clays that make up the unsaturated zone and the aquifer function as a large sand filter and help to limit the impact of contaminants contained in effluents to groundwater as long as the density of development is not excessive.

Most commercial buildings within Suffolk County are also served by on-site sewage disposal systems. It has been estimated that there are more than 39,000 active commercial properties within Suffolk County using on-site sewage disposal systems. Some of these sites have multiple on-site sewage disposal systems serving the building(s) located on the parcel. Similar to residential sewage disposal systems, commercial on-site sewage disposal systems that comply with current standards consist of a precast septic tank for primary treatment and precast leaching pool(s). In 1984, standards were developed to address both the construction of such systems as well as the allowable sanitary flow permitted to be discharged from a commercial/industrial parcel. Therefore, there are many sites constructed prior to 1984 that may exceed the current density requirements of Article 6 and may have cesspools as a means of sewage disposal.

Subsequent to a 2014 tour of the septic replacement programs in Maryland, New Jersey, Rhode Island and Massachusetts, Suffolk County launched the first of two pilot programs to test I/A OWTS. Thirty-nine systems were donated by 14vendors and installed at homes around the county. As of early 2017, three of the systems have been provisionally approved by Suffolk County. These systems have reduced average nitrogen concentrations in the effluent from an average of 70 mg/L to less than 19 mg/L. An upcoming pilot will look to install several hundred systems in critical areas in close proximity to surface waters as was done in the Maryland and Rhode Island programs. This preliminary success will prepare the county for the up to $22 million in water quality funding starting in 2018 for the five East End towns pursuant to the referendum that approved allocation of 20% of the Community Preservation Fund for that purpose.

Since the cost of sewering has become prohibitively expensive, it is expected that the vast majority of the 360,000 residents and businesses using systems that do not reduce nitrogen or other contaminants will opt for the relatively reasonable cost of I/A OWTS. The typical price for such a system at a site with no complicating factors currently is $17,500. An amendment in 2016 of Article 19 of the Suffolk County Sanitary Code authorizes the SCDHS to act as "Responsible Management Entity" in the evaluation, approval, registration and oversight of I/A OWTS installations. Given that the north shore of Nassau County has at least 50,000 homes on cesspool/ septic systems and given the prohibitive expense of connecting to sewers, these developments address their circumstances.

Environmental Impacts due to Wastewater Effluent

Nitrogen in various forms can present a public health hazard in drinking water and can impact surface waters. The SCDHS samples for total nitrogen in wastewater effluent. Tertiary wastewater treatment plants discharging into the ground in Suffolk County are required to have an effluent total nitrogen concentration of 10 mg/L or less. Total nitrogen consists of organic nitrogen, ammonia (NH_4^+), nitrate (NO_3^-) and nitrite (NO_2^-). It has been estimated that wastewater nitrogen contributes approximately 69% of the total nitrogen to ground and surface water resources. The main source of wastewater nitrogen in Suffolk County is from the approximately 360,000 on-site sewage disposal systems utilized by county residents to meet their wastewater needs. Other sources of nitrogen to Suffolk County's water resources are storm water, fertilizers and atmospheric deposition.

In 2014, the SCDHS prepared an evaluation report of nitrate trends in Suffolk County supply wells. This report was an expansion of work previously completed by Camp, Dresser, and McKee (CDM) in the Draft Comprehensive Water Resources Report, which compared the 1987 and 2005 nitrate water quality data. The SCDHS expanded CDM's work by including 2013 nitrate data. Suffolk County has approximately 1,000 public water supply wells and an estimated 45,000 private wells. Several public water supply wells in Suffolk County are approaching or exceeding the nitrate drinking water standard and must blend or treat to reduce nitrate concentrations in drinking water delivered to the public. Public water suppliers on Long Island can spend an estimated $3.5 million in capital expenses for a nitrate removal system at a typical pump station and can spend an additional $125,000 per year in operating costs for electricity and disposal of waste products.

Nitrate data was compared at public supply wells screened in the Glacial and Magothy Aquifers. The Lloyd Aquifer was not evaluated since there are currently only a total of five public supply wells installed in the Lloyd Aquifer. The nitrate results for the Glacial Aquifer wells were based on samples collected from the same 173 wells sampled in 1987, 2005 and 2013. Nitrate concentrations in the Glacial Aquifer wells rose more than 41% from an average concentration of 2.54 mg/L in 1987 to 3.58 mg/L in 2013. As with the Glacial Aquifer, the nitrate levels in the Magothy Aquifer were based on samples collected from the same 190 public supply wells sampled in 1987, 2005 and 2013. Nitrate concentrations in the Magothy Aquifer wells rose more than 93.2% from an average concentration of 0.91 mg/L in 1987 to 1.76 mg/L in 2013.While these average concentrations are still below the drinking water standard of 10 mg/L, the increases are still a cause for major concern.

While nitrogen has historically been the most discussed and studied pollutant associated with wastewater management, it constitutes only one portion of our wastewater problem. Wastewater effluent contains other contaminants of concern

such as pharmaceuticals, microfibers, 1,4- dioxane, volatile organic compounds, gasoline, herbicides, heavy metals and pathogens. Some of these substances are legacy pollutants while others are newly emerging.

In addition to impacts on groundwater, wastewater effluent also impacts surface waters. Many of Suffolk County's 360,000 homes with cesspools and septic systems are situated in low-lying areas that have less than 10 feet separating their systems from the water table. When flooded or submerged in groundwater, septic systems do not function as designed and fail to adequately treat pathogens. In addition, the excess nutrient load from this wastewater is impacting coastal ecosystems through groundwater flow to our estuaries. Recent studies by researchers Kinney and Valiela demonstrate that 69% of the total nitrogen load for the Great South Bay is from septic systems and cesspools.

Impact of Wastewater Treatment on Water Balance

In the mid-1980s, the United States Geological Survey (USGS) did an extensive evaluation on the impact of sewering and reported that increasing eastward urbanization on Long Island during the past century has placed an increasing stress on the Island's groundwater resources. The introduction of sanitary sewers to reduce groundwater contamination from underground waste- disposal systems has deprived the groundwater reservoir of a large amount of water that would otherwise provide substantial recharge. This investigation was undertaken to predict the declines in groundwater levels and base flow that would result from an estimated loss of 140 cfs of recharge through the implementation of sewering in Nassau County SDD 2 and SDD 3 and, in Suffolk County, the SWSD. Results indicate that the stress will cause drawdowns as great as 8 feet along the Nassau-Suffolk County border, but the effects will decrease eastward across the subregional area. The predicted effect of sewering in southwest Suffolk County is less severe than that in Nassau County (Reilly, T. E., and Buxton, H. T., 1985, "Effects of sanitary sewering on groundwater levels and streams, Long Island, New York. Part 3 Model development for southern Nassau County"; U.S. Geological Survey Water-Resources Investigations 83-4210, pp. 41).

Hydrologic conditions on Long Island since the 1950s have shown a direct response to increasing urbanization. Extensive impervious land-surfacing also contributed to a decrease in infiltration and resulted in further reduced recharge. From the late 1960s through the mid-1970s, the stress of lost recharge abated and the hydrologic system approached a temporary equilibrium condition. In addition, the steady increase in consumptive pumpage in neighboring Queens County had stopped. This had been a large stress with considerable effect on the area studied, but, during the 1970s, it remained relatively constant (Buxton and others, 1981).

By 1990, sanitary sewers in the Nassau County SDDs 2 and 3 and the Suffolk County SWSD were projected to divert to ocean outfall 140 cubic feet of water per second that would otherwise be returned to the groundwater system through septic tanks and similar waste disposal systems. Sanitary sewers have long been used in western Long Island to limit the amount of contamination entering the groundwater system through septic tanks and similar waste disposal systems. The disposal of the treated wastewater to the surrounding salt water, however, instead of to the ground, removes a large volume of water that provided substantial recharge to the groundwater system. This reduction in recharge lowered the water table and potentiometric head throughout the groundwater system. The greatest water table decline (approximately 8 feet) occurs along the Nassau-Suffolk County border and decreases eastward. This is because most of the sewering stress is in Nassau County SDD 2 and 3.

The Comprehensive Water Resources Management Plan (the Comp Plan) concluded sanitary sewering systems that discharge to surface waters result in a net loss of groundwater from the aquifer system and a potential reduction in the local water table elevation. Because groundwater provides the baseflow for the county's fresh surface water features, sanitary sewering with surface water discharge can also result in a loss of stream baseflow. Consideration of these impacts requires site-specific evaluation. The impacts of sanitary sewering in Suffolk County's largest sewer district, Sewer District No. 3 (SWSD) on groundwater elevations and stream baseflow have been previously documented (CDM, 1995, 2002). Suffolk County considers the potential impacts of sanitary sewering on groundwater levels (an increase in the water table due to recharge of treated effluent or a decline in the water table due to discharge of treated effluent to a surface water body – as part of its evaluation of sewering feasibility. (www.suffolkcountyny.gov/Departments/HealthServices/EnvironmentalQuality/WaterResources/ComprehensiveWaterResourcesManagementPlan.aspx, pp. 3-102)

The present day water balance reflects the impacts of development, most notably groundwater withdrawals of 187 MGD, which account for 17% of total recharge. Although the installation of sanitary sewers in portions of the county has reduced the amount of water returned directly to the groundwater system, total recharge to the system (estimated to be 1,120 MGD) is calculated to be greater than total predevelopment recharge. This is due to the construction of a network of storm sewers and recharge basins (Comp Plan, pp. 3-107). Only minor differences in inflows and outflows exist in the predevelopment and present day water balances. The construction of stormwater recharge basins has resulted in an increase in total recharge from 1,203 MGD prior to development to a present day total of 1,367 MGD.

The water balances confirm earlier assessments that, on a county-wide basis, the aquifer system can sustain current and projected rates of water supply pumping. While development of a "safe" or sustainable aquifer yield was not within the scope of this report, the water balances show that average water supply pumping is only approximately 15% of the average recharge rate. In fact, much of the water withdrawn in the county is returned to the aquifer system through on-site wastewater disposal systems. Consequently, throughout much of the county, significant declines of stream baseflow have not been observed (Comp Plan, pp. 3-118).

Conclusions

One of Suffolk County's primary groundwater resource management goals is the reduction of nitrogen loading in order to protect current and future drinking water supplies and to restore/maintain ecological functions of streams, lakes, estuaries and marine waters. Also, the goal is to arrest and reverse the trend of increasing nitrogen concentrations in ground and surface waters to the greatest extent feasible and practical by decreasing the nitrogen loading from septic systems and fertilizers. Sanitary wastewater management is the most important factor affecting nitrate levels in groundwater throughout most of the county. Due to the significant contribution of groundwater baseflow to the county's surface waters, improved sanitary wastewater management practices can also affect nitrate levels in surface waters.

The impacts of rising sea level could be very significant in coastal areas and along the forks with significant implications for water supply, stormwater and sanitary waste management as well as more widespread flooding. The impacts of sea

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level rise on the location of the salt water interfaces must also be monitored and addressed from a water supply perspective. The impacts of both sea- level rise and more frequent extreme precipitation events should also be monitored so that wastewater and stormwater runoff management strategies can be developed and implemented.

Recommendations

Given the disparate construct of wastewater treatment between the Nassau and Suffolk Counties, the preponderance of recommendations must necessarily be tailored to their respective circumstances. There are, however, some shared principles. Their large-scale STPs are located in close proximity to the ocean and are thus subject to the vicissitudes of sea-level rise. It is one thing to draw notice to the jeopardy coastal infrastructure may face moving forward and another matter entirely to face as practical proposition, both in terms of logistics and costs. In the near term, the challenges faced by existing STPs will necessarily be addressed in place. It is essential to coordinate with federal, state and local partners to continue to assess the vulnerabilities to sea- level rise.

As harmful algal blooms are an Island-wide issue, it is imperative to engage a coordinated strategy to reduce sources of nitrogen and other contaminants of concern and to address wetland stewardship and shellfish restoration as well as continuing to support and fund the use, where appropriate, of marine plants and shellfish as biofiltration to reduce pollutants in surface waters.

Nassau County Priorities

Nassau County priorities include nitrogen reduction, storm hardening and contaminants of emerging concern (CECs). Nitrogen reduction differs for Nassau County's north shore and south shore. The north shore must find cost-effective means to improve residential on-site septic systems and to leverage the available wastewater treatment capacity of the Glen Cove WWTP. The south shore must remove the Bay Park STP effluent discharge from local waterway (Reynolds Channel/western bays) through either a new ocean outfall or diversion of treated effluent to the Cedar Creek WPCP to share existing ocean outfall. Funding for this project has not yet been identified. As learned from Superstorm Sandy, climate change is a concern as treatment facilities are located near shorelines for ease of discharge. Storm mitigation/hardening must be considered along with usual technical aspects of a project. Contaminants of emerging concern, including pharmaceuticals and personal care products, are increasingly being detected at low levels in surface water and there is concern that these compounds may have an impact on aquatic life. Given the vast number, types and complexities of these contaminants, it is vital that federal and state agencies develop guidance information so that owners of wastewater treatment plants can include best practices in projects for mitigating impacts.

Suffolk County Objectives

STPs

- Siting of new or expanded STPs within the 0-25 year contributing area to sensitive surface waters should be minimized to the extent feasible; if an STP is located within this zone, an advanced treatment process shall be provided (SCDHS, 2014).
- Widespread adaption of discharge regulation that utilize mass loading of nitrogen rather than effluent concentration (parts per million). Currently, STPs discharging to the Long Island Sound have this type of restriction.
- Promotion of STP treatment technologies that addresses CECs.
- Accelerate wastewater reuse, mining for resources, energy production and source separation as ways to better value wastewater.
- Identify and prioritize parcels and determine the sewage treatment plant capacity to permit the connection of identified parcels.
- Identify and implement treatment technologies to improve wastewater effluent quality to reduce impacts and for permitting water reuse akin to Riverhead STP's initiative to re-use wastewater effluent for golf course irrigation for consideration countywide.
- I/A OWTS & Appendix A Systems.
- Prioritize parcels in critical areas that shall be required to install nitrogen-reducing I/A OWTS.
- Amend the Suffolk County Sanitary Code Article 6 to revise GWMZ 4 density requirements to conform to GWMZs 3, 5 and 6 to improve groundwater protection in the zone and improve surface water quality in the Peconic Estuary.
- Moving forward, separation distances between a water supply well and the leaching field of OWTS should be sufficient to ensure both pathogen removal and contaminants of emerging concern removal. Horizontal setback distances between OTWS and surface waters should be increased in order to increase treatment of CECs and PPCPs.
- Create a Wastewater Management District with a responsible management entity (RME) to oversee the financing, operation, maintenance and enforcement of I/A OWTS and cluster systems. Consider municipal partners to help advance installations.
- Create and/or identify funding sources and costs to meet on-site system objectives. Continue to advance a range and combination of on-site solutions that can treat to higher levels of treatment. Allow the vetting of systems to occur regionally to speed the acceptance of a larger range of options.
- Evaluate ways to reduce costs for the installation, oversight and maintenance of on-site systems. (e.g., guaranteeing X number of sales to manufacturers, alternative reporting methods, reduced permit fees for I/A OWTS upgrades, etc.)

- Allow installations of nonproprietary, natural and source separation systems.
- Modify the Sanitary Code to minimize the "grandfathering" of SPDES and/or SCDHS- permitted sanitary flows that exceed and predate Sanitary Code density requirements on other than single-family residential lots, without the installation of an I/A OWTS or connection to sewers; Review options to effect upgrades under the Environmental Conservation Law; New York State Codes, Rules, and Regulations and SPDES. Assess feasibility of updating the Sanitary Code to prohibit the replacement of failed on-site wastewater technology (e.g.,"replacement in-kind") without SCDHS approval.
- Implement a comprehensive integrated data collection, analysis and evaluation program to monitor groundwater, drinking water and surface water, and guide informed protection and management strategies.
- Reinstate comprehensive groundwater and stream monitoring program and report annually.
- Implement and upgrade the Bureau of Public Health Protection and Division of Environmental Quality databases and enhance their capabilities to provide a comprehensive integrated geo-coded data management program for all regulated facilities, public, and non- residential private wells (location, pumpage and quality); private well quality; groundwater and surface water quality data; salt water intrusion monitoring data; facility data; inspection records; STP Discharge Monitoring Reports (DMRs) and monitoring data; and on-site wastewater management systems' installation, maintenance, inspection and performance.
- Work closely with federal, state and local partners to share readily accessible, actionable information, identify synergies and share resources.
- Evaluate feasibility of inter-governmental water resource cradle-to-grave data management plan. (USEPA, USGS, NYSDEC, New York State Department of Health, SCDHS, Suffolk CountyWater Authority, towns and villages, other suppliers, stakeholders, etc.).
- Continue to support and to coordinate with the Peconic Estuary Program, the Long Island Sound Study and the South Shore Estuary Reserve Program to implement projects.

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Safe Yield

The Long Island aquifer system consists of a sequence of unconsolidated deposits of Late Cretaceous and Pleistocene Age that rest on bedrock beneath Kings (Brooklyn) and Queens Counties in New York City and Nassau and Suffolk Counties to the east. This groundwater system contains four major aquifers – the Upper Glacial, Jameco, Magothy and the Lloyd Aquifers (the Lloyd Aquifer being the deepest of the major aquifers). These aquifers provide the water supply that is used for drinking, domestic, commercial, industrial, agricultural, institutional and fire-fighting uses by residents of Nassau and Suffolk Counties.

The Long Island groundwater system has been designated by the United States Environmental Protection Agency to consist of the sole-source aquifers (SSA) of Brooklyn-Queens and Nassau-Suffolk, as authorized under Section 1424(e) of the Safe Drinking Water Act of 1974. The USEPA defines a sole or principal source aquifer as an aquifer which supplies at least 50% of the drinking water consumed in the area overlying the aquifer with no reasonably available alternative drinking water sources should the aquifer become contaminated. The SSA program enables the USEPA to designate an aquifer as a sole source of drinking water and establish a review area that includes the area overlying the SSA to ensure that proposed projects that receive federal funding do not contaminate the SSA.

The aquifers beneath Long Island have been used for water supply purposes for hundreds of years. According to the USGS (Nemickas, Mallard & Reilly, 1989), in the mid-17th century, virtually every house had its own shallow well that tapped the uppermost unconsolidated geologic deposits and also had its own cesspool that returned wastewater to the same deposits. By the end of the 19th century, as population increased, individual wells in some areas had been abandoned in favor of shallow public supply wells. During the first half of the 20th century, the contamination resulting from increased wastewater discharges led to the eventual abandonment of many domestic and shallow public supply wells for deeper high capacity wells. By the 1930s, over-pumping in Kings County had induced salt water intrusion; and, in 1947, all pumping for public supply in Kings County was stopped to prevent further salt water intrusion and replaced with water from upstate reservoirs (Buxton and Smolensky, 1998). The introduction of large-scale sewer systems in more heavily populated areas during the 1950s, which protected the aquifers from further contamination, diverted sewage to treatment plants, the bays and the Atlantic Ocean, thereby lowering the water table and reducing or eliminating stream flow.

Safe yield is defined as the maximum quantity of water that can be extracted from an underground reservoir, yet still maintain the supply unimpaired (Todd, 1959). Pumping in excess of safe yield leads to overdraft, which is a serious problem in certain groundwater basins in the United States and elsewhere. Until overdrafts are reduced to safe yields, permanent damage or depletion of the groundwater supplies can be expected.

The safe yield of a (surface water) reservoir of known size and capacity, defines the “maximum quantity of water that can be supplied from the reservoir during a critical period” such as a drought (Alley, et al, 2004). The term safe yield was first used in 1915 (Meyland, 2011). Its meaning has evolved over time, including its more recent use in groundwater studies.

Alley et al (1999) and Maimone (2004) have described the case of Nassau County, New York, as a tradeoff between groundwater quality and surface water quantity. In the 1970s and 1980s, with nitrate concentrations in groundwater increasing due to on-lot septic systems, a decision was made to install sewer lines and treatment facilities in approximately 85% of the Nassau County land area. The treated effluent then was discharged through ocean outfalls. In the ensuing years, groundwater levels dropped by as much as 14 feet in some parts of Nassau County. Thus, a decision had been made to allow for significant surface water and groundwater quantity impacts in exchange for improved groundwater quality.

In contrast to Nassau County, approximately 74% of Suffolk County is unsewered. As a result, most streams in Suffolk County still have relatively undiminished baseflow. Suffolk County officials chose to maintain groundwater and surface water quantity through the widespread use of on-site sewage disposal systems. This decision resulted in some degree of water quality impairment as a result of the use of such sewage disposal systems. Although Suffolk County has not adopted a formal definition of sustainable yield, the acceptable impact to streams has been defined. Permissible sustainable yields have been tentatively defined in water budget areas as percentages of the average recharge rates in order to control saltwater intrusion (Maimone, 2004).

The 1986 Long Island Groundwater Management Plan estimated the safe yield for Nassau County to be 180 MGD. The plan also provided an estimate for Suffolk County of 466 MGD. It should be noted that those were just initial estimates. In addition, different approaches were used to formulate the initial estimates. Detailed scientific study and review is needed to determine actual safe yield. Such a detailed study is underway and is part of the $6 million Long Island Groundwater Sustainability Project that United States Geological Survey is performing for the New York State Department of Environmental Conservation.

It is estimated that Nassau and Suffolk counties together have approximately 60 trillion gallons of groundwater stored within its aquifer system. Additionally, precipitation adds approximately 438 billion gallons of recharge to the aquifers annually (Masterson, 2016). According to the NYSDEC public water supply well pumpage data from 2000 through 2013, total annual pumpage from the aquifer system beneath Nassau and Suffolk Counties is approximately 137 billion gallons (this estimate is for public water supply only). Therefore, total pumping throughout Long Island is less than recharge by precipitation and only a fraction of the overall volume of water already stored in the aquifer system. However, only about 5-10%, or 3-6 trillion gallons, is “drainable” from the aquifers. So, while there is an abundance of groundwater beneath Long Island, judicious and efficient use of it is key to its sustainability. It should also be noted that there are natural discharges or outflows from the aquifer system that need to be maintained with the “excess” water in storage. This includes discharge to streams, and flow to deeper aquifers. Therefore, safe pumpage must be maintained at quantities far below recharge in order to preserve these outflows and keep the entire hydrogeologic system intact.

The 15-year daily pumpage average in Nassau County (from 2000 through 2014) has been 189 MGD, which is in excess of the initial estimated sustained yield of 180 MGD. Average daily water withdrawal in Suffolk County over the same period has been documented to be 187 MGD, which is less than the estimated safe yield of 466 MGD.

The following summarizes recharge, withdrawal and underflow to surface water bodies for each county:

Nassau County

- On average, 330 MGD of recharge enters the groundwater system.
- Withdrawal, on average, is 189 MGD from the system.
- Therefore, there is 152 MGD of underflow to subsurface sediments and surface water bodies.
- Salt water intrusion is a concern in Great Neck, Port Washington, Glen Cove, Locust Valley, Bayville and the southwestern section of the county.

Suffolk County

- On average, 1,120 MGD of recharge enters the groundwater system.
- Withdrawal, on average, 213 MGD from the system.
- 933 MGD as underflow to subsurface sediments and surface water bodies.
- Salt water upconing concerns on North and South Forks.
- Since the 1950s, consolidation of water supply systems in Nassau County has been discussed. Comprehensive studies in 1971 and 1980 formulated recommendations for various degrees of consolidation to address forecasted water supply deficits during the 1990s. Both studies projected that countywide pumpage would exceed permissible sustained yield during the respective planning periods. All water suppliers undertook responsible action during the mid to late 1980s to address potential water deficit concerns by embracing the Nassau County Water Conservation Ordinance (see Section 6.2). The ordinance was promulgated in 1986. Water utilities used this ordinance to promote customer awareness and to educate the public on conserving water.

This data clearly shows that a uniform (applied in a consistent manner to both counties) and more refined method for calculating safe yield must be developed. “The sustainable yield of an aquifer must be considerably less than recharge if adequate amounts of water are to be available to sustain both the quantity and quality of streams, springs, wetlands and groundwater-dependent ecosystems.” (Sophocleous, 1998). Some have suggested that a term well-matched to Long Island conditions is “managed yield,” which adds a margin of safety to traditionally developed levels of sustainable pumpage. (Meyland 2011). Meyland posits that this determination should be a community-wide assessment, not strictly a “scientifically defined” level of water withdrawal to determine a community assessment of what impacts are acceptable to the interconnected aquifer and surface water system.

The current data shows that Nassau County needs to evaluate water use and implement progressive water efficiency measures based on current pumpage patterns and preliminary safe yield estimates. Although Suffolk County pumpage is below the estimated safe yield, water efficiency strategies and measures should

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also be implemented to address regional salt water intrusion concerns, reduce the likelihood of wetland loss and reduce the rate at which contamination moves downward into the groundwater system.

Water Use and Regulation of the Lloyd Aquifer on Long Island, New York

The Lloyd Aquifer is the deepest of the four major aquifers on Long Island and contains groundwater that is up to thousands of years old and in many places of pristine quality. This aquifer is used extensively in Nassau County and minimally in Suffolk County as a source of public water supply. The aquifer is threatened by increasing salt water intrusion and migration of chemical contamination from aquifer segments in the overlying Upper Glacial and Magothy Aquifers. This report examines the hydrogeological condition of the aquifer, water quality, pumpage, the 1986 Moratorium on new Lloyd Aquifer wells, recharge and monitoring programs. The report also identifies investigations that are needed to further evaluate the condition of the Lloyd Aquifer, including the determination of “managed yield” and “water budget” and to further evaluate salt water intrusion. Lastly, this report provides recommendations for amendment of New York State Environmental Conservation Law (ECL) or the issuance of regulatory decisions by the commissioner of the NYSDEC to improve protection of the Lloyd Aquifer and the North Shore aquifer, which is interconnected with the Lloyd Aquifer, for future beneficial and sustainable use. This report examines the quality of groundwater in the Lloyd Aquifer, the quantity of supply well pumping, the estimated aquifer recharge, salt water intrusion investigations, monitoring programs and aquifer management and protection needs in accordance with the Nassau County and Suffolk County 2014 legislation that established the Long Island Commission for Aquifer Protection (LICAP).

United States Geological Survey Investigations and Reports

The USGS has completed extensive investigations of the Lloyd Aquifer on Long Island that were identified and summarized by Chu (2006). This report states that the earliest comprehensive study of Long Island’s groundwater resources was done by Veatch et al (1906) who were the first to name a stratigraphic deposit from Lloyd Neck as the Lloyd Aquifer. Chu (2006) identified subsequent USGS reports that estimated hydraulic properties, potential groundwater yield, regional rates of groundwater movement and the age of groundwater in the four aquifers, including the Lloyd Aquifer. The USGS has mapped Long Island’s geologic units, thickness, water table and potentiometric-surface altitudes of the Upper Glacial, Magothy and Lloyd Aquifers and has reported pumping of the Lloyd Aquifer in western Long Island. The USGS has also studied the geology and groundwater conditions in southern Nassau and southeastern Queens Counties and has demonstrated that the Lloyd Aquifer is hydraulically separated from the overlying units and contains fresh water.

Lloyd Aquifer Hydrogeology

The USGS (Chu, 2006) reports that the Lloyd Aquifer (Lloyd Sand Member of the Cretaceous Age Formation) on Long Island extends from central Kings, northwestern Queens and Nassau Counties and northeastern Suffolk County to the east and south. The aquifer deposits may be clear, white, yellow or grey and consist of a fine to coarse sand and gravel with layers of clay, fine sandy clay and clayey sand that give it moderate to low permeability. The Lloyd Aquifer rests upon a bedrock surface, is completely bounded above by the

Raritan confining unit (or Raritan Clay), which has very low permeability and is considered by the USGS to be the only fully confined aquifer on Long Island (Chu, 2006). The Lloyd Aquifer's thickness varies from zero in northern Kings County to more than 500 feet in south central Suffolk County. The depth to the top of the aquifer ranges from about 200 to about 1,500 feet below sea level (FBSL) (Olcott, 1995).

Groundwater Withdrawal from the Lloyd Aquifer

Table 1 identifies 46 Lloyd Aquifer public water supply (PWS) wells located in 18 public water systems in Queens, Nassau and Suffolk Counties (Leung and Pilewski, 2016; Young, 2016). The list provides the local and NYSDEC well number, depth and capacity in gallons per minute (GPM) and includes four Lloyd Aquifer wells in Queens County, 37 in Nassau County and five in Suffolk County. Figures 1 and 2 show the location of these wells and select observation wells in Kings, Queens, Nassau and Suffolk Counties, which are referred to later in this report.

Table 1
Long Island Lloyd Sands Aquifer Public Water Supply Wells

PWS GPM	WELL	DEC #	DEPTH		PWS GPM	WELL	DEC #	DEPTH	
QUEENS COUNTY					SUFFOLK COUNTY				
NYCDEP: Richmond Hills	17	Q-00031 7	552	1300	VA Medical Center: Northport	2	S-00004 9	728	150
NYCDEP: Jamaica	6 C	Q-00056 2	607	1800	VA Medical Center: Northport	1 A	S-12091 9	744	150
NYCDEP: Jamaica	18 A	Q-00056 7	627	1200	SCWA: Huntington	13 A	S-12586 5	588	450
NYCDEP: Richmond Hills	8 A	Q-00306 9	555	1000	SCWA: Huntington	14 A	S-12691 5	568	450
					SCWA:	15 A	S-12911	530	750

Note: SCWA: Suffolk County Water Authority; VA Medical Center: Veterans Administration Medical Center; NYAW: New York American Water; WAGNN: Water Authority of Great Neck North.

PWS GPM	WELL	DEC #	DEPTH		PWS GPM	WELL	DEC #	DEPTH	
NASSAU COUNTY									
Bayville (Village)	1-1	N-07620	480	1000	Manhasset Lakeville Water District	East Shore Road 5	N-09308	255	140 0
Bayville (Village)	1-3	N-08776	459	1000	Manhasset Lakeville Water District	Valley Road	N-12802	408	140 0
Bayville (Village)	2-1	N-10144	374	1000	Manhasset Lakeville Water	Lakeville Road	N-13749	567	950
Jericho Water District Lido-Point Lookout Water District Lido-Point Lookout Water District	11 3 1 A	N-05201 N-08534 N-12217	504 127 5 127 7	1200 1200 1200	District Mill Neck Estates Mill Neck Estates NYAW - Lynbrook (Atlantic Beach)	7 1 2 6-1	N-06042 N-08426 N-04405	340 360 620	60 160 140 0
Lido-Point Lookout Water District	2 A	N-12218	128 5	1200	NYAW - Sea Cliff	2	N-07857	614	140 0
Locust Valley Water District	4	N-00118	465	1250	Port Washington Water District	N-1	N-01715	480	510
Locust Valley Water District	5	N-00119	570	1600	Port Washington Water District	N-2	N-01716	483	550
Locust Valley Water District	6	N-01651	465	1000	Seawanhaka (Centre Island)	1	N-13532	450	30
Long Beach (City)	9	N-02597	123 5	1250	Split Rock	2	N-12525	Unknown (U)	U
Long Beach (City)	11	N-05308	122 1	1250	Water Authority of Western Nassau	16 A	N-10958	722	110 0
Long Beach (City)	12	N-06450	127 5	1250	WAGNN	5	N-00687	310	750
Long Beach (City)	13	N-07776	122 6	1180	WAGNN	6	N-01298	342	100 0
Long Beach (City)	15	N-08233	122 4	1250	WAGNN	7	N-02214	290	850
Long Beach (City)	16	N-08557	125 2	1250	WAGNN	8	N-03443	463	100 0
Long Beach (City)	17	N-13004	127 3	1200	WAGNN	11	N-08342	434	100 0
Long Beach (City)	18	N-13475	128 5	1250	Westbury Water District	9	N-02602	805	100 0
Manhasset Lakeville	SR 1	N-01328	746	1050					

Table 2 summarizes the quantity of Lloyd Aquifer public supply well pumpage in millions of gallons per day during 19 years of NYSDEC records from 1996 to 2014 (Pilewski, 2016) and compares it to the USGS (Chu, 2006) historical annual average and maximum (peak year) pumping from the Lloyd Aquifer in Kings, Queens Nassau and Suffolk Counties up to 1995.

This Table reveals a decrease in the Long Island average annual Lloyd Aquifer well pumping from 13.84 to 11.3 MGD and a decrease from 28.7 to 14.1 MGD in the total peak year pumping, resulting from the discontinuation of pumping in King and Queens Counties and a significant reduction in peak year pumping in Nassau County.

Table 2
Historical Lloyd Aquifer Public Supply Well Peak Pumpage

County/Area	Average Annual MGD (Up to 1995)	Average Annual MGD (1996-2014)	Maximum Annual MGD (Up to 1995)	Maximum Annual MGD (1996-2014)
Kings	0.74 (1929-46)	0	3.0 (1931)	0
Queens	4.1 (1920-95)[1]	0	8.2 (1944)	0
Nassau	9.0 (1920-95)	10.9	17.5 (1971)	13.3 (2012)
Suffolk	NR[2]	0.4	NR	0.6 (2007)
Long Island[3]	13.84	11.3	28.7	14.1

Note: 1. Excludes 0 MGD in 1993; 2. NR: Not Reported; 3. Sum of the Average Annual MGD or Maximum Annual MGD pumping in each county during pumping periods.

Also, the NYSDEC (Leung and Pilewski, 2015) reported that Lloyd Aquifer public supply well pumping in Nassau County, for the 15-year period of 2000-2014, averaged 10.6 MGD, approximately 6% of the 189 MGD average annual public supply well pumping in Nassau County during those years.

Lloyd Aquifer Recharge

The USGS (Chu, 2006) reports that the Lloyd Aquifer contains about 9% of Long Island's fresh water, but receives only 3.1% of the recharge through a narrow corridor that is only 0.5 mile wide along the groundwater divide in Kings, Queens, Nassau and Suffolk Counties. The USGS has also estimated that the annual recharge to the Long Island aquifer system is approximately 50% of total precipitation (Petersen, 1986); and has defined the "water-budget area" for Long Island (Cohen et al, 1968) as including about 760 sq. mi. in Nassau and Suffolk Counties excluding the north and south forks in Suffolk County. (Kings and Queens Counties are excluded from the water- budget area because of intensive urbanization and other related factors).

Since the average annual precipitation on Long Island is 45 inches per year (Petersen, 1986), it may be estimated that the total recharge to all aquifers in the "water-budget area" is approximately 814 MGD with approximately 25.25 MGD (3.1%) recharging the Lloyd Aquifer. This estimate of recharge, however, may not consider all of the water lost due to outflow from the Lloyd Aquifer, which for Nassau County has been reported to be as high as 6 MGD (Nassau County, 1998). It is also important to note that as the total volume

of fresh water in the Magothy and Upper Glacial Aquifer declines, the amount of water that recharges the Lloyd Aquifer also declines. A distribution of the total estimated Lloyd Aquifer recharge in proportion to the effective recharge areas indicates that Lloyd Aquifer recharge is approximately 7.25 MGD (29%) in Nassau County and 18.0 MGD (71%) in Suffolk County.

The average annual Lloyd Aquifer pumping in Nassau County (10.9 MGD) substantially exceeds the estimated Lloyd Aquifer recharge (7.25 MGD) indicating a significant deficit (3.65 MGD) condition that is producing a reduction in Lloyd Aquifer storage and, hence, inducing salt water intrusion. This deficit and reduction in storage may be even greater than 3.65 MGD depending upon the actual amount of aquifer outflow. It should be noted that these estimates do not include any inflow or outflow across county borders. The threat of a reduction in Lloyd Aquifer storage and eventual depletion has been recognized by NYCDEP when it warned in 2007 that "Currently, the Lloyd Aquifer's resources are depleting, mainly due to the rate of consumption by Long Island communities that is greater than the rate of natural recharge." In Suffolk County, the average annual Lloyd Aquifer pumping (0.4 MGD) is well below the estimated Lloyd Aquifer recharge (17.75 MGD), also not considering outflow losses.

Lloyd Aquifer Public Supply Well Quality

Table 3 lists the highest concentration of select chemical constituents detected in the most recently available testing of Lloyd Aquifer public supply wells in Queens County (Cartwright, 2002), Nassau County (Young, 2016) and Suffolk County (Hime, 2016). The NYCDEP (2015) has reported the following range of contaminants in the Queens County groundwater supply system but has not reported the range of contaminants in Lloyd Aquifer supply wells that are a part of the system: Iron: ND to 18.9 parts per million (ppm); Manganese: ND to 3.3 ppm; Nitrate: ND to 12.0 ppm; and Volatile Organic Compounds (VOCs): ND to 3,170 parts per billion (ppb).

Table 3
Lloyd Aquifer Public Supply Well Testing Results
Highest Levels of Select Contaminants

	Chloride (mg/L)	Iron (mg/L)	Nitrate (mg/L)	Perchlorate (mg/L)	VOCs (ug/L)
MCL/PAL	250	0.3	10.0	18	5
County					
Kings	N/A	N/A	N/A	N/A	N/A
Queens (1992/96)	22	NR	1.30	NR	23.9 (*TTHMs*)
Nassau (2013-2015)	141	13	4.33	1.1	29.8 (Freon 22)
Suffolk (2013-2015)	11	0.12	4.5	1.9	4.4 (TCE)

Note: mg/L: milligrams per Liter; ug/L: micrograms per Liter; N/A: Not applicable (there are no public supply wells in Kings County); NR: Not Reported; MCL/PAL: Maximum Contaminant Level (Primary Action Level for Perchlorate); TTHMs: Total Trihalomethanes; Freon 22: Chlorodifluoromethane; TCE: Trichloroethylene.

Chloride, which is found in high concentrations in sea water and road salt, has been detected in Lloyd Aquifer public supply wells in Great Neck (42.1-141 mg/L) and indicates that salt water intrusion is occurring. These levels are, however, below the 250 mg/L MCL, and the supply wells continue to be used. The level of chloride in Locust Valley Water District Well No. 5 (39.5 mg/L), Queens County Well No. 17 (22 mg/L) and Port Washington Water District Well N-2 (19.1 mg/L) indicate potential salt water intrusion. The chloride level in five Lloyd Aquifer public supply wells in Suffolk County (6-11 mg/L) and 22 Nassau County Lloyd Aquifer wells in the communities of Atlantic Beach (1), Bayville (3), Jericho (1), Lido-Point Lookout (3), Long Beach (8), Manhasset (4), New Hyde Park (1) and Westbury (1) that have less than 10 mg/L of chloride reflect pre-development conditions when chloride probably ranged from 3-12 mg/L (Cartwright, 2012). (See Tables 4 & 5 for chloride levels in monitoring wells).

Iron is a naturally occurring mineral that dissolves from aquifer deposits under reducing/oxygen depletion conditions. The highest levels of iron in Lloyd Aquifer public supply wells are found in the barrier beach communities of Atlantic Beach (7.1 mg/L), Long Beach (3.5-13 mg/L) and Lido- Point Lookout (3.16-4.81 mg/L) and require iron removal treatment. Lloyd Aquifer public supply wells inland and on the north shore of Nassau County have iron levels below 1.0 mg/L (< 0.02 to 0.84 mg/L) as do Suffolk County Lloyd Aquifer public supply wells (<0.1 to 0.12 mg/L).

Nassau and Suffolk County Lloyd Aquifer public supply wells have been impacted by nitrate contamination that originates from fertilizer and sanitary sewage discharges. These wells, which contain nitrate below the MCL of 10 mg/L, are located in Locust Valley (3.83-4.33 mg/L), Huntington and Northport (2.1-4.5 mg/L), Great Neck (1.74-3.7 mg/L), Mill Neck (1.42-1.46 mg/L) and Queens County (1.3 mg/L). Lloyd Aquifer wells in the Nassau County barrier beach communities of Atlantic Beach, Long Beach and Lido-Point Lookout have the lowest nitrate levels (<0.05-<1.0 mg/L) and reflect pre-development nitrate levels of less than 0.2 mg/L, measured as nitrogen (Cartwright, 2002).

Volatile organic compounds (VOCs) are found in industrial chemical solvents, paints, refrigerants, cleaning products, adhesives and numerous other products that may be toxic or carcinogenic. Trihalomethanes (THMs), which are typically produced by the reaction of chlorine or other disinfectant chemicals with organic material found in sewage, surface water, drainage or public water supply distribution systems, were the principal VOCs found in Queens County public supply wells where Total THM (TTHM) levels were found at a maximum level of 23.9 ug/L in USGS 1992/1996 testing (Cartwright, 2002). VOCs have also been detected in eight of 37 Lloyd Aquifer public supply wells in Nassau County. This includes: Manhasset-Lakeville Water District Valley Road Well (Freon 22: 29.8 ug/L), which has a VOC removal air stripping tower (AST) treatment; 3 Locust Valley Water District wells (0.6-5.8 ug/L) including Well 5, which has granular activated carbon (GAC) treatment; and four wells in Great Neck (0.5-17 ug/L) including Well 6 and Well 8 that also have ASTs. In Suffolk County, four of five Lloyd Aquifer public supply wells also contain VOCs (0.5-4.4 ug/L) but at levels below the MCL of 5 ug/L for an individual VOC.

Perchlorate, which is a component of rocket fuel, pyrotechnics and Chilean caliche fertilizer, has been detected in one Lloyd Aquifer public supply well in Nassau County (Locust Valley Water District Well No. 4) at a level of 1.1 ug/L and in one Lloyd Aquifer public supply well in Suffolk County (Northport Veterans Administration Hospital Well) at maximum levels of 1.8 and 1.9 ug/L. Perchlorate has not been detected in any of the three SCWA Lloyd Aquifer public supply wells in Huntington.

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Salt Water Intrusion

The USGS (Luscynski and Swarzenski, 1966) has reported that salty groundwater occurs in southern Nassau and southeastern Queens Counties as three wedge-like extensions that project landward in unconsolidated deposits from a main body of salty water that lies seaward of the barrier beaches in Nassau County and Jamaica Bay in Queens County. The highest chloride content of the wedges is reported to be approximately 16,000 ppm, which is approaching the typical chloride content of sea water (19,400 ppm). A leading edge of the deep wedge of salt water intrusion is located at the base of the Magothy Aquifer and at the shoreline east of Lido Beach extending inland about four miles to Woodmere and seven miles to South Ozone Park. The extent of salt water intrusion in the Lloyd Aquifer, which lies below the Raritan Clay, however, is not known. The USGS report also indicates that along and near the barrier beaches, salty water from the underside of the deep wedge is moving downward very slowly toward the freshwater in the Lloyd Aquifer. The report concludes that the very small increases in chloride detected in Long Beach, Atlantic Beach and Rockaway Park supply wells suggest downward salt water intrusion into the Lloyd Aquifer and possible lateral intrusion from offshore areas to supply wells in the upper beds of the Lloyd Aquifer.

Nassau County reopened a study of salt water intrusion in 1987 (Fitzgerald and Maimone, Camp Dresser & McKee, 1991) and reported that, although the location of the interface of a salt water wedge in the Lloyd Aquifer is not known, the use of a salt water intrusion computer model (DYNSWIM) -- using an arbitrary assumption that the wedge is located three miles offshore projected very slow rates of advance of less than 30 feet per year and only a one-half mile advance of the wedge over a 100-year period. The USGS updated previous studies of salt water intrusion and used a three-dimensional model to simulate salt water intrusion in the four major aquifers in Kings, Queens and western Nassau Counties (Terracciano, 1997; Misut, et al, 2002).

Table 4 presents the results of the testing of two Lloyd Aquifer observation wells in Kings County and four of eight observation wells in Queens County in 1992 and/or 1996 (Figure 1) that were found to have the highest chloride testing results as reported by the USGS (Cartwright, 2002).

Table 4
Select Kings and Queens County Lloyd Aquifer
Monitoring Well Chloride Testing Results

Observation Well	Location	Chloride (mg/L)	Year
K-2859	Coney Island	54	1992
K-3426	Southern Brooklyn near Queens	8,500	1996
Q-1071	Queens Barrier Beach	56	1992
Q-0287	Jamaica Bay Island (Howard Beach)	120	1992
Q-3657	Southern Queens	10,500	1992
Q-1373	Northern Queens near Flushing Bay	1,300	1996

The chloride levels detected in K-3426, Q-3657 and Q-1373 are far higher than the chloride concentrations detected in coastal Lloyd Aquifer observation wells such as K-2859 in Coney Island, Q-287 in Jamaica Bay and Q-1071 on the Queens County Barrier Beach. The USGS (Cartwright, 2002) suggests that the cone of depression in southern Queens County generated by public supply withdrawal from the Lloyd Aquifer (Buxton and Shernoff, 1995) has caused inland migration of salt water and that the fresh water-salt water interface may be about seven miles farther inland than previously estimated by Buxton and Shernoff. The USGS has also investigated the extent of salt water intrusion in the Lloyd Aquifer in northern areas of Nassau County and published three reports (Stumm, 2001; Stumm, et al, 2002; 2004) that provide information regarding the hydrogeological conditions of the aquifer, including the water table, potentiometric surface and salt water intrusion. A USGS paper (Stumm, 2006) states that the Lloyd Aquifer has been extensively or completely eroded in places and is hydraulically interconnected to a confined Pleistocene Age Aquifer (North Shore Aquifer), This report also states that public supply pumping reduced water levels to as much as 40 feet below sea level and over-pumping has induced eight wedges of salt water intrusion into the aquifer.

Stumm (2006) states that chloride concentrations in Lloyd Aquifer supply wells ranged from 5-10 mg/L and those in the North Shore aquifer were similar. However, six public supply wells (five in the Lloyd Aquifer and one in the North Shore Aquifer) have been shut down due to elevated chloride concentrations. A total of eight salt water wedges have been identified in Great Neck, Manhasset Neck and Oyster Bay, having peak chloride concentrations ranging from 180-13,750 mg/L.

Table 5 presents the results of the Nassau County Department of Public Works (NCDPW, 2005) testing of two Lloyd Aquifer south shore, eight Lloyd Aquifer north shore and one North Shore (Lloyd Aquifer-interconnected) Aquifer observation wells (Figure 3) that had chloride levels which reflect varying degrees of salt water intrusion.

Table 5
Select 2003 Chloride Testing Results Lloyd and North Shore Aquifer Observation Wells (NCDPW, 2005)

Observation Well	Location	Chloride (mg/L)	Aquifer
Q-00287	Howard Beach	145	Lloyd
N-10620	Atlantic Beach	45	Lloyd
N-12076	Kings Point	780	Lloyd
N-12153	Kings Point	5,900	Lloyd
N-12793	Port Washington	112	Lloyd
N-12508	Port Washington	800	Lloyd
N-12318	Sands Point	155	North Shore
N-12618	Bayville	45	Lloyd
N-12790	Bayville	2,850	Lloyd
N-12870	Bayville	108	Lloyd
N-12646	Lattingtown	28	Lloyd

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The NCDPW (2005) report also contains a map that shows a 5-foot potentiometric surface depression in the Lloyd and North Shore Aquifers that extends from the southeast corner of Great Neck to the southwest corner of the Manhasset Neck peninsula into the lower area of Hempstead Harbor. This cone of depression suggests that public supply well withdrawals from the Lloyd and North Shore Aquifers has resulted in the inland migration of salt water or salt water wedges as reported by the USGS (Stumm, 2001; and Stumm, et al, 2002; 2004). Chu (2006) reports that nearly all pumping from the Lloyd Aquifer has been in the western part of Long Island and states that the excessive pumpage has led to salt water intrusion in the Lloyd Aquifer in coastal areas.

NCDPW tested a line of progressively deeper Lloyd Aquifer monitoring wells from Long Beach Island to Jones Beach and Tobay Beach (Busciolano and Terracciano, 2013) that show a trend of low to high to lower chloride levels. The westernmost well in Atlantic Beach (N-13682, 1,237 feet deep) has 42 mg/L of chlorides while the next deeper and easterly well in Long Beach (N- 13879, 1,400 ft. deep) has 110 mg/L, showing clear evidence of salt water intrusion. The remaining deeper and more easterly wells from Long Beach (1,500 feet deep and 1,600 feet deep) to Tobay Beach (1,800 feet deep) have lower chloride levels (15, 18 and 6 mg/L, respectively).

There is currently very limited USGS monitoring of groundwater levels and no network of deep outpost wells to monitor salt water intrusion in Kings and Queens Counties, and it has been more than 12 years since the positon of the fresh water-salt water interface in the Magothy and Lloyd Aquifers was last assessed (done in 2004) (Misut and Voss, 2007). Nassau County has recently provided funding to reinstate the USGS annual well monitoring program; however, that contract expired on September 30, 2017 (Mangano, 2017). The county requested that the state provide a permanent annual funding source for the work which totaled $220,000 for the 2016-2017 federal fiscal year.

The Water Authority of Great Neck North (2013) has developed a Water Conservation plan of action to protect its resources. The plan consists of an aggressive conservation program coupled with a comprehensive well management plan. Under this plan, the Authority has constructed three operating wells off the peninsula to provide some relief for any salt water intrusion on the peninsula.

Lloyd Aquifer Moratorium

The New York Environmental Conservation Law (New York ECL) titled “Moratorium on the drilling of new wells in the Lloyd” (ECL, §15-1528) established a moratorium on the granting of new permits to drill public water supply, private water supply or industrial wells into the Lloyd Aquifer or to permit new withdrawals of water from the Lloyd Aquifer. The moratorium applies to all areas that are not “coastal communities” but shall apply to all areas including “coastal communities” for the storage or pumping of water into the Lloyd Aquifer. The moratorium requires that the waters of the Lloyd Aquifer be reserved for the use of “coastal communities,” but does not affect the permits of wells that were screened in the Lloyd Aquifer and withdrawing water at the time that the moratorium was enacted (1986). The NYSDEC commissioner, however, may grant exemptions to the moratorium upon a finding of “just cause and extreme hardship.” ECL§15-1528 was amended (September 25, 2008) to also apply to the storage or pumping (recovery) of water into the Lloyd Aquifer.

Per ECL º15-1528, the moratorium may only be lifted upon a finding by the commissioner that sufficient research has been conducted providing a sound working knowledge of the details, dynamics, water volume and levels of safe withdrawal appropriate to maintain a safe quantity of Lloyd Aquifer water. The commissioner must also find that a "workable program is in place that can properly administer a well permit program for the Lloyd Sands water. Such program shall take into account both the localized and regional aspects and implications of Lloyd Sands water withdrawals, with special attention given to the prevention of water contamination and salt water intrusion. The program must ensure that a safe level of withdrawal from the Lloyd Sands is not exceeded" (ECL§15-1528 Moratorium).

The NYSDEC has been directed under ECL §15-1528 to identify those areas of Long Island within the counties of Kings, Queens, Nassau and Suffolk, which for the purpose of that section, shall be considered "coastal communities." ECL §15-1502 defines "coastal communities" as meaning those areas on Long Island where the Magothy Aquifer is either absent or contaminated with chlorides. The NYSDEC, however, has not yet undertaken a comprehensive assessment of what constitutes a "coastal community" as required by the statute, thus the delineation at present has to be determined on a case-by-case basis (Grannis, 2007).

On April 27, 2004, the NYSDEC determined that a permit application (SCWA, DEC Project No. 1-4700-00010/00583) to install a production well into the Lloyd Aquifer was complete, and the application was referred for a hearing by the Department's Region 1 Office (Sanza, 2004). The application requested approval for the proposed construction of a 300 GPM well (No. 3) at the SCWA's Middleville Road well field that would pump Lloyd Aquifer water to blend with water from a Magothy Aquifer well that was contaminated with nitrates. The SCWA application was denied by the NYSDEC in the "Decision of the Commissioner" (Grannis, 2007), which stated that SCWA did not establish that its existing Middleville Road well field was "contaminated with chlorides" and cannot, therefore, be considered an exempt "coastal community" and that SCWA failed to meet the statutory standard of "just cause and extreme hardship."

During 2014, two new applications for the installation of new Lloyd Aquifer wells were submitted to the NYSDEC by public water suppliers in Nassau County, including the Bethpage Water District, which is pending, and the New York AmericanWater-Sea Cliff (NYAW-SC) water system, which was withdrawn on November 3, 2015. NYAW-SC has also submitted a Water Withdrawal Application (WWA) to the NYSDEC to replace the Lloyd Aquifer Well 1 at the Sea Cliff station, which had a screen failure in November 2016, with a replacement Well 1A at the same site. NYAW-SC inserted a new well screen in the existing well as a temporary repair for the 2017 pumping season.

The North Shore Aquifer

The North Shore Aquifer is defined as a sequence of poorly to moderately sorted, dark, olive- brown and olive-gray gravel sand and silt layers (Stumm, 2001). The aquifer was penetrated during drilling in the northernmost part of Great Neck in 1991-1996 where it was determined that the Lloyd Aquifer, the Raritan confining unit and the Magothy Aquifer had been completely removed from the northern part of the peninsula by extensive glacial erosion. The North Shore Aquifer name was introduced as a distinct hydrogeologic unit to represent a sequence of Pleistocene-Age sediments that are confined by a Pleistocene-Age clay (North Shore confining unit), that are in contact with bedrock and hydraulically interconnected with the Lloyd Aquifer. The North Shore Aquifer was also investigated in the northernmost and central part of Manhasset Neck (Stumm, Lange, and Candela, 2002) and in the northwestern, central and northeastern parts of the Town of Oyster Bay (Stumm, Lange, and Candela, 2004).

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Stumm (2001) states that the North Shore Aquifer deposits were called the Jameco Gravel and the Port Washington Aquifer by Kilburn and Krulikas (1987). The top of the aquifer ranges from 70-90 feet below sea level (FBSL) in the Great Neck peninsula, 70-300 FBSL in Manhasset and 150-500 FBSL in the Town of Oyster Bay. The aquifer thickness ranges from as little as 5-10 feet to more than 150 feet thick in Great Neck; 50-150 feet thick in Manhasset; and 100-230 feet thick in Oyster Bay. The rapid response of water levels to tides and/or pumping indicates the North Shore Aquifer is moderately permeable and confined (except for one area in Manhasset, where it appears to be semi-confined) (Stumm, Lange and Candela, 2002). Both the North Shore and the Lloyd Aquifers are impacted by pumping and tidal effects and vulnerable to salt water intrusion.

Long Island Groundwater Study

On February 25, 2016, Governor Andrew Cuomo announced a series of water quality initiatives, which will include a $6 million Long Island study conducted by the USGS for the management of groundwater across Long Island (Nikic, 2016). An NYSDEC (April 2016) statement indicated that the purpose of the USGS study is to create an updated and enhanced Long Island Regional Groundwater Flow modelling tool for use by the USGS, NYSDEC, Nassau County, Suffolk County and other key water resources management partners in the region. This will enable better management of the region's groundwater resources, including, but not limited to, managing for over-pumping, salt water intrusion, salt water upconing, plume migration, surface water impacts of groundwater outflow and determining safe-yield. The study will also update the hydrogeologic framework of Long Island to obtain a better understanding of groundwater flow and include the installation of a network of deep Lloyd and Magothy Aquifer observation wells to augment the current monitoring well network and determine the current and predicted future extents of salt water intrusion and salt water upconing.

Conclusions

The NYSDEC is the agency that has the responsibility of managing the water resources of New York State and enforcing the requirements of the ECL so as to protect the Lloyd Aquifer from the adverse impacts described in this report. The NYSDEC implements water supply protection programs on Long Island and the Water Withdrawal Application (WWA) permitting program to assure that groundwater resources are properly managed and allocated. The NYSDEC role is critical in assuring that the Lloyd Aquifer is protected and withdrawals allocated in a manner that will preserve this resource. The 1986 Lloyd Aquifer moratorium has been in place for more than 30 years to prevent the installation of new Lloyd Aquifer wells in non-coastal communities. This has helped preserve the aquifer for those communities that have no other cost-effective source of public water supply. The moratorium must be continued in the absence of a finding by the NYSDEC commissioner that a workable program is in place to properly administer a well permit program for the Lloyd Aquifer water with special attention to the prevention of water contamination and salt water intrusion. The program must ensure that a safe level of withdrawal from the Lloyd Aquifer is not exceeded. The absence of such a finding by the NYSDEC commissioner and evidence of continued over-pumping of the Lloyd Aquifer that promotes water contamination and increasing salt water intrusion requires that additional measures be taken to protect and preserve the aquifer and ensure that a safe level of withdrawal does not continue to be exceeded.

This section addresses several methods for protecting groundwater quality or quantity – by protecting the ground through which precipitation passes, using water more efficiently, reusing water or transmitting from an area with a groundwater surplus to another area with a groundwater deficit.

Land Preservation Opportunities

Land preservation is usually directed with the intent to preserve land for open space purposes. Avoiding future development and the potential adverse environmental impacts thereof also provides a significant direct benefit of water quality protection. Agencies in New York State, Nassau County, Suffolk County and New York City have historically employed land preservation efforts as a goal to protect water supplies. This section discusses measures and efforts affecting water quality preservation, including drinking water consumption rates, public water supply, land preservation, water quality and recharge rates, growth and demand for drinking water resources, water supply needs, indirect and economic benefits of land preservation and water quality protection initiatives and recommendations for further study.

Land and Preservation Needs for Water Quality Preservation

A number of state and regional studies, master plans and other adopted plans emphasize land preservation goals for the purpose of water quality protection. For example, New York State's 2014 Open Space Conservation Plan states, "Preventing development of land in Special Groundwater Protection Areas and Deep Flow Recharge Zones will help ensure the long-term integrity of Long Island's water supply and preclude the need for costly water filtration systems and groundwater remediation efforts." Nassau County's 1998 Comprehensive Plan states, "The first major environmental goal is to protect and preserve the county's critical natural resources, including the wetlands, aquifers, shorelines, water bodies, open space, significant vegetation and nature preserves." The Suffolk County Comprehensive Water Resources Management Plan states, "Preservation of open space is the most effective way to protect ground and surface water quality from a water resources management perspective" (SCDHS, 2015).

Although New York City's public water supply is surface-water dependent, unlike the sole source aquifer system supplying Nassau and Suffolk Counties, New York City protects the quality of its water supply through the acquisition of undeveloped land in the Catskill and Delaware River watersheds. By investing $1.5 billion, primarily in land acquisition, to protect its 2,000 square mile (sq. mi.) watershed, NYC has avoided spending $6 billion to develop a water filtration plant (The City of New York, 2015; NYCDEP, 2014).

The Long Island Comprehensive Special Groundwater Protection Area Plan referred to the "hierarchy of preservation techniques that can be employed to maximize the quantity and quality of future recharge. These techniques range from outright fee acquisition through acquisition of development rights or transfer of development rights to large lot zoning with clustering on one acre parcels." It also stated, "Often the most effective, most complete and often most costly strategy for maintenance of aquifer quality in the Special Groundwater Protection Areas (SGPAs) is to protect the overlying watershed land surfaces by placing undeveloped lands in the public domain, fencing them in and proving adequate policing to ensure against pollution."

In Nassau and Suffolk Counties, approximately 168,000 acres (22% of all land on Long Island) have been protected from development by federal, state, county and municipal governments. Approximately 20%, or 33,600 acres of this protected land, is located in Nassau County while the remaining 80%

of the protected open space is located in Suffolk County. In both counties, an estimated 113,000 acres of unprotected, undeveloped parcels consisting of farms, wetlands, forests, meadows and beaches still remain (NCMP, 2010). More than one third of the 113,000 acres is unlikely to ever be developed due to site constraints such as topography or other physical characteristics, but approximately 67,000 acres in Nassau and Suffolk Counties could still be developed (NCMP, 2010). More than 90% of the 67,000 acres, 60,300 acres, is in Suffolk County, and approximately 10% or 6,700 acres of private, vacant, developable land is in Nassau County.

According to the Nassau County Master Plan (2010), the number of undeveloped acres in Nassau County is expected to dramatically decrease from approximately 1,200 acres in 2010 to 250 acres by 2050. The report indicates that development pressure is significant due to competing needs and interests; however, efforts will be made to redevelop property, focus development in existing and emerging downtowns and protect open space.

Indirect and Economic Benefits

Land development is typically accompanied by increases in demand on water resources. Community and recreational facilities such as public schools, hospitals, emergency, services and recreational facilities such as parks and athletic fields also can place additional stress on existing water resourced. When land is preserved for water supply protection, the increased demands for these resources and facilities are minimized. Preservation results in secondary or indirect benefits that add value to properties and communities. These secondary benefits include: habitat protection, soil conservation and natural groundcover for aquifer recharge protection of scenic resources, preservation of historic and archaeological resources and natural open space. All of these secondary benefits also potentially offer significant quantitative economic benefits such as increased property values and resulting real estate tax revenue, and, in Suffolk County, increased agricultural food production and sales.

A 2012 report titled The Economic Benefits of New York's Environmental Protection Fund prepared by the Trust for Public Land (TPL) states that lands conserved through the Environmental Protection Fund (EPF), New York's funding source for critical environmental programs, provide valuable natural goods and services such as air pollution removal, water quality protection and stormwater management. The TPL estimated that $23.9 million is saved annually on Long Island in stormwater management and treatment costs due to the natural filtration of stormwater in parks and open spaces. The TPL analyzed EPF-conserved lands and found that every $1 invested by the State of New York returns $7 in economic value in natural resource goods and services alone.

The Nassau County Master Plan (2010) discussed transfer of development rights (TDR), tax revenue and cost saving relative to TDR programs. It states: "The key fiscal advantage of land preservation via TDR is that the assessed value of the preservation parcel is transferred to a receiving site along with the purchased development credit. This prevents the reduction of the local property tax base when property is preserved through other measures (i.e., government/not- for-profit acquisition). This regional planning approach may lead to future municipal cost savings due to the incremental increase in service and infrastructure demand resulting from new development in areas that are already provided with adequate infrastructure."

Recent proposed amendments to the Community Preservation Fund program in Suffolk's five eastern towns were approved by local residents to allow funds collected on the program to be used on water quality improvement projects and to extend the self-imposed transfer tax until 2050. Now, a maximum of 20% of each town's fund may be utilized for implementation of water quality improvement projects, such as: wastewater treatment improvement, non-point source abatement and control program projects, aquatic habitat restoration, pollution prevention, and operation of the Peconic Bay National Estuary program. The funds may not be used to permit or accommodate new growth.

Water Transmission

Unlike many parts of the country that have relied on distant water sources (consisting of either large well fields or surface impoundments) and long distance transmission to the points of consumption, Long Island water suppliers have relied on localized supply and distribution of water. It was recognized early on that an abundant fresh water supply exists below the ground virtually everywhere on Long Island; and the most economical and efficient method of providing water to an expanding Long Island population was to acquire land, construct wells as needed in response to population trends and to interconnect these multiple local sources of supply with appropriately-sized pipes for local distribution. The existing water supply infrastructure reflects this practice. Even in areas where regional-scale groundwater contamination has been a problem, such contamination has, for the most part, been handled using a similar localized approach. Beginning in the 1970s, volatile organic compound (VOC) contamination affected numerous wells throughout Nassau and Suffolk Counties. Such contamination has been addressed through the installation of granular activated carbon (GAC) adsorption units or air strippers installed at individual well fields.

Mains supplying water on Long Island are typically 12" to 16" in diameter and are designed to accommodate flows up to several thousand gallons per minute. Well fields are located within one to 2 miles of each other in populated areas. This practice has allowed for local control and local resolution to distribution-related problems. The manifestation of this local approach has been the formation of numerous water purveyors supplying water to a relatively small geographic area.

Nassau County exemplifies this localized approach, with 46 community public water systems serving a 287 sq. mi. area. In Suffolk County, this practice has been modified somewhat, with the formation of the Suffolk County Water Authority (SCWA), which today serves approximately 85% of Suffolk residents. Even so, Suffolk County historically has had a multitude of small- to medium- sized water purveyors serving many parts of the county. Over time, the SCWA has acquired the majority of them. Despite these acquisitions, there still currently are more than 30 other community public water systems and more than 200 non-community systems located throughout Suffolk County. This preponderance of small municipal and private suppliers has suppressed the implementation of a more regional approach to water supply, such as large centralized pumping centers and/or large diameter, high-capacity transmission mains.

The purpose of this report is to discuss the benefits and concerns of transferring bulk water across county lines or between public water supplier boundaries within a county.

Historical Studies of Water Transmission Opportunities

Since the 1960s, numerous studies of the groundwater and drinking water resources of Long Island have been prepared. Virtually every one of them has included discussions and recommendations relating to the transfer of water from a source other than the groundwater underlying a supplier's specific service area. In general, these reports identified issues with salt water intrusion in coastal communities as well as the potential for over-pumping the aquifers beneath Nassau County. The following is a partial listing of some of these studies and the recommendations of each with regard to long-distance transmission of water.

Comprehensive Public Water Supply Study CPWS-24 (Holzmacher, McLendon and Murrell, 1970)

This report predicted a water deficiency in Nassau County of 40 million gallons per day (MGD) by 1980 and 200 MGD by 2020 (pp. 179). Two possible plans for transmitting water from central and eastern Suffolk County to Nassau County were analyzed. Plan A would export 120 MGD to Nassau County until 2015 and 80 MGD thereafter, until the year 2020. Implementation would require 80 well fields, approximately 7,000 ft. apart, each with two wells with capacities of 2 MGD each, 55 miles of new transmission main (16" to 60" diameter) along the Long Island Expressway corridor, and two booster stations to maintain water pressure in the mains (pp. 180). Plan B would provide for the export of 80 MGD to Nassau County until the year 2020 using 70 well fields, 48 miles of new transmission main and two booster stations (pp. 181). The cost of these scenarios in 1970 was estimated at $1.9 billion for Plan A and $1.8 billion for Plan B (pp. 237). Adjusted to 2016 with inflation, this equates to $12 billion and $11 billion, respectively. Given the additional costs involved in well and pump station construction today that were not a factor in 1970 (such as additional contaminant sampling and environmental review), these inflation-adjusted costs could easily double or triple.

City of Long Beach, Nassau County, New York Master Water Plan (Holzmacher, McLendon and Murrell, 1971-1985)

This report recognized resource limitations and the distribution capacity problems of the Long Beach water supply system at that time and suggested the city "seek and support a county program of providing supplemental water...from new supplies in Suffolk County and from New York City..." (pp. 2). The report also recommended upgraded interconnections to adjacent suppliers to facilitate the wholesale purchase of water from them and also mentioned the possibility of other interconnections to the main body of Nassau County (pp. 120).

Comprehensive Public Water Supply, County of Nassau, State of New York (Greeley and Hanson, 1971)

This report summarized numerous other studies, all of which mention predicted deficiencies within Nassau County and possible supplemental supplies, including both Suffolk County and New York City (pp. 50). One particular report that was referenced mentioned the potential for a 50 mile-long aqueduct from upstate reservoirs within the Hudson River watershed to Nassau County, to provide 60-106 MGD by the year 2000 (pp. 52). Another report referenced in this study suggested linking New York City and Long Island water supplies together as well as importing water from Suffolk County into Nassau County (pp. 53-54).

Long Island Groundwater Management Program [New York State Department of Environmental Conservation (NYSDEC, 1986)

Portions of this report mention that the transfer of water from areas of abundance to areas with inadequate supply is an important alternative to consider in supplying these deficient areas (pp. III-62). The report later suggests interconnection of systems for greater flexibility and better emergency preparedness (pp. IV-75). It also suggests that Nassau County purchase the 72" diameter aqueduct that runs along Sunrise Highway and incorporate it into a county-wide transmission system (pp. IV-78).

Commonalities Among Studies

While the overall scope of each of the referenced studies was not exactly the same, similar conclusions and recommendations were made throughout the decades. The following is a brief summary of the most relevant conclusions and recommendations:

- Importation of water from Suffolk County or New York City to Nassau County to reduce pumping in Nassau County and/or to supplement its water supply.
- Interconnections and agreements between Nassau County water suppliers to assist smaller water suppliers most susceptible to salt water intrusion or other sustainability issues.
- Formation of a Nassau CountyWater Authority tomanage the locations of aquifer withdrawals county-wide.
- Shutdown of the Jamaica Water Supply system and connect it to the New York City surface water supply system.
- Installation of centralized drinking water wells and transmission mains to provide water to smaller water suppliers most susceptible to saltwater intrusion or other sustainability issues.
- Purchase of and rehabilitation of the 72-inch aqueduct along Sunrise Highway.

Some of the above conclusions and recommendations have been realized while others have not. A recent attempt to import water from the SCWA into the Village of Farmingdale was unsuccessful due to political objections. Interconnections now exist between all neighboring water suppliers. However, formal agreements may not exist in all cases. The formation of a Nassau County Water Authority has been met with political resistance. The former Jamaica Water Supply wells have been removed from service; however, NYC is currently pursuing the idea of returning these wells to service for possible drought protection. The concept of centralized wells and transmission mains has not been implemented.

Feasibility of Long Distance Water Transmission

Since construction of a long-distance water transmission main has never been attempted before on Long Island, developing an accurate cost estimate for such a specific project is difficult. Fortunately, the SCWA has investigated the concept of long-distance water transmission through relatively large-diameter water mains in two areas affected by elevated nitrate levels.

One such estimate consisted of more than 88,000 feet (16.8 miles) of water main ranging in size from 12” to 30” diameter. This main would originate in the Dix Hills area and connect to the Northport, East Northport and Huntington areas, all of which have wells with elevated nitrate levels. This main is designed to transmit approximately 12,000 gallons per minute (GPM), at an estimated cost of $20.5 million or $1.22 million per mile (about $231 per linear foot). The second transmission main project investigated by the SCWA involves construction of a water main connecting Greenport to Orient in the Town of Southold. It would consist of more than 17,000 ft. (3.36 miles) of 12” diameter pipe. With a design flow of approximately 500 GPM, its estimated cost is approximately $3.84 million or approximately $1.14 million per mile (about $216 per

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linear foot). There is remarkable similarity in price between the two project estimates, despite the fact that they are quite different in terms of quantity of water, size, and length.

Other area water suppliers have investigated the concept of long-distance water transmission as well. In a recent project under design, the Westchester Joint Water Works (WJWW) has investigated the use of the New York City Department of Environmental Protection Delaware Aqueduct (Shafts 20 and 22) as replacement water for its Rye Lake water source. The cost estimate for the transmission mains, which include mains from 12” to 60” in diameter, ranges from $200 per linear foot for 12” mains up to $3,000 per linear foot for 60” mains.

The WJWW also is investigating the feasibility of a 16” diameter transmission main project. The project design is done by modeling and involves 9,800 feet of 16” inch main. The cost estimate is approximately $5 million or $510 per linear foot. The cost includes a bridge crossing and approximately eight utility crossings.

Factors Affecting the Current Status of Water Transmission on Long Island

Many, if not all, Nassau and Suffolk County suppliers have emergency interconnections in place currently. However, formal agreements for the exchange of water do not exist at all interconnections. Further, many of these interconnections are not metered.

Many coastal water suppliers are vulnerable to the impacts of salt water intrusion and would most likely be among the first public water suppliers to consider importing water from neighboring water suppliers. These agreements should be incentivized and implemented.

Water suppliers which are impacted by large contamination sources may benefit from importing water from neighboring water suppliers. A cost analysis will be required to determine whether this is beneficial. Further, the potential impact to the movement of the contamination plume must be understood. Groundwater modeling is required prior to implementing this policy.

Prior to moving large volumes of water from county to county or from supplier to supplier, research must be conducted in several areas: (Impacts to the aquifer from the supplier providing the water by over-pumping a well or well field that could potentially change aquifer flow patterns and draw in contamination that may affect other supplier’s sources.)

- Jurisdictional boundaries set by state law (franchise territory) when districts and/or authorities were created that prohibit that district or authority from operating or managing systems outside of their coverage area.
- Studies, reports and hydraulic models should be referenced or conducted when investigating the effects of moving large volumes of water from one geographic area to another.

- Development of a regional groundwater model is required to fully understand the sustainability of the aquifer(s). A full understanding of pumpage versus recharge is required in order to make sound policy decisions. Data must be collected on a continuous basis in order to maintain the model into the future.
- A thorough cost analysis must be done. Such an analysis must include the actual cost of installing water mains of appropriate diameter as well as any land acquisition and booster stations that may be needed. The cost of any additional wells to supply water into the transmission mains must also be calculated. Ancillary costs, such as environmental studies, engineering and laboratory sampling, must also be included.

Additional Considerations

Routing

Numerous factors go into the decision on the exact route of a transmission main. Construction- related factors include the road opening permits that may be required from different municipalities (and the resulting necessary restoration), the proximity to wetlands and the mitigation that will be required, the depth to groundwater and any dewatering that may be necessary during construction (including the discharge and/or disposal of the pumped water) and the requirements for jacking or horizontal directional drilling for long underground crossings of creeks or highways. Overall planning-related factors influencing the route include: elevation changes and the number and severity of any bends in the pipeline, both of which dictate head losses along the route of the pipeline and the possible requirement for booster pumps. In order to recover the head loss due to friction and provide water at the proper pressure and at the proper elevation, several booster pumps undoubtedly will be required. Acquiring land for booster pumps as well as the electricity to operate the pumps will add substantially to the overall costs of any transmission project. All of these factors add to the expense of the overall project to a degree indeterminate at this time.

Hydrogeologic Impacts

In addition to the recommendations regarding the infrastructure and facilities required for long distance transmission, more recent studies have attempted to evaluate the potential hydrogeologic impacts of this practice. Since all the water in any scenario involving long distance transmission will be used and recharged a substantial distance from its source, it will be permanently lost from the groundwater system in the area from which it is pumped. This could result in the long-term lowering of the water table in coastal plain ponds and wetlands within sensitive areas (such as the Pine Barrens). The impacts of this hydrologic imbalance will need to be investigated to see if they meet permit criteria. Groundwater models are excellent tools for investigating and quantifying such impacts. In consideration of its transmission proposal as described above, the SCWA utilized the Suffolk County Groundwater Model in order to obtain a rough "order of magnitude" estimate of the hydrologic impacts of a hypothetical scenario involving consumptive pumping from the Pine Barrens area. In this simulation, five pumping centers were chosen each with a pumping rate of 2 MGD, for a total of 10 MGD of total additional pumpage. Each well was simulated to be screened in the middle Magothy Aquifer, in order to minimize impacts to the water table. The simulations resulted in

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water table drawdowns of up to three feet in some portions of the Pine Barrens at the simulated rate of 10 MGD. Some mitigating measures undoubtedly would be necessary to prevent long-term impacts to surface waters and wetlands. The NYSDEC would be best to comment on the feasibility of and mitigations required for a project of this size and scope.

Permitting

A cross county water transmission proposal would require a coordinated review by local health departments, water suppliers affected, the New York State Department of Health, the NYSDEC and possibly the United States Environmental Protection Agency. A process for evaluation and approval would need to be developed by those involved regulatory entities. As a minimum, it would include the preparation of an engineering report, engineering plans, obtaining public comment and potentially an Environmental Impact Statement. There would be a host of issues that would have to be addressed in the engineering report, including: the source and quality of the treated water, the protection of the water supply, storage and pumping, source and distribution system controls, pressure, flow and water quality monitoring, etc.

Conclusions and Recommendations

The following conclusions and recommendations are offered:

- Incentivize the implementation of intermunicipal agreements for water transfer to water suppliers that are threatened by salt water intrusion or other major sources of contamination.
- This includes the purchase and transmission of water from both New York City and Suffolk County into Nassau County.
- Fund the development of a regional groundwater model to be used for planning purposes.
- Evaluate the potential costs involved.

Efficiency Programs

Efficiency programs tailored to reduce the amount of water consumed offer significant benefits as described in this section. At present, there is no shortage of drinking water on Long Island. However, due to the combination of groundwater pumpage from the aquifers and ocean discharge of treated sanitary waste, the overall volume of water in the aquifers has decreased over the past several decades causing water table elevations to drop and the salt water interface to move landward. This has resulted in a loss or reduction of surface water wetlands such as streams, ponds and lakes. This loss of wetlands has required the implementation of expensive habitat and flow restoration programs in some areas such as Massapequa Creek. Because of changing climate conditions, proactive planning and implementation of efficiency measures to reduce water use will be vital to ensure that future Long Islanders will have both a safe and adequate supply of drinking water and healthy and abundant surface waters.

Proactive water efficiency measures have far reaching financial, emergency preparedness and operational benefits for water suppliers and the communities they serve. These water efficiency measures also can provide significant environmental benefits that result from reduced pumping rates. These benefits include: maintenance of surface water features by minimizing the lowering of the water table, minimizing salt water intrusion incidents and slowing the potential downward movement of contaminants entrained in the groundwater.

Efficient and sustainable use of potable water also will reduce energy demand, since pumping water from wells requires electric power. High-capacity electric pump motors, ranging in capacity from 60-200 horsepower, provide the primary power required to draw water from the aquifer and ultimately deliver it to homes. More efficient use of water will reduce electric demand on the water supplier and ultimately on the entire power system maintained by the electrical utility. In addition, less pumpage, particularly under peak conditions, allows water suppliers to reduce local stresses on the aquifer. This also ensures that an ample supply of water will be available during an emergency (such as a fire).

Water Demand and Usage

Water demand within both counties has been increasing in recent years due to increased usage, primarily from lawn irrigation, as depicted in Figures 1 and 2. This trend is even more significant in Suffolk County (Figure 2).

Figure 1 Water Use in Nassau County from 2000-2014

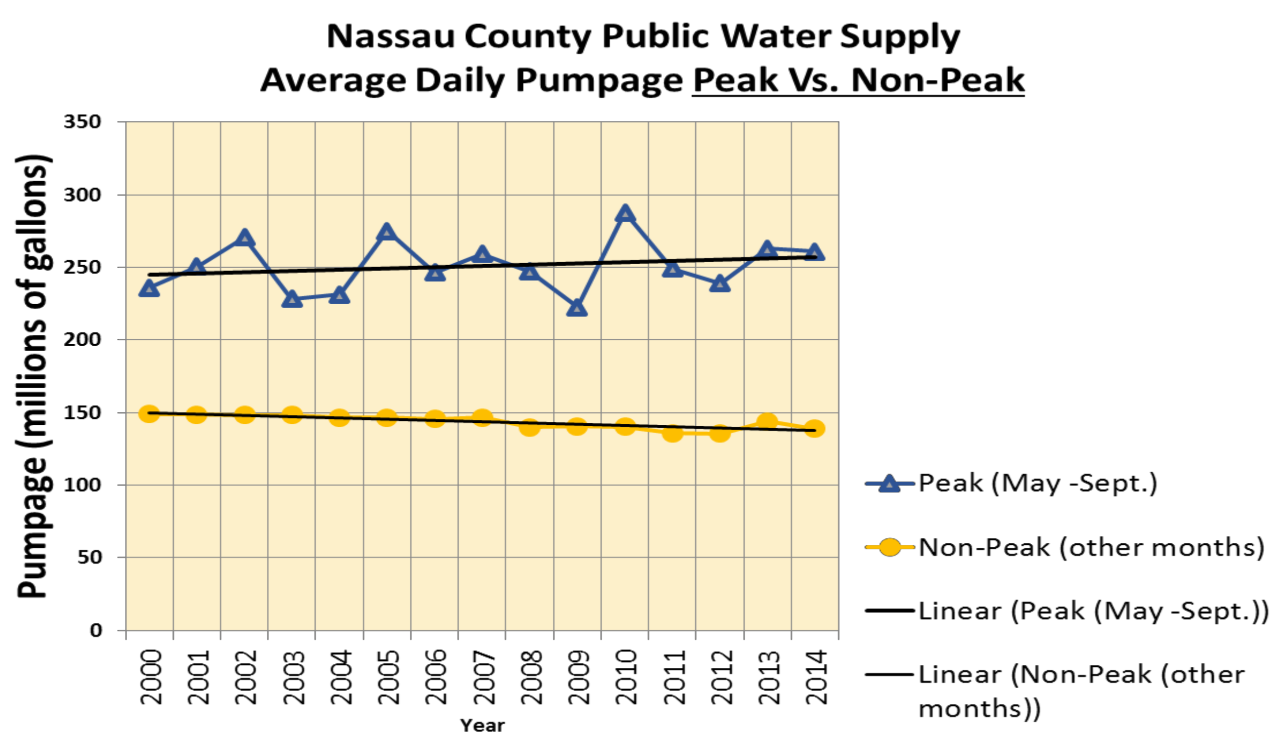
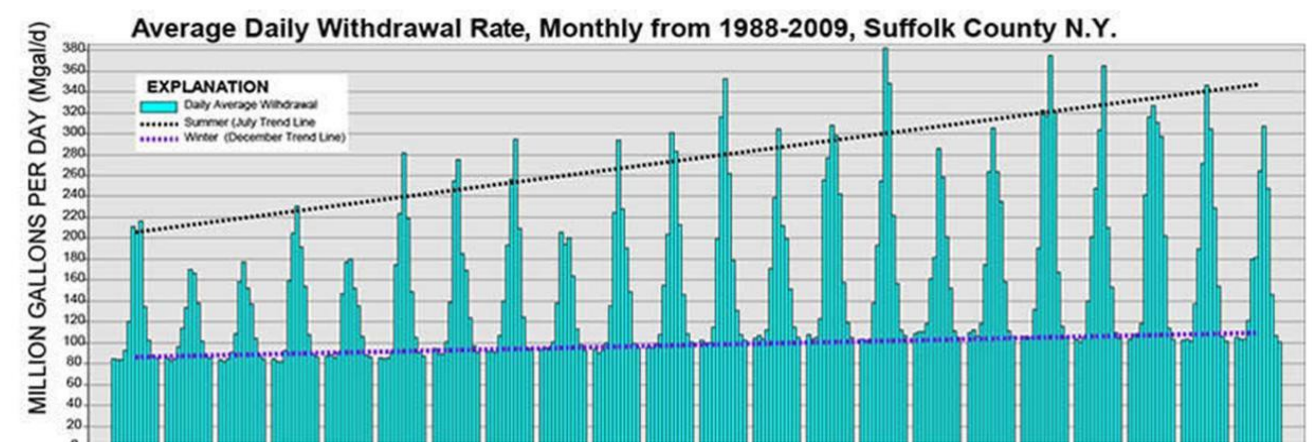
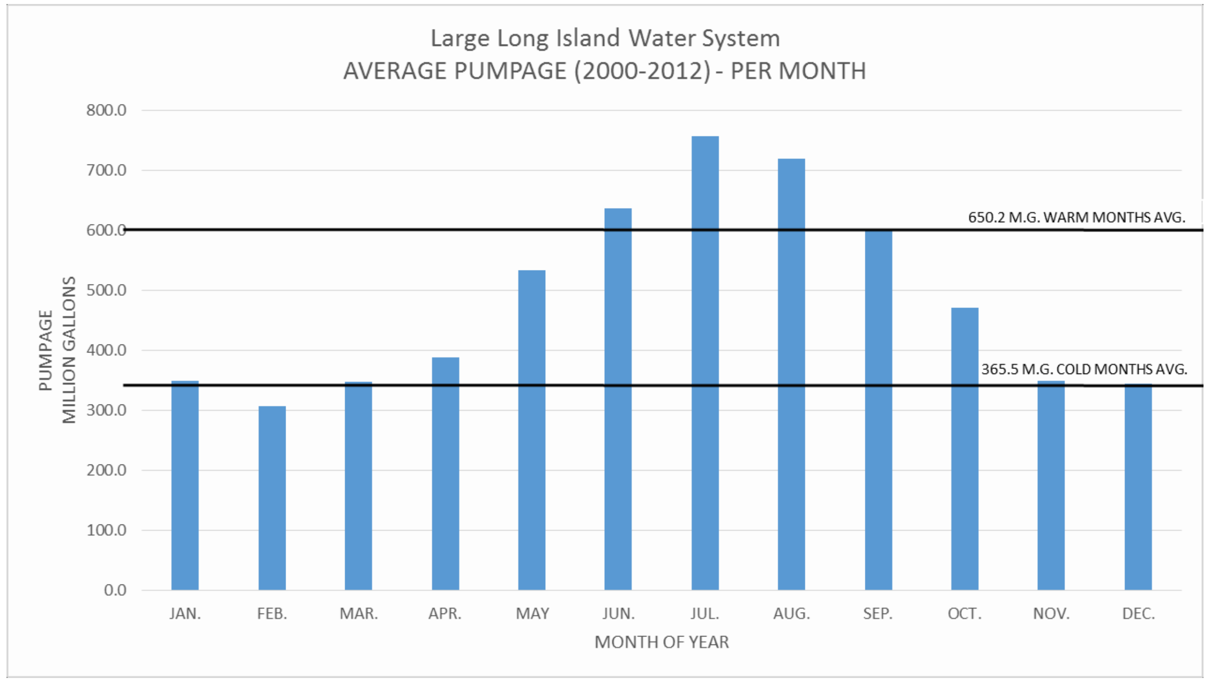


Figure 2 Water Use in Suffolk County from 1988-2009



Non-peak or cold weather water demand has been in slight decline in Nassau County and relatively flat in Suffolk County. This can be attributed to specifications in the state plumbing code requiring the use of water-conserving plumbing fixtures in both new construction and building retrofits. Figure 3 illustrates the clear difference between warm (May through September) and cold (October through April) weather pumpage. Peak summer pumpage is more than triple the average winter usage for a typical Long Island water system. Therefore, lawn irrigation is a practice that should be targeted in an attempt to prevent annual water demand from continuing to increase in the future.

Figure 3 Average Pumpage per Month for a Typical Large Water System



This increased warm weather water demand is largely due to automatic underground lawn irrigation systems. Such systems are more prevalent as real estate values increase and residents and business owners place a higher emphasis on property beautification through landscaping. In order to meet this increased demand, water purveyors need to accelerate their efforts at public education and conservation enforcement.

Benefits of Efficiency Improvements

Since best practices take time and planning to effectively implement, water efficiency measures must be proactively implemented prior to the onset of drought and emergency conditions. Effective water efficiency measures will provide numerous environmental, infrastructure and economic benefits while helping to ensure the long-term availability of a high quality drinking water supply. Environmental and infrastructure benefits include: protection of wetlands, prevention of salt water intrusion, better water quality, less energy use, reduced strain on the electric grid and improved drought and emergency response/preparedness.

Water Quality Benefits

- Efficient pumpage management assists with addressing water quality concerns.
- The less stress that is placed on the local aquifer segment reduces the potential for drawing contaminants deeper into the groundwater system. This leads to better management of contamination plumes.

Environmental Benefits

- Protection of wetlands.
- Prevention of salt water intrusion.

Energy Use Benefits

- Water transmission and distribution requires a significant amount of electric power.
- High capacity electric pump motors, ranging in capacity from 60-200 horsepower, provide the primary power required to draw water from the aquifer and ultimately to the home.
- Lower water demand results in lower energy use. Reduces potential for local brownouts and blackouts.
- Less energy that is used the less fossil fuel is used resulting in reduction of greenhouse gas emissions.

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Economic Benefits

- Since water systems are designed to meet peak day and hour demand, less water demand results in less water supply infrastructure required in order to meet peak demand.
- Less use of treatment chemicals, since less overall water is pumped.
- Lower energy costs. As shown below (what is this referring to) energy costs can range from 20-30% of the budget of a mid-sized Long Island water supplier.
- For consumers, lower water and energy use could lead to lower monthly bills.
- Effective sustainable practices will decrease energy, chemical, maintenance and capital costs.

Efficiency Implementation Challenges

Challenges to the successful implementation of sustainable practices include lack of public engagement, the proliferation and widespread improper use of automatic irrigation systems, aging infrastructure, the low cost of water (under valuation) and loss of revenue through metered water sales. To engage the public in order to change water use habits requires proactive public outreach. In order to be effective, outreach and education initiatives must be implemented through various platforms such as schools (engage the younger population to develop good water use habits), civic associations, newsletters, press releases and social media.

Changing habits through public engagement is an obvious and important element for promoting sustainable water efficiency. However, an evaluation and implementation of programs and measures that will achieve large-scale water savings must be undertaken. Such programs should focus on outdoor water use, water rate structure, aging and homeowner leak repair.

Efficiency Opportunities

Irrigation Efficiency Opportunity

Studies disseminated by Cornell Cooperative Extension of Nassau County have concluded that lawns on Long Island tend to be over-irrigated. Irrigation of lawns every other day at a rate of 1 inch per week is sufficient for most areas of Long Island. Because of this overwatering by automated irrigation systems, focusing efficiency efforts in this area yields the greatest potential results. Water suppliers should work with local planning boards to promote water-friendly landscaping and efficient irrigation system design.

The proper design and operation of automatic irrigation systems are vital to efficient use of the resource. Understanding and properly using various water applications, such as spray versus drip irrigation, can have a profound impact on water use. For example, the type of spray head and pattern are critical for optimizing water use. The strategic and proper use of weather sensors (such as solar radiation, temperature, rain and/or freeze sensors), soil moisture sensors and flow control devices can also achieve water savings. Use of smart controllers and weather sensors on lawn irrigation systems will automatically adjust water usage based on weather and soil moisture conditions. Finally, having a good understanding of the watering needs for particular landscape is essential to system design. Proper training and knowledge in the area of outdoor irrigation is necessary to achieve sustainable watering goals.

Irrigation industry professionals can be an invaluable asset in helping use water more efficiently. The Irrigation Association of New York (IANY), established in 1985, is a professional organization of contractors representing all specialties and disciplines of New York State's irrigation industry. It aims to foster development and economic advancement for its members and to promote water conservation through efficient irrigation practices and products. One of the organization's objectives is to support legislation to require irrigation contractors be certified and adhere to "Best Management Practices." The association has introduced the "Landscape Irrigation Contractor Certification Act" in the New York State legislature as a consumer protection measure that will foster adherence to the highest professional standards by irrigation contractors. Certifying irrigation professionals promotes the protection of public health and safety; supports the environmental, economic and social benefits of cultivated landscapes and helps to ensure the efficient use of water resources.

Louisiana, New Jersey, North Carolina and Texas are the only states that require irrigation contractors to obtain a license in order to practice landscape irrigation. The following states have provisions as an irrigation sub-category under plumbing or landscape contracting: California, Connecticut, Oregon, Illinois and Rhode Island. Florida offers a voluntary license that exempts the licensed individual from local irrigation contracting licenses.

In summary, outdoor water efficiency can be optimized through restrictions, efficient landscape design, properly scheduled irrigation (reducing peak demand impacts to water systems), efficiently designed and constructed irrigation systems and the use of technology (rain sensors, tensiometers, etc.). In addition, certification of irrigation contractors can provide Long Island water supply systems with a central database of contractors. This database could prove valuable to water suppliers who can use it to contact irrigation installers for assistance in cases where irrigation systems need to be adjusted or the use of them needs to be controlled or restricted.

Xeriscaping is a systematic method of promoting water conservation in landscaped areas. Although xeriscaping is mostly used in arid regions, its principles can be used in any region to help conserve water. Basic xeriscaping principles consist of the following:

- Planning and design. Provides direction and guidance, mapping water and energy conservation strategies, both of which will be dependent upon regional climate and microclimate.
- Selecting and zoning plants appropriately. Selecting and locating plants that will thrive in the regional climate and microclimate; grouping plants with similar water needs together.
- Limiting turf areas. Reducing the use of bluegrass turf, which usually requires a lot of supplemental watering, and substituting with a turf grass that uses less water.
- Improving the soil. Enabling the soil to better absorb water and to encourage deeper roots.
- Irrigating efficiently. Using the irrigation method that waters plants in each area most efficiently.

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- Use of mulches. This keeps plant roots cool, minimizes evaporation, prevents soil from crusting and reduces weed growth.
- Maintaining the landscape. Keeps plants healthy through weeding, pruning, fertilizing and controlling pests.

Maximizing Water System Efficiencies

"Unaccounted-for water" is water that is pumped by suppliers, but is not consumed by their customers. It is calculated by subtracting the water that is billed from the total water pumped. Unaccounted-for water consists of water used for flushing of water mains; water lost to leaks, main breaks and firefighting and numerous other purposes. This water is important to track and understand. As water main infrastructure ages, the potential for water leaks increases. This is critical to determine the effectiveness of conveying water to the consumer with minimal losses in the transmission and distribution system.

In 1996, the American Water Works Association (AWWA) Leak Detection and Accountability Committee recommended 10% as a benchmark for unaccounted-for' water. Water systems that are approaching the 10% threshold, or have exceeded it, should strongly consider the implementation of a proactive leak detection program. At a general cost of $120 per mile of water main surveyed, the payback can be considerable when leaks that have not surfaced are detected and repaired. Not only can significant water savings be achieved, leaks can be repaired in a planned manner rather than under emergency conditions that could involve overtime and damage to roads and other utilities.

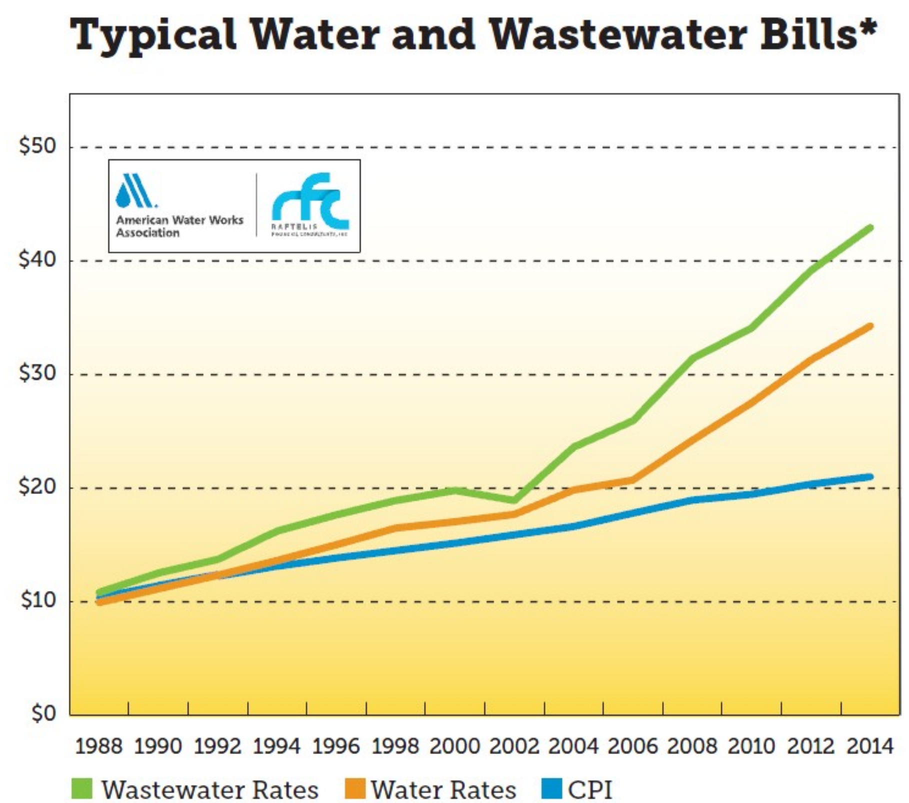
A leak detection program also should be used in conjunction with a water main replacement program. At a minimum, water mains should be replaced on a 100-year cycle. It should be noted that many factors contribute to main breaks and failure that can drive the need for water main replacement. These factors can include pipe age, pipe material, soil conditions, pipe laying/bedding conditions, temperature (internal water and ambient soil), frost load (related to soil temperature), traffic loading conditions, surges and higher than normal operating pressures.

Accurate metering of source water (pumped from wells) and consumption (water service lines) are vital to obtaining an accurate understanding of water use and loss. Proper meter management will control apparent water losses and provide a better understanding of water use patterns.

Metering strategies include the following:

- Meter management: This includes meter selection based on flow requirements, meter type and selection critical to accurate metering as well as the development and implementation of testing and replacement schedules.
- Calibrate production/plant-site metering that includes venturi tubes, orifice plates and other metering devices. AWWA recommends testing and calibration every year.
- Customer meter testing/replacement program.

Challenges to the successful implementation of sustainable measures include the potential loss of revenue. Reduced water use can result in lower revenue, but that can be offset by decreased operating, maintenance and capital expenses associated with lower water production. In addition, effectively crafted water rate structures can also assist with maximizing revenues in the face of decreased water demand. Since water system customer bases vary, careful consideration of rates must be provided to determine the best application of uniform, inclining and seasonal rates. Water tends to be undervalued and underpriced with rates that generally do not reflect the true cost of the resource and the need for infrastructure investment and/or replacement. The figure below from the American Water Works Association provides an overview of the price of water across the United States depicting the monthly combined water and sewer prices trends from 1998-2014.



*Residential monthly water or wastewater bills at a usage level of 7,480 gallons/month CPI: starting with the average of the water and wastewater bills in 1988, this level increases based on changes in the Consumer Price Index (CPI) provided by the Bureau of Labor Statistics

For more information, see the Water and Wastewater Rates webpage at awwa.org

Indirect Potable Water Use

Indirect potable reuse is currently in place in many municipal water systems outside of Long Island in which wastewater is treated to remove pollutants and released into local bodies of water. Once the effluent is released and mixed with the local water bodies, the water is pumped out to a municipal water supply and redistributed to its customers. However, there are instances where the middle step that releases treated effluent into local bodies of water is skipped. This is called direct potable reuse, and, although it is less

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common, it has been part of a solution in response to the recent droughts that have riddled arid regions of the country such as California.

Water reuse for non-potable situations is commonplace in the United States. According to the USEPA, approximately 2.2 billion gallons of water are reused daily in the United States. Florida, California, the arid Southwest and Virginia lead the way. The primary outlet for the reused or reclaimed wastewater is for irrigation purposes on golf courses, other green spaces and on a variety of agricultural crops, including both non-food and food products.

Industrial Reuse

Industrial reuse is one of the more prevalent forms of wastewater reuse in large-sale operations, typically used for cooling purposes. Because industry can account for significant water demand, many large operations outside of Long Island have implemented their own private treatment plants. This avoids tapping into the municipal water supply to meet non-potable operational needs such as cooling and washing.

Residential Reuse of Potable Water

On a residential scale, there are various options based on local circumstances. For instance, if an area typically requires septic tanks, people in that area could incorporate their own wastewater treatment system. There is also the option to avoid reusing wastewater as whole and instead use the water from daily tasks like laundry, showering and washing dishes. In this form, the reused water is called grey water and can be used for non-potable purposes such as laundry, toilets and irrigation.

Reclaimed Wastewater for Irrigation Water Reuse

Perhaps the most environmentally sound strategy for supplying water for the irrigation of landscaped properties, agricultural crops and golf courses is through water reuse. This involves irrigation utilizing wastewater from either a regional sewage treatment plant or a homeowner's on- site sanitary system (with appropriate treatment) rather than using water pumped from Long Island's underground aquifers. An important benefit of using reclaimed wastewater for irrigation purposes is that it can improve water quality in the receiving waters into which the wastewater was formerly discharged. Perhaps, as importantly, reusing wastewater for irrigation purposes can supplant the consumptive use of groundwater from the Upper Glacial Aquifer, thereby reducing stress on the groundwater system due to reduced pumping.

Reclaimed wastewater from sewage treatment plants has been reliably and safely used for irrigation purposes for many decades throughout the United States, most notably in California, Florida and the arid Southwest. The main recipients of the treated effluent have typically been golf courses, landscaped green spaces and non-food crop agricultural areas. Other uses have included industrial cooling and wetland creation and supplementation. As of 2008, the United States used approximately 2.2 billion gallons of reclaimed wastewater per day for these purposes.

Additionally, reclaimed wastewater has been used in a number of other countries, such as Israel, where 70% of the wastewater is reused for irrigation and other purposes. During this time a very extensive and comprehensive performance record has developed and no known human health problems have emerged from the use of and exposure to reclaimed water in these applications.

The general Long Island-wide benefits of water reclamation are significant. First, widespread reuse of highly treated wastewater, from the many publicly- and privately-owned sewage treatment plants, can achieve meaningful reductions in the total amount of nitrogen discharged directly to the Island's groundwater and coastal waters. This is accomplished by redirecting nitrogen-laden wastewater from these resources to beneficial reuse applications as mentioned above, some of which take up the nitrogen as a plant nutrient. Second, using reclaimed wastewater can reduce stresses on the Island's groundwater supplies since the reclaimed wastewater supplants the use of groundwater, thereby reducing pumping by an equivalent amount.

NYSDEC data on reported pumpage for golf course irrigation wells for the years 2010 and 2014 show that a total of approximately 2 billion gallons per year of water is pumped by golf course irrigation wells each year (it should be noted that the estimates provided did not include every golf course as there are some with no available data). Additionally, there are some golf courses that also utilize potable water for at least a portion of their irrigation requirements. Golf course irrigation is considered to be purely consumptive use of water, since virtually all water utilized for this purpose is lost to the aquifer system via either plant uptake or evaporation. Little, if any, irrigation water is recharged back to the aquifer system.

In this regard, there are several obvious benefits resulting from the reduction in the amount of water pumped from the Long Island aquifer system. From a water quality perspective, the less water pumped generally means a slower downward movement of contaminants through the aquifer system. Another key benefit has to do with water quantity: reducing pumpage minimizes water table drawdown, thus preserving surface water features such as lakes and streams and possibly preventing the landward movement of the fresh water-salt water interface in certain areas. There are also potential energy savings and a reduction in quantity of fertilizer required.

As an example of the reuse of potable water for irrigation purposes is the recently completed water recycling project between Suffolk County and the Town of Riverhead. This project (initiated in the summer of 2016) will redirect approximately 350,000 gallons per day of tertiary-treated wastewater from the Riverhead Sewage Treatment Plant (STP) away from the Peconic River to the adjacent Indian Island County Golf Course for irrigation of the turf grass.

Engineers involved with the project have determined that this single project will eliminate 2,000 pounds of nitrogen annually from entering the Peconic Bay/River system, and will eliminate the need to pump approximately 66 million gallons of water annually from the Upper Glacial Aquifer. An added benefit of the project will be financial savings to the golf course from reduced energy costs as a result of less pumping and lower fertilizer costs due to the elevated nitrogen concentration of the reused water which encourages plant growth. While this example involves two adjacent properties (which represents the ideal situation, economically and operationally), many water reuse projects may involve transmitting water over greater (but still feasible) distances. The Suffolk County Department of Planning has documented 26 golf courses within the county situated within one-half mile of a sewage treatment plant. Other potential recipients of treated effluent for irrigation include sod farms and other non-food agricultural crops such as nurseries, Christmas tree farms, floriculture and hay fields.

Emerging sewage treatment technologies for on-site sanitary systems can potentially assist homeowners in irrigating their landscaping and lawns. In these systems, the treated wastewater is dispersed through narrow tubes situated about 6-12 inches below the ground, collectively known as the drain field. The

shallow depth of the tubes allows for the water to be taken up by the roots of the turf grass. A significant advantage to this approach is that there is little to no opportunity for the wastewater to come into direct human contact. While these systems do not entirely replace the need for irrigating turf grass (since the drain field covers only a portion of the lawn area), they can reduce the amount of groundwater used for residential landscape irrigation.

Additional Strategies

On Long Island, two additional strategies need to be undertaken in order for the potential of water reuse to be fully realized. The first is for the NYSDEC to promulgate the enabling rules and regulations required to implement Title 6 of Article 15 – Water Efficiency and Reuse. The second is to undertake an Island-wide water reuse feasibility study which assesses the technical, logistical, financial and social dimensions of water reuse so as to provide a roadmap and blueprint for its implementation Island-wide.

Industrial reuse of treated sewage effluent also has some conservation potential. For example, the Port Jefferson Village STP is adjacent to the Public Service Enterprise Group (PSEG) power plant. Using treated wastewater to cool the plant rather than utilizing water from the Port Jefferson Harbor (as is the current practice), could have positive impacts on the ecosystem of the Harbor.

Other strategies that can be employed to achieve practical and sustainable water savings include:

- Water use audits for top users.
- Homeowner assistance programs to repair leaks and install water efficient devices.
- Plumbing code enforcement.
- Plumbing retrofit.

Conservation Pricing

Americans are not accustomed to paying and have been largely unaware of the true cost of treating and delivering clean, safe water to their taps. Americans pay less for water – about a penny per gallon on average – than do residents of most other developed nations. The historic underpricing of water is largely due to a perception that water is "free" – a fundamental human need supplied by the earth itself. The vast infrastructure required to treat and deliver that water where it is needed, however, is far from free.

Water rate structures should be designed to promote water efficiency and investment in water infrastructure replacement. In most instances on Long Island, water is the smallest part of any utility bill. For many, if not all water districts, the monthly cost of water for the average residential homeowner (based on water rates and property taxes) is less than broadband Internet service, despite the fact that water is vital to public health. Full-cost pricing will not only help water utilities continue to provide customers with safe and clean water, but will have the added benefit of encouraging more conservative use, ensuring a sustainable supply for future generations.

Alternative Water Sources and Technologies

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 may merit additional consideration locally. Additional water resource alternatives include non-potable reuse or supplemental use from such sources as: rainwater from roofs; stormwater collected from at- or below-grade surfaces, gray water 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 are discussed in the following sections.

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 [Florida Department of Environmental Protection (FDEP), April 2010, pp. 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, pp. ii). According to 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, pp. 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, pp. 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, pp. 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, pp. 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 [Global Water Intelligence (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, pp. 19).

Desalination Issues and Considerations

Disposal of waste brine can present environmental challenges. 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 fresh water 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.

Other Considerations

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].

According to the NGWA, desalination systems have recovery efficiencies of 60-85% for brackish groundwater, which means 15-40% of the available water is not used but is instead disposed of as a concentrate stream. Improving recovery efficiencies to 90or 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).

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

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 groundwater 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 groundwater 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 groundwater. 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 groundwater 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 groundwater 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 groundwater 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 groundwater 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 groundwater 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 groundwater supplies.

A primary issue of importance for water managers is water supply reliability. One 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

Artificial recharge (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 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:

Other Methods to Increase Recharge

Enhanced recharge through vegetation management involves replacing 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 alters groundwater flow patterns (or “gradients”) to induce water movement from streams to adjacent groundwater systems. 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 created by enhanced surface water management may result in additional recharged water even though 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

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(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.)

Alternative Water Sources

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 fresh water. Examples of alternative water sources include: harvested rainwater from roofs, on-site storm water, gray water, 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

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. Rainwater harvesting can help to manage stormwater by reducing the amount of runoff, which eases flooding and erosion, and by allowing it to soak into the ground, turning stormwater 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 diverters), monitoring for leaks, maintaining treatment systems (including filter replacement) and disinfection equipment and testing for water quality.

Stormwater Harvesting

Stormwater 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 previous section, stormwater 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. Stormwater 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 stormwater 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 stormwater 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 stormwater 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 stormwater harvesting and reuse plans need specialist input from a number of areas, including stormwater 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 systems as mentioned previously. Potential limitations and disadvantages of stormwater harvesting include: variable and unreliable rainfall patterns, environmental/land use impacts of storage facilities and potential health risks.

Reuse of Reclaimed Wastewater

Reclaimed wastewater (gray water) 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 fresh water. This water is often available at a significantly lower cost than potable water.

Gray water 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 fresh water is high and there is a lack of high-

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quality fresh water 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.

State and local governments regulate the use of gray water 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 5 feet away. Review the quality of reclaimed water to minimize the potential for harmful effects from long-term use such as salt buildup.

- The use of on-site gray water recycling systems should be considered when constructing new buildings. Even though many of these systems are costly to purchase, the payback period in savings from discharging less wastewater can be 10 years or less.
- The pathogenic organisms in sanitary gray water must not come into contact with either humans or animals. This can be done by treating the water to eliminate pathogens or avoiding their introduction into water by not mixing sanitary gray water with any potable water source. Human exposure can be prevented by not collecting or storing the gray water in an open container.
- Sanitary gray water used for irrigation should not be applied through a spraying device, but rather injected directly into the soil through drip irrigation. Drip irrigation provides the benefits of gray water use without contaminating animals, humans or edible plants.
- If a gray water recycling system is utilized, consideration must be given to the types of cleaning products used. Products that contain sodium, chlorine or boron should not be used. Cleaning products that contain high chemical levels may enter the gray water recycling system and could poison plants or damage soil through the buildup of inorganic salts.
- When gray water is used for irrigation, rain or excessive irrigating could cause ground saturation and result in pools of gray water on the surface. To help eliminate this situation, turn the gray water system off and divert the gray water to the sanitary sewer line during rainy periods.
- For buildings with slab foundations, recoverable gray water may be limited to washing machine discharge because most drain pipes, such as for sinks, are buried beneath the slab and thus are not easily accessible without a significant expense.
- For buildings with perimeter foundations, gray water may be recoverable from most sources by accessing piping from crawl spaces.
- The most appropriate gray water treatment method (e.g., media filtration, collection and settling, biological treatment units, reverse osmosis, sedimentation/filtration, physical/chemical treatment) will depend on the gray water source, application, recycling scheme and economics.

Maintenance programs for a gray water system must include the following steps, all of which must be performed regularly:

- Inspecting the system for leaks and blockages. Cleaning and replacing the filter.
- Replacing the disinfectant.
- Ensuring that controls operate properly.
- Periodically flushing the entire system.

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. http://energy.gov/eere/femp/best-management-practice-14-alternative-water-sources, retrieved from the internet August 16, 2016.

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This chapter reviews the current initiatives with the potential to provide significant quantities of data that will inform the implementation of the recommendations discussed in the following sections.

WaterTraq

In September 2016, the Long Island Commission for Aquifer Protection (LICAP) officially launched the historic mapping and database website known as WaterTraq. The program, the first of its kind in New York State, revolutionized the way public water providers tracked potential threats to the water supply and provided web accessible information to both the general public and to regulatory officials. With WaterTraq, this information about groundwater and drinking water quality became readily available to the public via the LICAP website: **www.liaquifercommission.com**

The idea for WaterTraq was proposed through the LICAP Water Quality Management Group subcommittee. One of the most frequently cited concerns during the early meetings of this subcommittee was the lack of a coordinated regional water quality monitoring and reporting program. The primary objectives of the Water Quality Management working group were to determine the water quality parameters most critical to monitor and report, to develop a universal data reporting format and to identify the most appropriate platform to store, analyze and share the water quality data. Earlier attempts by New York State to implement standardized electronic data deliverable formats utilized environmental information management systems, such as the database software application EQuisTM, and the United States Environmental Protection Agency (USEPA) storage and retrieval data warehouse (STORET). Some of the advantages of these programs were their capability in handling multiple sample types and their usability by other agencies to visualize data in specific geographical areas.While these programs had success with requiring certain types of data to be submitted electronically, the data had to be formatted to meet the guidelines specified by the reporting agency. In addition to the added complexity of formatting datasets, multiple versions of the same program existed and were incompatible with each other. The substantial costs associated with training laboratory staff and hiring consultants to process the data also proved to be a disadvantage.

The ESRI ArcGIS (geographic information system) platform was deemed by the working group to be a more user friendly platform due to the availability of the program across the various utilities and agencies. Because most organizations leverage GIS, or have GIS staff available, cost savings would result from greater efficiency in the logistics of transferring data. Since GIS maps provide an ideal platform to visualize and interpret datasets, using this platform in conjunction with water quality data would allow for increased decision-making and improved communication. While the ESRI ArcGIS could provide a mechanism to store and visualize the data, the greater concern was how to make the information easily accessible to the public.

ArcGIS requires users to have a license with ESRI, the maker of ArcGIS, which would be costly. In addition, users would have to learn how to use the desktop version of the program in order to search through the water quality data.

The challenge of sharing the data from various agencies with the public was ultimately solved through the introduction of the ArcGIS online platform. ArcGIS online is a cloud-based collaborative mapping platform that provides the ability to use, create and share maps, analytics and data. Because this online program required minimal implementation steps and no programming ability, the costs of implementation would be substantially reduced. In addition, the program could be made available to anyone with a web browser or mobile device and does not require a download.

With the GIS platform established as the tool to visualize the data, the next challenge focused on the data type that would be shared and exported to GIS. The initial concerns centered on the coordination efforts in having more than 50 water districts agree to share well data and have the respective laboratories in Nassau and Suffolk Counties export water quality data. Water suppliers were requested to provide both the latitude/longitude coordinates for all of their public supply wells as well as the well attributes (such as well depths, aquifer type and district served). The laboratories were requested to supply raw water quality information for the calendar year 2015. Suffolk County Department of Health Services also provided groundwater quality data from their monitoring well network.

The Excel program was then utilized as the tool to export the data because it is a universally accessible program used by both the water utility agencies and laboratories. The ease of Excel's use and the program's functionality allowed the data to be shared by all parties with minimal formatting. Since Excel allows for the analysis of large amounts of data, the data provided by the individual suppliers could be combined and analyzed efficiently with the existing filtering, sorting and search tools. The common identifier used to link the water quality sample data provided by the laboratory with the corresponding well location data was the New York State Department of Environmental Conservation-issued (NYSDEC) "S" or "N" (Suffolk or Nassau County) identification number uniquely assigned to each well. Combining the water quality data for each well with the well attribute data provided a mechanism to search for a compound and have the results visually displayed by concentration range and location. In addition, compounds could be searched based on well depth, aquifer type, water district and sample data. This allowed the water quality data to be displayed both in spatial dimensions and time. The framework of ArcGIS, linking the water quality data with public supply wells, provided an unprecedented view of water quality data on Long Island.

Both Nassau and Suffolk County water suppliers sample for more than 200 compounds, more than required by federal health regulation. Through this platform, water quality parameters can be immediately searched for and made visually accessible. WaterTraq was also able to attach existing aquifer-related datasets created by the United States Geological Survey (USGS), including depth to water and hydrogeologic units. These additional overlays allow for water quality samples to be contrasted with regional geology and water level variations. Borehole geophysical logs maintained by the USGS Water Science Center in Coram, New York were also attached to WaterTraq to create an interactive map that links the borehole database points to the corresponding hydrogeologic data.

WaterTraq blends interactive maps with data from spreadsheets in an effort to paint a clear picture of what exactly is in Long Island's drinking water for health officials, industry professionals and the general public. Users can set search parameters that will allow them to look up specific contaminant levels for any New York State drinking water parameter. These parameters include inorganic compounds (such as iron or chlorides), volatile organic chemicals (typically industrial solvents or gasoline constituents), emerging contaminants (such as pharmaceuticals) and a myriad of other compounds and chemicals for which drinking water purveyors are required by law to sample. WaterTraq users can then see if a given untreated water sample is at or below safe drinking water standards for a particular well or set of wells.

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WaterTraq also allows the user to overlay aerial photography, geological boundaries and contours that illustrate the depth to groundwater. The data provided through WaterTraq includes both untreated (raw) water test results and treated water that is sent to customers. The success of WaterTraq is the ability for the tool to share information with regulators and the general public at the click of a button. Unlike previous datasets that focused on a specific location or compound, WaterTraq gives users the chance to visualize all sampled data from an Island-wide perspective. WaterTraq allows for water professionals to draw conclusions based on the patterns of the dataset they see.

A WaterTraq user can now easily click on interactive maps to see data about water in a particular area or search for information by entering an address. In addition, a user can search among chemicals or compounds tested by water suppliers to determine their presence in groundwater. The WaterTraq site also contains links on how to read drinking water reports, water quality standards set by state and federal officials and listings of top compounds detected on Long Island. Instructional videos were also made available to show the public how to navigate WaterTraq; conduct address searches; search for untreated aquifer samples and search for compounds by aquifer, range, well depths and sample dates. The public was also educated about the state of the aquifer and the differences between groundwater and drinking water. The outreach campaign also discussed drinking water standards in New York State that are considered some of the most conservative in the nation.

WaterTraq has been cited by public officials as being an outstanding accomplishment and a valuable tool that allows water suppliers to share information with regulators and the general public. The increased knowledge gained through WaterTraq has empowered residents to be proactive in advocating to regulators for additional groundwater supply protection. The initiative has also been able to help advance a critical regional approach to Long Island water resources. WaterTraq has also been used to help the New York State's water quality rapid response team identify and respond quickly to drinking water issues. At colleges across Long Island, WaterTraq has been used to gather, map and display water quality data to help identify risks to drinking water sources. WaterTraq has also served as a mechanism for state officials to better coordinate and analyze water quality samples.

During the 2017 State of the State Address, Governor Andrew Cuomo offered a proposal to further develop WaterTraq, noting the considerable resources invested in cleaning up spills and remediating Superfund and Brownfield sites, all of which require considerable testing. Acknowledging the lack of integration with existing data statewide, he recognized the need to better combine the datasets to predict threats to public health and the environment and better facilitate interagency cooperation. Similar toWaterTraq's methodology, the state hopes to use the data it collects to pioneer a leading technology platform to manage sustainability, risks and potential contamination to drinking water supplies across New York.

United States Geological Survey Long Island Sustainability Study

Long Island is entirely dependent on the underlying sole-source aquifer system that currently supplies more than 400 million gallons a day (MGD) of fresh water from more than 1,200 public supply wells to more than 2.8 million people in Nassau and Suffolk Counties. As the name implies, Long Island's sole-source aquifer system is the only source of water available to meet the needs of Long Island's population.

In addition to its value for drinking and irrigation, groundwater is also the primary source of fresh water in streams, lakes and wetlands, and maintains the saline balance of estuaries. When large volumes of groundwater are withdrawn, the water table is locally depressed and this, in turn, reduces the quantity of groundwater available to discharge to streams and estuaries.

Large-scale sewering practices have also reduced groundwater levels and discharge to surface receiving waters. In some areas of Long Island, groundwater pumping has resulted in salt water intrusion into the aquifer system and has also impacted streams, ponds and coastal areas that rely on groundwater discharge to sustain them. In addition to these quantity-related impacts, additional factors such as urban runoff and the widespread use of septic systems have also affected the water quality of the aquifer system. Therefore, development and use of groundwater on Long Island is constrained by ecohydrological (i.e., the interactions between groundwater and surface water ecosystems) and water quality concerns.

from the Upper Glacial, North Shore, Jameco, Magothy and the Lloyd Aquifer. Several major clay layers are also present including the Gardiners and Raritan, which overlie most but not all of the Magothy and Lloyd Aquifers, respectively. These clay units influence the aquifer system in several ways: they act to confine and isolate the underlying fresh water zones; limit the rate of recharge to units below; protect underlying fresh water from surface contaminants; and in coastal marine environments, also influence formation of seaward-extended fresh water aquifer wedges under natural discharge conditions and, conversely, formation of inland salt water intrusion wedges under pumping conditions.

In 2016, Governor Andrew Cuomo announced a partnership between New York State, USGS, Nassau County and Suffolk County to study the effective management of Long Island's groundwater resources. Nassau and Suffolk Counties get their water solely from groundwater that is pumped from its aquifers (subsurface sands and gravels that store and transmit water). The quantity and quality of groundwater can be affected by natural processes such as drought or human activities such as groundwater pumping and urbanization. For that reason, decreases in groundwater levels, salt water intrusion and groundwater contamination have led to concerns about the future availability of groundwater on Long Island.

Groundwater sustainability can be defined as the development and use of groundwater in a manner that can be maintained for indefinite time without causing unacceptable environmental or socioeconomic consequences. Informed management of the Long Island aquifer system can help ensure a regionally sustainable groundwater resource. This study will evaluate the sustainability of Long Island's groundwater resource, now and for the future, by geologic mapping, water quality, and water level monitoring, and groundwater flow modeling this critical aquifer system.

Groundwater Flow Modeling

Groundwater models represent the understanding of how groundwater flow systems work and they provide tools that water resources managers can use to effectively plan for sustainable aquifer development. However, existing models lack the necessary geologic information to fully assess the sustainability concerns of the Long Island aquifer system. To improve the existing model, the USGS will map new geologic information by drilling groundwater wells throughout the Island. The extent of salt water intrusion will be identified by monitoring these new wells. Mapping and monitoring results will be used to improve existing models.

CHAPTER 7:
IMPLEMENTATION OPPORTUNITIES

A groundwater flow model will be developed using the USGS MODFLOW computer program (Harbaugh, 2005). Additional computer programs will be used to track groundwater flow paths from recharge to discharge and model the salt water-fresh water interface (Pollock, 1994; Bakker and others, 2013). The model will utilize updated geology and information about the observed location of the fresh water-salt water interface in the Magothy and Lloyd Aquifers. The groundwater flow model will be calibrated to match observed field data including chloride and water-level information. The model will be used to simulate various scenarios, including changes in groundwater withdrawals, aquifer recharge management and climate change. These scenarios will be developed in collaboration with the NYSDEC and the Steering Committee.

Hydrogeologic Mapping

A network of Lloyd and Magothy Aquifer groundwater wells will be installed at about 30 locations throughout the Island to fill in substantial data gaps. The existing groundwater well network consists mostly of shallow and deep wells in Nassau County, some wells in Suffolk County and some shallow wells in Kings and Queens Counties. The locations of the proposed groundwater wells will be selected by reviewing geologic, hydrologic and water quality information from the existing network. Geologic information obtained from newly installed groundwater wells will be used to improve existing maps (Smolensky and others, 1990) of Long Island's geology and included in newly developed groundwater models. During and after completion of the newly drilled wells, rock and sand core samples will be collected and analyzed to improve the understanding of Long Island's geology. Core samples will be analyzed at specific depths in wells to determine the presence of saline groundwater. Continuous geologic and water quality information will also be collected using geophysical methods along each well's depth.

Water Quality Monitoring

Land-based and waterborne geophysical surveys will be used to map geologic features, including aquifers and confining units. Results from these surveys will help guide site selection for new groundwater wells and fill data gaps where drilling new wells may not be feasible. Geophysical logging and chloride well sampling will also be used to monitor salt water intrusion in the Magothy and Lloyd Aquifers. Periodic and continuous water level measurements will be collected to define aquifer water levels (such as the elevation of the water table) that will be used to calibrate groundwater flow models.

Anticipated Outcomes

Hydrogeologic data on Long Island, pertaining to both water quality and water quantity (or availability), has been collected and archived for more than 70 years by a variety of public agencies and private firms. These data collection efforts have evolved over time in a rather piecemeal fashion and have been executed for specific purposes or projects. Until recently, there has been little coordination among agencies to share the data or to make it more publicly accessible. The two initiatives described in this chapter represent a change in this paradigm. The WaterTraq database allows anyone to obtain water quality data from wells across Nassau and Suffolk Counties for all aquifers. The USGS Long Island Sustainability Project will fill in some of the data gaps that have developed over time and will provide fresh insight into data analysis and predictive modeling moving forward. It is hoped that both of these initiatives will foster a new era of data sharing and cooperative problem-solving among public officials and private citizens.

The reports that comprise the main body of the Long Island Commission for Aquifer Protection (LICAP) Groundwater Resources Management Plan contain a total of 143 specific recommendations pertaining to some aspect of Long Island's groundwater environment and/or community. All of these recommendations were compiled into a spreadsheet, and prioritized by the LICAP board members into three categories: immediate, short-term or long-term. Additionally, some recommendations were eliminated from consideration completely. Occasionally, recommendations were combined and edited for brevity. The following pages summarize each category of recommendations.

Recommendations

Recommendations for Immediate Implementation

The following recommendations taken from the reports that comprise the Groundwater Management Plan have been deemed by LICAP to be considered for immediate implementation:

1. Investigate ways to further optimize pumping operations for wells located near shoreline areas to help minimize salt water intrusion.
2. Fund the development of a regional groundwater model to be used for planning purposes.
3. Implement conservation pricing at public water suppliers and include a full description of water conservation pricing in annual water quality reports issued by public water suppliers.
4. Establish guidelines for Best Management Practices to reduce peak demand for landscape irrigation.
5. Establish guidelines for use of water by geothermal systems.
6. Prevent public supply wells in Queens County from being reactivated because of their negative impacts to Long Island's sole source of water supply.
7. Fund federal, state and local agencies so they can conduct groundwater monitoring, plume identification and modeling.
8. Actively remediate or strategically contain groundwater contamination plumes, such as the Grumman/Navy plume, to minimize and prevent potential impacts to public drinking water.
9. Maintain, update and utilize the existing Nassau County Department of Public Works (NCDPW) monitoring well network (599 total wells) including: 366 Upper Glacial Aquifer wells, 167 Maggoty Aquifer wells and 66 Lloyd Aquifer wells.
10. Develop and expand WaterTraq for LICAP.
11. Require the notification of a public water supplier before a geothermal system is permitted in its service area.
12. Require the New York State Department of Environmental Conservation and the County Health Departments to review and provide comments on municipal planning board applications that may impact water resources through the State Environmental Quality Review Act process to identify and communicate potential groundwater issues to municipal planning boards.
13. Reauthorize LICAP with legislation in the Nassau and Suffolk County Legislatures.

14. Ensure that pumpage caps on public suppliers, if implemented in the future, are based upon sound scientific data.
15. Do not create any new state or regional entity to provide oversight of drinking water because the power to regulate and protect drinking water on a regional basis is already vested in the New York State Department of Health and the New York State Department of Environmental Conservation.

Recommendations for Short-Term Implementation

The following recommendations should be implemented in the near term:

1. Efforts to monitor the fresh water-salt water interface near shoreline areas should be continued or enhanced. Water suppliers with affected wells should initiate monitor well construction and water quality monitoring programs irrespective of governmental entities.
2. Facilities stockpiling and utilizing road salt and deicers should ensure that the requirements in the NYSDOT Highway Maintenance Guidelines, as well as the items noted the NYSDOT's Environmental Handbook for Transportation Operations, are being met. In addition, facilities should meet the requirements of Article 12 of the Suffolk County Sanitary Code and Article XI of Nassau County Public Health Ordinance.
3. Municipalities should consider coordinating their efforts with water suppliers and the appropriate regulatory agencies when planning new salt storage facilities and/or recharge and drainage structures as these relate to the location of drinking water wells. Source water assessments could be utilized for these purposes to help with optimizing the locations of these facilities with respect to drinking water supplies.
4. Water use efficiency programs should be mandated during the summer in order to reduce pumpage during peak hours of the day.
5. Consideration should be given to connections to New York City's water supply for western Nassau County barrier island and peninsula locations with salt water intrusion issues.
6. A computerized regional groundwater model should be developed with active participation among water suppliers, regulators and consultants to assess potential problems and evaluate solutions.
7. The NYSDEC should develop a method of coding water well permits to easily identify different water using sectors such as: irrigation, agricultural, geothermal, remediation, dewatering, industrial and public water supply.
8. Where contaminated plume remediation projects are operating, the recommended practice should be that, wherever possible, the extracted and treated groundwater be recharged to the aquifer system.
9. The well permit program should be revised to enhance its value in managing the groundwater resource, including the posting of well permit renewals as notices in the Environmental Notice Bulletin (ENB). Permitting should be guided by scientific knowledge of aquifer conditions and processes and managed yield goals and limits. Water withdrawal limits should be enforced.
10. Comprehensive groundwater management should be accomplished through a properly funded and staffed NYSDEC.

11. Water suppliers and land use regulators should coordinate to identify areas where population growth and development potential are expected to occur based on current zoning and land use regulations. Some funds may also need to be set aside to allow water suppliers to continue operating and to defray the costs of development to continue to provide clean drinking water to the public.
12. Coordination should occur among municipal authorities, water suppliers and developers to ensure that easement agreements are established on parcels to be developed or preserved. A portion of the land, if preserved for water quality preservation, should be set aside with an easement to the local water supplier to fulfill future public water supply needs.
13. Technologies, maps and other data and information used by municipal authorities and water suppliers should be shared to provide the most current and relevant information for efficient water supply planning purposes.
14. Explore water conservation preservation opportunities to avoid potential impacts on the aquifer and natural resources that may be affected by hydrologic changes.
15. Maintain and update the NCDPW monitoring well database to provide historic water quantity and water quality data.
17. Provide access to the NCDPW monitoring well network by other government agencies such as the NYSDEC, USEPA, USGS and NYSDOH and designate groundwater professionals and environmental firms for: collection of water level measurements and water quality sampling.
18. Restore and expand existing analytical capabilities at local health department laboratories such as aquifer evaluation, emerging contaminant studies, development of new analytical procedures and support of groundwater investigation.
19. Expand and enhance public water suppliers' self-monitoring activities, recognizing the need for additional monitoring commitments.
20. Support local laboratory and trained staff response capabilities to meet the objectives of the New York State Water Quality Rapid Response Task Force currently under development.
21. Restore and expand existing county-level test well drilling capabilities.
22. Expand the cooperative relationship with the USGS.
23. Restore health department industrial waste inspections to previous levels.
24. Commit to continued bi-county updates of water resource management plans and update existing Source Water Assessment Programs to also include GIS output.
25. Further development of a local uniform code and consistent permitting and approvals process should be explored. Suffolk County's Model Code could serve as the starting point and be modified as necessary.
26. Municipalities that have not adopted the Model Code should be encouraged to do so. Municipalities at their discretion can impose stricter requirements given local concerns.
27. A centralized database and map of existing geothermal heat pump (GHP) systems and a process to add future installations to the database should be created.

CHAPTER 8:
RECOMMENDATIONS AND IMPLEMENTATION SCHEDULE

28. For a proposed open-loop GHP system located within the capture zone of an existing public supply well field, the NYSDEC should require the owner of the system to perform the appropriate aquifer testing and modeling to the satisfaction of the water supplier.
29. For all open-loop systems, the NYSDEC should confirm that dedicated supply and return wells are in use when a permit is filed or being renewed in order to prevent the use of public water for supply water or the discharge of the return water to the ground.
30. The NYSDEC should disallow discharge of the return water from an open-loop system to a regulated surface water body or wetlands.
31. GHP systems may need to be curtailed or restricted in sensitive aquifer areas as per the concerns of local municipalities. Local municipalities can also opt to limit the drilling depth of GHP boreholes within their jurisdiction (to minimize breaching of clay layers).
32. Regulations should be enacted for reporting and addressing a release of refrigerants from a d irect exchange (DX)-to-ground contact system and for replacing the sacrificial anodes and cathodes.
33. Regulations should be enacted to require double-wall piping of the horizontal return pipes for a direct exchange (DX)-to-water contact system [geocolumn(c)] to prevent a release of refrigerant to the ground from a break or leak in the piping.
34. Require an inspection signoff by an International Ground Source Heat Pump Association (IGSHPA) accredited GHP system installer, GHP system inspector or certified geothermal designer (CGD) for grouting of closed loop boreholes if major confining clay layers are penetrated.
35. The NYSDEC and the county health departments should delineate areas over or near known contamination plumes where GHP systems may not be recommended and promulgate the appropriate restrictions.
36. North shore areas in Nassau must improve residential on-site septic systems and the available capacity of the Glen Cove Wastewater Treatment Plant. South shore areas must reroute the Bay Park effluent discharge through a new ocean outfall to the Cedar Creek Plant to share its existing ocean outfall. Storm mitigation/hardening must be considered as part of the technical aspects of a project.
37. Siting of STPs inside of the 25-year contributing area to sensitive surface waters should be minimized; if this is not possible, an advanced treatment process shall be provided.
38. Efforts should be made to improve wastewater effluent quality to reduce impacts and for permitting water reuse for golf course irrigation.
39. Upgrade the Bureau of Public Health Protection and Division of Environmental Quality databases to provide a more comprehensive data management program for all regulated facilities; groundwater and surface water quality data; facility data; inspection records; STP monitoring data; and on-site wastewater management system installation, maintenance and inspection.
40. Develop science-based permissive yield pumpage values for each county and regions subject to salt water intrusion.
41. Target lawn irrigation as a water use practice in an attempt to prevent annual water demand from continuing to increase in the future.

42. Expand Nassau County water conservation ordinance to Suffolk County standards (with appropriate modifications).
43. Require irrigation contractors to be certified/licensed in New York State and require that these certification requirements adhere to the guidelines of a national professional organization, such as the National Irrigation Association. Additionally, require that these regulations follow standards established by the United States Environmental Protection Agency's "Water Sense" program.
44. Request water suppliers to work with local planning boards to promote water-friendly landscaping and efficient irrigation system design.
45. Promote conservation by requiring rain sensors, at a minimum, to prevent automatic sprinkling systems from switching on while it is already raining. This must include retrofitting existing systems. Require that rain sensors be tested annually and replaced every five years.
46. The 1986 Lloyd Aquifer Environmental Conservation Law (ECL) §15-1528 Moratorium must be continued in the absence of a finding by NYSDEC that a workable program is in place to properly administer a Lloyd Aquifer well permit program. Additional measures should be taken to protect the aquifer and ensure that a safe level of withdrawal is not exceeded.
47. Incentives should be considered to encourage water suppliers to drill Lloyd replacement wells in overlying aquifers. These incentives could take the form of financial grants to offset potential treatment costs or other means to discourage the continued use of Lloyd Aquifer wells in areas where other aquifers are available.
48. The North Shore Aquifer should be protected from overpumping, salt water intrusion and migration of contamination in a similar manner to the Lloyd Aquifer.
49. The state should provide permanent funding of groundwater quality and water level monitoring programs, including updated studies of the location of the salt water interface in the Magothy and Lloyd Aquifers. Water budget and managed yield analyses should be performed along with appropriate computer modeling. This information should be evaluated by the NYSDEC to improve the management and protection of Long Island groundwater resources.

Recommendations for Long-Term Implementation

1. The information in the Chloride contamination report should be shared with municipalities and other entities that maintain roadways so that alternative deicing compounds and practices may be considered. In addition to compliance with permit conditions, public water systems may want to investigate and identify sources of elevated chlorides in supply wells as part of their own due diligence. This work has already been performed by the SCWA and at several public supply wells.
2. The cost, benefits and environmental impacts of water supply alternative technologies such as ASR and brackish water desalination should be studied for possible use in marginal areas.
3. Incentivize intermunicipal agreements for water transfer to water suppliers that are threatened by salt water intrusion or other major sources of contamination. This should include the purchase and transmission of water from both New York City and Suffolk County into Nassau County with consideration to the potential costs involved.

4. Water use for each county, with details on large water-user categories, should be reported annually, and this data should be available on the Internet so that it can be tracked more easily. NYSDEC should provide this service. Per capita water use data for Long Island is needed.
5. The NYSDEC should comply with the state law requiring it to identify quantity and quality- stressed areas of the aquifers/groundwater system.
6. Improvements in recharge basin management should be implemented to increase aquifer recharge.
7. An educational program for all well permit holders should be developed and implemented so that accurate information on water pumped can be reported and the information used.
8. Implement a drought monitoring plan with an associated monitoring well network.
9. As more information is provided on the location of the fresh water-salt water interface and risk from salt water intrusion becomes available, a change in water withdrawals programs should be developed and implemented. More attention should be given to all the issues related to salt water intrusion and its mitigation.
10. Consider the preparation of a groundwater study that analyzes the feasibility, sustainability and potential environmental impacts that may occur as a result of transporting water across multi-jurisdictional boundaries.
11. Quantify drawdown impact thresholds for future water supply projects.
12. Identify contamination sources or locations and need to supply public water in developed communities where water quality is degraded and water resources are limited.
13. Assessing the sustainability of long-distance transmission should become a routine practice in the future. This may include changes to zoning codes to modify the developed landscape where it is sustainable based on the availability of resources.
14. Identify areas where growth should be encouraged or discouraged relative to available clean drinking water supplies. Coordinate with current land use development initiatives (e.g., around transit hubs, in downtown areas, etc.) to ensure adequate water supplies exist.
15. Examine existing policies, provisions and regulations that apply to the transmission of public water, including permit requirements and prohibited activities (i.e. across jurisdictional boundaries).
16. Coordinate with the Central Pine Barrens (CPB) Joint Planning and Policy Commission on a determination of jurisdiction for the transmission of water from the CPB to communities outside of Suffolk County.
17. Identify the locations of water supply wells that have groundwater contributing areas inside the CPB area to better understand exactly which wells draw groundwater from the CPB.
18. Evaluate cumulative impacts of expanded sewering in Suffolk County along with potential impacts from long-distance public water transmission on groundwater resources.
19. The NYSDEC should clarify whether closed loops can be drilled and installed into the Lloyd Aquifer even though they are not pumping wells.

20. Prior to designing and installing a large closed-loop GHP system, conduct due diligence focused on determining the presence, depth and thickness of major clay confining units; presence of contaminated soil or groundwater; and presence and distance to sensitive ecological receptors, water supply wells and other GHP systems.
21. Better define as-built drawing requirements to include showing other buried infrastructure that could conflict with a GHP bore field or wells, such as drywells, on-site sanitary, underground storage tanks, etc., and transfer to the new owner when the property changes hands.
22. Demonstrate that the ground heat exchanger (GHE) is properly sized for the heating and cooling load profile for large GHP systems as determined through a suitable building energy model. Address any serious imbalance in the load profile and implement measures to reduce the loads and/or supplement the design with conventional mechanical equipment (i.e., a hybrid design).
23. Engage in a study with the NYSDEC, the SCWA and the USGS on the feasibility of using aquifer thermal energy storage (ATES) systems on Long Island, whereby the usual thermal effects on the aquifer are contained rather than allowed to migrate beyond the site's boundaries.
24. Promote further research into the potential thermal effects of individual operating GHP systems on groundwater, surface water and ecological resources with a goal to establish procedures to determine safe setbacks from these resources and to enact appropriate regulations if needed. Potential research partners could include local colleges and universities, the NYSDEC, the SCWA, the counties, private industry and the USGS.
25. The current state policy of first-come-first-served for underground water rights should be reassessed to address cumulative thermal and hydrogeologic effects of high concentrations of small GHP systems. Regional modeling (building on the USGS groundwater model) could be performed to define the safe concentration of such systems with appropriate limits enacted by either the NYSDEC or the local municipalities.
26. The NYSDEC should require intermediate heat exchange (HX) for open-loop systems permitted under the Long Island Well Permit program. The NYSDEC should also require installation of an intermediate HX on existing systems that do not employ HXs before permits are renewed. The NYSDEC could reach out to owners of such existing systems in advance of the permit date for voluntary retrofit.
27. The NYSDEC should require due diligence for LIWP applications for large GHP systems similar to that required by Region 2.
28. Better education and training is needed on the proper implementation of GHP systems, possibly facilitated by local professional organizations in association with the NYSDEC or other agencies. A GHP system inspector training program should be developed specifically for Long Island municipal building inspectors.
29. Siting of STPs inside of the 25-year contributing area to sensitive surface waters should be minimized; if this is not possible, an advanced treatment process shall be provided.
30. Enact discharge regulations that utilize mass loading of nitrogen rather than effluent concentration.

CHAPTER 8:
RECOMMENDATIONS AND IMPLEMENTATION SCHEDULE

31. Accelerate wastewater reuse, mining for resources, energy production and source separation as ways to better value wastewater.
32. Identify and prioritize parcels and determine the sewage treatment plant capacity to permit the connection of identified parcels.
33. Prioritize parcels in critical areas that shall be required to install nitrogen reducing in-site wastewater treatment systems (I/A OWTS).
34. Revise Article 6 Groundwater Management Zone 4 density requirements to conform to Zones 3, 5 and 6 to improve groundwater and surface water quality in the Peconic Estuary.
35. Increase horizontal setback distances between OWTS and surface waters.
36. Create a Wastewater Management District with a responsible management entity (RME) to oversee the financing, operation, maintenance and enforcement of I/A OWTS and cluster systems. Consider municipal partners to help advance installations.
37. Create and/or identify funding sources and costs to meet on-site system objectives. Continue to advance a combination of on-site solutions that can treat to higher levels. Allow the vetting of systems to occur regionally to speed the acceptance of a larger range of options.
38. Evaluate ways to reduce costs for the installation, oversight and maintenance of on-site systems
39. Modify the Sanitary Code to minimize the "grandfathering" of State Pollutant Discharge Elimination System (SPDES) and/or Suffolk County Department of Health Services Approvals. The following issues should be reviewed:
    a. SCDHS permitted sanitary flows that exceed and pre-date Sanitary Code density requirements, on other than single-family residential lots, without the installation of an I/A OWTS or connection to sewers; review options to effect upgrades under the Environmental Conservation Law, New York Codes,
    b. Rules and Regulations and SPDES.
40. Assess the feasibility of updating the Sanitary Code to prohibit the replacement in kind of failed on-site wastewater technology without SCDHS approval.
41. Implement a comprehensive integrated data collection, analysis and evaluation program to monitor groundwater, drinking water and surface water, including reinstatement of the comprehensive groundwater and stream monitoring program.
42. Require that certified contractors obtain continuing education credits by attending technical and business related classes. Use the certification process to establish and maintain a database for use in cooperation with public water supply systems.
43. Require water purveyors to adopt a rate structure that promotes water conservation and to implement a homeowner conservation assistance program.45. Have the NYSDEC develop an Island-wide water reuse feasibility study, looking at the logistical, financial, technical and social issues related to water reuse, and develop the necessary rules and regulations so the legal framework is in place to fully implement water reuse as required by the ECL Article 15, Title 6.

The Long Island Commission for Aquifer Protection (LICAP) would like to formally acknowledge the

In 2013, Nassau County and Suffolk County created a bi-county entity called the Long Island Commission for Aquifer Protection (LICAP) to address and to advocate a coordinated approach to the groundwater issues facing the region. LICAP was extended for five years in 2018. The legislation set the operational terms and conditions of a Commission which would build on existing studies, identify research areas and program opportunities to prevent further deterioration of the Long Island Sole Source Aquifer System, and identify mechanisms for improving its water quality and safeguarding its quantity.

Further, LICAP was directed to establish two standing subcommittees: the 2040 Water Resources and Infrastructure Subcommittee (WRIS) and the Water Resource Opportunities Subcommittee (WROS). As noted in the enabling legislation, the WRIS subcommittee was to develop a WRIS plan to identify long-term risks to the Long Island water supply industry created by global climate change and recommend short-term measures to strengthen public water distribution systems against these risks. Some of these measures include development of well placement criteria, mechanisms for hardening distribution system infrastructure in coastal areas, and loss mitigation strategies including methods for isolating vulnerable portions of the distribution system.

Also, as stated in the legislation, the WROS subcommittee was directed to identify and quantify short-term risks, if any, to groundwater resources. Climate Change and its potential impacts are discussed in the GWMP Chapter 4, "Groundwater Quality and Quantity Threats." Reference to an Island-wide groundwater model is among the notable needs in that section. Absence of this planning tool causes discussions to become more conjecture than science.

CHAPTER 9:
2040 WATER RESOURCES AND INFRASTRUCTURE (WRIS) REPORT BACKGROUND

Introduction

Today, perhaps more than ever before, there are numerous challenges facing Long Island water suppliers and the approximately 2.8 million residents who rely exclusively on their Sole Source Aquifer. The following discussion covers four specific areas of focus related to concerns around global climate change. Water utilities and their leadership must consider and plan for each of the following:

Environmental changes; existing and future impacts

- Sea level rise
- Varying weather patterns and precipitation
- Impacts of saltwater intrusion on the potable aquifer

• Facility managers' response

- Assessment of long-term viability of well sites
- Utilizing transmission mains to service areas where wells may become non-viable
- Potential increase in monitoring requirements

• Water consumption patterns

- Actions that may be necessary in controlling consumption to address potential loss of supply

• Regulatory changes

- Efforts likely to center around conservation
- Private well impacts

These areas of concern highlight opportunity for improved planning and coordination. LICAP can provide leadership in these areas and should continue to work closely with the community of responsible water providers to develop planning and implementation strategies that are practicable.

Environmental Challenges

While the magnitude of the impacts is subject to debate, climate data from 1900 to present shows that temperature and precipitation are increasing. The trend for sea level rise is equally compelling. Additionally, whether consensus is ever reached on the topic of storms of increased frequency and intensity, the impacts of recent Regional and National events provide sufficient examples of the need for overall planning exercises. New York State Department of Health (NYSDOH), under Title 10, Part 5, Subpart 5-1.33 calls for all community water systems serving greater than 3,300 people to develop approved "water supply emergency plans (ERPs). Hurricane Irene in 2011 and Superstorm Sandy in 2012, along with their devastating impacts to infrastructure and extraordinary economic impacts, demonstrate to water suppliers and government planners the necessity of thoughtful planning. In the aftermath of Superstorm Sandy, the Federal Emergency Management Agency (FEMA) has funded scores of project initiatives, designed to create greater resiliency around vital infrastructure systems such as water treatment and supply facilities. Many of these projects are still underway and many more are likely to proceed over the ensuing decades.

Information from FEMA shows the vast majority of resiliency projects have fallen into the following broad categories:

- Complying with or exceeding National Flood Insurance Program floodplain management regulations.
- Enforcing stringent building codes, flood-proofing requirements, seismic design standards and wind-bracing requirements for new construction or repairing existing buildings.
- Adopting zoning ordinances that steer development away from areas subject to flooding, storm surge or coastal erosion.
- Retrofitting public buildings to withstand hurricane-strength winds or ground shaking.
- Acquiring damaged homes or businesses in flood-prone areas, relocating the structures and returning the property to open space, wetlands or recreational uses.
- Building community shelters and tornado safe rooms to help protect people in their homes, public buildings and schools in hurricane and tornado prone areas.

These facility related planning concerns should be coupled with short, mid, and long-term water quality, demand, and cost-benefit studies to inform a comprehensive strategy.

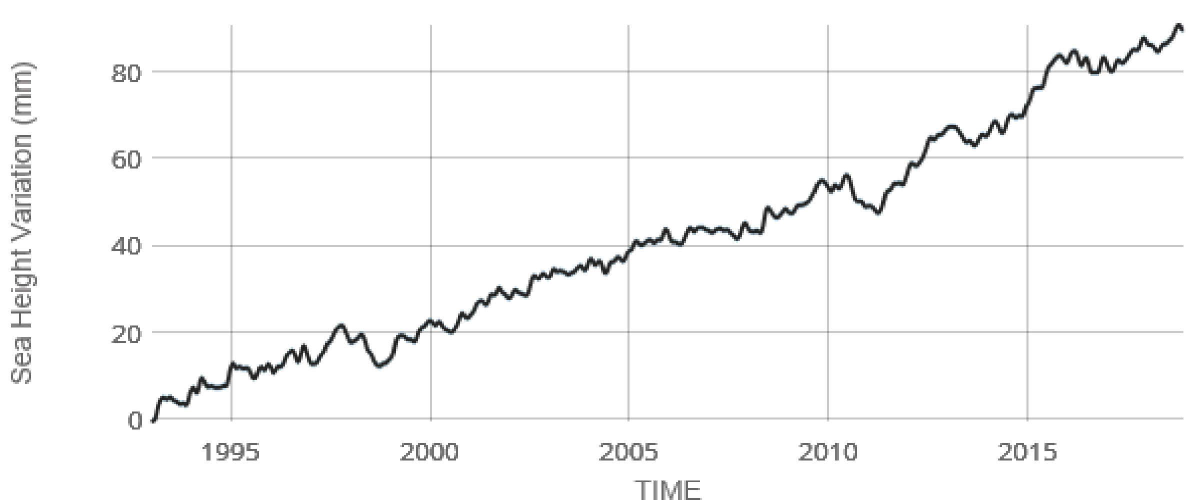
Sea Level Rise

There are numerous sources of data and analysis on the topic of sea level rise and the rate at which changes are occurring. Differing assumptions lead to distinctions in each source, but the scientific community is generally in agreement that sea level rise is happening and will continue. The rate at which it does so, its impacts, and the public water suppliers' strategies in planning for these impacts are the issues at hand. For this report, we have elected to use the National Aeronautics and Space Administration's (NASA) data and estimates of sea level rise of approximately 3 millimeters (mm) per year since 1993, or approximately 78 mm (approximately 3 inches) over the past 26 years.

Figure 1

SATELLITE DATA: 1993 - PRESENT

Data source: Satellite sea level observations. Credit: GSFC/PO.DAAC



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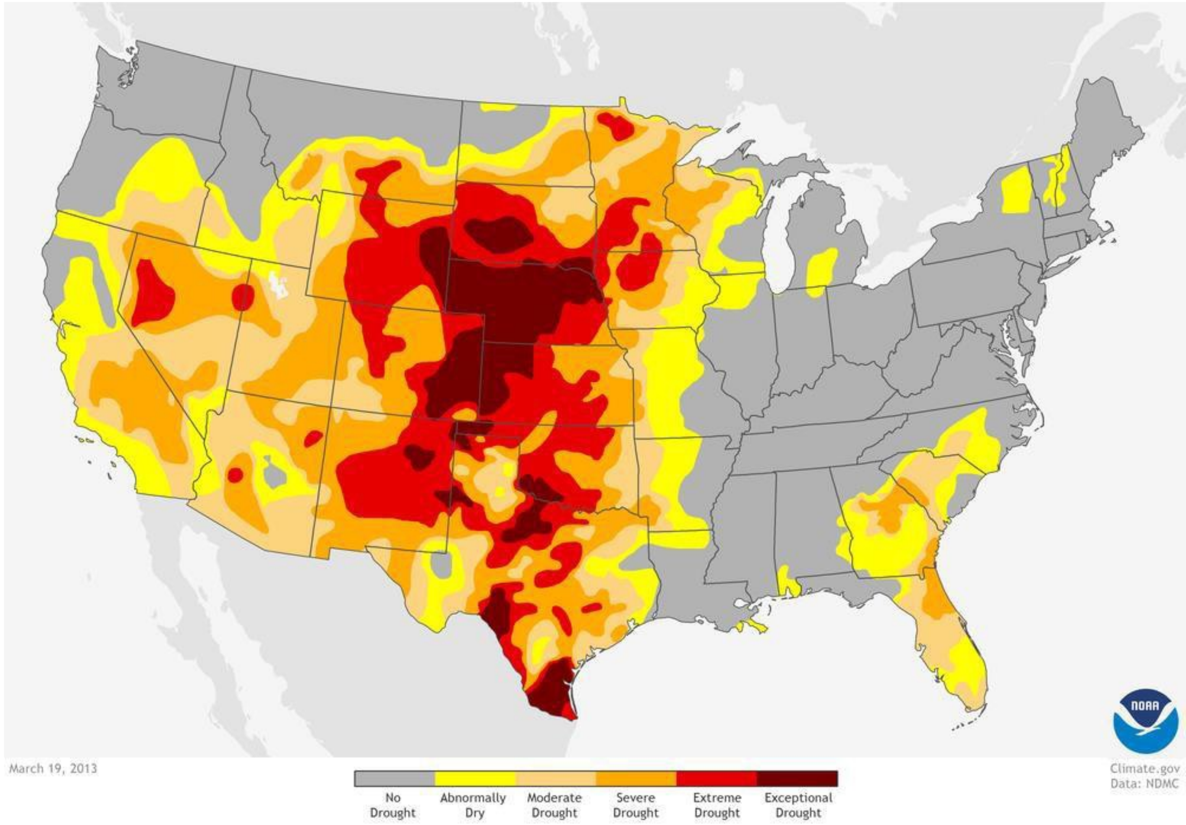
2040 WATER RESOURCES AND INFRASTRUCTURE (WRIS) REPORT BACKGROUND

Extrapolating the data forward, assuming a conservative straight-line trend, increased levels of approximately 2.5 inches or greater could result by 2040. The National Oceanic and Atmospheric Administration (NOAA) suggests that scientists are very confident that global mean sea level will rise at least 8 inches (0.2 meters) but no more than 6.6 feet (2.0 meters) by 2100. This is a significant variation, but the more specific concerns for water utilities should focus on planning for the certainty of sea level rise and adapting to the trending as more information becomes available. Practically, the year 2100 projections present planning scenarios far beyond this work, yet worthy of longer-term planning consideration. Planning for sea level rise impacts involves consideration of the concerns highlighted above that encompass many of the FEMA initiatives, but also other impacts discussed below, such as salt-water intrusion. Our focus will consider the likelihood of more modest sea level rise, coupled with more episodic storm surge events, which can create short to medium term disturbances in supply and operations.

Precipitation Trends

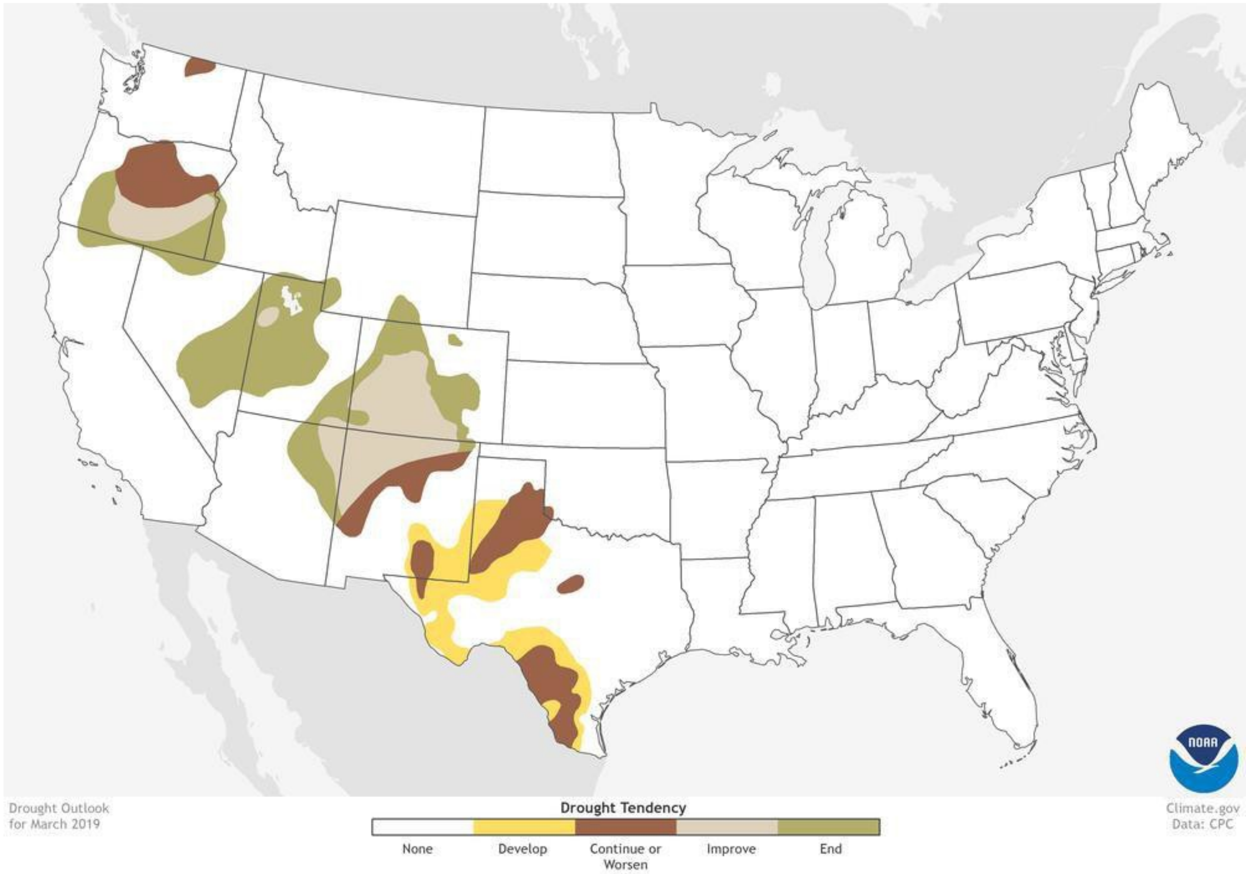
Data on precipitation trends is not as clear as that for sea level rise. However, events of the past decade have demonstrated that while annual precipitation totals fluctuate, the frequency of more intense, episodic events appears to be increasing.

Figure 2



NOAA climate analysis looks at long range drought conditions. The graphic above illustrates the long-term view for the Northeast as being of no drought concern. Further, NOAA projections for the Northeast suggest wetter precipitation periods through 2050, with increases ranging to as high as 15% greater.

Figure 3



Current modeling suggests that drought concerns through 2019 appear to be low in the Northeast. This suggests that the core issue likely to be faced by Long Island water suppliers will be demand management, particularly during summer months with high irrigation demands, and challenges from water quality impacts both known and unknown.

However, cyclical precipitation on a regional level must be carefully monitored and evaluated on a regular basis. Groundwater models, which can be used to predict the recharge effects from fluctuating precipitation, should be developed and utilized by water suppliers as a planning tool, as the challenges of delivering potable water become more complex and costly. Some large municipalities maintain in-house staffing or contract resources to provide climatic planning and analysis, including drought, precipitation, and hydrological forecasting. Long Island water suppliers and regulators should consider the value of similar tools, along with the other assessments for groundwater modeling. Joint funding agreements should be evaluated. Where funding constraints may present challenges to in-house resources, close partnerships with such Government agencies as National Weather Service, the United States Geological Survey (USGS) and NOAA can provide significant planning data.

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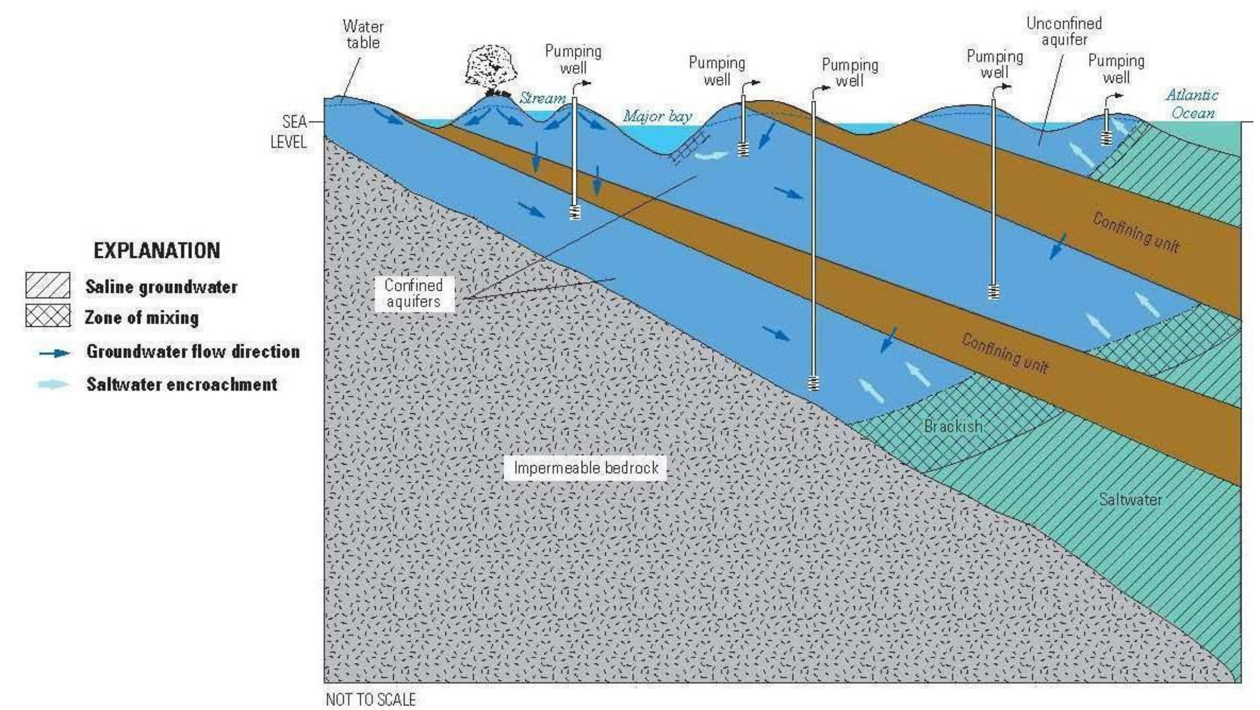
Water utility operators and municipalities have been proactively taking measures to mitigate climate change effects. Storm hardening and flood control measures are most prevalent in the response toolkit. Utilities must assess their ability, as well as the practicality and the cost to attenuate the impacts of high intensity storm events. Further considerations are presented below in the Facility Manager's Response section.

Effects of Salt Water Intrusion

Most experts agree that movement of the coastal saltwater/freshwater interface is likely. The timing and magnitude of this impact, specific mitigation measures, and the planning horizon for action, in which municipalities are likely to be affected, is somewhat indeterminate. Engineers and scientists agree broadly that the confined fresh water interface along the coastline is highly susceptible to salt water intrusion.

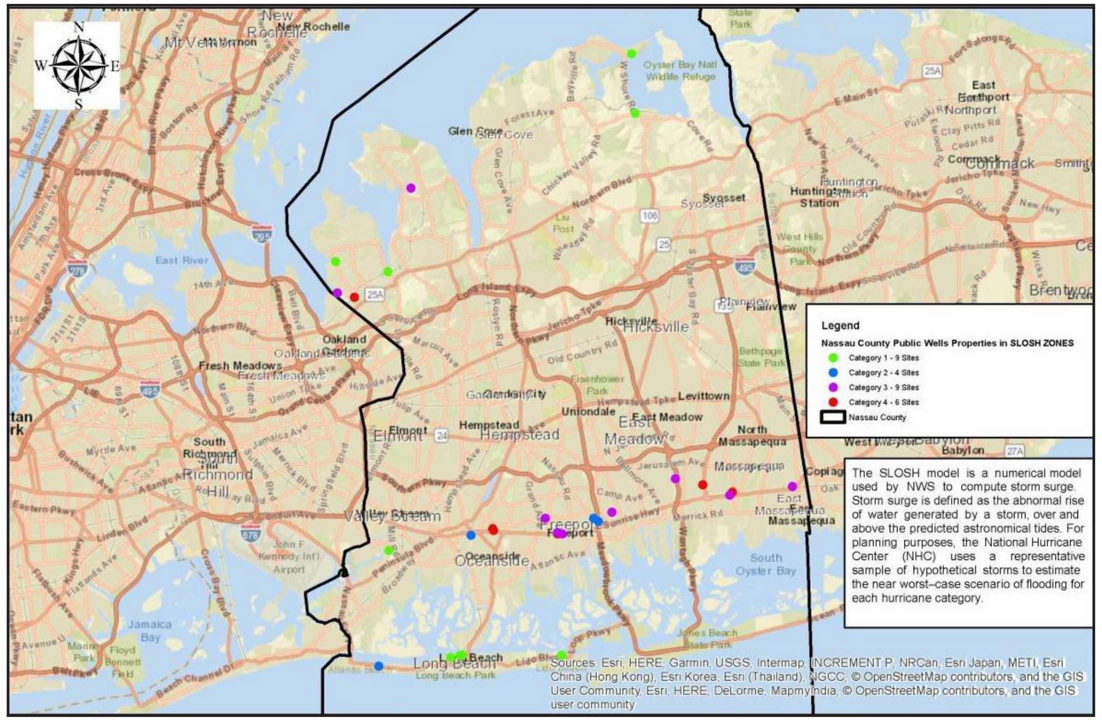
The USGS describes the mechanism for saltwater intrusion in the following way, "When excessive groundwater pumping occurs close to the shoreline, the potential exists for saltwater intrusion as the boundary between fresh and saline groundwater, referred to as the freshwater-saltwater interface, moves landward," (source USGS.gov).

Figure 4



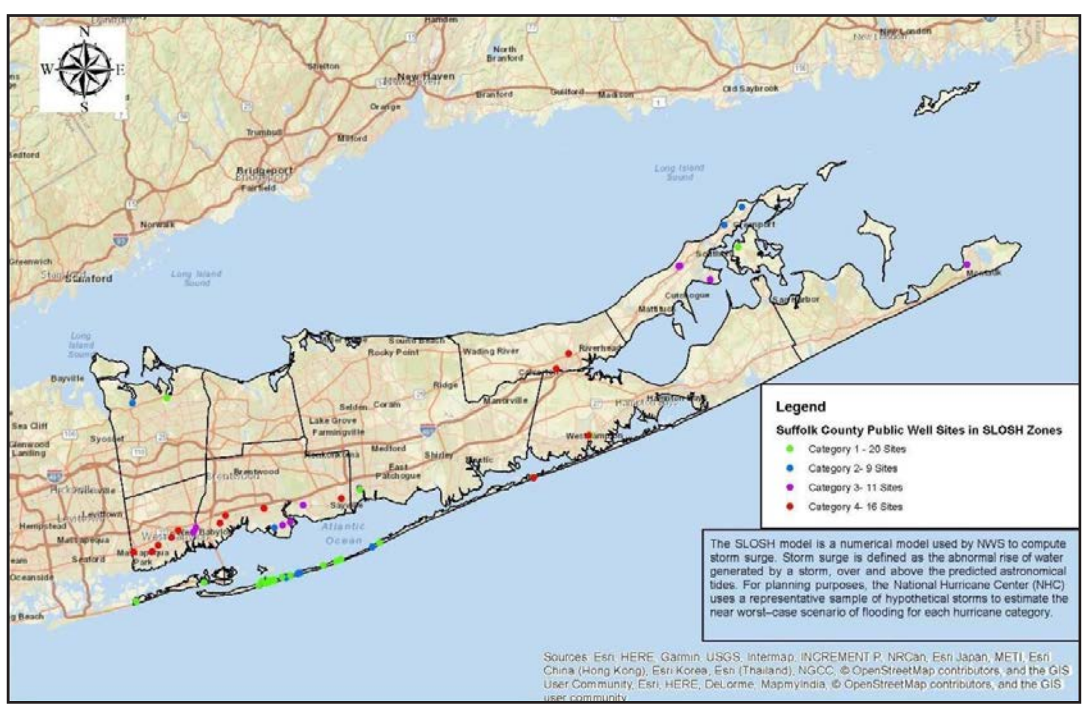
The hydrostatic equilibrium of the saltwater/freshwater interface is impacted by issues such as over pumping, where drawdown at the wellhead tends to influence the flow of the salt or brackish water. The exact dynamic presented by the potential of sea level rise on the confined freshwater layers is less clear. It is reasonable to assume that increases in sea level could impact some well stations that become submerged. The following figures illustrate the need for consideration of salt water intrusion.

Figure 5



Sea, Lake, and Overland Surges from Hurricanes (SLOSH)
Nassau County

Figure 6



Sea, Lake, and Overland Surges from Hurricanes (SLOSH)
Suffolk County

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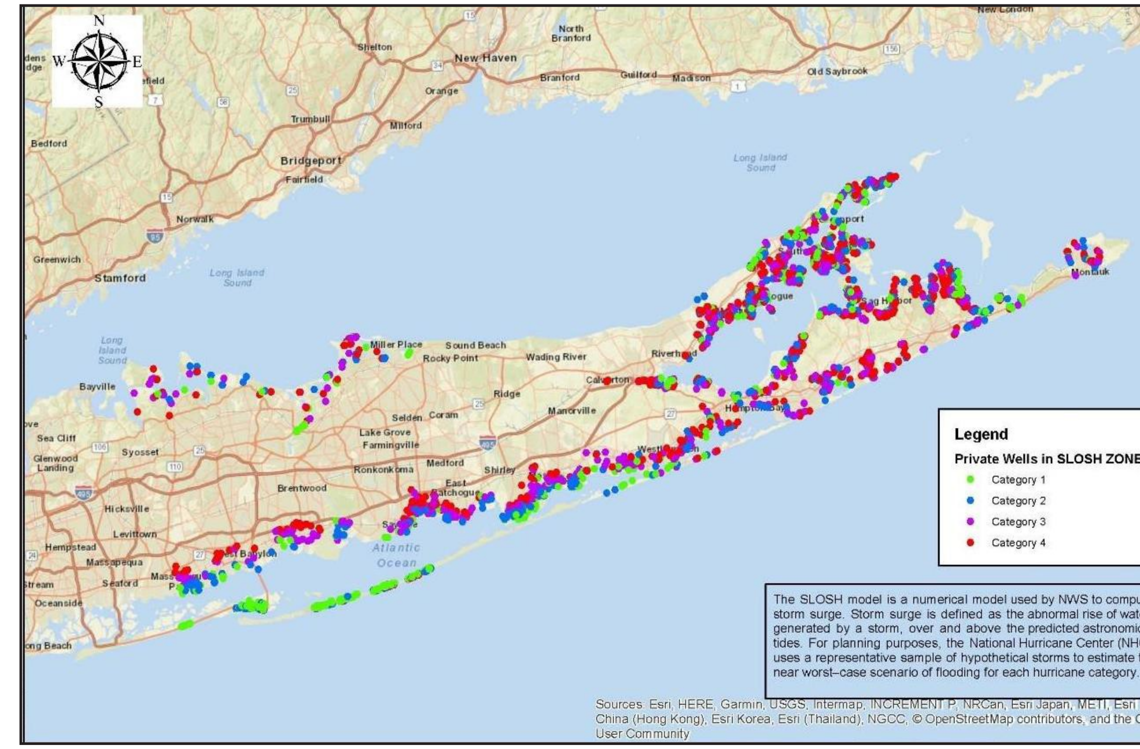
Figure 7



Sea, Lake, and Overland Surges from Hurricanes (SLOSH)
Private Wells in SLOSH Zones

Sea, Lake, and Overland Surges (SLOSH) maps, are generated by the National Weather Service using numerical models to compute storm surge. There are approximately 28 public well sites in Nassau County (Figure 5) and 64 in Suffolk County (Figure 6) that fall in areas of concern. There are also nearly 12,000 private wells (Figure 7) that fall into these areas.

In the case of the deeper Lloyd Aquifer, the timing and ultimate impacts deserve more concerted study in the form of proper groundwater modeling. This highlights the critical importance of the funding, advancement and proper stewardship of a hydraulic model for the Island. The recommendations for immediate action contained in both the Executive Summary and Chapter 8 of the GRMP demonstrate the consistent view supporting the need for this tool.

Facility Manager Response

Facility managers must consider all of the variables discussed above in order to properly plan for both immediate and longer-term events and trends. Regarding sea level rise and extreme weather events, long-range planning should inform short-term planning and action plans.

Consideration of facility hardening or resiliency upgrades must be evaluated. The Environmental Protection Agency (EPA), recognizing the importance of these considerations to water utilities Nationally, has created tools to facilitate planning and assessments. Climate Resilience Evaluation Page and Awareness Tool

(CREAT) assists utility managers in understanding a number of variables of concern including flooding, drought, demand management, water degradation due to issues like saltwater intrusion and impacts to environmental ecosystems. Many utilities impacted by coastal storms like Irene or Sandy, have either begun or completed efforts to comply with new flood plain management regulations, by elevating key mechanical/electrical systems and by storm hardening plants against flooding.

An example of operational planning might consider pre-positioning equipment and resources in anticipation of a storm event that has been identified to trigger such a response. Emergency power generators, sand bags, or other deployable "dam" equipment, etc. are considerations. Personnel scheduling and mutual aid agreements should be approved and in place in advance. Other considerations would be electively taking assets offline pre-event; moving critical equipment, where feasible, to higher ground; etc. to limit loss and improve post-recovery response and capability. All of these considerations should be part of long- and short-term operational and emergency plans, to be reviewed and updated on a continuing basis.

Much of this effort has been supported by FEMA funding. Making effective judgments about the best course of action with regard to potential sea level rise entails assessing these impacts coupled with coastal surge events. Flood models and simulation tools provide additional guidance about impacts to specific sites and capital investment decision making. Water suppliers who manage well sites within low-lying zones which may become inundated either permanently or episodically must assess not only the ability of the plant to deliver water short-term, but whether abandonment of specific sites due to these considerations is warranted. There are generally still grant funding opportunities available for utilities which present a demonstrated need. Decreasing, where feasible, the percentage of impervious area as in the case of green infrastructure planning, can increase the amount of groundwater recharge potential and simultaneously soften the effects of localized flooding from extreme runoff events.

Current drought projections do not appear to signal cause for alarm. Other environmental issues, such as saltwater intrusion, contaminant plumes and new regulations related to emerging contaminants (such as 1, 4 Dioxane and perfluorinated compounds), if coupled with a drought, would surely impact the supply management strategy of individual suppliers. In any emergency scenario, sound demand management, especially related to overpumping resulting from irrigation, should continue to be a top concern. From the standpoint of supply and demand management alone, water suppliers would appear to have limited options available to address this concern:

- Conservation and efficiency
- Additional supply wells
- More comprehensive inter-municipal water sharing agreements to mitigate specific localized impacts of over pumping
- Meaningful and enforceable drought or water management regulations
    - ◊ Behavioral patterns with regard to water usage, even in emergency, are difficult to change
    - ◊ Smart metering and monthly billing options

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- ◊ Many municipalities maintain tiered rate structures for the purpose of encouraging water conservation, particularly in summer months. Consideration could be given, in extreme circumstances, to forced water conservation through a mechanism such as emergency water usage charges

All of the above options present challenges. The construction of additional supply wells, especially in areas that may already be facing declining water quality (including salt water intrusion), become increasingly difficult and costly. When evaluating the possibility of transmission mains to these coastal areas, consideration must be given to the potential impacts of increased pumpage on the inland suppliers whose service areas may have water quality problems of their own. Such Regional water supply planning can only succeed where common objectives are agreed upon and coordinated. Additional planning consideration is warranted for construction of wells in potentially impacted (SLOSH) areas shown above.

Potential short-term actions might include de-activation of specific well sites, that may be impacted, until the event has subsided. Considering the potential for periodic impacts, including short-term contamination, the following items need to be considered:

- Assessments
    - ◊ Impacted service areas
        - » Number of customers affected (supply volume)
        - » Well placement criteria
            - ➤ Cost benefit of rehabilitation of existing versus new wells inland and main extensions
    - ◊ The viability of the source well and operating equipment
        - » Is there a need for increased water quality monitoring, sampling, etc. either routinely for potentially impacted wells, episodic in response to discrete events?
    - ◊ Consideration of the possible necessity of using non-potable delivery for sanitation and fire protection on an emergency basis
- Notifications
    - ◊ Communication plan
- Decontamination
    - ◊ Plans for disinfection should be prepared and approved by health departments in advance
    - ◊ Disinfection and start-up procedures should be documented, approved and well understood by operational staff.
- Start-up and testing
    - ◊ Depending on the severity of the event and the impact to operations this could run from routine to complex. For example, loss of electric systems, telemetry, treatment equipment, etc. would entail more complex recovery.
- Water quality sampling protocols
- Commencement of normal distribution operations

Abandonment of well sites due to these considerations should be evaluated from carefully modeled supply and demand projections. Figures 5, 6, and 7 above present some general guidance relative to risk based on geography. Additional new well sites, not considering costs for advanced treatment, property, permitting, etc., can cost as much as $1.5-2.0 million. Extensions of new water mains are estimated at $1.5 million per mile, where feasible, to leverage inland well capacity to service areas where wells may need to be abandoned. Main extensions of up to two miles, at a cost of approximately $3.0 million, would typically extend inland beyond the immediate impact zones related to sea level rise. For longer-range sea level projections and extensions for south shore wells, could project as far north as five miles (for example, Sunrise Highway in Nassau County), with approximate construction costs of $7.5 million. Main sizing and exact costs will be dependent upon the number of wells impacted and demand projections.

Careful long-term water supply demand, water quality and capital improvement planning will become more important as these conditions become more prevalent, and the need for a more sophisticated, holistic view of a public water supplier's operations will be required. Coastal water suppliers should seek opportunities to partner with other inland municipalities in these planning exercises.

In consideration of the above, where new wells become either infeasible or impractical, inter- municipal water sharing and/or new wells drilled inland of the area of impact predicted by sea level rise, become essentially the only reasonable course of action. The former requires demand projections and management by both suppliers and formalized sharing agreements. The latter requires additional planning and permitting, if for example the location falls outside of the water supplier's service area, of what might normally be required for simple localized well siting.

Overall, the Utility Operator's toolbox of preparation should consider:

- Comprehensive Water Supply Management Plans
    - ◊ Periodic updates
- Groundwater modeling
- ERP development and maintenance
    - ◊ Approved by Health Departments
    - ◊ Location specific and system-wide strategies based on generated scenarios
    - ◊ Risk Assessments
    - ◊ Inundation maps
    - ◊ National Incident Management System Training
- Communication Plans (Separate Plans)
    - ◊ Level of impact dependent
        - » Government Leadership
        - » First responders
        - » Regulators (public health notifications)
        - » Media
        - » Customers

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- Climate Modeling
    - ◊ Increasing the use of greater intensity storms in planning scenarios; but cost benefit versus risk must be weighed
- Greater consideration in future siting of facilities
- Asset management programs
    - ◊ Emergency equipment and resources, procurement, and maintenance
    - ◊ Upgrades that incorporate hardening measures
- Drought Plans
    - ◊ Enforcement capability
    - ◊ Water/Wastewater Agency Response Network (WARN) Agreements
    - ◊ Partnerships that establish and allow rapid resource sharing
- Opportunities for interconnections
- Operational plans for isolation and restoration
    - ◊ Ensuring Maps and GIS layers are accurate (with appropriate resolution)
        - » Including facility and condition use maps
    - ◊ Valve testing and maintenance operations o Sanitation
        - » Consideration and planning for potential use of non-potable water for public health related to basic sanitation
    - ◊ Fire protection
        - » Consideration and planning for potential use of non-potable water for public safety and fire protection before final re-establishment of the distribution system.

Demand and Regulatory Considerations

Consideration of planning related to demand management and regulatory regimes fall into a few distinct categories. Future planning, projecting trends, behaviors and anticipating future operational necessities, including management of water infrastructure and assets, is an ongoing activity. On Long Island, LICAP, along with regulatory agencies should serve as focal entity to facilitate and coordinate the interjurisdictional areas of this planning effort. Working in this role, LICAP, along with groups like the Long Island Water Conference, can provide responsible stewardship by identifying emerging issues, facilitating cooperative approaches to solutions and serving as a strong advocate voice for the overall preservation of the aquifer system as the vital natural resource that it is.

Immediate and emergency planning is also critical in the face of the changing environment. Experience has demonstrated that considerations of these issues is highly variable, depending upon the severity of the event. Managing demands, at any time, can prove challenging. Operating utility planning should consider the possible implementation of drought surcharges during severe demand related events. Smart metering technology could provide for greater control of in-ground irrigation systems, which typically represent the greatest demand challenge during peak flow periods. Legislative authority to implement these types of approaches may be necessary for water suppliers to legally enact. The AWWA Manual M1, Chapter 3, Drought and Surcharge Rates, can provide some insight and additional information on this topic. Demand isolation and shutdown planning, which for example might be implemented in the event of a catastrophic break or infrastructure failure concurrent with a sea level surge event, will generally allow for isolation and recovery of distribution and plant infrastructure more quickly. Planned, deliberate and carefully implemented pressure regulation/reductions for example, can potentially serve to reduce demand considerably.

We will assume, for this discussion, that an event has reached a duration of impact or disruption of two weeks or greater. However, it should be noted and clearly understood by all operational staff, that ERPs, while often designed for specific circumstances and conditions, if designed properly from inception, should work modularly. Operations managers should always consider the ability to leverage full or partial plans during an event, to mitigate impacts and advance recovery.

For example, the City of New York Bureau of Water and Sewer Operations, maintained numerous discrete plans to address events such as water main breaks, contamination events, pressure events, flooding, treatment disruptions, power loss, etc. When Hurricane Sandy hit in 2012, modifications to the existing separate procedural documents, combining of elements and creating new strategies from existing planning efforts, both internally and externally, allowed for faster, more coordinated response.

No two emergencies are likely to be identical. The value in planning is preparing staff to effectively leverage applicable strategies and techniques that staff are trained on and familiar with to the greatest extent possible.

From the standpoint of regulatory considerations, partners at the local and state levels of both Departments of Health and Environmental Conservation play an important planning role. In the context of this report, perhaps the most tangible direct impact regulators could achieve are programs that reduce and ultimately eliminate the utilization of private wells for potable water. As our understanding of existing and emerging issues improves it becomes increasingly clear that individual private well owners face significant challenges in ensuring water quality and quantity. Preparation for the types of matters and concerns contained herein, are daunting for small private well owners, but have significant public health implications for the approximately 75,000 residents reliant upon these wells. Enhancement of existing oversight and guidance can provide necessary leadership and direction. To ensure these capabilities, agencies must have the necessary resources and funding commitments to support their missions and strategic planning should account for both present and future needs in this area.

Regulators must continue working with utilities and ensure that all providers create and maintain ERPs and associated documents. Emergency sampling protocols provide great utility in major events, when perhaps limited regulatory oversight resources are stretched geographically. Advance approvals of templates for testing, re-activation, notifications, etc. will facilitate response. Resource sharing across government agencies can also provide valuable assistance in emergency events. For example, the ability to leverage a state equipment or materials contract can shorten procurement timelines. This could involve items like chemicals, fuel, safety equipment, etc.

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Joint planning exercises can identify opportunities for operational plans to address issues such as emergency permit approvals for discharges or other extraordinary emergency actions of a similar nature. Pre-approved, well-constructed plans covering procedures to manage contamination events at multiple levels of severity, along with at least the structure of templates that can be instituted for various events, allow for faster and more efficient recovery. Issues like demand management can be supported regulatorily by supporting the creation of emergency “drought” regulations and assisting with necessary enforcement support to achieve compliance. The operative theme is preparedness and planning. Knowing what needs to be done is only a part of the solution. Planning and implementation strategies tie all elements together and allow the greatest opportunity for success by the utility operator.

Background

In 2013, Nassau County and Suffolk County created a bi-county entity called the Long Island Commission for Aquifer Protection (LICAP) to address and to advocate a coordinated approach to the groundwater issues facing the region. The legislation set the operational terms and conditions of a Commission which would build on existing studies, identify research areas and program opportunities to prevent further deterioration of the bi-county, sole source aquifer system, and identify mechanisms for improving its water quality and safeguard quantity.

Further, LICAP was directed to establish two standing subcommittees. The 2040 Water Resource and Infrastructure Subcommittee (WRIS) and the Water Resource Opportunities Subcommittee (WROS).

This WROS report shall investigate short-term risks facing water suppliers as it relates to the treatment and distribution of potable water from the aquifers to the residents of Long Island. The risks to be evaluated include increasing peak water demands, impact of additional sewering in Suffolk County, and various groundwater contamination issues.

The WROS report will outline which water suppliers will be impacted by identified specific risks and suggest ways these suppliers can avoid and to mitigate the impacts of the risks.

Today, perhaps more than ever before, there are numerous challenges facing Long Island water suppliers and the approximately 2.8 million residents who rely exclusively on the sole source aquifer as its only available potable water resource.

Introduction

With approximately 2.8 million people of Long Island living, working, and playing directly above the aquifers of Nassau and Suffolk Counties, one would expect some level of adverse impact to occur to the water resource. More importantly, with this aquifer system being the sole source of potable water to the people of Long Island, management of this precious resource is critical.

Prior to the 1970s, no one really understood the potential adverse impact our everyday activities were having on our aquifers and eventually our water supply. Since the 1970s, numerous environmental regulations and programs were enacted to help protect the aquifers. However, the "legal" and legacy site discharges to the groundwater during the 1940s-1970s has had, and will continue to have, negative impact on our water quality. While we now realize the sensitive nature of our aquifer system, there still are activities that occur every day that significantly impact our groundwater.

Even with all the numerous stringent environmental regulations and programs developed as described in the LICAP Groundwater Resources Management Plan – Chapter 3 entitled "Existing Regulatory and Management Regimes," the significant population growth, increase in development, increase in water withdrawal, and an increase in the number of on-site septic systems being installed, we are still seeing an increased adverse impact on the aquifer system. This report will examine activities, identify the impacts, and offer suggested actions to mitigate impacts.

This WROS will evaluate the short-term risks facing the public water suppliers who withdraw their supplies from the aquifers and will suggest ways to minimize the short-term impact.

Increasing Peak Water Demands

The water suppliers of Long Island maintain approximately 1,600 active public supply wells. As discussed in the LICAP Groundwater Resource

Management Plan Chapter 6 entitled, "Management Opportunities," there is no shortage of water beneath Long Island. However, due to the increasing groundwater pumpage, the overall volume of water in the aquifers has decreased over the past several decades, causing the water table to drop and saltwater interface to move landward in sensitive areas. In order to ensure that future Long Islanders will have a safe and adequate supply of water, we must proactively implement a plan of water conservation and water efficiency to reduce the overall water use across Long Island.

The 15-year daily pumpage average in Nassau County (2000-2014) has been 189 million gallons per day (MGD), which is in excess of the initial estimated sustainable yield of 180 MGD. Average water withdrawal in Suffolk County over the same period has been documented to be 187 MGD, which is less than the estimated sustainable yield of 466 MGD.

Based on recent pumpage records, the water suppliers of Long Island pumped an average of 650.2 MGD during the warmer months, with peak day demands, increasing up to 60% more during the hottest and driest days of the summer. As shown on the following figure, average day water demands across Long Island for the cold weather months is calculated to be approximately 365.5 MGD or 130 gallons per day per capita (gpdpc). This average day demand increases to approximately 650.2 MGD or 232 gpdpc during the summer months. This increase in water use can be directly attributed to lawn irrigation practices of Long Islanders. Automatic lawn irrigation systems are, by far, the single largest consumer of water in the home.

These water use figures are some of the highest in the Nation. For comparison purposes, the United States Geological Survey (USGS) has calculated the National average water use at 89 gpdpc in 2010. The USGS study has determined that there is a national trend of water use reduction of about 10% over the past five years, mostly due to the use of water efficient plumbing fixtures. However, the water use figures on Long Island show an increasing trend.

The combination of Long Islanders desire to maintain a green lawn together with the increased number of automatic irrigation systems being installed across both Counties, and the relatively low cost of water, drives up the water demands during the warmer months.

This increased demand translates into several water supply impacts:

- Need to construct additional supply wells to meet peak day demands plus a reserve for fire flow protection
- Stressed aquifers and possible over pumping in saltwater intrusion sensitive areas

While the public water suppliers do not have the direct responsibility or direct control of water demands, the water supply industry should take a leading role in educating and influencing the demand trends. This extreme peak demand situation is an Island-wide condition and can be more effectively addressed regionally rather than locally. The public water suppliers working together as an industry would likely be the most effective way to address this situation.

Suggested actions to reverse the trend of increasing peak demands include:

- Implement a Regional/Island-wide water conservation public educational program. Public education is essential in the area of reducing excessive summer water demand
- Consider Island-wide irrigation restrictions, such as odd/even day limitations and time of day restrictions similar to limits already imposed in Nassau County
- Encourage all water suppliers to set an increasing water rate structure that would increase unit prices for increased usage and encourage conservation
- Encourage mandatory use of Smart Controllers for irrigation systems that would include soil moisture sensors, weather forecasting, and historical use controlling
- In early 2017, the New York State Department of Environmental Conservation (NYSDEC) notified all Long Island public water suppliers that they must prepare and submit a Water Conservation Plan to the Department as required by New York State Codes and Regulations, Title 6, Chapter V, part 601.10. In addition, the NYSDEC is now requiring the submission of a Long Island Public Water Supply Water Conservation Yearly Update Form that provides a summary and status report of what conservation actions are being taken by each individual water supplier and the effectiveness of their conservation plan. The goal of this NYSDEC initiative is to obtain a 15% reduction in peak season water demand. It is suggested that the NYSDEC continue to require yearly updates from all public water suppliers.
- Implementation and continued enforcement of NYSDEC Water Conservation Program includes the following components:
    - ◊ Leak Detection Programs (at least once every five years)
    - ◊ Meter Replacement Programs (replace meters every 15 to 20 years)
    - ◊ Water Audits of Major Water Users – Top 10 Users (Annual Audit)
    - ◊ Water Rate Structures
    - ◊ Water Main Replacement Programs
    - ◊ Public Outreach and Education
    - ◊ Reduce Unaccounted for Water (Goal of less than 10%)
- Work with Town and Village Planning Boards to require mandatory wastewater reuse as part of major development projects.

Increase in Sewering – Suffolk County

Currently approximately 74% of the dwelling units in Suffolk County utilize on-site septic systems for sewerage disposal that equates to approximately 360,000 homes that discharge wastewater, essentially untreated, into the groundwater.

As detailed in the LICAP Groundwater Resource Management Plan Chapter 5 entitled, "Assessment of Adequacy of Existing Programs," the need for additional sewers in Suffolk County is necessary for the

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protection of water quality in both groundwater and surface waters.

While nitrogen from sewage has historically been the contaminant primarily discussed and studied with wastewater management, many other contaminants of concern may have a more serious impact on our aquifers. These contaminants include pharmaceuticals, volatile organics, personal care products, and pathogens; as well as emerging contaminants.

From a water quality protection standpoint, all wastewater should be properly collected, treated, and disposed of. Due to the significant cost of sewage collection and treatment, we do not expect the majority of Suffolk County to become sewered in the near future, if at all. The Task 3A Report provides a more detailed analysis of sewering opportunities in both counties. The adverse environmental impacts of installing additional sewering need to be properly evaluated including potential for lowering groundwater table levels, impact on stream flows, and impact on saltwater interface. The decision to sewer areas to improve water quality must be weighed against the loss of water recharge. Areas of Suffolk County that are currently being considered for possible sewering include:

- Mastic/Shirley (Forge River)
- Carlls River (Babylon)
- Oakdale
- Patchogue (beyond Village boundaries)
- Ronkonkoma
- Huntington Station
- Smithtown
- Kings Park

As these sewering plans progress and more homes are connected to wastewater collection and treatment facilities (most likely utilizing surface water effluent discharges), the cumulative effect on the changing water balance must be evaluated.

Consideration must be given to alternative effluent disposal including artificial recharge, aquifer storage and recharge, and water reuse (lawn and golf course irrigation).

We can learn from the lessons in Nassau County from the extensive sewer installations in the 1960s and 1970s and southwest Suffolk County in the 1970s and 1980s, where diverting of wastewater discharge from groundwater (via on-site septic systems) to ocean outfalls, add significant impact on the overall water balance.

It is suggested that the Regional Groundwater Model be utilized to determine the impact of increased sewering on the water table levels and adverse impact on stream flows and saltwater interface for each sewering area being proposed.

Contamination

Public water suppliers routinely test for over 140 contaminants as required by Federal, State, and local health departments. As is well documented in the LICAP Groundwater Resource Management Plan Chapter 4 entitled, "Quality and Quantity Threats," there are many water quality issues that have impacted water suppliers at varying degrees and varying locations across Long Island.

As laboratory testing equipment becomes more advanced, we are detecting smaller and smaller levels of contaminants. Approximately 40 years ago, we were only able to test down to parts per million (ppm), then parts per billion (ppb); we now have the ability to detect down to parts per trillion (ppt).

The following section will discuss the contaminants of concern that are currently impacting the water suppliers of Long Island.

Volatile Organic Compounds (VOCs)

Volatile Organic Compounds (VOCs) are chlorinated solvents that are widely used in industry and in common household products. The use of VOCs on Long Island started to become widespread in the mid-1940s. Manufacturing and other heavy industries were the biggest users of VOCs.

VOCs began being tested and detected in groundwater in 1976. VOCs are now the most common contaminant found in the raw water of Long Island supply wells. In 1989, the VOC maximum contaminant level (MCL) was lowered from 50 ppb to 5 ppb.

Public water suppliers started to construct wellhead treatment systems for VOC removal in the 1980s. As of today, there are approximately 280 wells (24%) treated for the removal of VOCs. Air strippers or Granular Activated Carbon (GAC) filters are two effective treatment processes used to remove VOCs.

The number of wells impacted by VOCs is rather stable, with a slight increase as VOC plumes continue to move within the aquifer. Many of the treatment systems have been in service for over 30 years and water suppliers are rehabilitating or replacing these treatment systems as they near the end of their useful life.

The most significant risk of VOC contamination is related to the continued movement of VOC plumes from the large legacy hazardous waste sites. It is suggested that public water suppliers continue to monitor the progress of any groundwater remediation projects; review all documentation; request updates as available; and ask for additional monitoring wells that could act as sentinel wells providing additional information as to if and when the supply well may be impacted by a plume. Water suppliers should also monitor emerging contaminants that may have been in the legacy plume but never included in the water quality monitoring. Groundwater remediation treatment systems most likely were not designed to remove emerging contaminants and they may have unknowingly been recharged back into the aquifer.

Nitrate (Nitrogen)

Nitrate contamination is a major issue for several water suppliers on Long Island with a limited number of public supply wells being significantly impacted. A total of approximately 12-20 wells (1- 2%) have nitrate levels over the MCL of 10 milligrams per liter (mg/L). These include Manhasset- Lakeville Water District, Hicksville Water District, Westbury Water District, Inc. Village of Garden City, Suffolk County Water Authority and Northport VA Facility, as well as several smaller community water suppliers. Several nitrate removal systems have been installed (ion exchange process).

Blending of wells on the same well site to obtain

a combined nitrate concentration below 10 mg/L is also utilized by several water suppliers. Nitrate levels throughout the center of Nassau County have actually started to decline in recent years, due to the installation of sewers in the 1960s and 1970s. The recent and proposed expansion of sewer collection systems throughout Suffolk County will have a positive effect on decreasing the nitrogen loading to the aquifers and in turn decrease nitrate levels.

Perchlorate

Perchlorate is both a naturally occurring and man-made chemical that is used to produce rocket fuel, fireworks, flames, and explosives. Perchlorate is also known to be present in bleach and some imported fertilizers.

Perchlorate was first tested for in potable water under the Unregulated Contaminant Monitoring Rule (UCMR). It was detected in 100+ wells (9%) on Long Island with a detection level of 1.0 ppb.

New York State Department of Health (NYSDOH) has established an Action Level of 18.0 ppb for Perchlorate. Only a few community public water supply wells have been tested to exceed this Action Level and this includes Suffolk County Water Authority, Locust Valley Water District, and Bethpage Water District.

The United States Environmental Protection Agency (USEPA) had originally decided to regulate Perchlorate back in 2007 but reversed its decision in 2009. The USEPA has stated that it will propose a draft regulation in late 2019. Should the MCL be set at 15.0 ppb (the EPA Interim Drinking Water Advisory) or higher, there will be limited impact on Long Island water suppliers.

Perchlorate can be removed from raw water utilizing the ion exchange process. Selective resins have been used by water suppliers to remove Perchlorate.

Emerging Contaminants – 1,4-Dioxane

At the time of the writing of this report, the NYSDOH is in the process of finalizing the proposed regulations for three critical emerging contaminants, perfluorooctanoic acid (PFOA), perfluorooctane sulfonate (PFOS) and 1,4-Dioxane.

Based on recommendations from the New York State Drinking Water Quality Council, we expect the PFOA and PFOS MCL to be 10 ppt, and the 1,4-Dioxane MCL to be 1.0 ppb. These MCLs will have a drastic adverse impact on Long Island water suppliers.

1,4-Dioxane has been detected in approximately 70% of all supply wells. It is estimated that approximately 100 wells (8%) are over the 1.0 ppb level. With a planning level threshold for treatment of 0.5 ppb, it is estimated that approximately 175 wells (14.5%) may need treatment. Water suppliers that will be impacted severely by the proposed 1,4-Dioxane MCL where more than 50% of their supply wells may require treatment, include the following:

WATER SUPPLIER	POPULATION SERVED	# OF WELLS >1.0PPB	# OF WELLS >0.5 PPB
Bethpage Water District	33,000	6 of 8 (75%)	8 of 8 (100%)
Garden City Park Water District	18,000	2 of 6 (33%)	4 of 6 (67%)
Inc. Village of Garden City	22,300	6 of 10 (60%)	9 of 10 (90%)
Hicksville Water District	42,000	10 of 14 (80%)	12 of 14 (90%)
Franklin Square Water District	20,000	2 of 4 (50%)	2 of 4 (50%)
Plainview Water District	34,000	9 of 12 (75%)	9 of 12 (75%)

Depending on the MCL to be established and the time period being allowed for phased-in or compliance to new MCL, many water suppliers may not be able to implement a wellhead treatment program in time to allow for full compliance. This possible compliance deadline could mean required water restrictions across most of Nassau County rather than supplying water that does not meet the drinking water standard. This situation has the potential of being the worst water shortage condition Long Island has ever faced. The water suppliers across Long Island are requesting a phased-in approach to compliance to allow time to construct effective wellhead treatment.

Water suppliers will need to coordinate efforts to ensure shared resources; in terms of possible sharing of water, sharing of treatment resources, and the joint communication of the situation with the public should water use restrictions be required.

It is anticipated that water purveyors will more fully explore all of their options if and when the new MCLs are established. In addition, the use of water from the New York City system to augment the water sources for water purveyors in western Nassau suppliers is addressed in the Task 3B Report.

Perfluorinated Compounds – PFOA/PFOS

At the time of the writing of this report, the full impact of PFOA and PFOS contamination is somewhat unknown. PFOA and PFOS were first tested for under UCMR3 in 2014/2015. However, the reporting limits utilized by the testing laboratories were only down to 20 ppt for PFOA and 40 ppt for PFOS. Under the UCMR3 testing program, less than 1% of the wells on Long Island showed PFOA and PFOS detections. Recent laboratory testing standard methods now have provided detection limits down to 2.1 ppt.

More recent testing (2018) by some, but not all, water suppliers have detected PFOA/PFOS in a similar percentage as 1,4-Dioxane (upwards of 50% detection level). Most water suppliers will be conducting testing all wells in 2019 utilizing the new lower detection level. Any future action by NYSDOH to establish MCLs for PFOA and/or PFOS at levels of 10 ppt, will likely present additional financial, operational and compliance concerns for public water suppliers.

PFOA and PFOS removal treatment appear to be accomplished well with the use of GAC filtration or Ion Exchange selective resins. Implementation of treatment for PFOA and PFOS will likely be accelerated due to the already widespread use availability and acceptance of GAC.

Emerging Contaminants – Future Issues

Water suppliers on Long Island, as well as all water suppliers across the U.S., are currently conducting the next phase of the USEPA UCMR4 Program. Under Phase 4 of the Unregulated Contaminant Rule, approximately 30 contaminants are being tested for in 2018/2020. In addition, new UCMR testing with new contaminants will continue every five years. With over 100,000 man-made compounds being used in the environment, and as testing equipment continues to improve and evolve, allowing lower and lower detection limits, public water suppliers will likely be faced with additional challenges to overcome. This highlights the critical need for collaborative action by water suppliers, regulators, public health officials, engineers, scientists, manufacturers, and elected officials to face these potential challenges in a manner consistent with a risk-based protection of public health, predicated on the "application of the best available technology, treatment techniques, or other means which are generally available, taking costs into consideration" (NYSDOH Title 10, Part 5, Section 5- 1.90).

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WATER RESOURCE OPPORTUNITIES SUBCOMMITTEE
(WROS) REPORT

One group of contaminants that water suppliers and health departments have started to discuss include pharmaceuticals and personal care products. With approximately 74% of Suffolk County continuing to utilize on-site septic systems for wastewater disposal plus 100+ sewage treatment facilities that have groundwater discharges, there is a long list of pharmaceuticals and personal care products potentially being discharged directly to the groundwater.

Suggested actions to minimize the risk of supply well contamination include:

- Evaluate potential point source sewage discharges within the 25-year contributing area for each public water supply well
- Conduct water quality testing for pharmaceutical and personal care products on wells with point source sewage discharges within supply well contributing areas
- Work closely with NYSDEC and County Health Departments on approval of future sewage treatment discharge locations in relationship to supply well contributing areas
- Develop and maintain a regional groundwater model to evaluate the potential impacts of point source discharges on existing public water supply wells

Saltwater Intrusion

As detailed in the LICAP Groundwater Resource Management Plan (GRMP) Chapter 2 entitled, "Existing Conditions, Qualitative and Quantitative Groundwater Data," saltwater intrusion is not a major issue across Long Island but is a serious concern in select areas. Saltwater sensitive supply wells have been detected over the past several decades mostly in shoreline areas including:

- Great Neck
- Port Washington
- Southwest Nassau County (New York American Water, City of Long Beach)
- Bayville
- Riverhead
- South Fork (East Hampton)
- North Fork (Southold)
- Hampton Bays
- Shelter Island

The data collected from potable supply wells during a 2014 sampling program shows that mean chloride concentrations are significantly below the drinking water and groundwater standard of 250 ppm; however, wells located near shoreline areas can be susceptible to chlorides via saltwater intrusion and upconing. In addition, the analytical results indicate the chloride concentrations in wells screened in the Glacial Aquifer are greater than chloride concentrations identified as deeper wells screened with the Magothy and Lloyd Aquifers, suggesting that various land uses and activities may be having a greater impact upon the shallower wells (e.g. from road salting, developed properties, salt storage facilities, etc.).

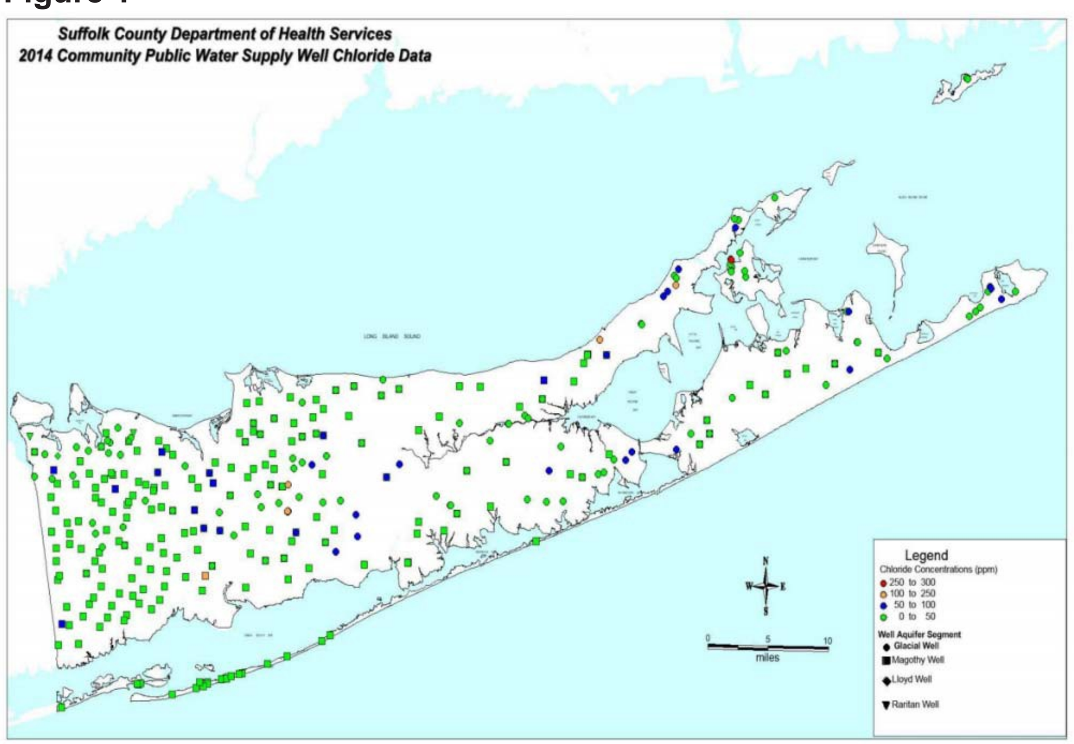
The elevated chloride levels in most of these areas can be directly attributed to over pumping of supply wells. However, a few public supply wells with elevated chloride levels have been determined to be related to close proximity to salt storage facilities and/or recharge basins handling road runoff impacted by road salts. Pump tests have determined that if pumpage is decreased and managed that chloride levels will decrease. In many cases, the required decrease in pumpage to control the chloride level and prevent saltwater intrusion is too restrictive, suggesting the water supplier may need to place the well in reserve and only utilize in emergencies or not at all.

Suggestions to water supplies in the areas listed above with saltwater intrusion conditions include:

- Develop pumping management plan to optimize pump operations and minimize stress/over pumping select wells
- Conduct pump tests and monitor outpost wells to monitor freshwater – saltwater interface
- Consider water transmission from outside immediate area to allow reduction or elimination of pumping of chloride sensitive well

Further discussion of the long-term saltwater intrusion condition is presented within theWRIS Report.

Figure 1



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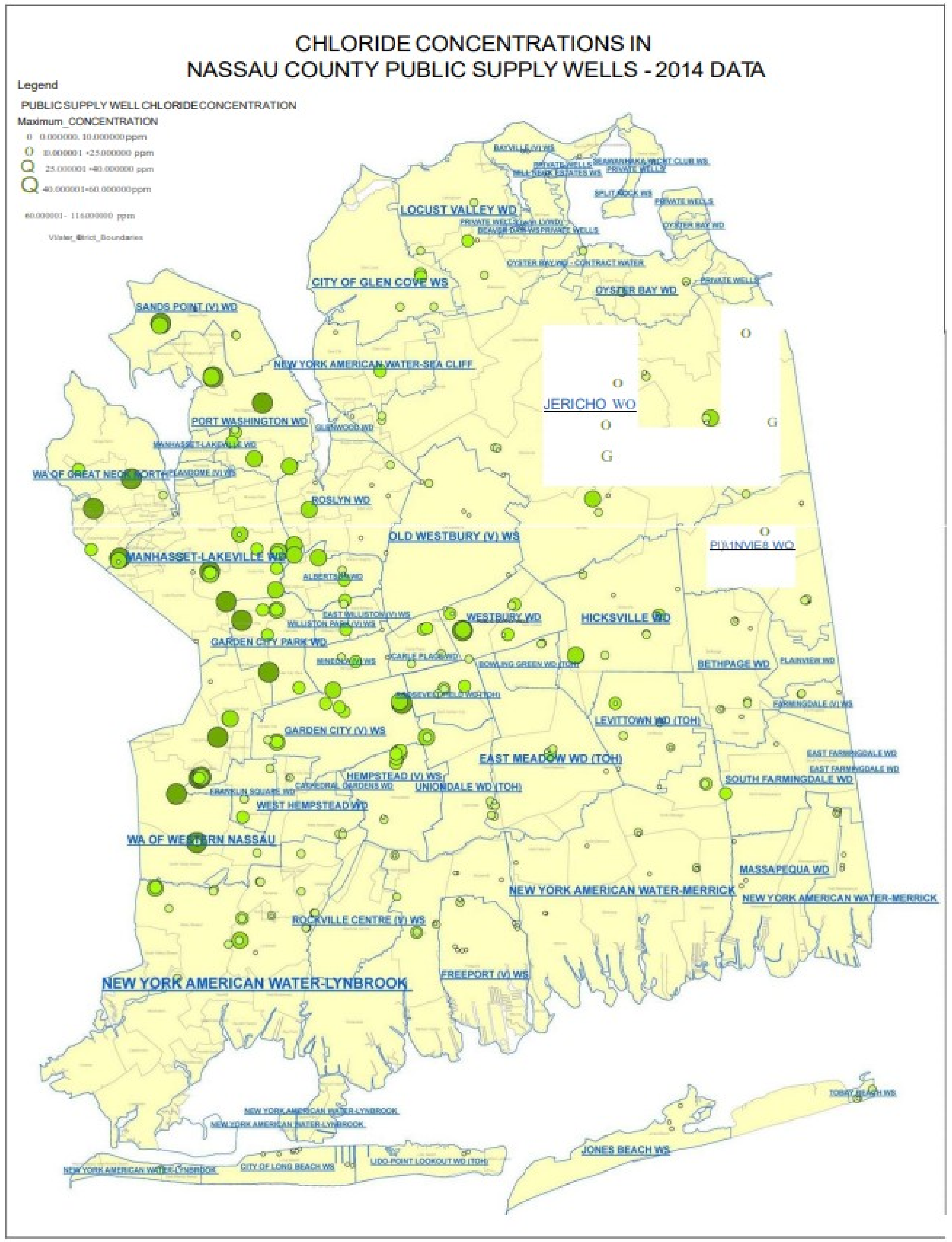

As defined in the Board's initial request, this report confines itself to one specific category of privately-owned wells—specifically "private household wells," on-site wells which provide for the drinking water and sanitary service needs of single-family residences. Wells that are used for potable supply for commercial purposes or non-residential uses are not considered in this task report. Some of these non-residential potable wells are classified as Non-Community Public Water Supplies and are subject to Nassau or Suffolk County Health Department (NCHD/SCHD) oversight and inventoried by those departments. Other wells in private ownership used for irrigation, geothermal, cooling, or industrial purposes are discussed elsewhere in the plan.

Background

According to the National Groundwater Association, in the United States, private wells serve approximately 13.168 million single family homes and well over 35 million people. In Governor Cuomo's September 7, 2017 message calling for Aggressive New Water Quality Protection, he noted that there are over 1.1 million people served by private wells in New York alone. That message included a proposal for private well testing upon construction of a new well and testing upon resale of such homes and calling for provisions for protection of tenants on private wells. These are issues that have been addressed to a greater or lesser extent in local County-level regulations, including Long Island.

Prior to 2017 funding expiring, New York State Department of Health (NYSDOH) and New York State Department of Environmental Conservation (NYSDEC) had received grant funding from a Centers for Disease Control (CDC) Grant pilot program "Supporting Public Health Drinking Water Programs to Improve Efficiency and Effectiveness for Controlling Drinking Water Exposures." This program was designed to meet the following objectives:

- To identify those private wells subject to flooding, potentially impacted by concentrated animal feedlot operations, or located in karst[1] formations
- To develop outreach materials to vulnerable populations
- To use State Office of Real Property Services records to estimate private well locations. This New York State pilot effort took place in several upstate Counties but was never extended to Long Island

CDC reports that NYSDOH staff used Safe Water for Community Health (Safe WATCH) program support guidance documentation to respond to private well water contamination and illness associated with concentrated animal feeding operations (CAFOs) and flood zones. Staff enhanced Geographic Information Systems (GIS) partner maps show well locations in karst geological zones near CAFOs and wells in 100 and 500 year flood zones. NYSDOH created new maps of counties with high percentages of vulnerable wells. NYSDOH staff analyzed regulations and outreach materials from other states to develop outreach materials on flooding and CAFOs. The new maps will enable New York State to rapidly respond in the event of an animal feed lot manure spill. NYSDOH staff identified vulnerable private wells and unregulated water sources potentially affected by the spill. Local health departments used the new resources when contacting owners of vulnerable wells. Finally, NYSDOH staff used NYSDOH's syndromic surveillance[2] methods (such as emergency room admission data) to identify peak syndromic signals that may indicate waterborne illness associated with flooding incidents. There have not been any apparent State initiatives in the area since the end of the pilot.

Subtask 2A - Estimation and Location of Private Wells

As directed by the Long Island Commission for Aquifer Protection (LICAP) Board's request, the following discussion outlines the approach used in this development of an estimate of the number of private household wells, the sources of information used in the derivation of the estimate, and estimates approximate infrastructure needs to connect them to public water and the generalized costs and necessary pumpage to meet the average and peak demand needs of these connections.

Prior to 2015, estimates of the number of private wells in both Nassau and Suffolk County were derived utilizing total population estimates from planning sources in the Counties and from the electrical utilities. Public water supplier customer estimates were then subtracted to yield private well service population and estimate the number of individual wells. This is understood to have been the approach used in the earliest readily available documented estimate of the number of private wells in Suffolk County (50,000 in 1959, which was a substantial number of the residences at the time, as the County population was about one-third of what it is today). U.S. Census data provided a different approach. The Census used detailed questions which went to a subset of households which were then used to derive an estimate. For Suffolk County, the U.S. Census for 1980 estimated 77,800 private wells and 63,000 for 1990. We were unable to find similar references for Nassau County. The 2000 Census did not include a source of water questionnaire. The 1980 Census was used for the estimate in the 1987 Suffolk County Comprehensive Plan. Locally, it was always understood that the Census process would likely undercount a Suffolk County estimate, due to a failure to capture those seasonal residences not captured at the time of the Census count.

In Nassau County the number of private wells has been assumed for many decades to be not more than several hundred, due to the extension of public water supply concurrent with suburban development in that County; we confirmed this through conversations with County personnel and evaluations of the extent of public water mains historically through that County.

Particularly for Suffolk County, the need to move beyond gross estimates of the number of wells towards an inventory of well location has been recognized as an important resource management programmatic objective, and planning need.

In 2015 as part of the Suffolk County Comprehensive Water Resources Management Plan Update (SCCWRMP), CDM utilized a GIS analysis to update an analysis last performed for Suffolk County in

1 Karst aquifers form in chemically soluble bedrock, mostly carbonate rock, such as limestone and dolomite. In these rocks, the chemical action of flowing water containing carbon dioxide from the atmosphere or soil zone generates a network of hydraulically connected fractures, conduits, and caves. These hydraulic fractures make karst aquifers more susceptible to pollution.

2 CDC describes syndromic surveillance as "an investigational approach where health department staff, assisted by automated data acquisition and generation of statistical alerts, monitor disease indicators in real-time or near real-time to detect outbreaks of disease earlier than would otherwise be possible with traditional public health methods."

1987 for the previous Comprehensive Plan. The procedure and estimates were detailed in their July 31, 2009 Task 7.5-Private Wells Report to the Suffolk County Department of Health Services (SCDHS). CDM estimated a total of 46,902 residential parcels served by private wells, and attributed the significant decline since the previous plan to a large number of connections and expansions of public water service areas of the Suffolk County Water Authority (SCWA) and in the Town Water District service areas of Riverhead Water District and Hampton Bays Water District.

Suffolk County - Approach and Information Resources Used for the Estimate

For this latest estimate for Suffolk, H2M architects + engineers (H2M) created an inventory of private wells utilizing a similar GIS approach which consisted of the following steps:

Parcel data with land use attributes were collected from several Towns (East Hampton, Huntington, and Southampton) that update this data field. For the Towns that did not maintain their own land use parcel information, H2M utilized parcel and land use information from Suffolk County Real Property 2018 data. Consistent with the task assignment, all non-residential parcels were eliminated (that included all land use codes that were not between 200 and 283). Parcels that had missing land use codes, parcels that were roads, bodies of water, utility easements, or vacant were removed from the remaining set of parcels based on comparison with 2016 aerials, ownership, and 2006 building foot prints from Suffolk County.

H2M received a connection point GIS file from SCWA containing 2018 connection points and based on discussions with SCWA the accuracy of these is approximately 99% inclusive of current customers. Utilizing this point file, H2M removed all parcels that intersected these connection points and then checked through the data to remove errors, such as parcels that were part of large private residential communities such as condominiums that are connected to SCWA via master-metering arrangements.

For parcels in Dix Hills, South Huntington, Greenlawn, Smithtown, Saint James, Riverhead and Hampton Bays Water District, H2M maintains distribution water mains in GIS format for the service areas of these Districts. These water suppliers provided spreadsheets that contain addresses of connected customers. All parcels that were within a 75 foot radius of water mains were eliminated and then the rest were cross referenced with the connected customer addresses and removed from the remaining set of parcels. For Shelter Island, parcels within Happy Groundhog, Shelter Island Heights and Dering Harbor Water Districts service areas were all considered connected based on conversations with the Town of Shelter Island. West Neck Water District confirmed two residential private wells within their service area. For most smaller purveyors, such as the Village of Ocean Beach and Maidstone Park Cottages, the parcels in their service areas were considered serviced and therefore eliminated from the remaining set of parcels. For the vicinity of Babylon's Oak Beach community water system (merged from former McCarren, McCrodden, Dougherty Water Supply systems which serve approximately 60 homes when operational), a review of tax maps and aerials were used to add some 40 additional private well residences to the total for Suffolk County.

CHAPTER 11:
REPORT ON PRIVATE WELLS ON LONG ISLAND

Fishers Island was removed for analysis as part of this task. Fishers Island Waterworks (FIWW) is a private water company owned in part by the Development Corporation which has historically ensured that any development would be provided with public water. According to reported conversations between SCDHS and FIWW, the Waterworks maintains an inventory of 21 well owners of which 14 are within 500 feet of existing water mains. Public water would be available to these locations subject to conditions of the FIWW tariff approved by the New York State Department of Public Service. All other residents in this overwhelmingly seasonal community are connected to FIWW.

Table 1 illustrates the findings of this analysis by Town; and following the approach used previously, compares the Town estimates to the results generated in 2009.

Table 1

LOCATION / TOWN	CDM STUDY 2009	PRIVATE WELLS 2019	% CHANGE	MILES OF MAIN TO EXTEND TO WELLS	PRIVATE WELL BEYOND 150 FT OF MAIN	PRIVATE WELL REQUIRING EXTENSION, OF 150 FT OF MAIN OR LESS	PRIVATE WELLS ADJACENT TO SCWA MAIN
BABYLON	2,416	625	-74.13	7.70	296	16	313
BROOKHAVEN	14,786	3,865	-73.86	44.80	1,306	268	2,291
EAST HAMPTON	9,656	7,493	-22.40	192.60	6,235	343	915
HUNTINGTON	1,425	450	-68	3.40	51	60	339
ISLIP	3,338	321	-90	2.30	24	28	269
RIVERHEAD	619	198	-68.01	16.80	180	18	0
SHELTER ISLAND	1,788	2,099	17	69.00	2,097	2	0
SMITHTOWN	2,267	451	-80.11	4.50	69	49	333
SOUTHAMPTON	5,644	5,965	5.69	136.50	4,410	93	1,462
SOUTHOLD	4,963	3,210	-35	78.40	2,071	157	982
TOTAL	46,902	24,677[3]		556.00	16,739	1034	6,904

H2M utilized a GIS analysis of the residential private well parcel locations and public rights of way to develop the estimated miles of water main extensions needed to service those lots. These are reported by Town. Finally, we provided a specific estimate of the number of those well locations that front an existing water main and those within 150 feet of an existing water main.

Nearly one-third of the total number of private well property locations, or 7,938 well locations, are within 150 feet of an existing main, and nearly 90% of these private well locations have a water main adjacent to the property line. Experience shows that many homeowners will operate their wells to failure, and then are faced with the difficult decision between arranging for connection to public water and service line installation (which may be costly but, in any case, can take time) or installing a replacement well.

Figure 1 illustrates the findings for Suffolk County; individual town maps in the Task 2 Report Appendix show locations for each Town in somewhat greater detail.

Nassau County: Approach and Information Resources Used for the Estimate

Largely because of the way in which residential development proceeded in Nassau County, public water supply largely met postwar suburban needs as they occurred. The estimate of several hundred private wells, defined by 543 large residential lots, confined to older North Shore communities (Centre Island, Mill Neck, Laurel Hollow, Cove Neck) is supported by the absence of public water mains. This is consistent with conversations with NCDOH and Department of Public Works (DPW) staff.

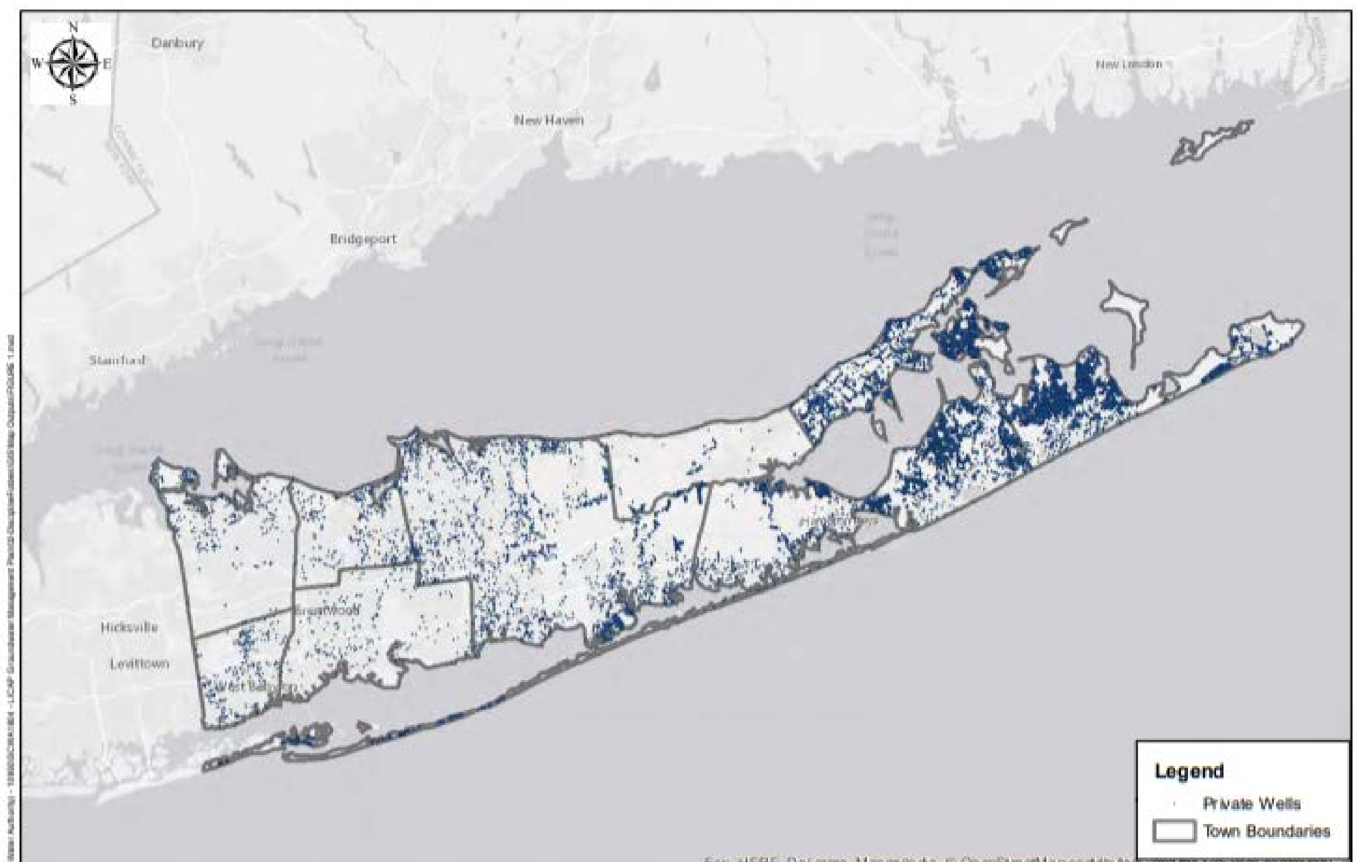

FIGURE 1
REVIEW AND UPDATING OF THE LICAP GROUNDWATER MANAGEMENT PLAN
Task 2 Private Wells Report
Suffolk County Unserved

H2M architects + engineers

3Including commercial and industrial potable use categories, SCDHS estimates a total of approximately 30,000 to 35,000 facilities utilizing on-site domestic well systems. The SCDHS estimate also includes the "private household wells" as defined in this Task Report.

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Figure 2 illustrates the Nassau County private well locations.

Infrastructure Needs to Connect Existing Private Wells

The potential transfer of an estimated 24,677 parcels in Suffolk County from private wells to public water will require an estimated $600 million - $900 million of capital costs. In Nassau County, where the frequency of private wells is considerably lower, the estimated cost to transfer 500 parcels to public water is $15 million. These costs to provide public water to all parcels across Nassau and Suffolk County was developed by considering four general areas:

1. Cost for water main extension and service connections
2. Cost for additional supply and treatment
3. Cost for additional water storage
4. Annual operation and maintenance (O&M) costs

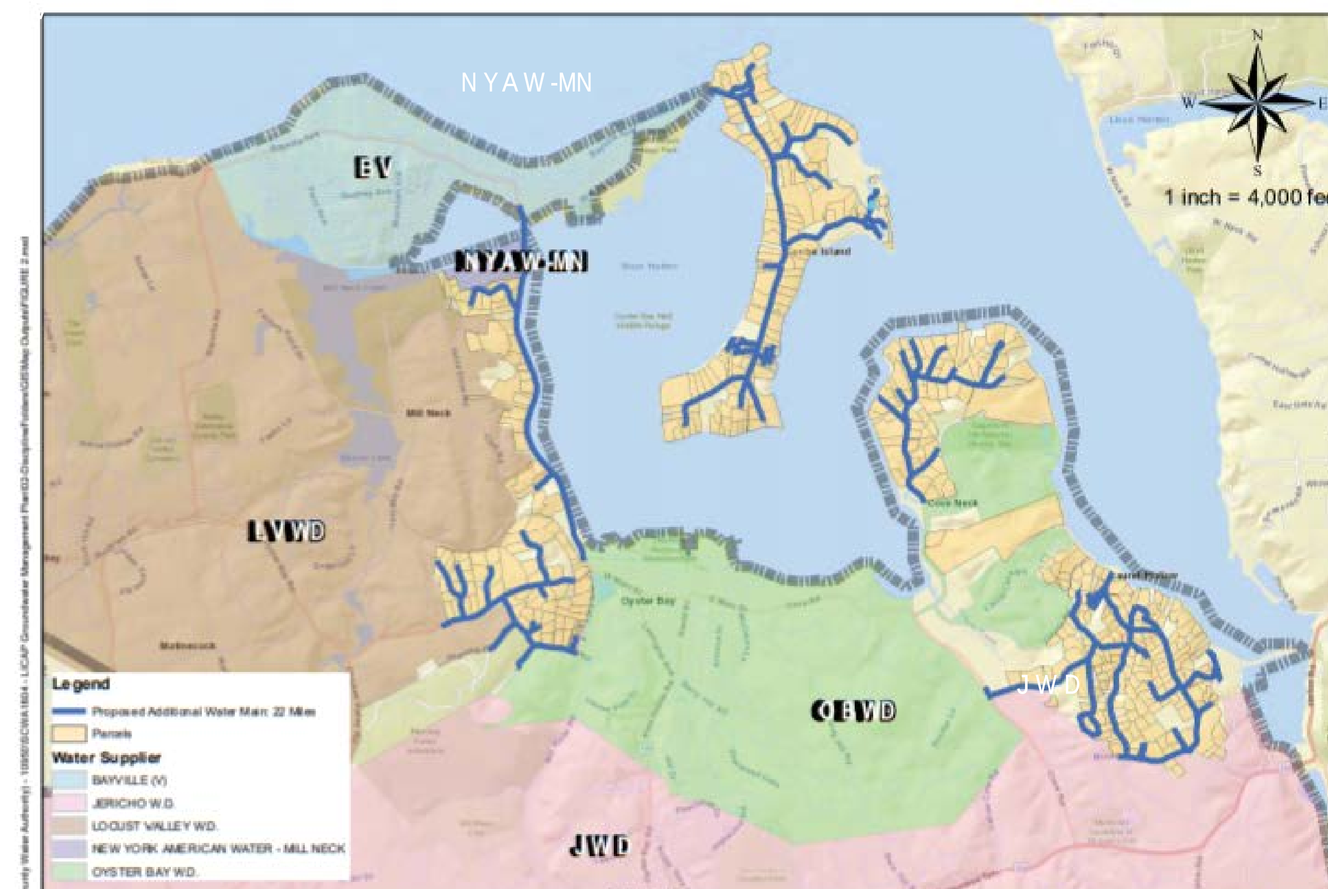

FIGURE 2
REVIEW AND UPDATING OF THE LICAP GROUNDWATER MANAGEMENT PLAN
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Nassau County Unserved

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The following sections summarize the method utilized to perform the cost analysis as it relates to each of these areas and determine estimated costs.

Water Main Extension and Service Connections

In order to analyze the projected costs to incorporate all known private residential well locations to the public water supply, the GIS model that H2M developed was used. As previously discussed, this model contained known private well point data, street shape files, and existing water main shape files. The model was used to analyze the location of residential parcels with private wells in Nassau and Suffolk Counties and predict which parcels currently have water distribution facilities across their frontage and which would require distribution facilities to be extended to provide municipal service to the parcel. All cost estimates are in 2019 dollars.

Suffolk County Analysis

After determining the number of parcels requiring facilities to be extended, water main extension segments were generated through the GIS to estimate the total linear feet of main required to serve all parcels without access to existing water distribution facilities. It is important to note that in certain instances, the extended segment of main generated by the GIS model extended past the parcel being serviced, often to connect to another existing main on the opposite end of the street. These instances of "extra" main are considered valid as newly installed water mains are generally "looped," or connected to existing mains at two points to avoid creating dead-ends in a network of water main. Overall, the model created is intended to provide a reasonable order of magnitude estimate of total quantity of main required and should not be viewed as an exhaustive or exact analysis.

It is generally the responsibility of the homeowner to bear the cost for service connection, commonly referred to as a "tapping fee." This fee does not include any system construction charges or similar costs assessed to new service connections. Some public suppliers require additional upfront costs to be borne by the homeowner which are usually fees intended to offset the need for additional well capacity, certain specified capital improvements, or other specified needs. Finally, some water main extensions may be subject to delineated area contract fees and conditions relating to prior extension contracts calling for partial reimbursement of the cost for an associated water main extension. Costs to homeowners may also include the need for a backflow containment device, subject to the water supplier's regulations. A detailed evaluation of these costs is beyond the scope of this task report.We have assumed a cost per service connection of $2,500 to the main and piping to the property line. This cost affects all properties involved, including those existing developed residences with water mains adjacent to their property lines. Thus $2,500 is multiplied by the total number of parcels with private wells (approximately 25,000 parcels). The estimated connection cost for existing parcels with private wells to public water approximates $63 million. An additional cost not estimated here and not included in commonly charged fees are those covering service line connection from the property line to the residence, which is generally the responsibility of the homeowner. Service line connection varies in price depending on size, length, material used, and restoration.

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In order to estimate the cost of extending water distribution facilities to those parcels with private wells and no current access to public water facilities, a unit price per linear foot of water main extension was assumed based on standard rates for water main installation on Long Island ($225 per linear foot of water main). This rate assumes distribution size water mains that generally range in size from 6 inches to 12 inches in diameter. The total footage of main extension required was determined from the GIS model described previously, allowing for a total cost to be calculated. The result of the analysis provides that approximately 556 miles of water main is required to be extended to provide public water access to all parcels with private wells; resulting in a cost of approximately $1.19 million per mile.

Additional Supply Wells and Treatment

The next step in this cost analysis involved determining how many additional supply wells would be required to satisfy the increased demand on the water systems. To estimate this increase in demand, the following assumptions were considered:

- The total number of private wells in Nassau and Suffolk County is approximately 25,220 and all parcels with private wells will eventually be added to the public supply system
- An average capita per private well of three persons is assumed based on U.S. Census Bureau data of persons per household for Suffolk County in 2013-2017
- A total average per capita water use of 60 gallons per day per capita (gpdpc) is estimated for indoor use and an average of 60 gpdpc for outdoor water use as well. These estimates are based on the United States Environmental Protection Agency (USEPA) Water Conservation Plan Guidelines, as well as the Water Research Foundation's 2016 Residential End Uses of Water analysis. The result is a total average per capita water use of 120 gpdpc
- This results in an average demand of 360 gallons per day for each residence to be supplied
- A peak day factor of 3.0 times average day demand is utilized based on typical water use data for various Long Island water purveyors
- The average capacity of a Long Island supply well or well field is 1.0 million gallons per day (MGD), actual design capacity may be higher or lower subject to individual well siting conditions
- Current water purveyors are operating at or near capacity and maintain neither a significant source surplus or deficit

Using these assumptions yields estimated values for an anticipated additional average day demand of 8.88 million gallons (MG) and a peak day demand of 26.7 MG.

Based on an approximate average well field size of 1 MGD, a projected 27 additional supply wells would be required to provide the capacity needed to satisfy the extra demand (note: a well field in Suffolk County generally incorporates more than one well). However, in areas where flow withdrawal would be limited, such as the North Fork or Shelter Island, a 1 MGD flow withdrawal could not be reasonably be expected from a single well. Thus, it is assumed that in some areas multiple wells and additional sites would be required to reach the capacity of 1 MGD per well field that is being used in this analysis. This approximation does not preclude approaches involving smaller, isolated, or decentralized public water source and treatment approaches.

The evaluation of the overall cost for these additional well fields must include the construction of a standard well field with standard wellhead treatment, as well as supplemental wellhead treatment required for potential contamination. It is assumed that 20% of well fields installed would require granular activated carbon (GAC) vessels for treatment of common contaminants found across Long Island such as volatile organic compounds (VOCs) and considered an effective approach for the perfluorinated compounds (PFAS) considered for New York State regulation (perfluorooctanoic acid [PFOA] AND perfluorooctane sulfonate [PFOS]). Additionally, 10% of well fields are assumed to require filtration for iron or manganese treatment.

A projection as to the likely number of future wells requiring treatment for PFAS or the advanced oxidation treatment (AOP) needed for 1,4-Dioxane contamination was beyond the scope of this report. However, evolving information suggests that, when encountered, additional treatment costs for this contaminant could be substantial, with estimates between $1.7 million to $2 million per well.

The cost for the construction of an average well field not requiring supplemental treatment is projected to be $1.2 million per well field, based on industry standards. The addition of GAC filtration, considering exterior installation of a set of two filter vessels, is estimated at an additional $0.5 million per installation. Finally, the addition of iron treatment at a well field would require an additional $1.0 million per installation. Thus, the overall projected cost for the installation of 27 additional well fields, including required supplemental treatment at the ratios described above, is approximately $37.8 million, or an average of $1.4 million per well field (note: land acquisition costs would be an additional factor in overall cost but are not included in this analysis).

Additional Storage

The added water supply infrastructure would require additional water storage capacity. This estimate utilized common industry guidance that minimum storage capacity for a system should be equal to the average daily consumption. While larger systems on Long Island tend toward substituting significant well capacity for a portion of this treated water storage recommendation, use of this storage guidance may be a more conservative approach in serving areas with limited well capacity/withdrawal potential. Therefore, the additional storage required in this scenario is approximately 8.39 MG. Considering an average volume of 1.0 MG per storage tank, an additional nine new storage tanks are required. The cost of a single tank, assuming a concrete ground storage tank with accompanying booster station, is estimated at $1.5 million based on industry standards. Thus, the total cost to provide the additional storage required would be approximately $13.5 million.

Annual Operation and Maintenance

In estimating cost of providing public water across Long Island, the annual O&M for each new well field must be considered. The standard O&M include costs for electrical usage, plant maintenance, plant monitoring, laboratory sampling, treatment chemicals, and GAC replacement. The incremental costs of distribution maintenance are assumed to be negligible.

Electrical usage was determined by estimating equipment loads, lighting loads, and heating loads aggregating actual operations data for Long Island suppliers with the assumed standard 1 MGD well field and an accompanying 600 square foot well field building. To calculate electrical usage, the following assumptions were made:

- Annual hours of operation were calculated based on estimated peak and off-peak usage over 12 months. Off-peak month (October – May) usage was assumed to be 60 gpdpc, and peak month (June – September) usage was assumed to be 120 gpdpc. For a 1 MGD well field, the estimated annual hours of operation were determined to be 1930 hours
- Current demand and energy charges are based on the local electrical utility provider (PSEG) and an electrical rate code of 285
- Assumption that a building heating load of 3 kilowatts per square foot (kW/SF) for 24 hours/day for 180 days/year and lighting load of 1 kW/SF for 12 hours/day
- Assumumption that an average well field load has 62 horsepower (HP)

Based on the above, the total estimated annual electrical cost for a single well field is projected to be $19,000 per year.

Maintenance costs for the assumed standard 1 MGD supply well field would include well pump replacements (estimated every 10 years) and chemical pump replacements (estimated every five years, for two chemical pumps per well field). The annual maintenance cost for these replacements is estimated to be $6,000 per year per site. This does not consider replacement of booster pumps related to ground storage tank sites.

Plant operational monitoring costs are estimated based on hourly rates for a plant operator to perform daily inspections as well as routine maintenance. Assuming one operator is on site for one hour per day for 365 days per year, and assuming labor and benefit cost of $75/hour, the added annual plant monitoring costs is assumed to be $27,000.

Laboratory sampling/analytical costs include costs for required water quality testing at a well field. The required analytes included in this cost analysis include current unregulated contaminant monitoring, inorganic compounds, synthetic organic compounds, perchlorate, volatile organic compounds, bacteriological, and radiological sampling. Each type of contaminant requires sampling at different frequencies throughout the year. For some contaminants, frequency of analysis is determined in part based on previous results. Assuming outsourced laboratory costs and the corresponding required sampling frequencies, the total estimated annual sampling cost is $5,000 per year per well field.

Chemical treatment at each well field is assumed to include lime for pH adjustment and sodium hypochlorite for disinfection. Average dosage rates and costs per pound or gallon of chemical were considered in this analysis. An approximate annual cost for all chemicals for each well field is $5,000 per year. It should be noted that certain water purveyors utilize a form of blended polyphosphate for sequestration/corrosion control; however, those costs are not considered herein.

Lastly, for this analysis we assumed that GAC vessels require the carbon media to be replaced approximately once every three years. Based on average costs per pound of carbon, and assuming 40,000 pounds per vessel for two GAC vessels, the annual cost for carbon changeouts would be approximately $53,000 per year. An annual operating cost for iron treatment is negligible as changeouts are required on a much less frequent basis.

In summary, the total annual O&M cost for a well field without GAC treatment is approximately $65,000, and approximately $120,000 with GAC treatment. Considering GAC treatment would be required at 20% of the 27 projected wellfields, the total annual O&M costs for all new well fields is approximately $2.0 million per year.

Summary of Total Costs

A relatively high variation factor of 20% is considered when estimating the overall costs of providing public water to parcels with private wells. Thus, the total capital costs, including water main extensions, service connections, additional supply well fields, and additional storage tanks, is approximately $600 million - $900 million, and compensates to an extent for alternative supply, storage or transmission decisions that would be more site specific. The total annual operation and maintenance costs of the additional supply well fields are $1.6 million - $2.4 million. A summary of these costs is presented in Table 2.

To delineate how these costs are distributed across Suffolk County, Table 3 provides a breakdown of estimated costs for the ten Suffolk County Towns. This Table shows the number of private wells and corresponding linear footage of required water main extension for each Town. The portion of the total capital cost for each town is shown, as well as the capital cost per capita. The capital cost per capita is calculated using the assumption of three persons per dwelling, as described previously. From Table 3 we can see that the Town of Riverhead has the highest capital cost per capita, followed by Shelter Island, East Hampton, and Southold.

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Table 2 Summary of Suffolk County Total Costs

Capital Costs					
Total cost of Additional Water Main:	$	660,528,000.00			
Total cost of All Service Connections:	$	61,692,500.00			
Total cost of Additional Supply (well fields):	$	37,800,000.00			
Total cost of Additional Storage (ground storage tanks + booster stations):	$	13,500,000.00			
Total capital cost:	$	773,520,500.00			
Variation Factor (%, +/-)		20%			
Total capital cost range:	$	618,816,400.00	-	$	928,224,600.00
Operation & Maintenance Costs					
Total annual operating costs:	$	1,950,600.00			
Variation Factor (%, +/-)		20%			
Total O&M cost range:	$	1,560,480.00	-	$	2,340,720.00

Table 3 Total Capital Cost per Suffolk County Town

Location Town	Private Wells 2019	Miles of Main to Extend to Wells	Projected Capital Cost for WM Extension	Projected Capital Cost for Service Connections	Projected Capital Cost for Additional Supply Well Fields	Projected Capital Cost for Additional Storage	Total Projected Capital Cost	Capital Cost per Capita
BABYLON	625	7.70	$ 9,147,600	$ 1,562,500	$ 957,369	$ 341,918	$ 12,009,387	$ 6,405
BROOKHAVEN	3,865	44.80	$ 53,222,400	$ 9,662,500	$ 5,920,371	$ 2,114,418	$ 70,919,689	$ 6,116
EAST HAMPTON	7,493	192.60	$ 228,808,800	$ 18,732,500	$ 11,477,708	$ 4,099,181	$ 263,118,189	$ 11,705
HUNTINGTON	450	3.40	$ 4,039,200	$ 1,125,000	$ 689,306	$ 246,181	$ 6,099,686	$ 4,518
ISLIP	321	2.30	$ 2,732,400	$ 802,500	$ 491,705	$ 175,609	$ 4,202,214	$ 4,364
RIVERHEAD	198	16.80	$ 19,958,400	$ 495,000	$ 303,295	$ 108,319	$ 20,865,014	$ 35,126
SHELTER ISLAND	2,099	69.00	$ 81,972,000	$ 5,247,500	$ 3,215,229	$ 1,148,296	$ 91,583,025	$ 14,544
SMITHTOWN	451	4.50	$ 5,346,000	$ 1,127,500	$ 690,838	$ 246,728	$ 7,411,065	$ 5,478
SOUTHAMPTON	5,965	136.50	$ 162,162,000	$ 14,912,500	$ 9,137,132	$ 3,263,261	$ 189,474,893	$ 10,588
SOUTHOLD	3,210	78.40	$ 93,139,200	$ 8,025,000	$ 4,917,048	$ 1,756,089	$ 107,837,337	$ 11,198
TOTAL	24,677	556.00	$ 660,528,000	$ 61,692,500	$ 37,800,000	$ 13,500,000	$ 773,520,500	$ 110,042

Note that 22,380 of the total 24,677 Suffolk County residential parcels with private wells identified are in the SCWA service area. Of these, 6,904 (nearly one third) are established in the GIS model to be on parcels currently facing an existing SCWA water main. These private wells would therefore not need any additional main extension to be serviced by the SCWA public water supply and would only need a service connection. However, the added demand on the system must be considered when incorporating these private wells. This data set could be used to suggest locations with the greatest degree of cost effectiveness optimized around the largest populations which could be served.

Prioritization by Private Well Density/Population Analysis

Using the GIS model, a density map was created to analyze which areas are most densely populated with private wells, that is, where there are the most private wells per square mile. This provides insight into which areas hold highest priority based on cost effectiveness. The generated density maps can be found in Figures 3, 4, and 5. Each figure shows density for private wells per square mile. Figure 3 shows the total number of wells in each area of 100 wells per square mile or greater. Likewise, Figures 4 and 5 show total linear feet and population density, respectively. Population density is calculated by multiplying the private wells per square mile by the estimated three persons per private well.

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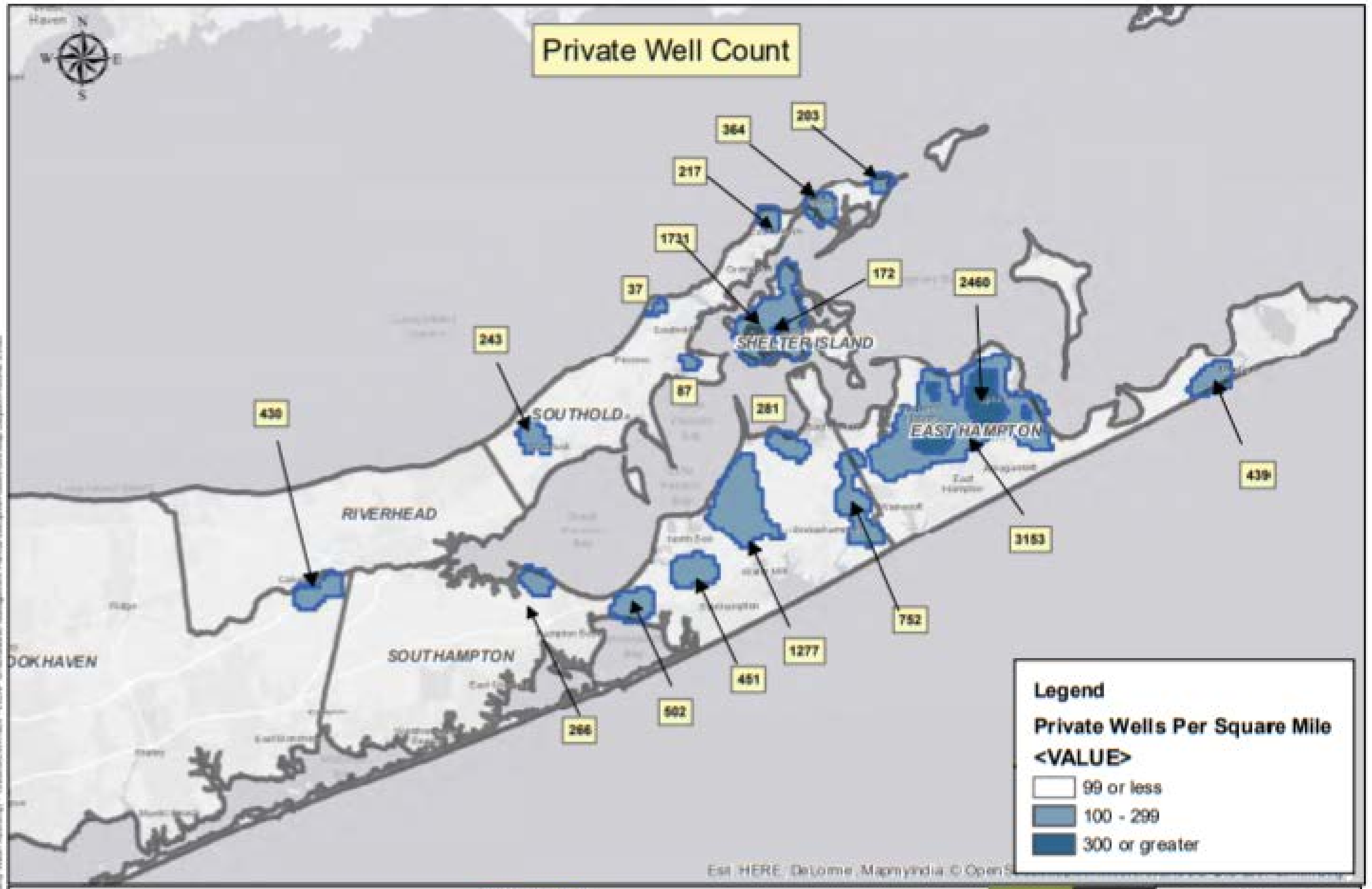

FIGURE 3
REVIEW AND UPDATING OF THE LICAP GROUNDWATER MANAGEMENT PLAN
Task 2 Private Wells Report
Private Well Count

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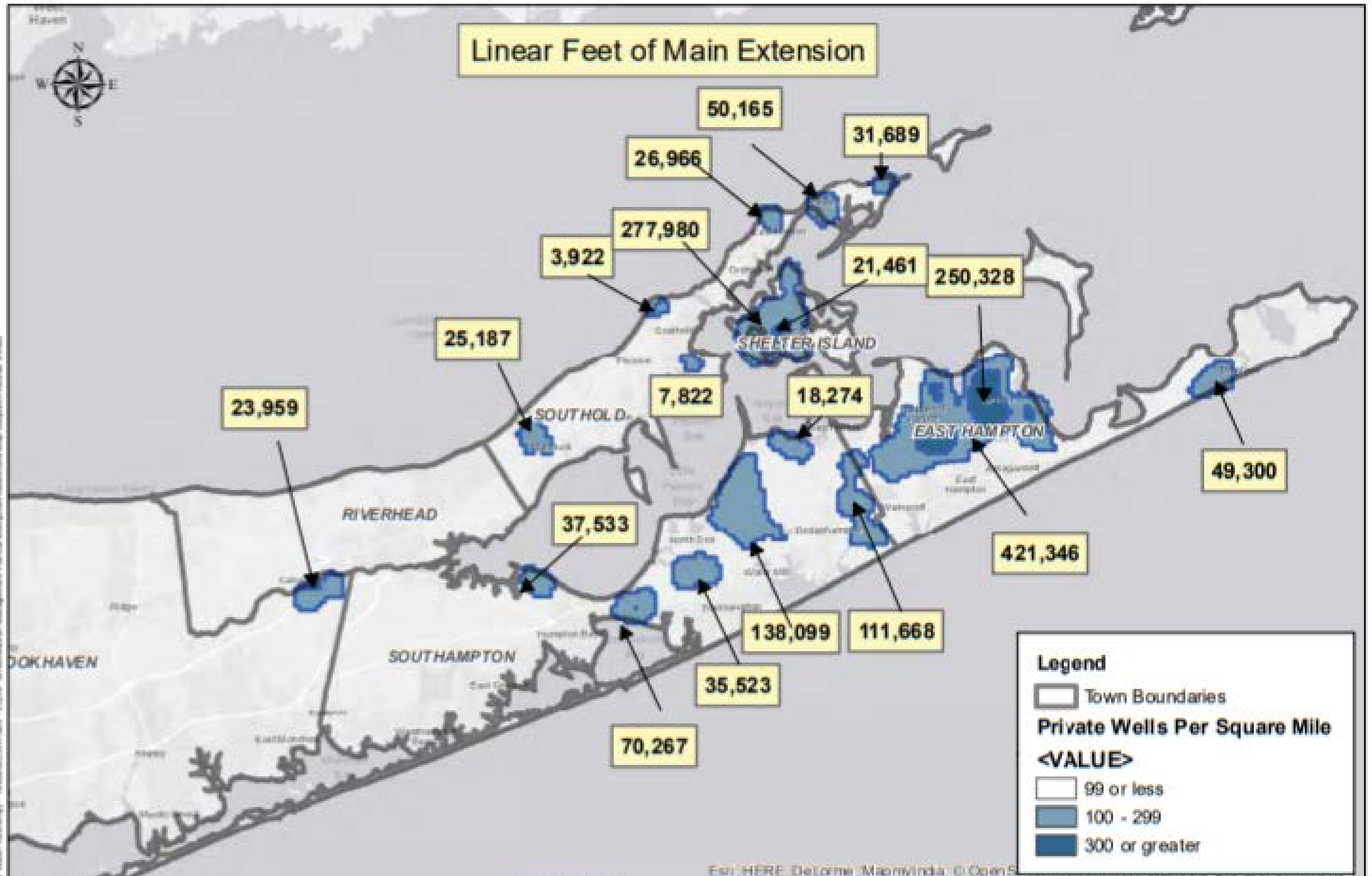

FIGURE 4
REVIEW AND UPDATING OF THE LICAP GROUNDWATER MANAGEMENT PLAN
Task 2 Private Wells Report
Linear Feet of Main Extension

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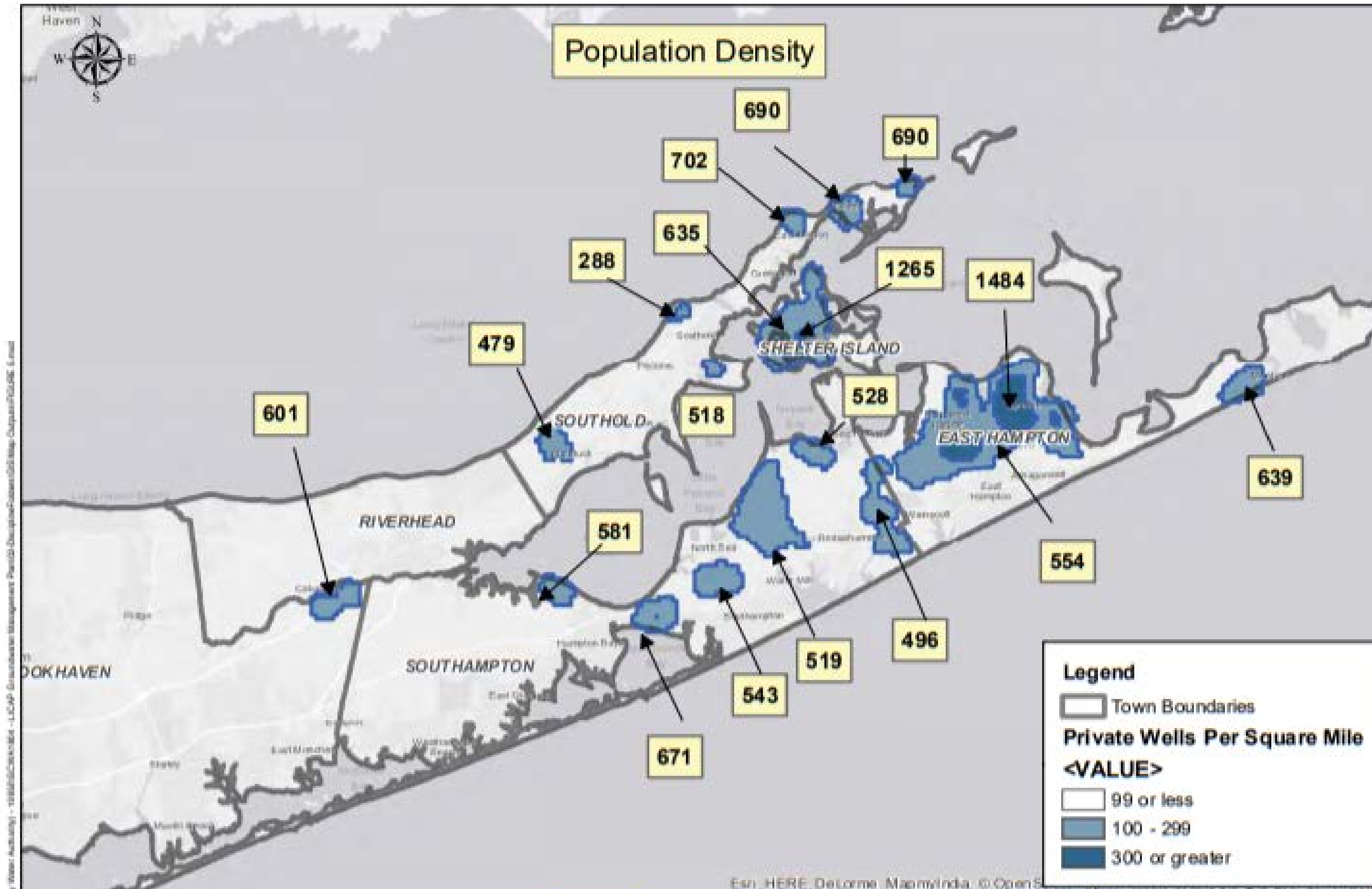

FIGURE 5
REVIEW AND UPDATING OF THE LICAP GROUNDWATER MANAGEMENT PLAN
Task 2 Private Wells Report
Population Density

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A separate capital cost analysis has been performed for five of the most densely populated private well areas. The analysis uses the same assumptions and methods as the overall cost analysis described but is re-run for their individual areas of high density. As discussed earlier, some water main extensions may be subject to delineated area contract fees and conditions relating to prior extension contracts calling for partial reimbursement of the cost for an associated water main extension. With that exception, per capita cost estimates for these five densely populated areas are as follows:

- East Hampton: 5,613 private wells at an estimated capital cost per capita of $10,657
- Shelter Island: 1,903 private wells at an estimated capital cost per capita of $13,633
- Southampton:1,277 private wells at an estimated capital cost per capita of $10,067
- East Marion - Orient Area: 784 private wells at an estimated capital cost per capita of $10,180
- Southampton - Bridgehampton Area: 752 private wells at an estimated capital cost of $13,256

Additionally, the same analysis was done for two of the least densely populated areas:

- Southold - North Shore Area: 37 private wells at an estimated capital cost per capita of $34,909
- Southold - Hog Neck Area: 87 private wells at an estimated capital cost per capita of $18,688

The results of this analysis are tabulated in Table 4. By comparing the capital cost per capita for each density map area, it is clear that the less dense areas have a higher capital cost per capita. Therefore, it is most economical to first provide public system water supply to the highest density areas. This will allow for the most private wells to be incorporated into the public supply at a lower cost per capita.

Table 4: Projected Capital Costs for Density Map Areas

Location	Total Private Wells	Miles of Main to Extend to Wells	Population Density	Projected Capital Cost for WM Extension	Projected Capital Cost for Service Connections	Projected Capital Cost for Additional Well Fields	Projected Capital Cost for Additional Storage	Total Projected Capital Cost	Capital Cost per Capita
Density Map Area - Highest Density									
1 (East Hampton)	5,613	127.21	2377	$ 151,126,650	$ 14,032,500	$ 9,800,000	$ 4,500,000	$ 179,459,150	$ 10,657
2 (Shelter Island)	1,903	56.71	2217	$ 67,374,225	$ 4,757,500	$ 4,200,000	$ 1,500,000	$ 77,831,725	$ 13,633
3 (Southampton - North Sea/Noyac area)	1,277	26.16	606	$ 31,072,275	$ 3,192,500	$ 2,800,000	$ 1,500,000	$ 38,564,775	$ 10,067
4 (East Marion - Orient area)	784	16.06	2429	$ 19,084,500	$ 1,960,000	$ 1,400,000	$ 1,500,000	$ 23,944,500	$ 10,180
5 (Southampton - Bridgehampton area)	752	21.15	579	$ 25,125,300	$ 1,880,000	$ 1,400,000	$ 1,500,000	$ 29,905,300	$ 13,256
Density Map Area - Lowest Density									
6 (Southold - North Shore Area)	37	3922	336	$ 882,450	$ 92,500	$ 1,400,000	$ 1,500,000	$ 3,874,950	$ 34,909
7 (Southold - Hog Neck Area)	87	7822	605	$ 1,759,950	$ 217,500	$ 1,400,000	$ 1,500,000	$ 4,877,450	$ 18,688

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It is important to note that in the case of the Shelter Island area (denoted as Area 2), it is likely that the actual cost will be higher than the result of this cost analysis. This is because higher capacity wells would be subjected to salt water impacts. Due to this, the construction of multiple, large potable water supply wells on Shelter Island capable of sustainable supply is not feasible and potable water may be required to be imported from the North and South Forks. The costs of the transmission required to import water to the Island is not included in the overall analysis presented herein.

Like Shelter Island, the Orient area of the North Fork (denoted as Area 4) is also isolated and multiple potable supply wells may not be feasible in this area. Thus, potable water may need to be transmitted from the west. The costs presented do not include the costs of this transmission. A more detailed analysis would be needed to evaluate service options.

Nassau County Analysis

Although the focus of the preceding cost analysis is on Suffolk County, the unit prices presented translate to Nassau County. There are approximately 500 parcels with private wells remaining in Nassau County with the highest density of private wells occurring along the North Shore in the vicinity of Oyster Bay and Locust Valley.

The aforementioned GIS model was used to analyze this area and determined that approximately 22 miles of water main extensions would be required to provide service to all parcels with private wells. The output of this analysis can be found in Figure 2. As these areas are within proximity to boundaries of public water suppliers, it is likely that the unincorporated parcels would be incorporated to neighboring water utilities.

Based on this output and data presented previously in this report, the anticipated cost to bring public water to all parcels with a private well is approximately $30,000 per site, with a total estimated cost of $15 million. This number does not include the construction of transmission lines to isolated areas. Note the data on locations with private wells in Nassau County was not as readily available as Suffolk County, and therefore there may be small clusters of or single private wells that may exist elsewhere in the county. However, based on conversations with Nassau County public water suppliers, such locations would have access to existing water mains, and this would not appreciably affect this estimate.

Prioritization by Flooding Potential For Nassau and Suffolk Counties

As discussed in the LICAP Groundwater Resources Management Plan Chapter 4, Groundwater Quality and Quantity Threats, hurricane storm surge events are of significant concern. The Sea Lake and Overland Surges (SLOSH) map (Figure 6) for four hurricane intensity categories are mapped as a GIS coverage which can be used as an overlay to identify private well locations within the four SLOSH zones. The SLOSH Map Categories correspond to four established hurricane categories:

Category	Barometric Pressure (Inches)	Windspeed (Miles Per Hour)	Storm Surge (Feet)
I- Minimal	Above 28.94	74-95	4-5
2- Moderate	28.50-28.91	96-110	6-8
3- Extensive	27.91-28.47	111-130	9-12
4 - Extreme	27.17-27.88	131-155	13-18
5- Catastrophic	Less Than 27.17	More Than 155	More than 18

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The SLOSH model is a numerical model used by the National Weather Service (NWS) to compute storm surge. Storm surge is defined as the abnormal rise of water generated by a storm, over and above the predicted astronomical tides. Flooding from storm surge depends on many factors, such as the track, intensity, size, and forward speed of the storm and the characteristics of the coastline where it comes ashore or passes nearby. For planning purposes, the National Hurricane Center (NHC) uses a representative sample of hypothetical storms to estimate the near worst–case scenario of flooding for each of the four recognized hurricane categories. It is noted that Category 5 storm surges are not predicted in the SLOSH maps because there is little probability of such storms and no historical data exists for reference.

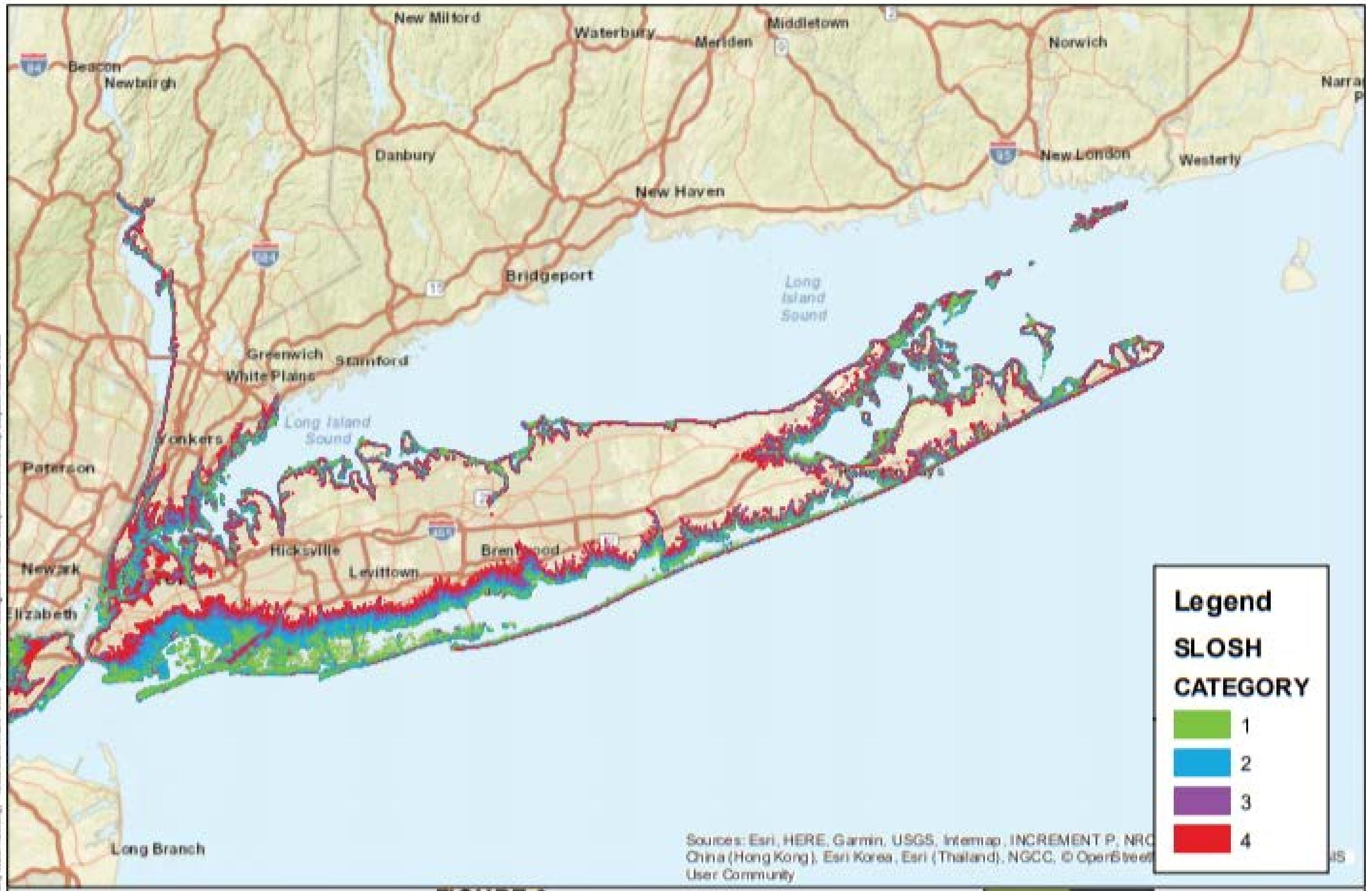

FIGURE 6
REVIEW AND UPDATING OF THE LICAP GROUNDWATER MANAGEMENT PLAN
Task 2 Private Wells Report
Sea, Lake, and Overland Surges from Hurricanes (SLOSH)

This overlay for Suffolk County is shown in Figure 7 which yields a substantial percentage of the 24,677 identified Suffolk County private well parcels as being potentially subject to such flooding. In addition to the possibilities of microbiological contamination due to the well seal being compromised in such events, tidal flooding of a shallow private well can result in chloride contamination. Additional chemical contamination due to proximity of failed sanitary systems and compromised oil tanks or chemical storage is recognized as being likely to occur. The duration and geographical extent of such contamination would be directly related to the flooding, and to any extraordinary measures that may have been taken to protect the private well. Table 7 indicates the number of Suffolk County private wells located in each SLOSH category, corresponding to hurricane categories. This analysis would be applicable to an evaluation of potential impacts due to projected sea level rise.

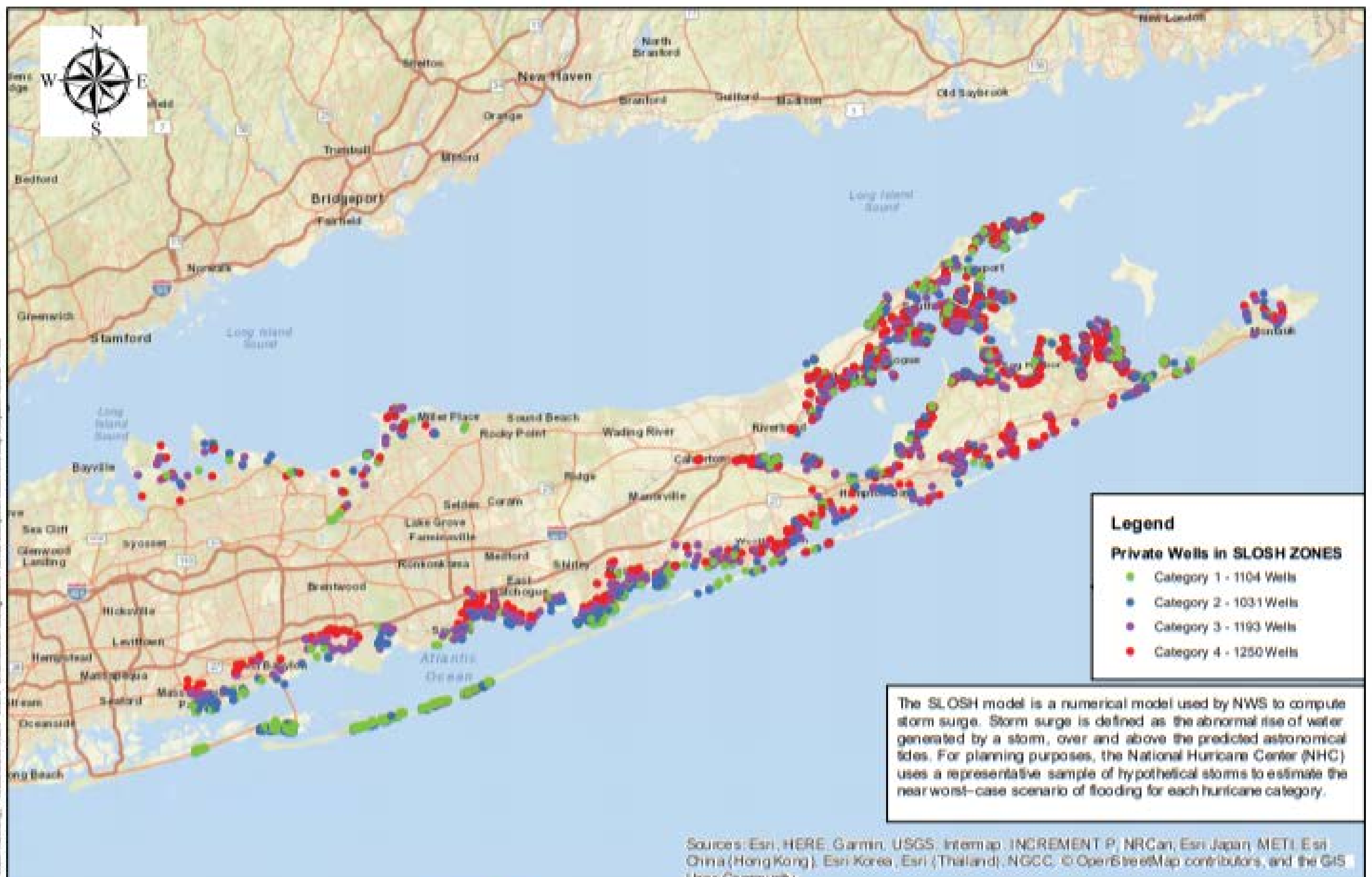

FIGURE 7
REVIEW AND UPDATING OF THE LICAP GROUNDWATER MANAGEMENT PLAN
Task 2 Private Wells Report
Sea, Lake, and Overland Surges from Hurricanes (SLOSH)
Suffolk County Private Wells

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Table 7: Private Wells in Suffolk County Subject to Flooding – See Figure 7

SLOSH Category	Private Well Count
1	1104
2	1031
3	1193
4	1250
Grand Total	4578

Table 7: Private Wells in Nassau County Subject to Flooding – See Figure 8

SLOSH Category	Private Well Count
1	22
2	14
3	20
4	28
Grand Total	84

A similar review was conducted using the Nassau County private well data, as shown in Figure 8, indicating a total of 84 out of an estimated 500 private wells are located with designated SLOSH designated storm surge areas in Nassau County.

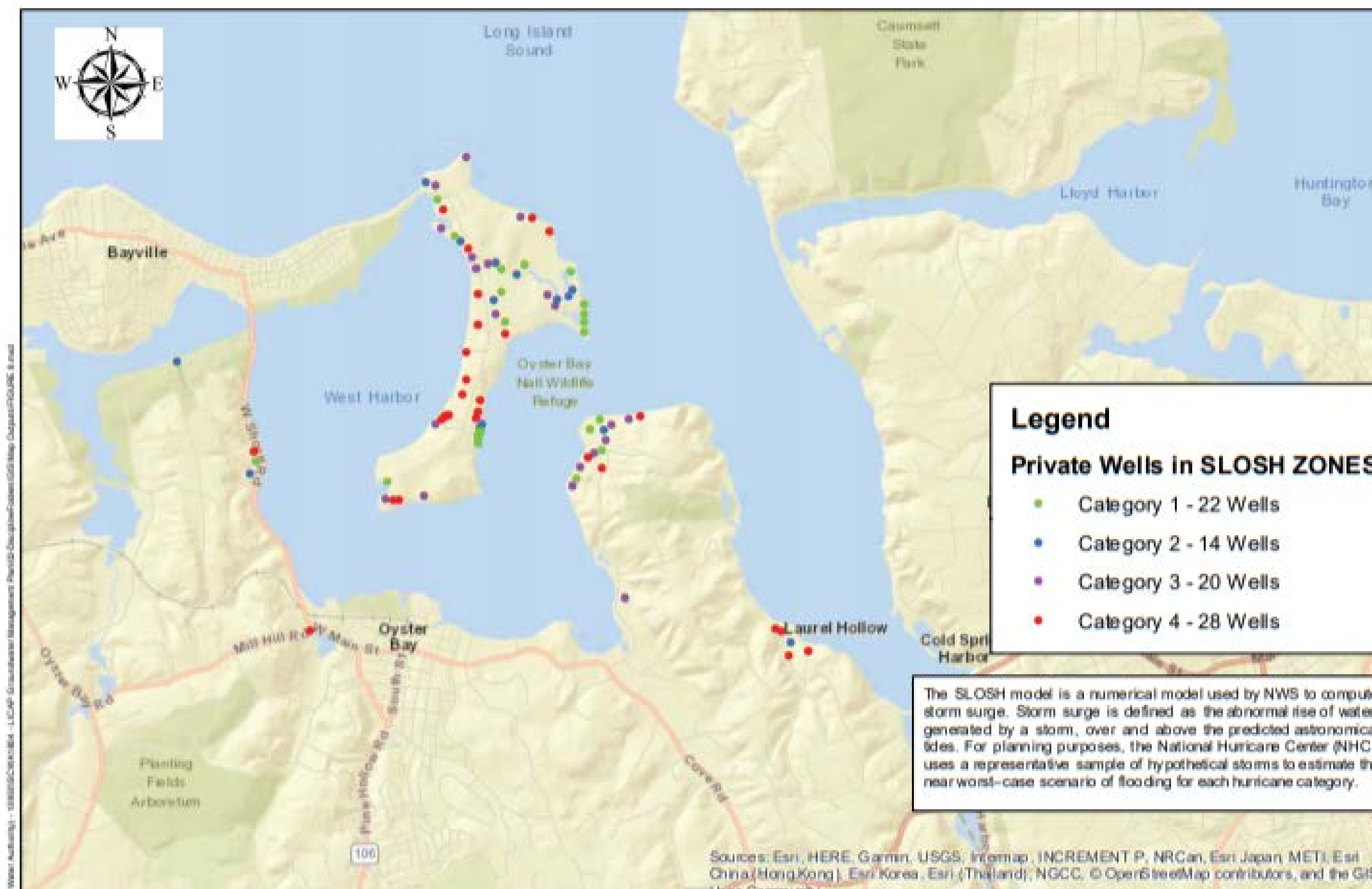

FIGURE 8
REVIEW AND UPDATING OF THE LICAP GROUNDWATER MANAGEMENT PLAN
Task 2 Private Wells Report
Sea, Lake, and Overland Surges from Hurricanes (SLOSH)
Nassau County Private Wells

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Private Well Construction Standards and New Wells

Pursuant to their sanitary codes, both Counties have historically required private wells, where permitted, to be constructed in conformance with their respective standards. Other New York Counties have enacted their own standards as allowed by the Public Health Law. Elsewhere in New York State, Part 75 - Standards for Individual Onsite Water Supply and Individual Onsite Wastewater Treatment Systems, effective date 3/16/16 and Individual Water Supply Systems - Statewide Water Quality Standards, 10 CRR-NY Appendix 75-C are the basis for such approvals.

Regulations and procedures in both Nassau and Suffolk County are distinguished by a commitment that proliferation of private wells is to be discouraged to the extent possible. Suffolk's current Private Water Systems Standards (latest revision, July 1992) evaluates access to public water as part of the application process for new residential construction. It requires the extension of public water mains to any lot to be developed where water mains exist within 150 feet of an applicant's property line, where minimum separation distances or depth requirements cannot be met, or untreated water quality is unsatisfactory, extension of public water mains to the lot is required up to 250 feet. For a proposed realty subdivision serviced by private wells to be considered, each lot size must be at least 40,000 square feet, and in addition public water extension is required where water mains exist to a distance equal to 150 feet times the number of lots proposed, measured from the applicant's property line. For new subdivisions to be considered with private wells the Standards specify a procedure for test well installation by the applicant, with test well siting and sample collection undertaken by SCDHS staff. Test well water quality requirements for nitrate (less than 6.0 milligrams per liter [mg/L]), chloride (less than 100 mg/L), are a fraction of the recognized drinking water standards for these contaminants; and iron and manganese concentrations must be less than 1 mg/L in all of a subdivision's test wells. All other contaminants must be demonstrated to be within existing New York State public water standards. In this way, prior to subdivision approval, the applicant must demonstrate that wells meeting the Standards can be installed on each lot.

It should be noted that the Standards' specified distance requirements for extending public water mains, based upon proximity to an existing public water main, were based on an economic evaluation that considered the cost of such an extension compared to the cost of a home and the "true" cost of a private well (which considers its probable replacement over time, electrical cost of pumping, and treatment). As part of the Suffolk County ComprehensiveWater Resources Management Plan Update Private Wells Task Report (Comp Study Task Report), in 2009 the typical capital cost of private well installation was estimated at $11,500. Whole-house treatment was considered likely and was estimated at $3,250 for a typical capital cost of $14,750. Annual private well electrical and treatment operational costs were estimated at $639. Well replacement costs were not considered.

This economic evaluation was one consideration from the Comp Study Task Report that recommended revisions to the Private Water Systems Standards. Others included:

- For new residential construction of vacant or undeveloped properties (single lot parcels), amend to require connection to public water if within 500 feet (currently required at 150 feet, or 250 feet if water quality on-site is unsatisfactory)
- Require a variance review in all cases where wells are terminated in the aquifer at less than 40 feet below the water table due to the location of a salt water interface
- Evaluate the feasibility of increasing the minimum distance required between a well and a cesspool location from 150 feet to 200 feet
- Require double casing for private wells installed through a confining layer or aquiclude
- Add the following additional parameters to the required private well water analysis for new homes; perchlorate, nitrite, sodium, hardness, alkalinity, and turbidity

A review of application and construction data provided by SCDHS indicated the following statistics related to new or modified residential structures utilizing private wells:

- From 2002-2018, 79 new subdivisions were approved with private wells, totaling 235 homes
- From 2009-2018, 932 individual new homes were given final approval for occupancy with private wells; 1,163 applications made during the period were approved for construction
- The department also reviews existing home additions and/or accessory buildings proposed for construction. Of these, from 2009-2018:
    - ◊ 577 existing homes with private wells were given final approval for additions/accessory buildings
    - ◊ 636 existing homes with private wells were given approval to construct additions/ accessory buildings.

A more detailed analysis of construction data is beyond the scope of this task report. However, comparison of the relatively low number of new private wells that would be added from new subdivisions, to the numbers from the development of previously subdivided vacant lots appears to support the recommendations from the Comp Study Task Report regarding revisions to the water main extension requirements currently in the Private Water Systems Standards.

Observations and Conclusions

- Although new residential construction served by private wells continues in more rural areas of Suffolk County, the number of private wells has continued to decline significantly since the late 1980s and the current estimate in Suffolk County stands at slightly under 25,000
- Nearly one-third of Suffolk County's residential wells (7,938) are within 150 feet of an existing main
- Within the SCWA service area, 31% are in locations fronting an existing water main
- Density and private well water quality provides a reasonable basis for prioritizing water main extensions. The value of private well water quality testing is discussed in the next section of this report
- The significant number of private wells abutting or near existing water mains points to the desirability of a review of existing regulations affecting new construction, residential modification, rental properties, and property ownership transfer
- For homes abutting existing water mains in particular it can be demonstrated that public water connection is less expensive than, and certainly competitive to, the annualized private well replacement/operational costs; educational outreach; and possible incentives to connect to public water prior to private well failure may prove productive
- Review of Nassau County residential information indicates that the number of private wells in the limited areas shown in Figure 2 is 543, consistent with anecdotal reports
- The provision of a sustainably sourced water supply is a critical consideration in future developments, and Town and County planning should consider this requirement as a necessity to sustainable future development
- A substantial number of private well owners in the two Counties face the possibility of impacts from tidal flooding during hurricane events. This can form one basis for prioritization of efforts to connect these homes to existing or new water mains through incentivization, regulation, or improved public outreach efforts. Private well owners should be made aware of the availability of existing CDC, EPA, State, and local health department informational resources for private well owners, including recommendations for steps to be taken in the event of flood. Water quality problems in private wells have been, and are likely to continue to be, underreported. A more restrictive, and rigorously enforced requirement for sample analysis with data provided to each respective Health Department is in the public interest and consistent with the Departments' basic mission to protect public health while providing a modicum of privacy to those involved in property transfers. Even more so, the existing Public Health Law requires provision of a potable water supply in residential rental situations; failure to require sample analysis in private well situations is inconsistent with the stated responsibilities of these regulatory agencies. As discussed in the following subtask these issues are being addressed in other New York County jurisdictions and other States.

Subtask 2B - Enhanced Private Well Testing Program
SCDHS Private Well Survey Monitoring and Surveillance Program

Private well owners are often the most immediate receptors of groundwater contamination events. Therefore, a testing program is part of formal Municipal Health Department Service Plan responses in the event of contamination events. Recent incidents involving private and public water supply well contamination from PFAS illustrate the difficulties which can occur from the lack of local (Regional or sub-Regional) health department laboratory facilities. Continued review of laboratory capacity and analytical needs is necessary as additional emerging contaminants come to light and improved analytical methods are developed.

Close coordination and communication between local, State, and Federal agencies is needed to effectively evaluate emerging contaminant occurrence, identify potential sources and receptors such as private wells, and take the necessary regulatory and, if necessary, legal steps to control contamination.

Although a common misconception, NYSDEC does not directly conduct routine groundwater surveillance monitoring, although it directs limited monitoring actions associated with State Pollution Discharge Elimination System (SPDES) permitted discharges, permit violations, and evaluations involving formal Superfund remediation, including plume delineation and receptor identification. Locally, SCDHS has cooperated with NYSDEC in conducting private well investigations associated with these activities. Conversely, SCDHS survey findings have resulted in nomination of sites to NYSDEC for remediation actions.

NYSDEC is also required by State law to conduct groundwater impact investigations relating to use or misuse of regulated pesticides. For more than two decades SCDHS has continued pesticide monitoring efforts. Pesticide and other private well related activities and laboratory equipment enhancements and improvements are also supported through county general funds, the County ¼% sales tax funded Water Quality Protection and Restoration Program (WQPRP), Land Stewardship Initiatives, and state Drinking Water Enhancement grants. These activities are discussed in Chapters 3 and 4 of the Groundwater Resource Management Plan (GRMP), and in the Task 3C Report.

A private well monitoring program has long been recognized to be a valuable component of a comprehensive source water protection program. In Suffolk County, the typical private well terminates at a depth of 40 feet into the water table, making water quality from that well a useful indicator of relatively close land use and recent recharge/travel time. As such, private well data is often a highly useful tool for evaluating water quality relating to emerging contaminants and changing land use patterns. Conversely the data viewed over time can facilitate monitoring of corrective steps to protect groundwater. The emergence of the gasoline additive methyl tertiary-butyl ether (MTBE) and the pesticide aldicarb (trade name Temik) and actions to ban their use were initially measured largely by private well monitoring, demonstrating value to all users of the aquifer system. Residential land uses, including the use of private on-site sewage disposal systems, predominate in the groundwater contributing areas for many private wells in Suffolk County. Those locations can provide a significant opportunity to evaluate both the occurrence in the residential waste stream and waste treatment effectiveness for an array of contaminants of emerging concern that are under study: PFAS, 1,4- Dioxane, as well as pharmaceuticals and personal care products (PPCPs).

Noting these issues, the GRMP includes a short-term recommendation (Chapter 8) supporting "local laboratory and trained staff response capabilities to meet the objectives of the New York State Water Quality Rapid Response Task Force currently under development." SCDHS has cooperated with the Task Force in joint NYSDOH/NYSDEC investigations relating to groundwater contamination from use of PFAS Aqueous Film-Forming Foams (AFFF) in proximity to several airports, as discussed in more detail in the Task 3C Report. Although the response is limited to expected PFAS contamination, primarily locations downgradient of fire training areas, other commercial uses of PFAS warrant investigation and are suspected to be related to more widespread occurrence which has only come to light with lower laboratory detection limits now coming into practice.

Suffolk County's Public and Environmental Health Laboratory's (PEHL) capabilities have allowed, as needed, SCDHS Drinking Water, Groundwater Resource drilling and hydrogeological staff and Office of Pollution Control inspectional services staff to coordinate efforts to monitor private wells to meet numerous objectives:

- Enforcing source water protection provisions of the Suffolk County Sanitary Code
- Providing designers of water supply and sewage disposal systems with authoritative information to be used in the design of such systems
- Evaluating potential receptor well-sources as part of land use or contamination source evaluations of regulated or emerging contaminants
- Providing analytical data to NYSDEC as part of established workplans under their Long Island Pesticide Management Plan (discussed in the Task 3C Report and in Chapters 3 and 4 of the LICAP GRMP)
- Providing continued programmatic support for sample collection and testing relating to SCDHS settlement of claims and class action suit settlement with Union Carbide and its corporate successors regarding groundwater contamination dating to uses of the carbamate pesticide aldicarb (trade name Temik) from 1975-1979. At the height of this program over 3300 private wells were provided with granular activated carbon treatment.

Using the estimate of the number of private wells developed from Subtask 2A, laboratory and manpower needs, and alternative approaches can be developed. Considering the likely private well related responsibilities of the New York Water Quality Rapid Response Team [4], a monitoring program service model must be robust, sustainable, flexible, anticipate emerging contaminant needs, and should have strong public support, while encouraging well-owner cooperation. Regional laboratory capacity may play a role in meeting the team's evolving responsibilities and discussions should be undertaken with State agencies as to whether they envision a role for the Suffolk PEHL. It appears that the anticipated local needs could also meet similar Regional needs sometime in the future, opening the possibility of cost sharing.

SCCWRMP recommendations were considered relevant to the testing program and may also be applicable to Nassau County. Private well program informational activities and requirements in other jurisdictions were reviewed. Staff from the Bureau of Drinking Water at SCDHS provided annual statistics as to fees received, number of sample events/wells sampled, and number of samples collected for various analytical groups from 2008-2018. In order to consider laboratory approaches for emerging contaminants, National and Long Island results for public water supply monitoring under EPA's three previous Unregulated Contaminant Monitoring Rule (UCMR) programs were reviewed along with available UCMR4 data and EPA's stakeholder outreach materials for UCMR5.

In 2016, the Centers for Disease Control and Prevention (CDC) sponsored a national study exploring issues of private well-owner "stewardship behaviors."[5] The CDC identified several barriers to well water testing: inconvenience, cost, lack of knowledge, and mistrust of government and (if treatment were to prove necessary) water treatment system companies. Clearly these issues cannot be solved without providing the public with credible stakeholders and effective messaging to sufficiently motivate homeowners to take the necessary steps to protect themselves.

CDC noted that overcoming misperceptions and disincentives involves active public engagement. This necessitates an extended and focused public information program focusing on the benefits of testing, presenting the public with information while assuring some measure of privacy. A program must also provide clear and straightforward guidance on interpreting the significance of results and, as needed, treatment.

Another disincentive can be added to CDC's findings: the Property Condition Disclosure Statement requirements of the New York State Department of State, which incorporates several disclosure items relevant to private well issues. Despite a Suffolk County Local Law (7-2000) requiring "Well-Water Testing Prior to Acquisition of Residential Home" and assurances to prevent the data from being disclosed to a government entity, the local law contains a provision for the testing requirements to be waived. Property condition disclosure requirements may discourage some homeowners from seeking reliable water quality information out of fear of possible property value concerns. Anecdotal discussions with local private laboratories following passage of this local law suggests that sampling- on-transfer is not a common practice for home resale in Suffolk County.

In January 2019, A01103/S07814 a "Private Well Testing Act" was introduced in the State Legislature. If enacted it would require the NYSDOH to develop standards and require testing on transfer of ownership and periodic testing of rental properties served by private wells. Data would be made available to the health department and to tenants under this proposed Act. The Bill did not come to an Assembly Floor vote during the 2018 Legislative session. As requested by SCDHS, an on-line review of similar regulations in the area indicates County requirements in Westchester and Rockland and State-wide regulations in New Jersey was conducted. All differ from the current Suffolk law in four significant ways: they address rental or leased residences in addition to property transfers, they require analytical submission to a Government

4 Created in 2016 at the direction of the Governor of New York, the team is led jointly by the Commissioners of NYSDOH and NYSDEC. The team is charged with addressing "matters ranging from currently regulated contaminants… to emerging contaminants" and to review issues related to "testing and oversight of drinking water systems including private wells and state of the art water treatment options."

5 https://www.cdc.gov/nceh/ehs/safe-watch/index.html

entity (the County Health Departments, or New Jersey Department of Environmental Protection [NJDEP]), they do not contain a mechanism for waiving the requirement, and they unambiguously designate authority for enforcement.

The availability of an additional stream of reliable private well water quality data associated with property transfers would serve to enhance the SCDHS's own surveillance efforts and would further provide water quality-based incentives to connect homes served by private wells to public water where practical.

Cost is recognized as the most significant disincentive to homeowner-initiated well water testing, and the need to address a host of VOCs, pesticides, and emerging contaminants greatly amplifies this issue. SCDHS has maintained a private well monitoring program since the late 1950s. The program's complexity, lab support, and staffing response has changed significantly over time. In the early 1980s the Suffolk Health Commissioner directed the SCDHS to provide service to a triennial request from an existing private well owner without fee. A substantial increase in the number of sampling requests followed. Additionally, significant press coverage of private well contamination problems added to public concerns. Contamination problems associated with pesticide use, chlorinated organics and gasoline contamination, population density, and the misuse of homeowner chemicals led to substantial response delays, as the number of requests grew to several thousand each year.

The imposition of a fee in 1989 resulted in a significant decline in the number of requests. The fee increased twice, lastly more than 10 years ago to the current $100. The County's service response includes a comprehensive analysis valued at several times that amount. The Suffolk County Legislature originally provided for an income-based waiver of the fee which has been unchanged since its inception. At $25,000, that income limit stands far below the minimum wage. A 2009 Task Report for the Suffolk Comprehensive Water Resource Management Plan recommended increasing the income limit for fee waiver to $50,000. Adjusting for inflation, this should probably be closer to $51,000 today. No action has been taken on this recommendation.

Over the last 10 years the number of private wells sampled under this fee-paid request program ranged from a low of 272 to a high of 491, averaging 369 per year for the period. Fee-waived samples and private well surveys initiated by the Department's investigation of contamination events increased the number of sample site visits to an average of 724 for the same period, as shown in Table 9. This is a significant number but still quite low compared to the current estimate of the number of private wells in Suffolk County.

The cost of a reasonably comprehensive private well water analysis, equivalent to that required by SCDHS for new home (private well) construction, collected and analyzed by a New York State approved laboratory is approximately $650. Health agency and the CDC recommendations for private well sampling frequency ranges from three to five years. Since only about 1.5% of homeowners represented in the current inventory of private wells take advantage of the County's relatively low-cost option, it is evident that education and incentives, or enforced public health regulation are needed for private well owners to recognize the need to test.

A responsive private well program aimed at meeting the objectives of a comprehensive GRMP must overcome the disincentives listed above. A significant public information, data availability, and public education component is needed to sustain this program.

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A discussion of the private well testing program including a link to a request form can be viewed online at the Suffolk County website at:

http://www.suffolkcountyny.gov/Departments/HealthServices/EnvironmentalQuality/WaterResources/RequestingPrivateWellWaterAnalysis.aspx

The SCDHS Bureau of Drinking Water compiles general statistics on the progress of private well testing program activities, summarized annually for Departmental planning, County budget and NYSDOH program reporting needs. At our request, reports from 2008-2018 were reviewed and summarized below:

Table 9 SCDHS Private Well Sample Events 2008-2018

Event Category	Range	Average
Private Wells	392-1446	724
Subdivision and Individual Lot Test Wells	3-44	16
NYSDEC Pesticide Study Sample Events (Private Wells Only)	8-85	44
Aldicarb Program	3-35	15

For the reviewed period, nearly half of the sample events were conducted in surveys related to investigations of known contamination events. SCDHS records indicate 118 surveys were conducted during this period, in communities in every Suffolk County Township. Investigations focused on defining the extent of contaminant impacts including aldicarb, imidacloprid, MTBE and other petroleum contaminants, propane, perchlorate, freons, 1-propanal, nitrate, suspected landfill leachate impacts, radionuclides, elevated dissolved metals including chromium, chlorinated solvents, and perfluorinated chemicals including PFOS and PFOA.

The review also indicates slightly less than half of the sample events were collected in response to residents' requests and were fee-paid. Only 1% were collected on request while taking advantage of the restricted-income fee waiver. The balance were events connected with subdivision test wells, test wells that may be required under the discretion of the Department, and fee-paid events associated with new residential construction. The overwhelming majority of new residential construction private well samples are collected by representatives of state-approved laboratories at the applicant's expense. Although private lab costs are higher than SCDHS fees, these analyses can be scheduled more easily by the builders and laboratory turnaround for analytical results tends to be shorter.

It is noteworthy that the last two years reviewed experienced the highest number of private well sample events for the eleven-year period. This represents an increased demand for surveys conducted in cooperation with ongoing NYSDOH/NYSDEC investigations at known or suspected sites where PFAS firefighting foams were used. Because the SCDHS PEHL does not analyze for PFAS compounds, outside laboratory assistance was needed, and those costs were assumed predominantly by NYSDEC or NYSDOH.

The PEHL has drinking water analytical capabilities for 17 broad analytical groups. In addition, 1,4-Dioxane was added in 2015 as a routine analyte. The distinction between analytical groups is useful because nearly each group incorporates a specific analytical method, involving unique individualized equipment setups, and individual training and staff commitments. Some methods yield results for a single contaminant of concern, including the recent expansion to 1,4-Dioxane and perchlorate. Because of manpower and equipment limitations, not every analytical group is utilized for every sample, and four groups are rarely used in routine private well monitoring activities. As this task is confined to the needs of the private well sampling effort, analyses performed for public water supply surveillance and groundwater resource test well investigations are not included in the Table 10 summary. Similarly, PEHL analyses performed on other media (wastewater, soils) for the SCDHS are not included. It should be recognized that these other sampling events are significant portions of the PEHL analytical workload, and at times those programmatic demands compete significantly for laboratory resources. A discussion of private well analytical needs cannot be made in complete isolation from these other important water resource and public health protection objectives.

Table 10 Analytical Group Summary for Private Wells 2008-2018

Analytical Group	Total	Minimum Year Total	Maximum Year Total
Aldicarb	4504	241	619
Bacteriological	4883	272	701
Dacthal	4503	240	618
Chlorinated Pesticides	4436	245	580
Standard Inorganics	5586	340	839
Optional Inorganics	0	0	0
Metals	5423	254	838
Volatile Organics	4906	286	656
Chlorinated Acids	57	0	15
Semi-Volatile	3844	226	577
Radiological	453	22	67
Perchlorate	1835	0	481
Semi-Volatile (Method 526)	0	0	0
Semi-Volatile (Method 527)	535	0	298
Herbicide Metabolites	4456	235	584
Oil	20	0	11

Private Well Program Enhancement Areas to Consider

Overcoming Disincentives

Homeowners and tenants at properties served by private wells need to be made aware of available resources and guidance. Periodic testing of private wells is important to assure the well-being of the residents. Water quality data will also provide information useful for future decisions as to connection to public water or, if necessary, relocation or deepening of a well, or providing treatment. Consider ways to improve outreach and information programs to encourage homeowners to take advantage of the testing program and to better understand its value. The SCDHS Comp Plan private well task report recommendation to increase the income limit for fee-waiver would appear to be an appropriate step. The current waiver is set at a level well below the median income-level target used when it was originally initiated in 1989.

Electronic media including the existing SCDHS Facebook site can be useful in areas of general outreach to private well owners, and focused outreach should be used for tenants in residences served by wells, for private well owners with ready access to public water mains, and in areas designated with flooding potential. Existing websites providing emergency preparedness assistance such as the Suffolk County Fire Rescue (SCFRES) Facebook site can be linked to CDC recommendations for private well owners in flood prone areas. Outreach efforts should be coordinated with SCWA, Town and Village building agencies and County and Town emergency management agencies.

To date, State Legislation requiring well testing on property transfer has not been passed. As discussed previously, other counties in the downstate region have, like Suffolk, adopted varied requirements. Several are more extensive than Suffolk's requirements, covering rental properties, and directing analytical results for mandated samples to be provided to the health department. Although beyond the scope of this Task Report, it would be beneficial to further investigate the issues and experiences of neighboring jurisdictions.

PEHL and Bureau of Drinking Water Staffing and Analytical Support

As has been the case since the late 1970s, emerging contaminant monitoring, and investigation will likely continue to be a program driver. The SCDHS PEHL continually reviews expansion of existing analytical methods to include pesticides in active use and degredates known to develop over time as well as pharmaceuticals and personal care products. In recent years, additional chlorinated solvents, forms of freon, chlorate, cobalt, hexavalent chromium and other trace metals, have been added to routine PEHL capabilities using existing methods as appropriate. At times new methods require the acquisition of analytical equipment when seen as necessary, as in the case of 1,4-Dioxane.

PFAS findings throughout the Nation demonstrate the need to investigate and better understand potential contamination sources. This evaluation is not possible without a significant expansion of PFAS analyses beyond the immediate focus of currently suspected contamination sites. PFAS analytical costs are on the order of several hundred dollars a sample. Additionally, there is significant and expanding National competition for a relatively limited amount of lab capacity for PFAS analysis. Utilization of private laboratories exclusively, to service the level of PFAS response which may be needed, is not considered to be cost-effective in a long-term program. SCDHS is evaluating a range of options in the short-term including laboratory assistance from SCWA, capabilities funded by New York State at SUNY Stony Brook, NYSDOH Wadsworth Laboratory support for public water analyses, and a continuation of private laboratory support, while developing in-house PFAS analytical capabilities as a long-term objective. As in the past, laboratory equipment enhancements and improvements may be supported through County General Funds, the county ¼% sales tax funded WQPRP and Land Stewardship Initiatives (WQPRP), and NYSDOH Drinking Water Enhancement grants. The USEPA has Draft Method 533 under development for additional PFAS compounds utilizing SPE LC/MS/MS. Potentially both this method and Method 537.1 may be utilized to significantly expand a PFAS focus in UCMR5, scheduled for 2023-25. According to EPA the Draft Method will be finalized in before the end of 2019. This will address a need for evaluation of additional PFAS compounds about which little is known about persistence, mobility, fate, and transport in aquatic and groundwater environments.

The Governor's September 7, 2017 budget message called for aggressive new water quality protection measures which in part would incorporate unregulated contaminant monitoring for water systems serving fewer than 10,000 people, a need that previously had not been addressed under the federal Safe Drinking Water Act. Under the 2018 America's Water Infrastructure Act (AWIA) amendments to the Safe Drinking Water Act (SDWA), UCMR monitoring for all systems serving populations from 3,300 to 10,000 will be added beginning in 2023. The State Legislature responded with an amendment to the Public Health law directing the State health department to accomplish just that. The SCDHS performs oversight monitoring of all public water suppliers incorporating comprehensive testing of these small community and non-community public supplies. Management of the analytical capability and capacity enhancements discussed are one way in which expansion of the PEHL range of analytes could meet this state legislative mandate in Suffolk County, potentially in cooperation with Nassau County.

Developing an estimate of additional support required several assumptions including continuation of the recent increase in the number of private well locations sampled at the current level of 1,250 per year.We anticipated that the continued need for focused surveys in areas of private well contamination and some expansion of incentives and outreach to other private well owners would likely maintain response at these levels. The additional analytical needs for other Departmental programs, while recognized to be of significance, are beyond the scope of this task.

Additional private well analytical support, therefore, would be confined to maintaining approximately the same number of locations and sample events. This discussion of additional analytical capabilities focused on an evaluation of the list of previous and current UCMR program analytes and the capabilities of the analytical methods associated with those analytes.

It is emphasized that the PEHL has historically expanded its capabilities for unregulated contaminants, well ahead of formal consideration in the national UCMR program. Detailed discussion of the following contaminant groups may be found in other task reports and in the LICAP GRMP.

PFAS: While the PEHL is regarded to be well placed with respect to ability to analyze for emerging contaminants, as well as positioned to support surveillance monitoring needs for all regulated drinking water contaminants known to potentially be found in groundwaters, PFAS analytical group capabilities are considered at this point in time to continue to represent the most critical need for expansion of local PEHL analytical capabilities. As discussed earlier two EPA Methods are recognized for PFAS analysis, Method 537 and Method 533 which is under development. EPA documentation indicates that Method 533 is a Solid Phase Extraction method targeting shorter chain PFAS, those with fewer than 12 carbons in the PFAS matrix. This Method addresses a weakness in Method 537 providing better detection of certain short chain PFAS compounds such as PFBA and PFBS.

There are several competing methods for additional PFAS analyses but are not approved for potable water and have quantitation limits that are higher than currently required for PFOA and PFOS. We recommend that the Department continue to use available options for PFAS analyses while moving forward on acquisition of the necessary LC/MS/MS equipment to develop an independent Method 537 capability. Additional capabilities for Method 533 should be considered a priority dependent on finalization of that Method.

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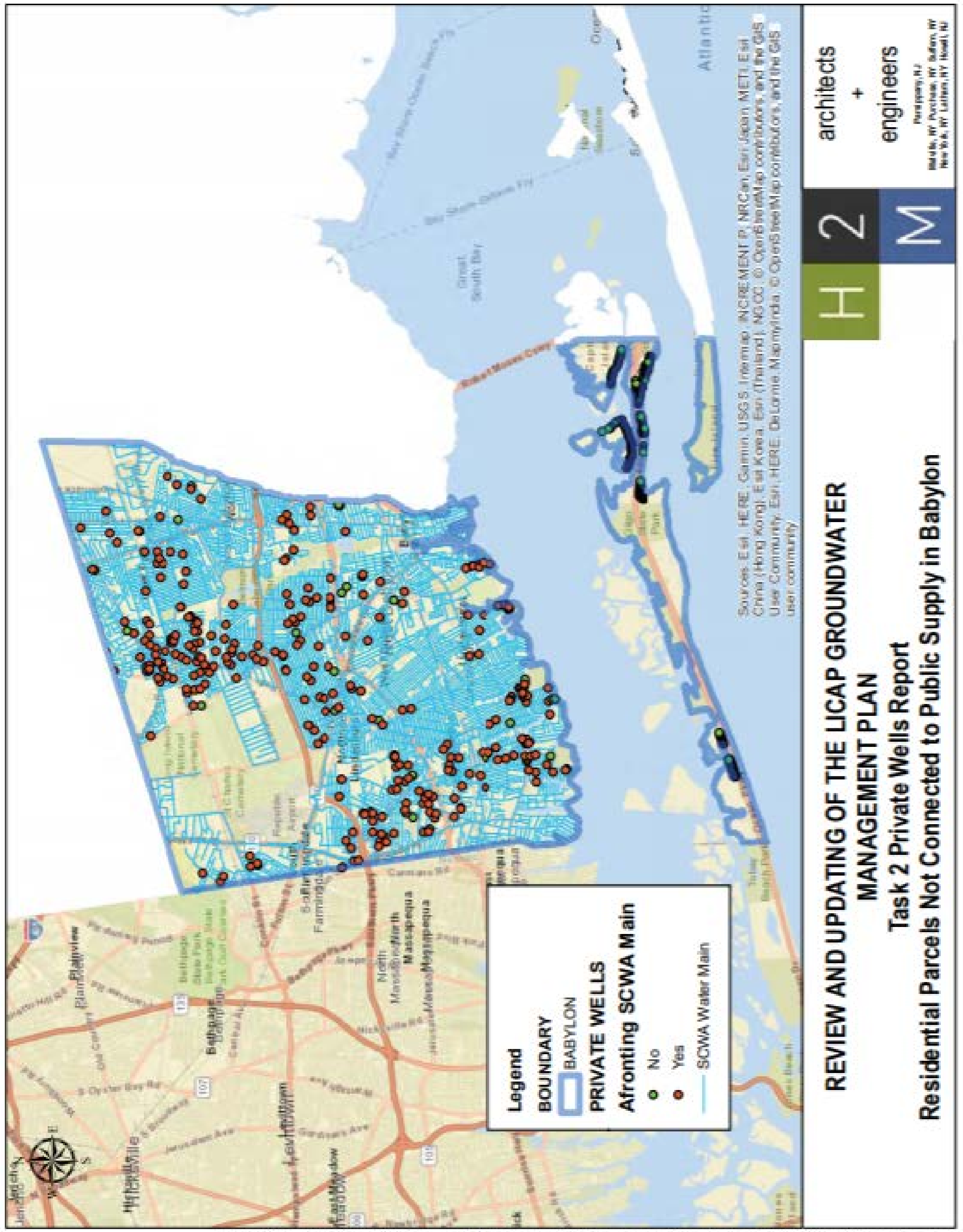
Perchlorate: In the July 11, 2019 Federal Register, the USEPA published a (corrected) proposal for the regulation of perchlorate. EPA is seeking comment on a series of regulatory options, including three maximum contaminant level (MCL) alternatives and a withdrawal of the intent to regulate. A review of current WaterTraq data indicates over 100 public wells on Long Island have had perchlorate concentrations exceeding 1 parts per billion (ppb) consistently. Current NYSDOH requirements since 1998 require public water suppliers plan for the possibility of an enforceable MCL when encountered at 5 ppb and requires public notification for perchlorate at 18 ppb (the Two-Tier Action Level). EPA's 2019 proposal allows five different analytical methods, one of which (IC/MS) was utilized by the PEHL prior to 2015. The PEHL is scheduled to return this capability to service in 2020 using this Method. Since private monitoring began in 1999, PEHL has detected perchlorate in private wells, largely considered indicative of past agricultural practices.

UCMR3: The 2013-15 National monitoring requirement incorporated Method 524.3a capillary column Gas Chromotography/Mass Spectrometry (GC/MS) which produced lower reporting levels for several (Federally) unregulated contaminants which have been detected on Long Island previously at higher concentrations within the reporting range in current use at the PEHL. The results followed a familiar pattern - additional detections at new locations. Of concern were detections of 1,2,3 trichloropropane which has a very low (0.0004 ppb), non-enforceable EPA reference concentration. Discussions indicate that upgrades to existing GC/MS equipment may be possible. Consideration should be given to this, depending on whether NYSDOH were to give approval to this method for NYS-regulated VOCs. Method 524.3 is not listed by EPA for all VOCs currently being analyzed by the PEHL. Environmental Laboratory Approval Program (ELAP) regulatory developments should be monitored for consideration when SCDHS equipment requires replacement.

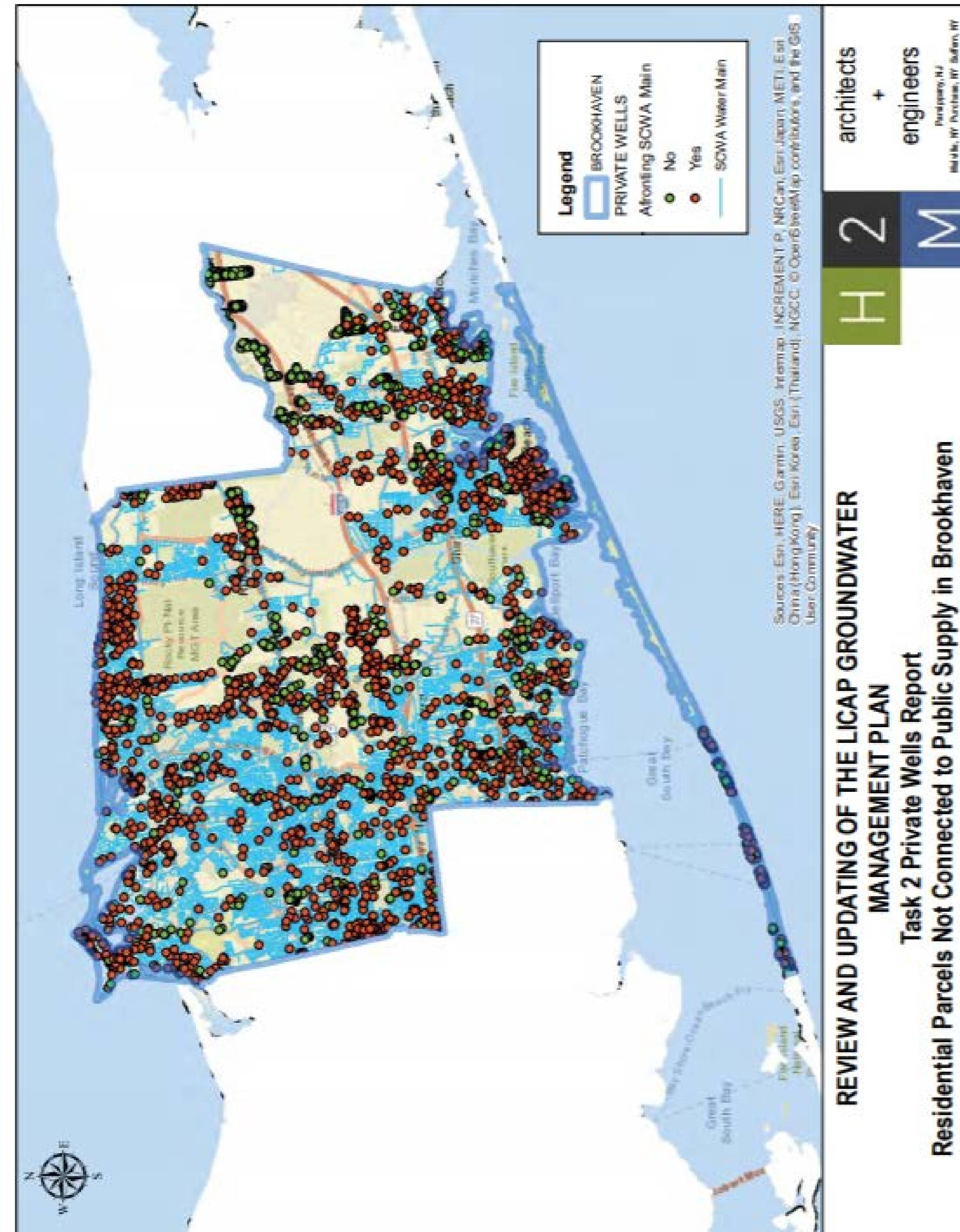
UCMR 1 and 2 Pesticides: The acetanilide pesticide and degredate Methods utilized in UCMR1 and 2 were not both demonstrably more effective than the semivolatile and herbicide metabolite method variants in use at the PEHL. The PEHL has demonstrated the effectiveness of the semivolatile method for over 95 analytes. Drinking water standards for additional acetanilide are not anticipated in the near future. As the methods in-use have been considered to be adequate in this regard, this issue should not require immediate consideration. Technology developments in this area should be monitored for consideration when equipment requires replacement.

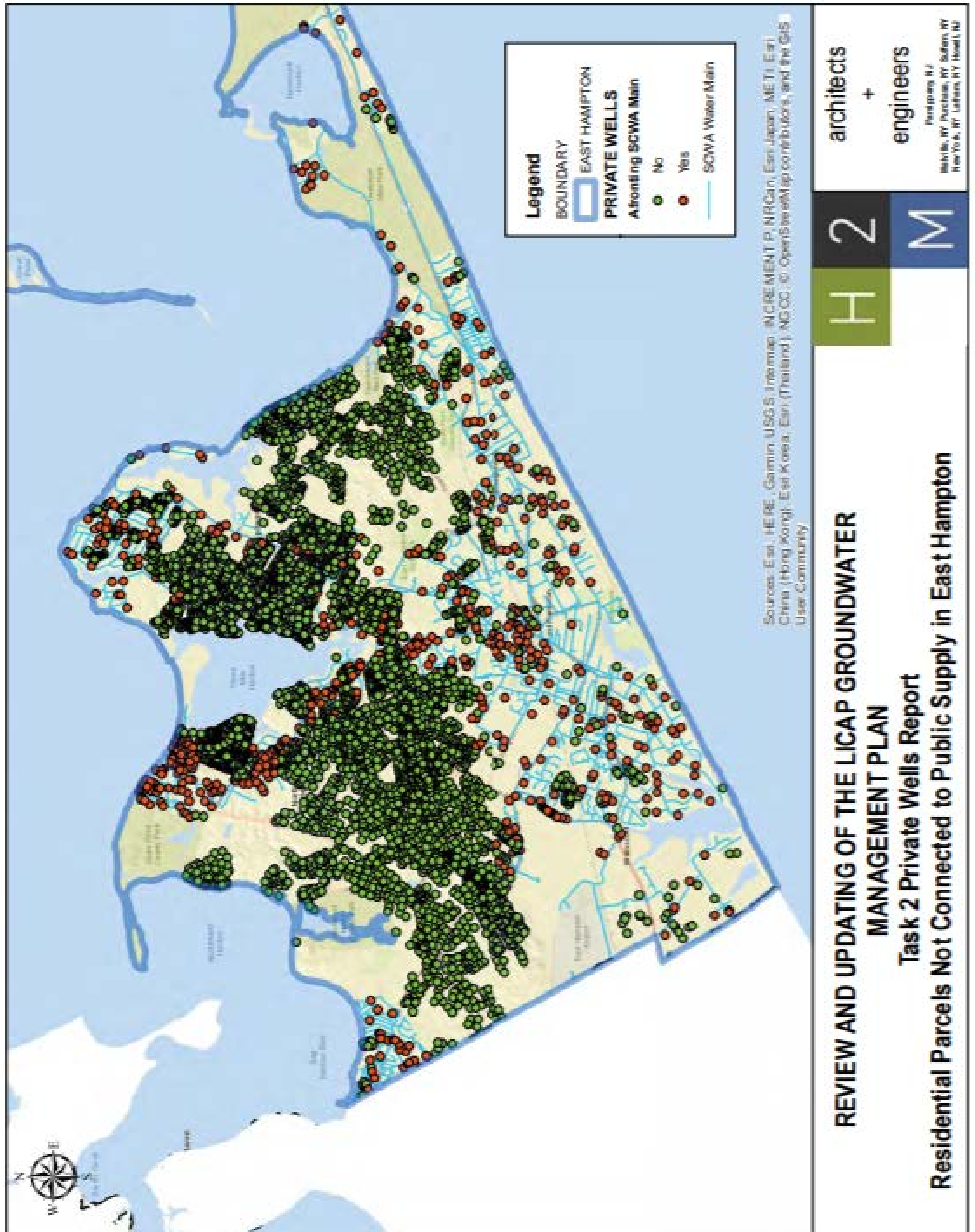
UCMR4: This monitoring program, to be completed in 2020, incorporates Methods for certain defined pesticides (525.3), semivolatiles (530), and alcohols (541) to analyze for many unregulated contaminants currently addressed by existing PEHL variant protocols. National data thus far indicate very few detections and regulations would appear unlikely. UCMR4 cyanotoxin Methods (544, 545) are not required for groundwater system UCMR4 consideration. HAA9 (haloacetic acid, a disinfection byproduct) analyses are required utilizing either Method 552.3 or the newer Method 557. The HAA5 regulated contaminant group has not been found in significant concentrations in disinfected Long Island water suppliers and has not been a prominent analytical priority for SCDHS. UCMR4 results thus far do not indicate the need to reconsider this prioritization.

Based upon our evaluation of the previous and current UCMR program analytes, it appears that the SCDHS PEHL's current capabilities are adequate to address the majority of the priority analytes. It is recommended that SCDHS continue to pursue expanding the PEHL analytical capabilities for PFAS and perchlorate.



LICAP
Long Island Commission for Aquifer Protection
CHAPTER 11:
REPORT ON PRIVATE WELLS ON LONG ISLAND
Task 2 Report Appendix- Suffolk County Private Well Maps





Legend
BOUNDARY
EAST HAMPTON
PRIVATE WELLS
Afronting SCWA Main
No
Yes
SCWA Water Main
Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, © OpenStreetMap contributors, and the GIS User Community
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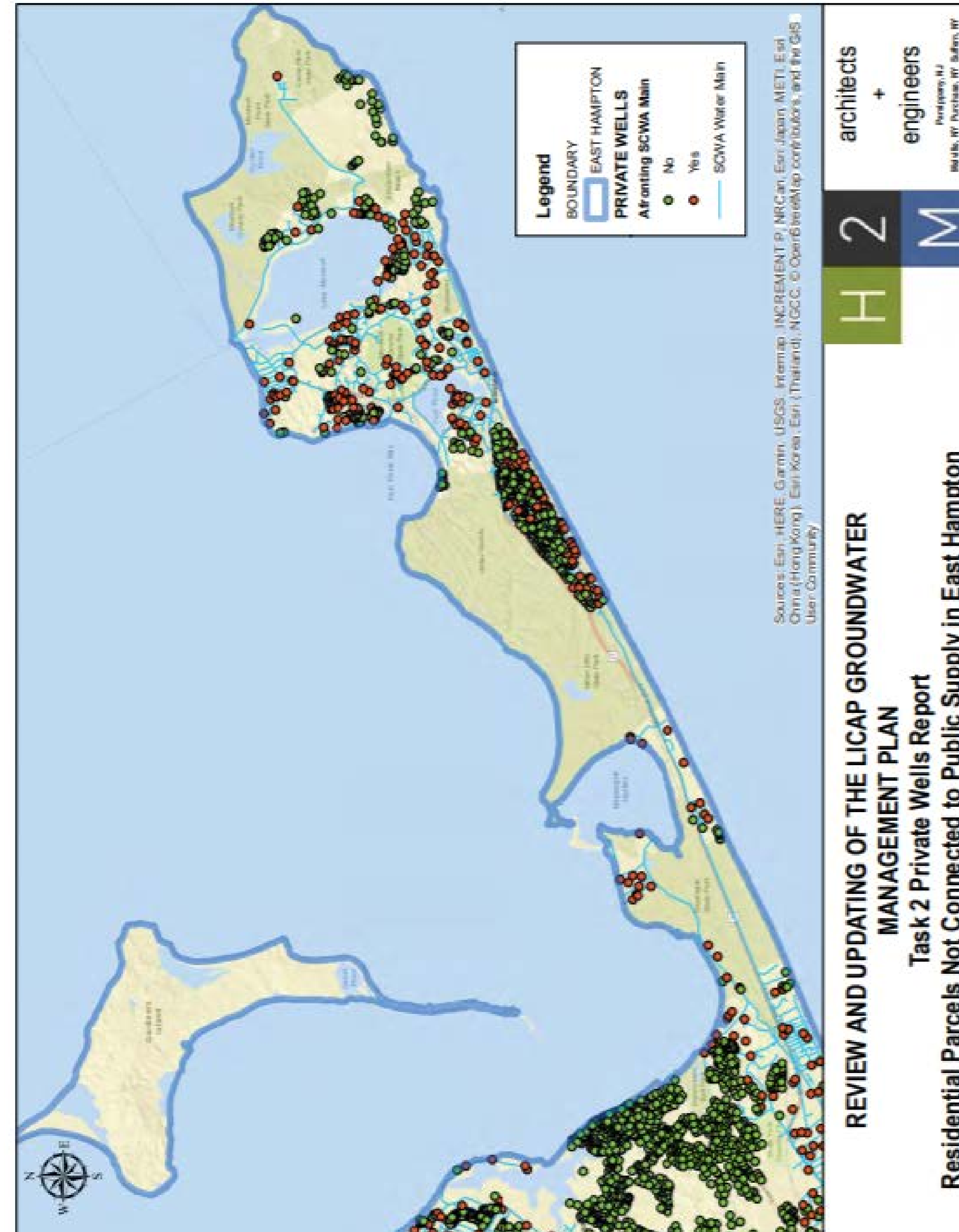
REVIEW AND UPDATING OF THE LICAP GROUNDWATER MANAGEMENT PLAN
Task 2 Private Wells Report
Residential Parcels Not Connected to Public Supply in East Hampton



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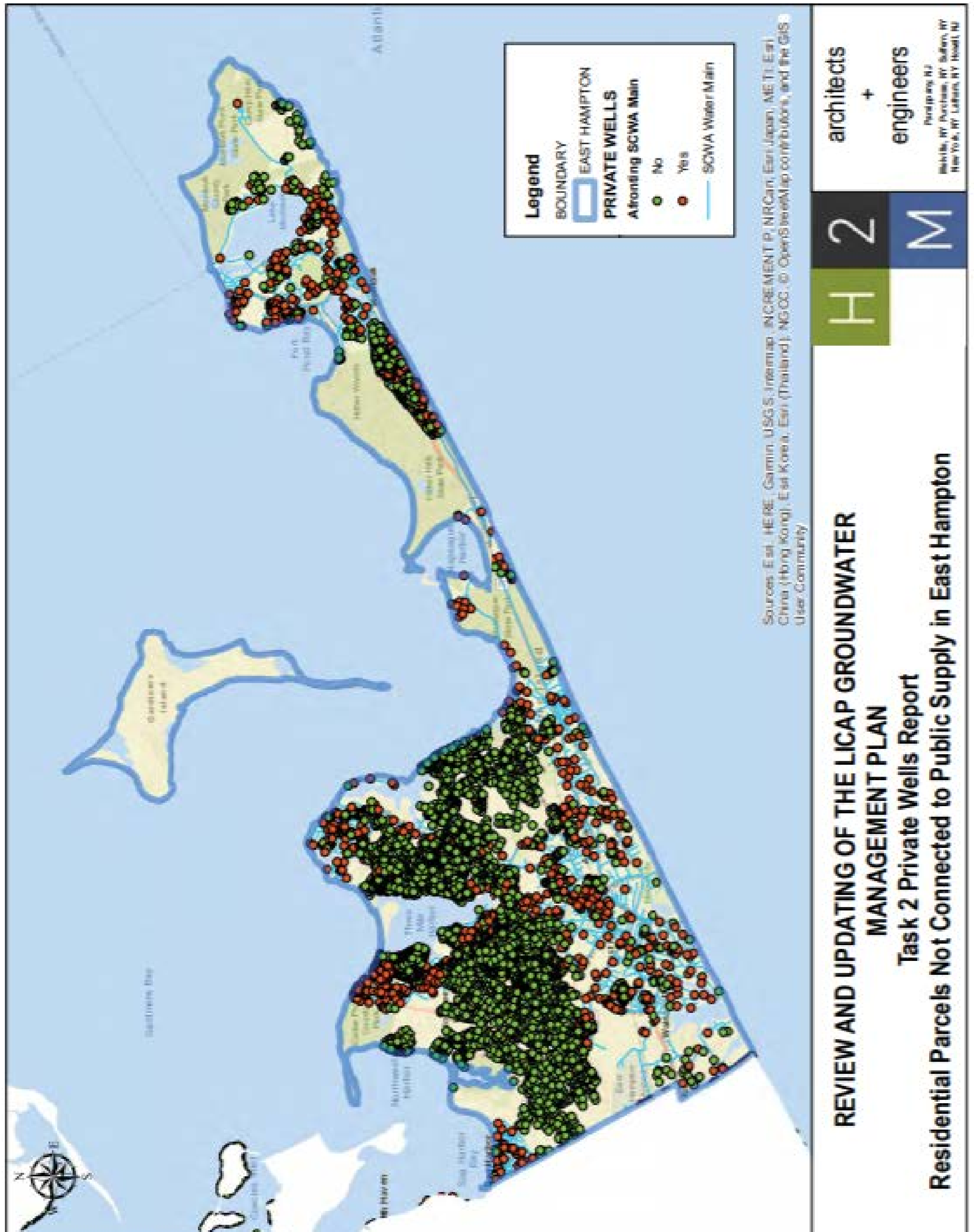

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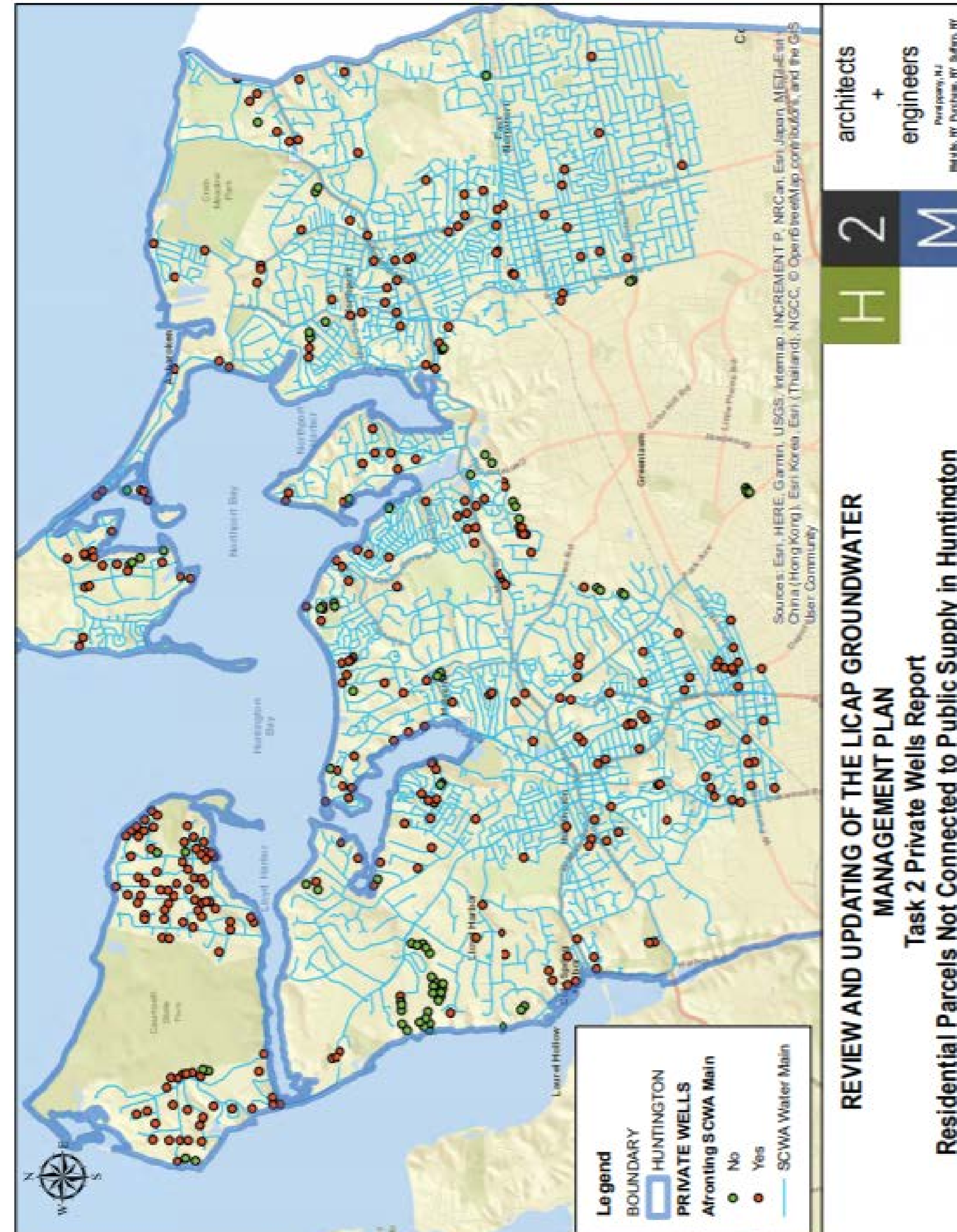

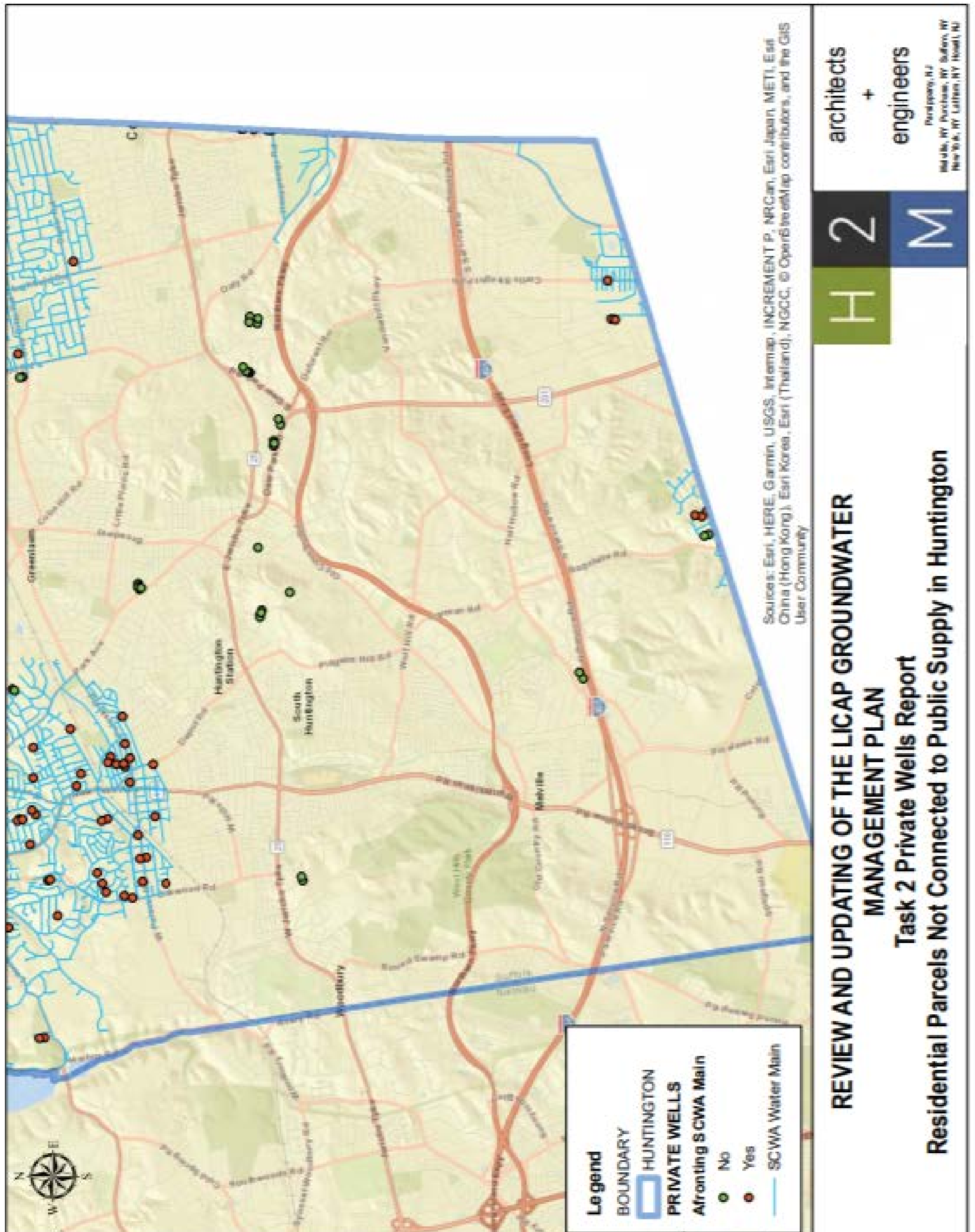

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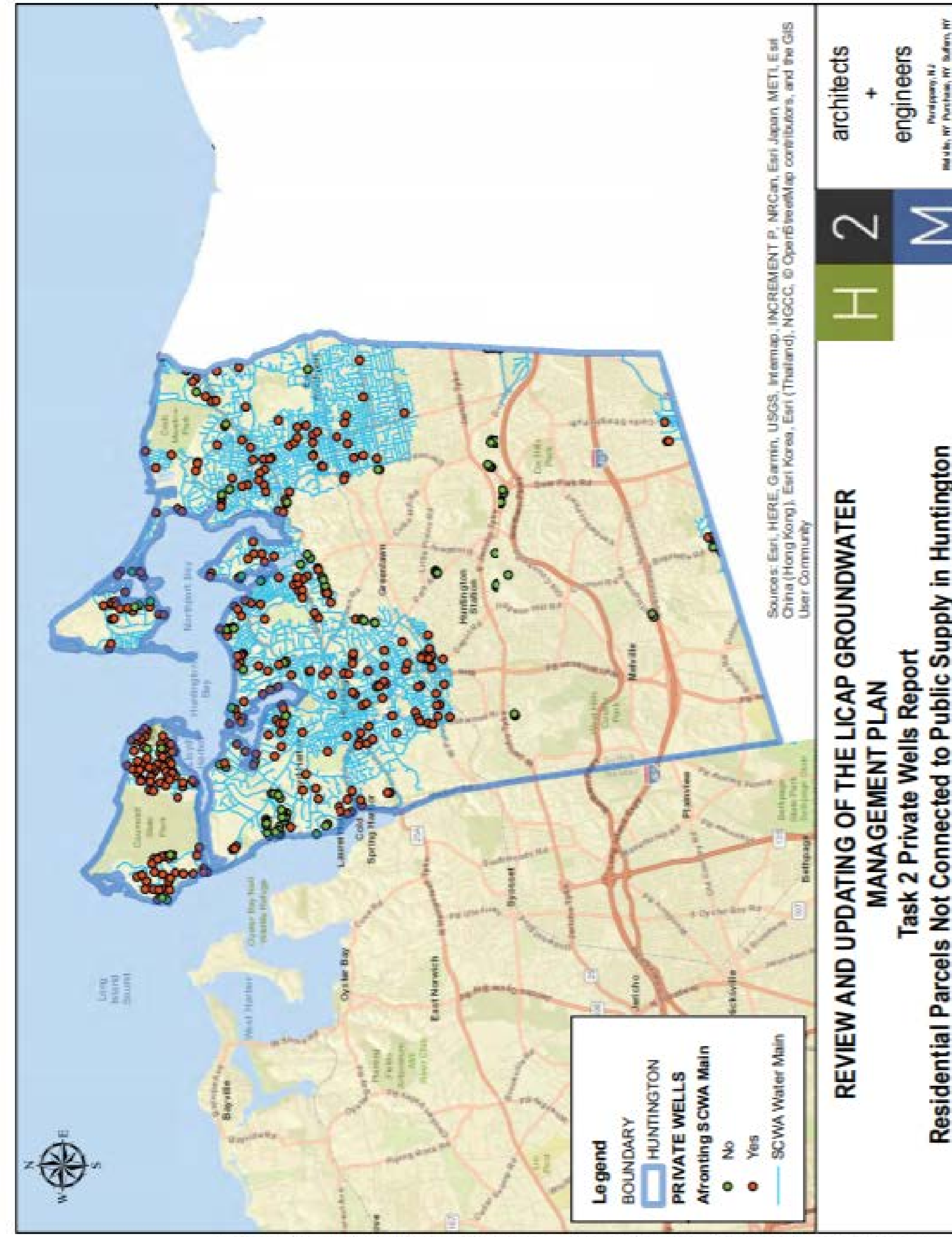

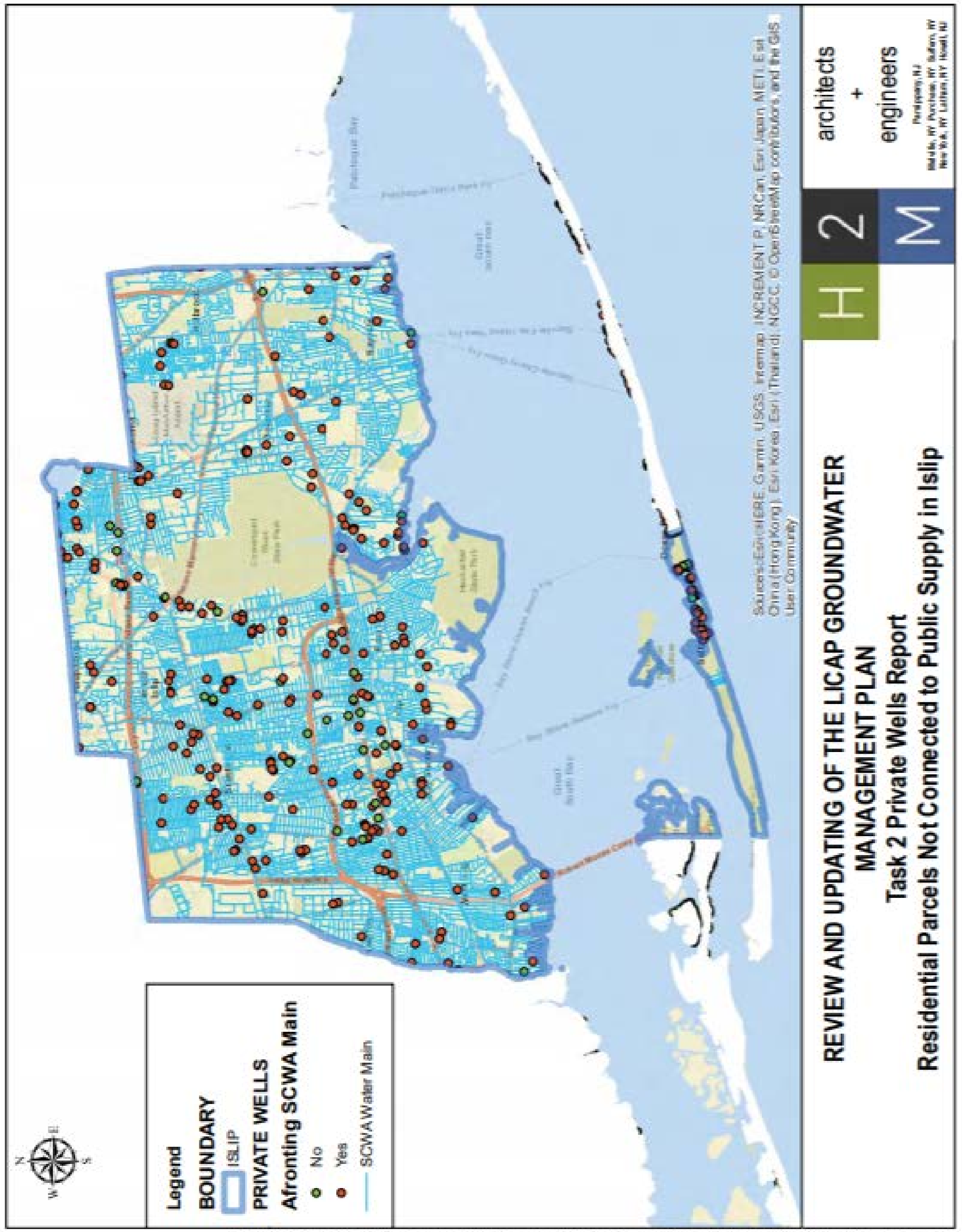

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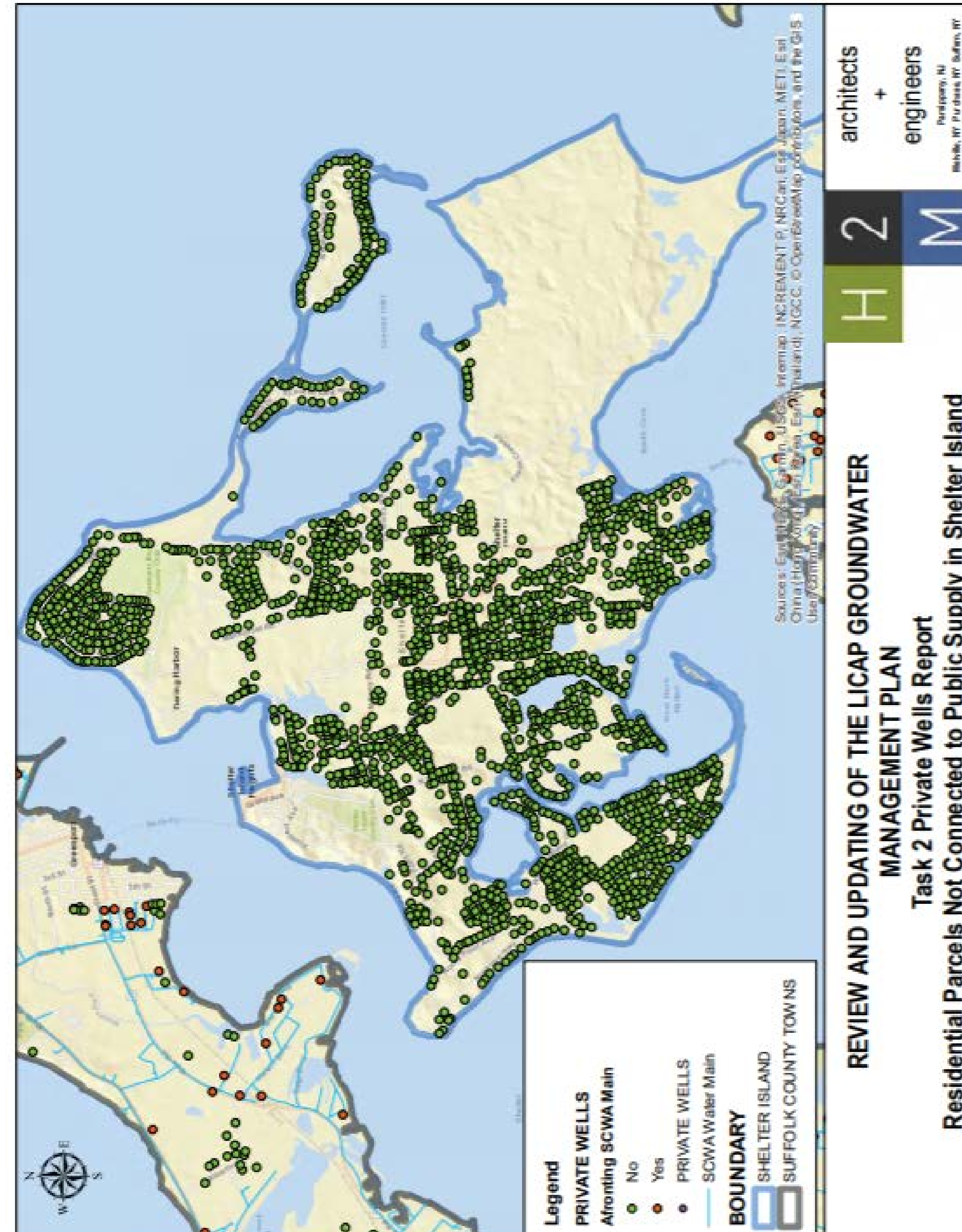

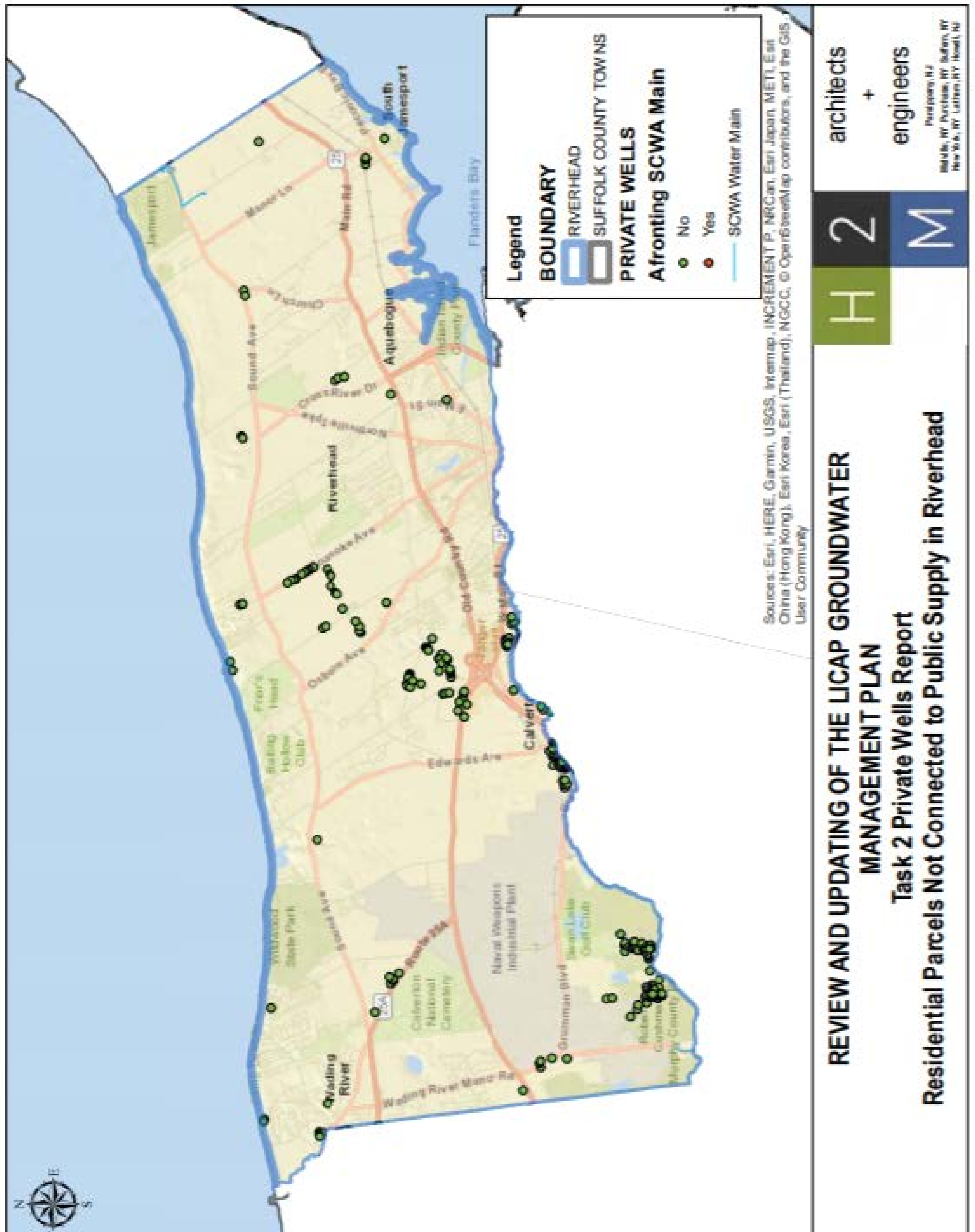

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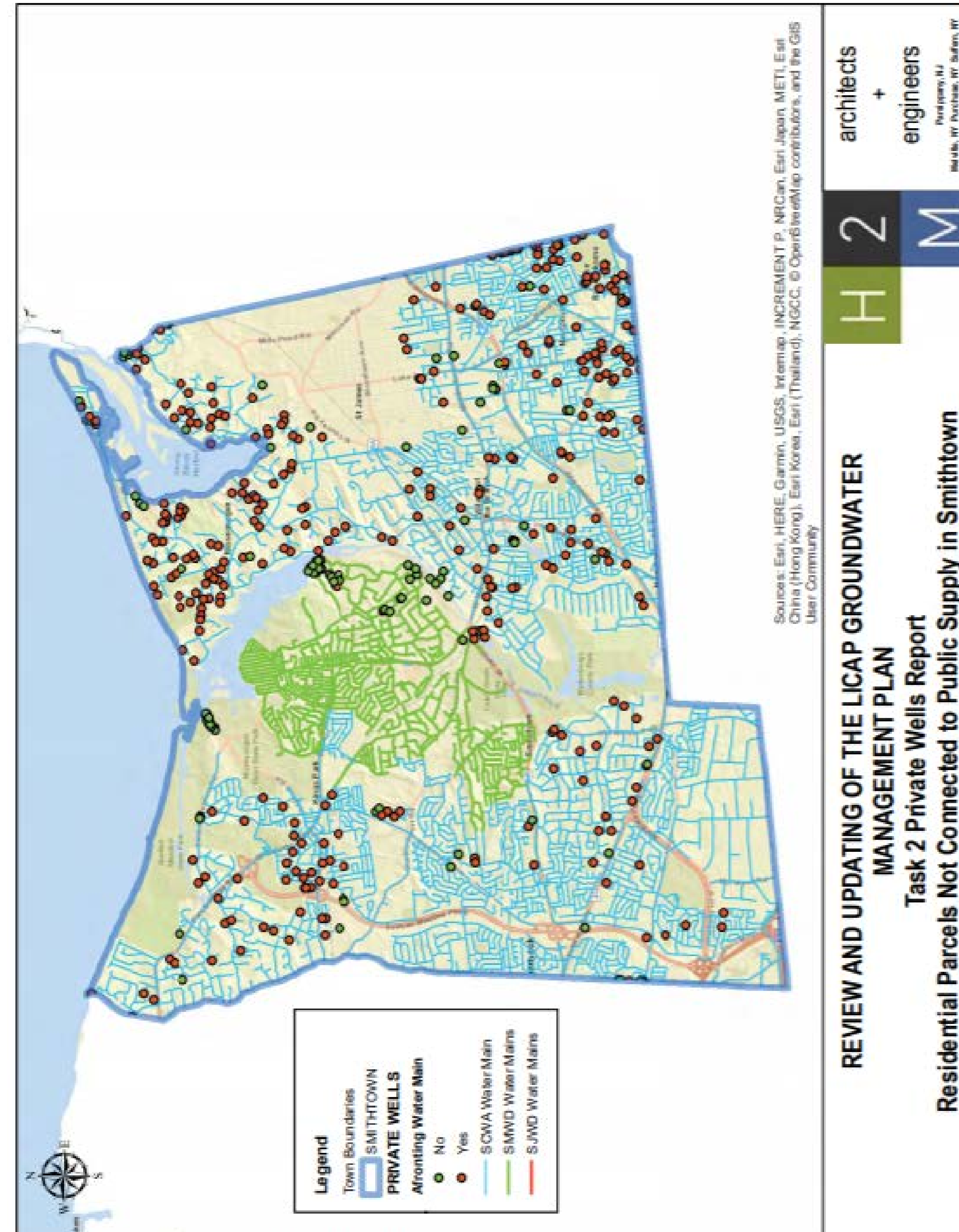

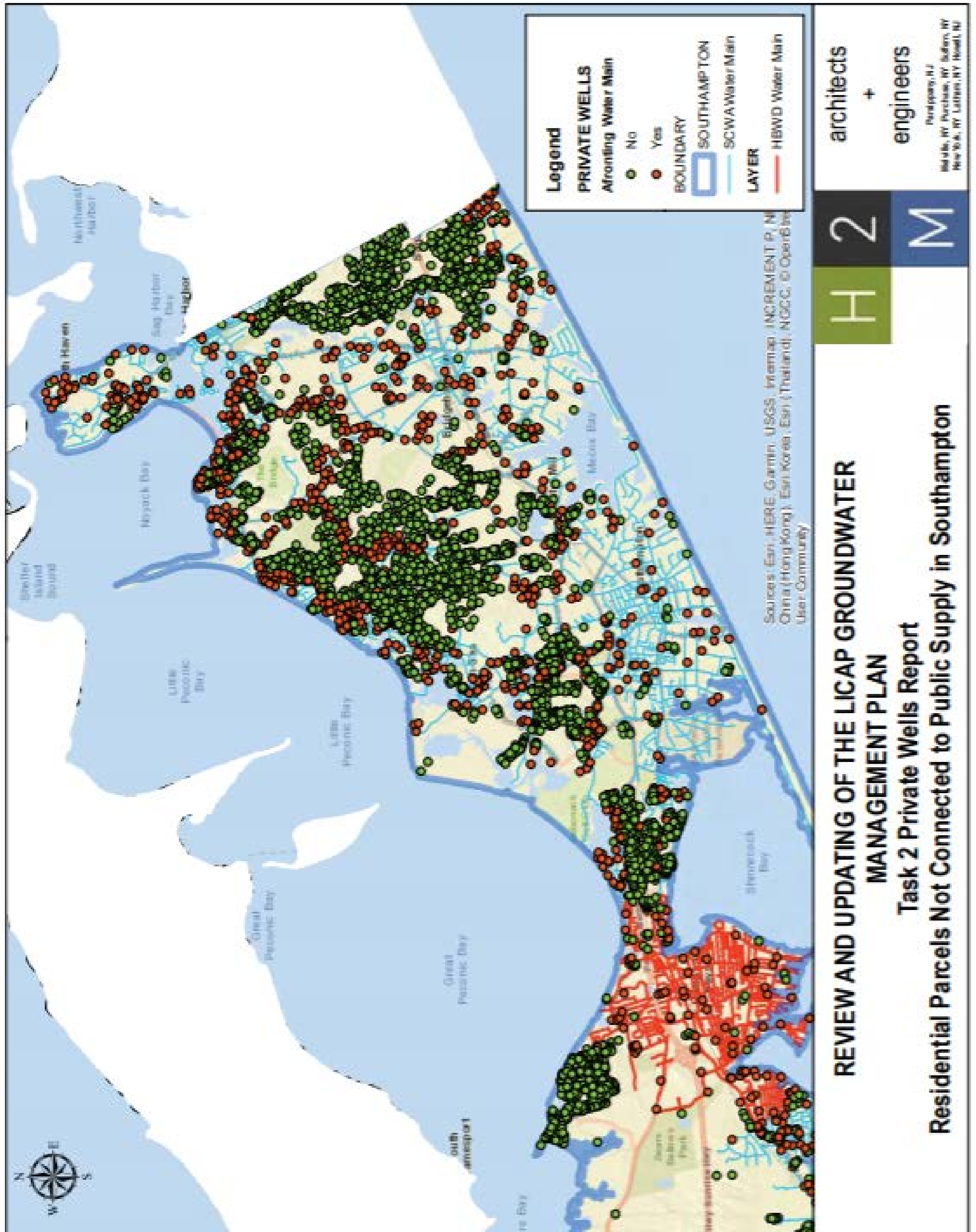

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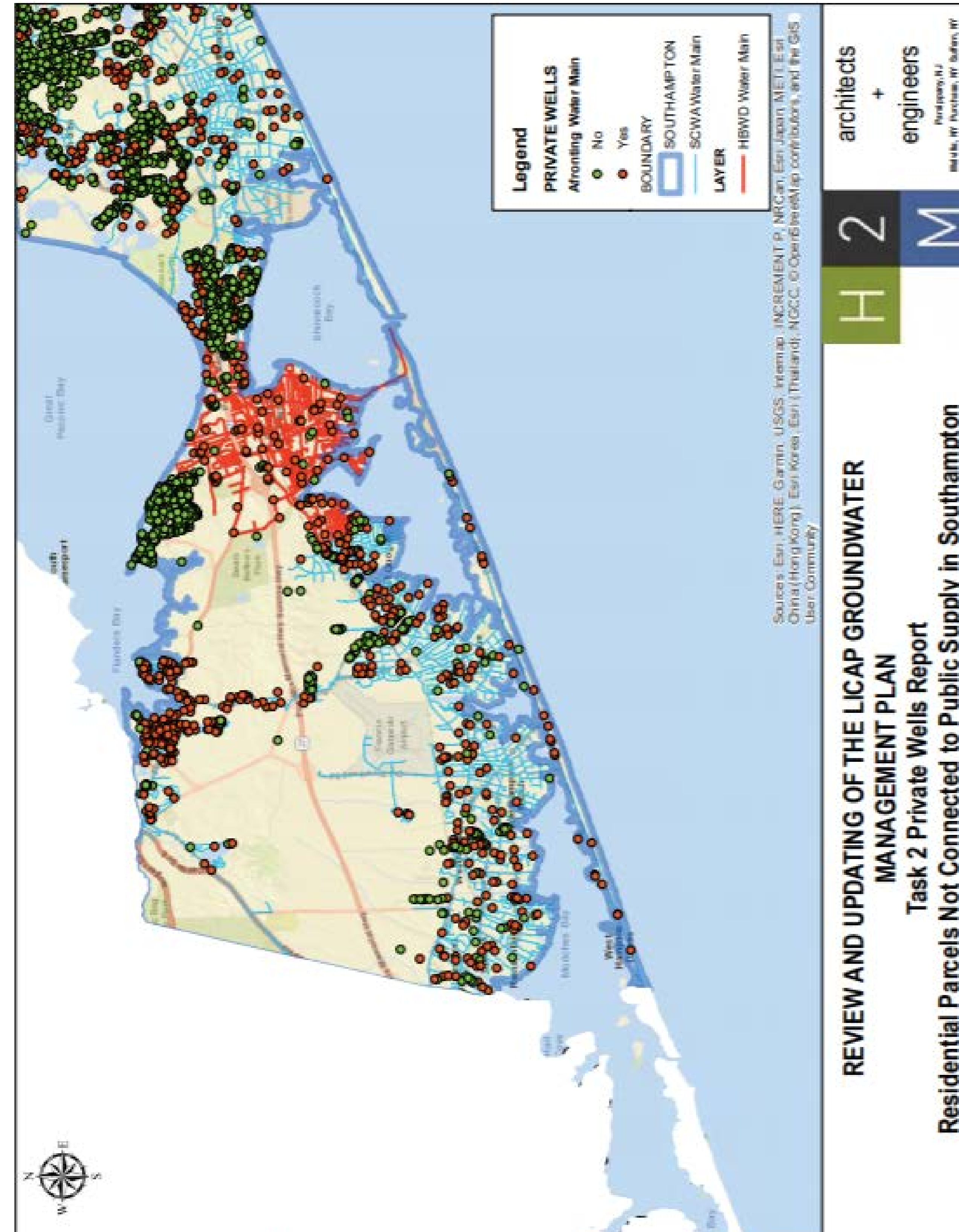

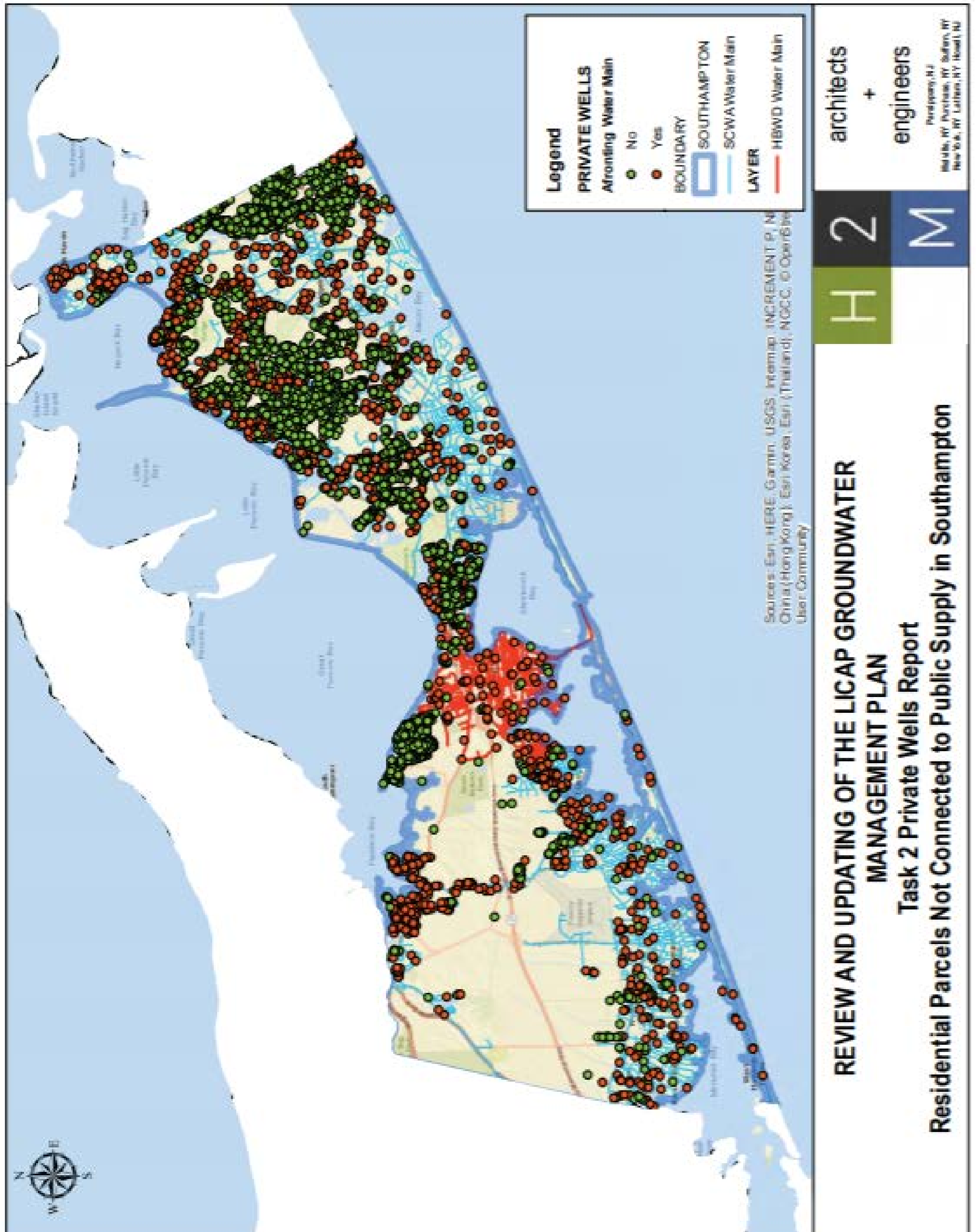

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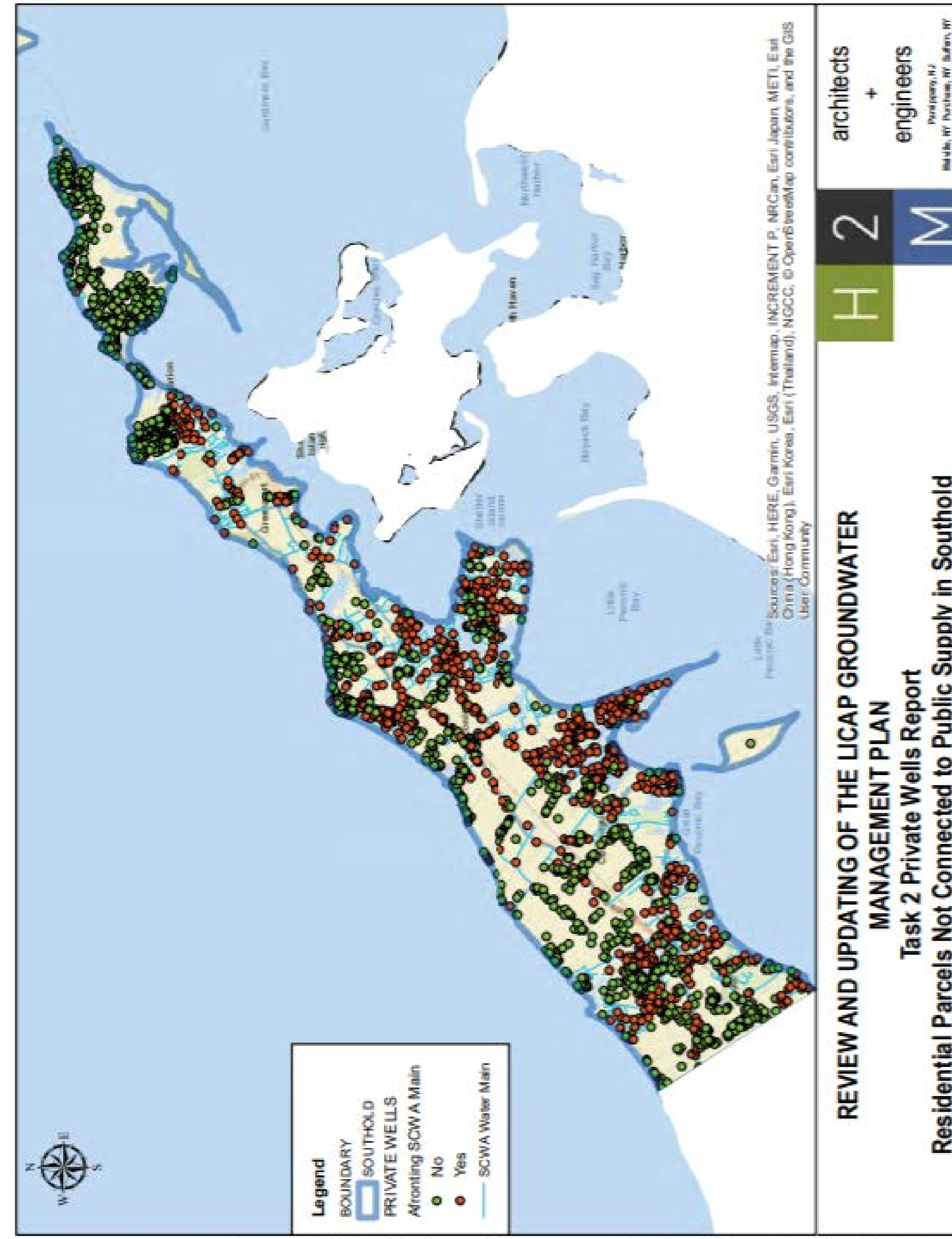


This report expands upon existing reports in the Interim Long Island Commission on Aquifer Protection (LICAP) Groundwater Resource Management Plan (GRMP) related to wastewater management. Additionally, the costs of infrastructure relative to both Nassau and Suffolk Counties will be evaluated, where the latter has nearly 70% of the population unserved by community wastewater treatment (either public or private). Before delving into these specifics and for ease of reference, some history and statistics are presented. The sources of reference from Chapter 5 of the Interim GRMP and some of the references cited herein may differ nominally on exact figures and percentages, but all data is on the same order of magnitude and does not impact the purposes of this report relative to its analysis.

Long Island Wastewater Background

Modern wastewater collection, conveyance, and treatment infrastructure exists to varying extents throughout Nassau and Suffolk Counties. The oldest of this infrastructure dates to the early 1900s and was originally constructed to provide sanitation to many of the local downtown business corridors of Villages and Hamlets that did not otherwise have available space for the siting of individual on-site wastewater disposal systems. As development expanded outside of these local downtown business corridors, throughout Nassau and Suffolk Counties, environmental controls were put in place to regulate how wastewater was managed to protect the environment and human health. With advancements in technology, and our understanding of how new contaminants impact our local water resources (i.e. surface and ground waters), more rigorous regulations have evolved. These regulatory changes have done much to improve environmental impacts to streams, rivers, and oceans, along with their natural habitats; however, they are not identical to the regulatory requirements and concerns related directly to drinking water. Many of the new wastewater regulations have focused on reductions of nutrients, like nitrogen and phosphorus, in waterways, but do not consider the broader context and potential impacts of the various other constituents that are contained in municipal wastewater, such as pharmaceuticals and personal care products (PPCPs), heavy metals, and household solvents and cleaners. Scientific consensus on the criticality of PPCPs for example, does not yet appear to have been achieved.

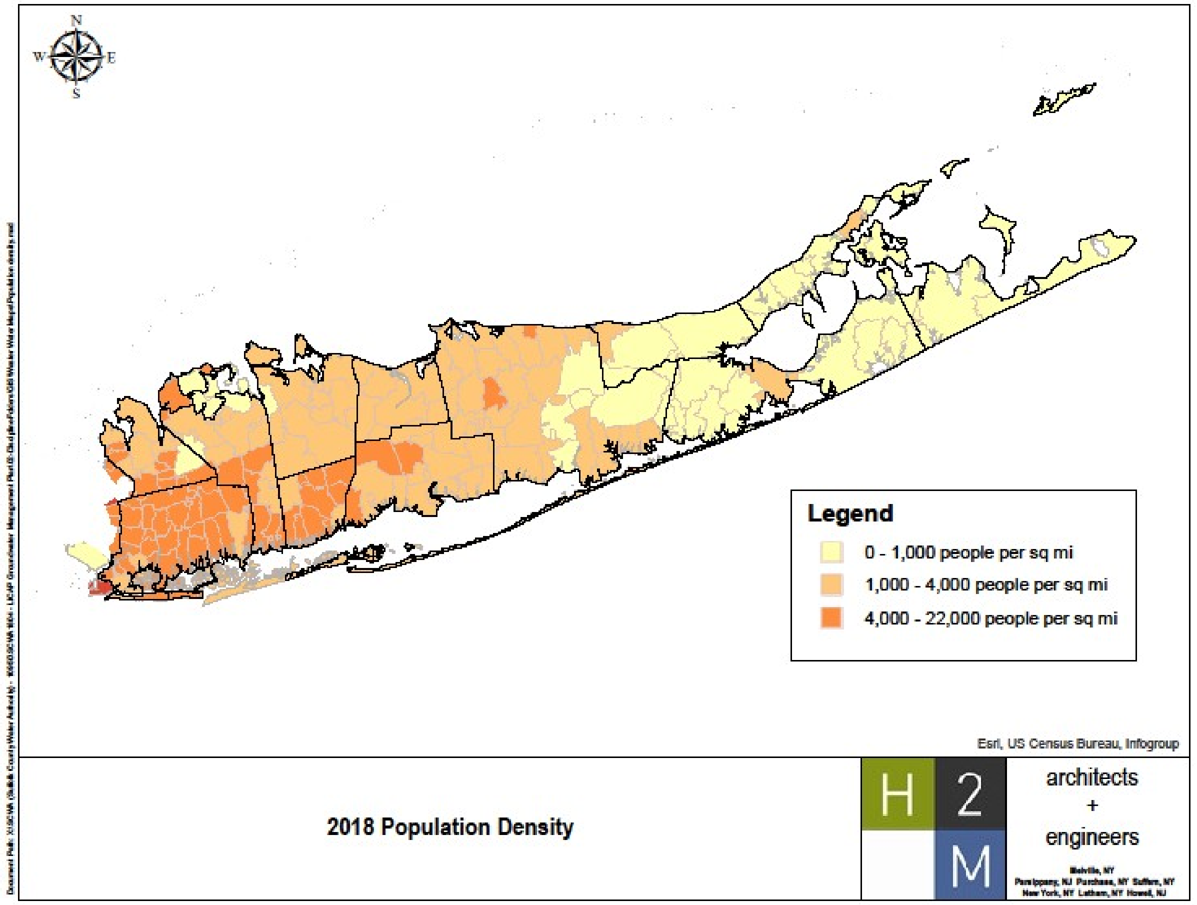
Moreover, the efficacy of wastewater treatment processes for removal of these constituents, through practices currently routinely employed by conventional treatment facilities, is still under review. Research suggests that membrane reactor or activated sludge systems and aeration may be effective in managing endocrine disruptor chemicals (EDCs). Activated carbon has been demonstrated to be effective with pesticides and pharmaceuticals, but until wastewater regulations drive the implementation of these types of technologies, there will remain a gap between the two ends of the water cycle, wastewater, and drinking water.

Currently, Nassau County's wastewater infrastructure is primarily comprised of municipally owned and operated facilities that provide collection, conveyance, and treatment to approximately 90% of the wastewater generated. In contrast, Suffolk County's wastewater infrastructure is comprised of a mix of municipal, private, Federal and State agency owned and operated facilities, that combined, provide collection, conveyance, and treatment to approximately 30% of the wastewater generated.

CHAPTER 12:
WASTEWATER MANAGEMENT IN NASSAU AND SUFFOLK COUNTIES

For the purpose of performing a high-level assessment of the level of additional infrastructure build- out and costs, we will use population density and theoretical wastewater generation values to provide projections. Population data published by the United States Census Bureau, dated July 1, 2017[1], identify Nassau County to have an estimated population of approximately 1.37 million persons and Suffolk County as having an estimated population of approximately 1.50 million persons. The Census Bureau also defines the boundary of Nassau County to encompass a total area of 453 square miles, of which 285 square miles is comprised of land (i.e. 63%) and 168 square miles are comprised of water (i.e. 37%). The 285 square mile land area is further reduced by 25 square miles of parks and open space to arrive at approximately 260 square miles of developable land area. Dividing the population by this land area yields an average population density of approximately 5,270 persons per square mile. Similarly, the same data source defines the boundary of Suffolk County to encompass a total area of 2,373 square miles, of which 912 square miles are comprised of land (i.e. 38%) and 1,461 square miles are comprised of water (i.e. 62%). The Suffolk County land area is further reduced by 118 square miles, which includes parks, open space, and non-developable areas of the pine barrens, leaving approximately 794 square miles of developable space. This projects to a Suffolk County average population density of 1,890 persons per square mile. The population density in Nassau County is slightly less than three times greater than that of Suffolk County. Figure 1 shows this population density across Long Island.

Figure 1: Population Density on Long Island



[1]United States Census Bureau.Web. 3 April 2019. https://www.census.gov

To create theoretical per capita wastewater volumes, reference was made to the Great Lakes-Upper Mississippi River Board of State and Provincial Public Health and Environmental Managers (GLUMBR) Recommended Standards for Wastewater Facilities (commonly referred to as Ten States Standards), of 100 gallons per day per capita (gpdpc). This was applied to the estimated population for Nassau County and Suffolk County, to yield theoretical average daily wastewater generation rates of 137 million gallons per day (MGD) and 150 MGD, respectively.

Existing Nassau County Wastewater Treatment Status

The Bay Park Sewage Treatment Plant (STP) and Cedar Creek Water Pollution Control Plant (WPCP) provide treatment for approximately 88% of the 132 MGD of wastewater collected within Nassau County. The flow treated by these two facilities is collected within unincorporated areas of the county as well as the following municipal sewer districts: the Villages of Cedarhurst, Lawrence, Garden City, Freeport, Mineola, Hempstead, Roslyn, and Rockville Centre. The remaining 12% of the collected wastewater within Nassau County is treated at the following facilities: Glen Cove Water Pollution Control Plant, City of Long Beach Water Pollution Control Plant, Jones Beach State Park Sewage Treatment Plant, Port Washington Water Pollution Control District, Belgrave Water Pollution Control Plant, Great Neck Water Pollution Control District, Greater Atlantic Beach Water Reclamation District, and Oyster Bay Sewer District. See Table 1 below for permitted and actual flows, along with available capacities for each of the facilities currently in operation within Nassau County.

Table 1 Nassau County Treatment Facilities Flows[2]

Facility	Permitted Flow (MGD)	Actual Flow (MGD)	Available Capacity (MGD)
Bay Park	70.00	58.00	12.00
Cedar Creek	72.00	58.00	14.00
Glen Cove	5.50	2.70	2.80
Long Beach	7.50	4.60	2.90
Jones Beach	2.50	0.08	2.42
Port Washington	4.00	2.60	1.40
Belgrave	2.00	1.30	0.70
Great Neck	5.30	2.90	2.40
Atlantic Beach	1.50	0.80	0.70
Oyster Bay	1.80	1.10	0.70
Totals	172.10	132.08	40.02
		% Available Capacity	23%

Refer to Figure 2 for an overview map that illustrates the general location of the sewer coverage areas in Nassau County.

2 Excess capacity as indicated may not necessarily be available for new development, as some or all of that excess capacity may already be associated with existing parcels.

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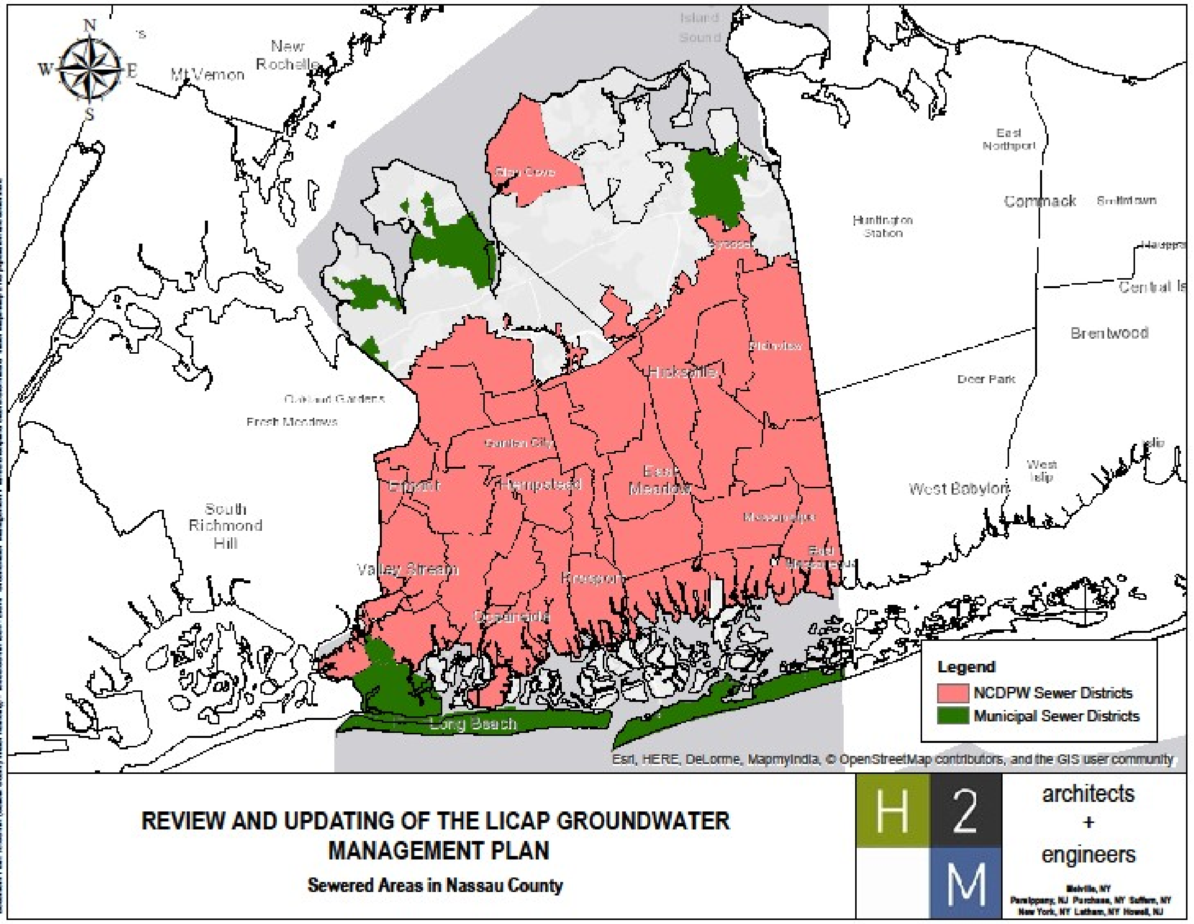


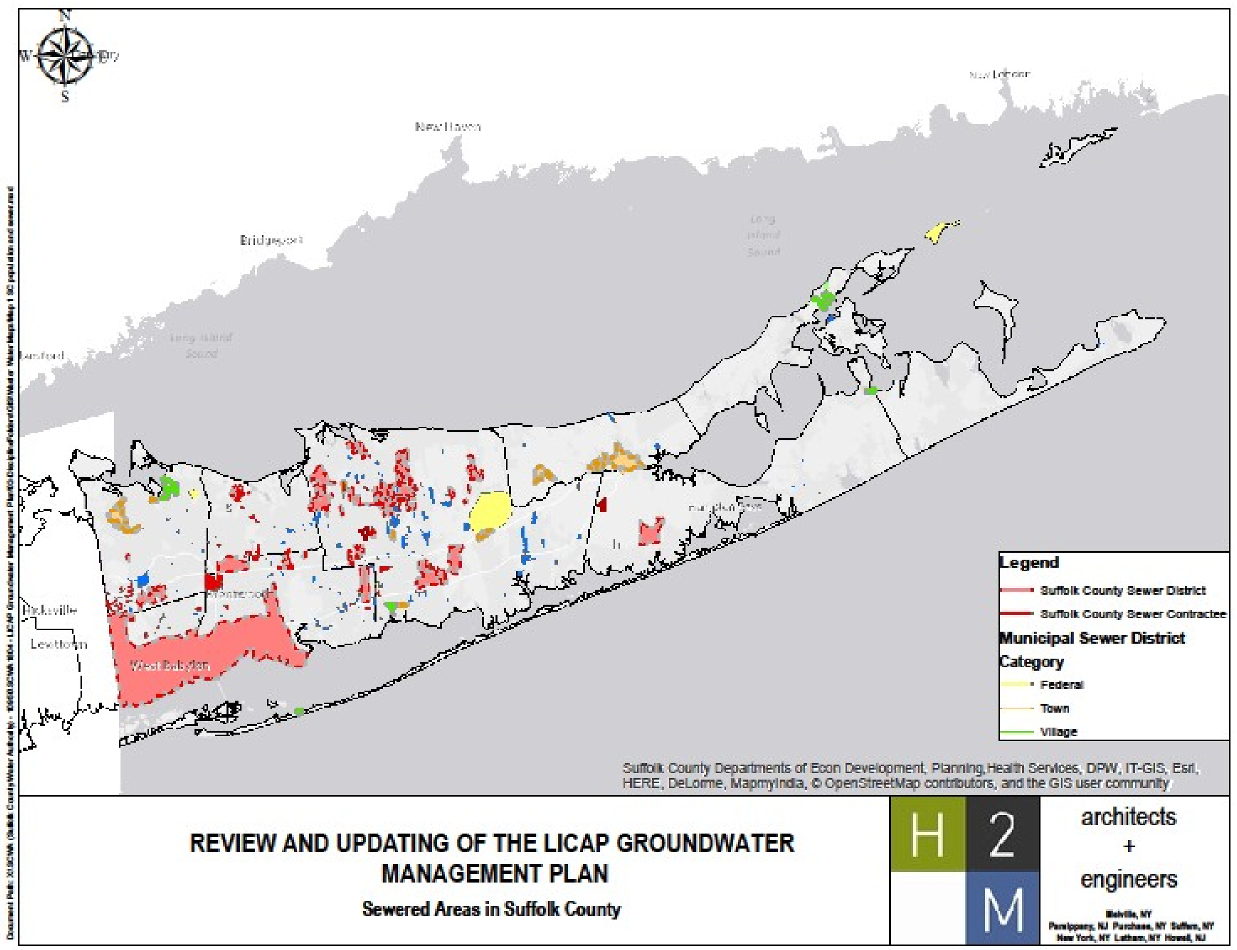
The wastewater treatment facilities summarized above discharge all treated effluent to surface waters surrounding Nassau County, totaling approximately 132 MGD of actual flow, with a permitted discharge equal to 172 MGD. This practice diverts this volume of potential recharge water from where it could help reduce water pumpage stress on the aquifer. The pumping stress is amplified during warm weather months when there is increased demand on the water supply wells, mainly due to residential/commercial irrigation and other non-potable uses (e.g. swimming pool make-up water, commercial HVAC cooling tower make-up water, etc.) that generally do not exert a demand on the water supply during cold weather months.

The remaining wastewater generated in Nassau County, approximately 5 MGD, is currently disposed via on-site wastewater disposal systems (consisting of septic tanks and/or cesspools), which provide no advanced levels of treatment and allow untreated wastewater to naturally attenuate through subsurface soils until it reaches the water table.

Existing Suffolk County Treatment Status

Suffolk County is essentially the inverse of Nassau County. Refer to Figure 3 for an overview map that illustrates the general location of the sewer coverage areas in Suffolk County.

Figure 3: Sewered Areas of Suffolk County



The existing wastewater infrastructure is comprised of facilities that are owned and operated by Federal, County, Town, Village, and private entities. Based on information obtained from Suffolk County Department of Public Works (SCDPW) last revised on September 24, 20123, there are four Federal facilities, 24 County districts, 9 Town districts, 5 Village systems and 153 private facilities. The total combined permit capacity for the Suffolk County wastewater facilities is approximately 58 MGD, with actual flows of approximately 47 MGD. Using the theoretical wastewater generated by Suffolk County at 150 MGD, this means that approximately 30% of Suffolk County is provided with wastewater collection, conveyance, and treatment infrastructure. 4 See Table 2 below for permitted flow, actual flow, and available capacities for each category of facilities currently in operation within Suffolk County.

3 Suffolk County Department of PublicWorks.Web. 3 April 2019. https://www.suffolkcountyny.gov/Departments/Economic-Development-and-Planning/Planning-and-Environment/Cartography-and-GIS/Sewered-Areas-and-Sewage-Treatment-Plants-Maps

4 Suffolk County estimates that in 2019 this number is closer to 26%.

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Table 2 Suffolk County Treatment Facilities Flow[5]

Facility	Permitted Flow (MGD)	Actual Flow (MGD)*	Available Capacity (MGD)
29 County Districts	42.72	31.60	11.12
4 Federal Facilities	2.80	2.80	0.00
9 Town Districts	1.65	1.65	0.00
5 Village Systems	2.65	2.65	0.00
153 Private Facilities	8.20	8.20	0.00
Totals	58.02	46.90	11.12
		% Available Capacity	19%

* Actual flow values used for Federal, Town, Village, and Private facilities are equal to permitted flow using the assumption that there is no available capacity.

Based on the same data set, 32.8 MGD, or approximately 67% of actual flow, discharges treated effluent to surface water. The remaining treated wastewater in Suffolk County (14.1 MGD) is recharged into the ground.

Performance of Existing Sewage Treatment Plants in Suffolk County

As of 2017, Suffolk County has 200 operational centralized and decentralized STPs, the vast majority of which are designed to remove nitrogen from the wastewater with typical effluent total nitrogen of 10 milligrams per liter (mg/L) or less. These types of plants are considered tertiary plants. The remaining 26 STPs are considered secondary plants, capable of reducing biochemical oxygen demand (BOD5) and suspended solids (SS). Of the 197 STPs, 15 discharge directly to surface waters. The 2017 average effluent total nitrogen for the tertiary plants in Suffolk County was 6.3 mg/L, which is less than the maximum allowed of 10 mg/L per State Pollution Discharge Elimination System (SPDES) permits.

The STPs in Suffolk County can be categorized as either centralized or decentralized. Centralized systems involve advanced processes that collect, convey, treat, and discharge large quantities of wastewater. Municipalities usually own the centralized STPs. There are 24 centralized STPs located in Suffolk County. Some of the major centralized sewer districts in the County include Bergen Point (Sewer District #3) and Selden (Sewer District #11), owned and operated by Suffolk County and the Town of Riverhead and Village of Patchogue STPs, which are operated by those municipalities. Bergen Point STP is the largest treatment plant in Suffolk County with an operating capacity of 30 MGD and has completed its expansion to 40 MGD with permit effective on July 22, 2019. Bergen Point STP is a secondary plant that discharges treated effluent two miles offshore into the Atlantic Ocean.

Recent Suffolk County Department of Health Services (SCDHS) actions facilitated STP upgrades and repairs, the reduction of nitrogen in STPs County-wide that has far surpassed regulatory requirements in many cases, and the overall compliance rate with New York State Department of Environmental Conservation (NYSDEC) effluent requirements is notable. Recent observations and trends included STP permit compliance improving significantly; overall tertiary STP compliance in 1990 was 35% and is now

93.7% (based on plants in steady state). This has translated into nitrogen reductions. Overall effluent Total Nitrogen (TN) for plants in steady state is down, from 9.9 mg/L in 2011 to 6.3 mg/L using data from all 175 tertiary plants in steady state in 2017 (6.6 mg/L if the seven non-steady State plants were included in the average). Nitrogen outputs from the 165 low risk tertiary plants now averages 5.5 mg/L.[6]

Recent Sewer System Expansion In Suffolk County

In 2014, Governor Andrew Cuomo announced that $383 million of funding would be made available to sewer communities along four river corridors, the Carlls River in Babylon; the Forge River in Mastic; the Patchogue River in Patchogue; and the Connetquot River in Great River, all of which are low-lying areas along Suffolk County's south shore that had been inundated by Superstorm Sandy. The leading goal of the project is to reduce nitrogen pollution to ground and surface waters to improve coastal resiliency against future storm events. These Suffolk County Coastal Resiliency Initiative (SCCRI) sewer extension projects are being funded through the Governor's Office of Storm Recovery's (GOSR) post-Sandy resiliency funding.

In January 2019, the Babylon, Mastic, and Great River projects went to ballot for public vote. As the Patchogue community was already served by a community sewer system, no vote was taken. The Babylon and Mastic projects were approved by 87% and 85%; while the Great River project, the smallest of the three, failed. Therefore, the two projects are being advanced as well as the Patchogue project. The funding earmarked for the Great River project was shifted to serve the Oakdale community, Great River's easterly neighbor. In addition, two other regional projects, the Ronkonkoma Hub extension and the Kings Park Business District, have received funding for design and/or construction.

The balance of the generated flow, approximately 103 MGD or 74% of estimated wastewater generated in Suffolk County, is handled via individual traditional on-site wastewater disposal systems that discharge wastewater directly back into the ground at each wastewater source location.

These on-site sewage disposal systems are either systems consisting of cesspools (also known as leaching pools) or a combination of a septic tank and leaching pool (conventional on-site sewage disposal system) and serve most residential and commercial buildings within the County.

Suffolk County estimates indicate that there are approximately 19,000 active commercial properties within the County using on-site sewage disposal systems. Some of these sites have multiple on-site sewage disposal systems serving the building(s) located on the parcel. Similar to residential sewage disposal systems, commercial on-site sewage disposal systems that comply with current standards consist of a precast septic tank for primary treatment and precast leaching pool(s). In 1984, standards were developed to address both the construction of such systems as well as the allowable sanitary flow permitted to be discharged from a commercial/industrial parcel. Therefore, there are many sites constructed prior to 1984 that may exceed the current density requirements of Article 6 and may use cesspools as a means of sewage disposal.

Recent On-Site Treatment System Developments in Nassau and Suffolk Counties

To address the need for advanced treatment while recognizing the inherent expense associated with such treatment, the Suffolk County Comprehensive

[5] Excess capacity as indicated may not necessarily be available for new development, as some or all of that excess capacity may already be associated with existing parcels.
[6] 2017 Suffolk County Sewerage Treatment Performance Report

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Water Resources Management Plan[7] established the first integrated framework to address the legacy problem from on-site wastewater disposal systems in an effective process including a detailed list of program objectives and recommendations. A fundamental basis for all wastewater management recommendations was the acknowledgment that the use of new Innovative/Alternative On-site Wastewater Treatment Systems (I/A OWTS) would be a critical component of any overall wastewater management strategy in Suffolk County.

To identify areas that might benefit most from I/A OWTS versus sewering and/or other mitigation measures, the Comp Water Plan recommended an integrated campaign to launch the use of I/A OWTS in Suffolk County. The integrated strategy began with two I/A OWTS demonstration programs to evaluate the performance of I/A OWTS in Suffolk County and to initiate creation and promotion of a local I/A OWTS market. Contemporaneously, the Suffolk County Legislature enacted Article 19 of the Suffolk County Sanitary Code in 2016, which permits the use of I/A OWTS in Suffolk County. In addition, it set forth the testing and approval requirements for new I/A OWTS; requirements for operation and maintenance (O&M) for I/A OWTS; establishment of a Responsible Management Entity (RME) to provide regulatory oversight of system design; installation, and long-term O&M of I/A OWTS; and annual reporting requirements.

Since the cost of sewering has become prohibitively expensive in most applications, it is expected that a vast majority of the 360,000 residents and businesses using systems that do not reduce nitrogen or other contaminants will opt for the relatively reasonable cost of I/A OWTS. As of September 2019, the typical cost for such a system at a site with no complicating factors is running at about $22,000-$25,000 with a pressurized shallow drainfield. An amendment in 2016 of Article 19 of the Suffolk County Sanitary Code authorizes the SCDHS to act as RME in the evaluation, approval, registration, and oversight of I/A OWTS installations.

In 2017, the Suffolk County Septic Improvement Program (SIP), was launched in New York State. The SIP promotes the use of I/A OWTS in Suffolk County and also acts as a pilot program for the eventual implementation of a larger county-wide phased septic upgrade program, should a recurring revenue source be established. Under the SIP, homeowners who decide to replace their cesspool or septic system with the new I/A OWTS may be eligible for combined grants of up to $30,000. Grants are disbursed through a combination of two funding sources. The Suffolk County portion of the funds is derived from the Suffolk County ¼% Drinking Water Protection Program for Environmental Protection (Fund 477). The County provides up to $20,000 in SIP funds per eligible parcel, including a base grant of $10,000 with a $5,000 incentive for low-to-moderate income property owners and an additional $5,000 for those homeowners who utilize Pressurized Shallow Drainfields (PSDs) following their I/A OWTS (PSDs allow shallow dispersal of treated effluent to enhance treatment).

The State portion of the funds are from the State Septic System Replacement Program (SSRP). In 2018, New York State announced the award of $10.025 million to Suffolk County from the New York State Septic Replacement Fund. The $10.025 million award represents the single largest disbursement – nearly 70 percent - of the $15 million made available statewide. The disbursement demonstrates New York State's commitment to and support of ongoing wastewater upgrade efforts in Suffolk County. The SSRP funds are available to residents in grants of up to $10,000 toward the purchase of an I/A OWTS.

[7] https://www.suffolkcountyny.gov/Departments/Health-Services/Environmental-Quality/Water-Resources/Comprehensive-Water- Resources-Management-Plan

Select individual Towns and Villages have also taken proactive measures to reduce nitrogen from (on-site disposal systems (OSDS) within their respective jurisdictions by setting forth local laws requiring the installation of I/A OWTS and/or by offering I/A OWTS rebate program using Community Preservation Funds (CPF). In 2018, the five East End towns, pursuant to a referendum, approved allocation of 20% of the CPF for rebate purposes.

Similarly, but on a much smaller scale, Nassau County was awarded $1 million from the State SSRP for the reimbursement of replacing property owners failing septic systems. The funds would be available for property owners in grants of up to $10,000 towards the installation of an I/A OWTS which reduces nitrogen concentrations in effluent by 30%. The program in Nassau County will be rolled out in 2020.

On-Site and Conventional Treatment Versus Water Quality Concerns

Existing on-site wastewater disposal systems are, at best, only partially treating wastewater and allow for nitrogen and other contaminants of concern to continue to impact surface and groundwater within both Counties. Suffolk County has commendably amended their Sanitary Code to allow for the installation of I/A OWTS to replace existing OSDS. The I/A OWTS is intended to reduce the nitrogen concentrations, compared to what would otherwise be discharged by a traditional on-site wastewater disposal system, into the ground. However, these systems do not address pharmaceuticals, personal care products, heavy metals, home cleaning agents, etc. While the I/A OWTS are not intended to allow for increased density, they are viewed as a cost-effective option when compared to providing advanced treatment to properties located in areas of the County where connection to central collection, conveyance and treatment infrastructure is not yet cost effective. The I/A OWTS program established by Suffolk County is a practice for Nassau County to consider in evaluating better on-site management of their water resources in the unsewered areas of the County. Importantly, traditional wastewater plants, with state-of-the-art technologies for advanced treatment do not currently focus on many of these contaminants either. Monitoring and evaluation of treatment impacts to water suppliers needs to be carefully assessed in concert with any decision to more expansively re-purpose the effluent from wastewater plants directly to the aquifer. Existing wastewater treatment facilities are not required, nor designed, to remove the same contaminants as drinking water treatment facilities. Therefore, discharge limits on wastewater facilities should be re-evaluated if groundwater recharge were to be implemented more broadly as a potential water resource recovery and reuse alternative, to promote improved quality of the local groundwater resources. In a very basic way, wastewater plants operating under current regulations would be discharging water with potential contaminants that receiving drinking water facilities would be required to treat (filter, air-strip, oxidize, etc.) for removal. It should also be noted that many of these contaminants are currently not directly regulated by the drinking water regulations. Requiring increased treatment of the wastewater facilities would essentially shift treatment costs for drinking water from the drinking water utility to the wastewater utility. Because, in the vast majority of cases on Long Island, there are different agencies or districts managing the two disparate enterprise goals, reconciliation of these costs would become an obvious issue needing resolution through appropriate policies. The New York State Department of Health (NYSDOH) and NYSDEC, while coordinated by the Governor's office on many planes, are somewhat autonomous of each other with regard to regulatory authority over the bifurcated responsibilities surrounding all aspects of water as a singular resource. The DOH is focused,

as it relates to water, with drinking water and its impacts on public health. DEC is focused, as it relates to wastewater, on public health and water quality of the oceans, streams, estuaries, lakes, etc. Reconciling authority on issues related to all aspects of water, could perhaps pave the way for the resolution of the challenges related to different regulations created for different intents.

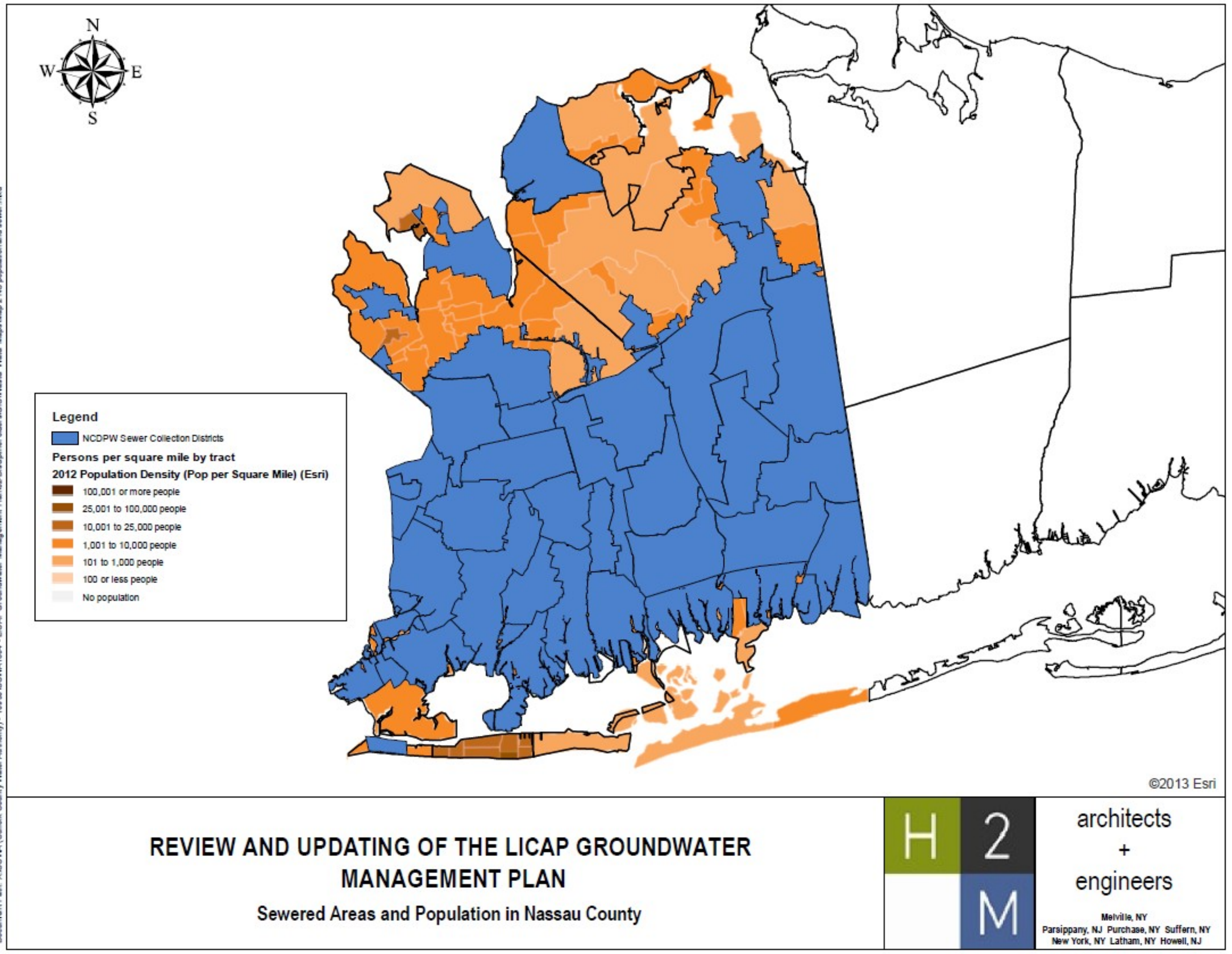
Concerns regarding sea level rise and associated increases in water table elevations, fall into two major categories. First, the likelihood of more frequent failures and second, the effects of untreated wastewater on the aquifer, as travel time between on-site disposal systems and the aquifer decrease.

Constrained manpower and financial resources required to keep pace with the large number of private facilities in Suffolk County has resulted in inconsistent effluent water quality oversight. Consolidation of facilities and/or districts in Suffolk County is one approach being considered to manage the effluent water quality. Reducing the number of facilities by converting existing treatment infrastructure into pump stations and interconnecting districts would reduce the total number of treatment facilities that need to be operated and maintained. However, initial capital improvement costs and limited land area for expansion are key factors that must be considered as part of the feasibility analysis that would be required as part of the planning process. In addition, the consolidation concept is viewed as a potential mechanism to reduce overall life cycle costs by providing larger scale treatment facilities, similar to what is in existence in Nassau County, that could be more effectively leveraged to support wastewater recovery, reuse, and potential recharge of treated wastewater back to the aquifer.

Potential for Additional Sewers on Long Island

Abandonment of existing on-site wastewater disposal systems and connection to collection, conveyance, and treatment infrastructure will remove direct point sources of nitrogen and other contaminants of concern from continuing to impact the water quality of the aquifer and related surface water bodies. By providing additional sewers and treatment facilities, the reduction of nitrogen and other contaminant discharges will allow for higher density districts and increase the potential for water reuse possibilities based on larger facilities with higher capacities and new designs which incorporate water resource recovery methods. In this section we discuss the approximate costs associated with providing additional collection, conveyance, and treatment to Nassau and Suffolk Counties.

The figures below show the existing sewering and population densities of each of the respective counties:



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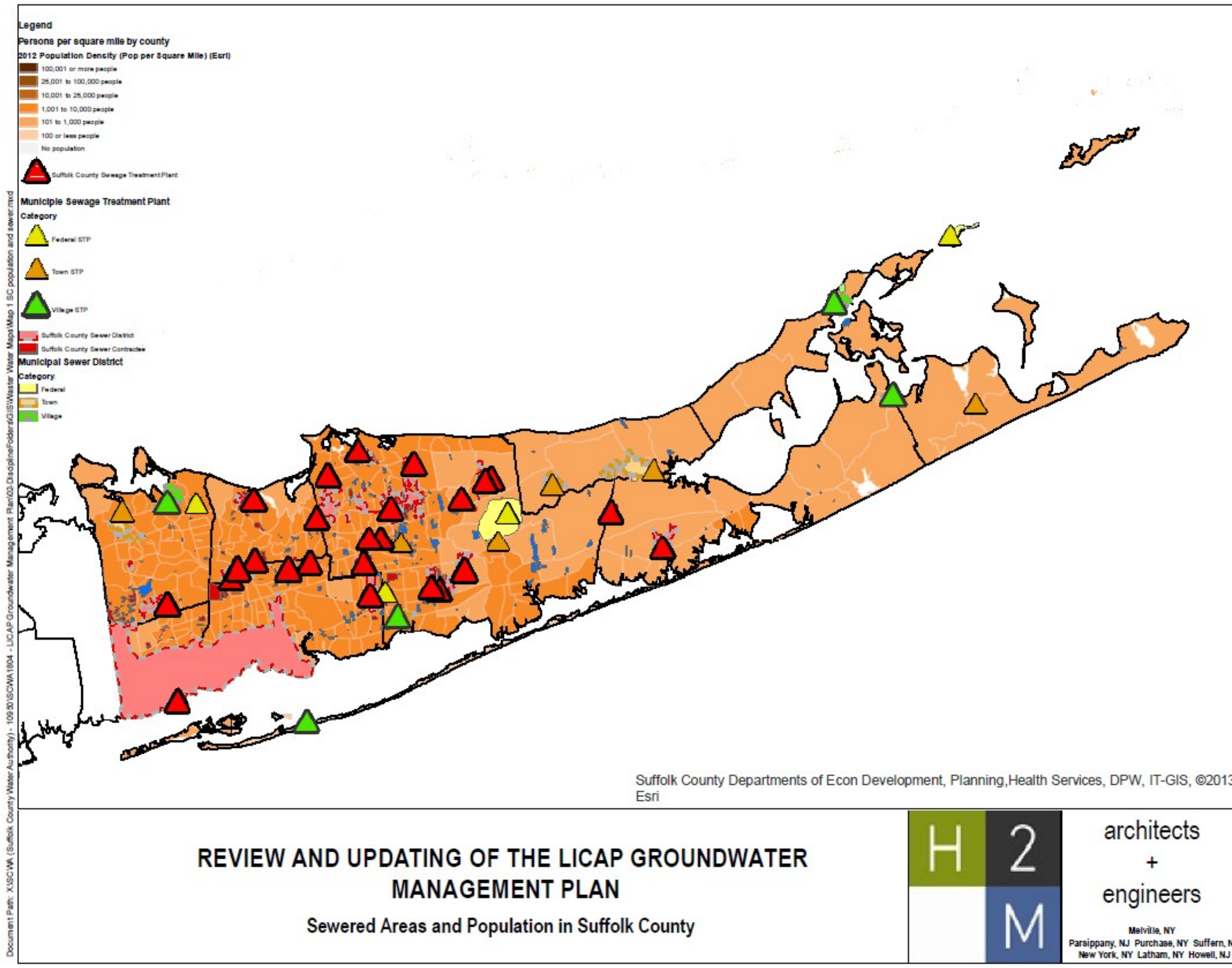

Costs:

Planning studies have been commissioned in both Nassau and Suffolk Counties to evaluate the feasibility of providing new sanitary infrastructure to parts of each County that are currently unsewered. These studies were spearheaded by each County's Department of Public Works (DPW). The analytical methods, including costs/benefits evaluation have been made available to varying levels of detail. For purposes of this report, the cost information identified in the Suffolk County DPW feasibility study to sewer portions of Mastic and Shirley has been used as the basis to distribute engineering design and construction costs consistently across the unsewered areas of both Counties. A $700 million project cost, which included engineering, soft and construction costs for collection, conveyance and treatment, was identified for approximately 9,900 properties across a seven square mile service area. The study further identified the breakdown in costs for conveyance to be 80% and treatment to be 20% of total costs. Extrapolating this data produces costs per parcel as shown in the table below:

Estimated Project Cost	Parcels Served	Cost/Parcel	Conveyance Component	Treatment Component
$700,000,000	9,900	$70,707	$56,566	$14,141

This cost breakdown is representative of the costs per parcel in the Mastic/Shirley area, which, for this discussion, is assumed to have a population density of 2800 capita per square mile. For analysis purposes a cost for overall treatment and conveyance of $71,000 and for conveyance only of $57,000 will be used, adjusted to the ratios of population densities in the distinct Counties. This approach presents a general macro level approach to identifying the order of magnitude of proposed costs. Utilizing this approach, rough estimates could be generated for more targeted areas dependent upon the specific population density of the focus area. So, for example, Nassau County's average population density is approximately 5,270 capita per square mile. Comparing the Nassau County unsewered areas to the Mastic/Shirley example would result in a factor of 2,800/5,270 or 0.531. Using this factor would suggest that the overall cost per parcel in an average unsewered area in Nassau County would be $37,630 per parcel ($71,000 x 0,531). Similarly, comparing against the average population density in Suffolk County of 1890 capita per square mile, you would arrive at a factor of 2,800/1,890 or 1.48. Extrapolating the Mastic/Shirley Cost to the Suffolk County average unsewered area yields a cost of $105,000 per parcel. ($71,000 x 1.48) The percentage allocation of 80/20 for conveyance and treatment would be viewed as remaining valid. These costs only do not account for the additional cost factors that would otherwise need to be considered for wastewater reuse. These additional costs are considered in greater detail below, but dependent upon location opportunity, they can range between 8-15% higher.

Nassau County recently conducted a sewer feasibility study within Hempstead Harbor communities such as Sea Cliff, Glenwood Landing, Glen Cove, Roslyn Harbor, Greenvale, Port Washington and Crescent Beach. Preliminary construction cost estimates were $670,000,000 to connect 5,606 properties which yields a cost of $120,000 per parcel. This estimate did not include soft costs such as legal, engineering, administrative, and financing.

It has been estimated, in a previous LICAP report,[8] that Nassau County has approximately 50,000 residential properties that currently discharge their wastewater to on-site wastewater disposal systems. Similarly, Suffolk County has approximately 360,000 residential properties discharging their wastewater to on-site wastewater disposal systems. For purposes of this report, it is assumed that each residential property discharging to an on-site wastewater disposal system is comprised of a single family residence and will generate approximately 300 gallons per day (gpd) of wastewater, based on the standard design criteria set forth by SCDHS and Nassau County Department of Public Works (NCDPW). Distributing this standard

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wastewater generation rate across the unsewered residential properties in Nassau and Suffolk County results in totals of 15 MGD and 108 MGD respectively. These wastewater generation rates and property counts will be used as the basis to estimate costs associated with collection, conveyance and treatment infrastructure as it pertains to the creation of new, consolidation of existing, and/or installation of I/A OWTS. These costs can serve as guides for assessment of necessary efforts to improve the water quality and quantity within Nassau and Suffolk Counties through better management practices focused on the recovery, reuse and potential recharge of wastewater. Note that these rates and volumes are theoretical values and while there is a minor differentiation between these values and actual recorded values at existing treatment facilities, they provide sufficient accuracy for the purpose of this analysis.

In Nassau County, there may be excess available capacity of approximately 38 MGD within the existing treatment facilities which in theory is enough to handle the expected 15 MGD from the 50,000 unsewered parcels. If we assume that collection and conveyance only is needed for the Nassau County unsewered areas for $$30,104 ($37,630 x 0.80) per parcel, this equates to a projected total for providing new sewers, as extensions of existing collection and conveyance systems, of $1.51 billion.

In Suffolk County there may be available capacity of approximately 11 MGD at the existing county facilities. Bergen Point in particular could offer perhaps the greatest opportunity for consolidation based strictly on available flow capacity of approximately 7 MGD. The larger single capacity would allow for the consolidation of a larger area to be served by this single facility. Assuming the entire existing available capacity were able to be utilized, approximately 37,000 parcels would be served at a cost of $84,000/parcel ($105,000 x 0.8), or $3.11 billion. The remaining 323,000 parcels, and 97 MGD, at approximately $105,000/parcel, would amount to an estimated $23.92 billion. In total this equates to an estimated $38.54.0 billion in total capital costs across both counties.;

New I/A OWTS are now available to replace traditional on-site wastewater disposal systems for individual properties to provide nitrogen/nutrient removal prior to groundwater recharge. It has been estimated by the Suffolk County Department of Health Services Reclaim Our Water Septic Improvement Program9 that the average cost for approved systems is approximately $19,200 per parcel which includes engineering and construction of a typical system where existing leaching structures are reused. Using this average cost per I/A OWTS on a typical property, this would result in approximately $960 million and $6.91 billion in today's dollars for Nassau and Suffolk Counties respectively, using the previous estimates of unsewered properties in each county. Use of I/A OWTS would improve nitrogen impacts from unsewered properties and require significantly less capital expenditure, but would not accomplish the higher level of treatment achieved even under current regulations, at conventional wastewater treatment plants. The difference in costs for the two approaches, total sewering versus exclusive use of IA/OWTS technology, would account for approximately $32 billion dollars. Consideration of how costs for additional treatment, at either a wastewater or drinking water facility, with regard to drinking water systems and the aquifer, which is the overall focus of the LICAP effort, should be analyzed in the context of overall cost benefit for the consumer/taxpayer.

[8] Dale, Dorian. Wastewater Management in Nassau and Suffolk Counties: Long Island Commission for Aquifer Protection, 2017. Web. 3 April 2019. http://liaquifercommission.com/images/Wastewater_Management_Report.pdf

[9] Suffolk County Department of Health Services Reclaim Our Water Septic Improvement Program.Web. 3 April 2019. https://reclaimourwater.info/SepticImprovementProgram.aspx

Other Considerations:

The potential negative environmental impacts of sewering existing areas center on the elimination of decentralized groundwater recharge, especially in Suffolk County, where it is more prevalent. These discharges, from on-site wastewater disposal systems, have historically contributed to the overall recharge rate accounted for in the water budget. Concentrating the recharge at a centralized treatment site could affect the gradients in the shallow aquifer such that the rate and transport of existing contaminants of concern in the aquifer could shift and result in worse long-term impacts to supply wells. Conversely, diverting treated wastewater more directly into surface waters, rather than recharging into groundwater, has continued to raise concerns with the existing water budget by its potential reduction of groundwater elevation.

During the design of new sewers and treatment systems, these two methods of treated wastewater disposal must be considered as there will be a trade-off between the effects on water quantity and water quality. Today's wastewater treatment facilities are not currently designed to remove the emerging contaminants of concern, personal care products or pharmaceuticals. Until considerations are made to remove or handle these contaminants, discharge or recharge locations may continue to show elevated levels of these substances. In summary, the issues clearly suggest comprehensive modeling associated with any planned capital sewer collections and treatment initiatives.

Sewage treatment facilities also place a large demand on existing electrical infrastructure which may or may not be able to handle the new loads. Considerations in new designs should include the use of solar and/or wind power for electricity and for collecting biogas for use in supplementing heat generation equipment. Another challenge for sewage treatment is siting, which requires extensive environmental review and impact considerations, including required setbacks from inhabited areas. These challenges are not easily overcome especially in areas that are already developed based on plans that did not consider the siting of wastewater infrastructure, such as the case in already developed and unsewered areas of Nassau County and Suffolk County. Coupled with the aging existing infrastructure the overall cost to maintain the systems will increase the operations and maintenance expense budget. Suffolk County continues to assess and evaluate opportunities to create strategy, districting concepts, funding alternatives, and feasibility of the best-case alternative mix of localized public treatment and enhanced private on-site treatment.

Water Reuse Opportunities

Water reuse possibilities, from greywater to full potable re-use (direct or indirect), have been utilized throughout the country and has been proven to be an effective measures for conservation of water supplies. There are opportunities for recycling water all over Long Island. In the case of re-use systems, the challenges that arise come in many forms, including public perception and education regarding proper practices for handling reuse water and ensuring that there is no potential for unsafe/illegal cross connections. The inexpensive nature of drinking water was too often a deterrent to consideration of these approaches, but with the increased treatment and operations costs associated with emerging contaminant regulations, the economic cost benefit gaps are closing and require careful consideration in planning analyses. The Long Island Nitrogen Action Plan initiated a workgroup in 2017 looking into water reuse, with focus on its nitrogen reduction potential and other secondary benefits, currently establishing acceptable bacterial limits for wastewater reuse at golf courses.

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Water Reuse Costs

Water recycling systems, similar to the wastewater treatment options previously discussed, can be restricted to individual on-site systems or be larger scale systems that serve multiple properties and/or regional area. An example of an individual on-site greywater recycling system would be secondary treatment including filtration and disinfection paired with collection piping and holding tank, pumping system and controls where distribution piping would be required to connect to the desired usage whether it is flushing water, cooling tower water or irrigation. A typical skid mounted system capable of up to 200 gpm could cost approximately $300,000 and would include the pumps, controls, UV disinfection and coarse/fine filters. This cost does not include the holding tank, collection piping or distribution piping. These additional costs would be defined based on the application and would be considerably less expensive on new construction as compared to outfitting an existing building which would require extensive demolition to retrofit the additional reuse plumbing appurtenances. Rain and stormwater can also be recycled using similar methods to greywater for similar applications. This is another alternative that can be considered when considering aquifer management to reduce demand exerted on the water supply by supplementing with other external sources. Large-scale/Regional reuse system costs must be considered in addition to the cost for wastewater treatment as current regulation stands. Enhanced levels of treatment, creation of supplemental reuse outfalls and distribution and conveyance systems for reuse water are all factors the need to be evaluated to determine economic impacts associated with any potential large-scale reuse opportunity. The 1.5 MGD Town of Riverhead Water Resource Recovery Facility (WRRF) is one example of a local reuse opportunity that has become a reality. The project was a retrofit of an existing 1.2 MGD Sequencing Batch Reactor including pre-treatment for the removal of inorganic material, an upgrade to the biological treatment process, a new effluent disinfection system and effluent reuse facility to meet the discharge permit, which had been modified to meet the total maximum daily load (TMDL) placed on the Peconic Estuary. The strict nitrogen discharge limit of this facility resulted in the necessity for effluent reuse. A secondary high strength ultraviolet disinfection vessel and two pumping systems were installed in a new effluent reuse facility building to transfer up to a total of 550,000 gallons per day of reuse water for make-up water at the WRRF (up to 100,000 gpd) and golf course irrigation (up to 450,000 gpd). The effluent reuse systems added approximately $2 million, resulting in a total construction cost of $23 million. The project saves up to 100 million gallons of aquifer withdrawals per year.

It should be mentioned that a unique factor of the Riverhead reuse project was that the golf course and the WRRF are direct neighbors sharing a fence between the two properties. A 1,200 linear foot (LF) horizontal directional drill was performed to install a new 10-inch diameter pipe to transfer the treated effluent to integrate with the existing irrigation supply piping. The proximity of both sites is noted as a major cost saving factor. Obviously, efforts to transport treated effluent water to facilities separated by greater distances will require both additional study and expense. To estimate the cost of distribution, a typical water main installation cost of $225 per foot can be used. This translates to approximately $1.2 million per mile, plus pumping and O/M costs, for a typical force main.

Photo 1 – Riverhead WRRF and Neighboring Indian Island Golf Course. The blue building in lower left contains reuse UV and pumping systems and the receiving building for golf course irrigation is located adjacent to the third fairway up from adjoining fence. Each building is approximately 1,200 LF from each other.

When reuse is desired, the economic benefits could be evaluated based on the costs of the reuse systems relative to the decrease in purchased potable/ground water. This would include capital costs for infrastructure and life cycle costs for the additional equipment operations (electricity) and maintenance (repairs and replacements) compared to the long-term water supply rates and projected usage.

Typical water costs on Long Island range from approximately $2/1,000 gallons in Suffolk County to upwards of $5/1,000 gallons in Nassau County. To use the Town of Riverhead example, their average water use for daily plant operations is approximately 100,000 gpd. At the current lower cost of water consumption, this is approximately $73,000/year. With the reuse system online, a 50 hp booster pump runs for 24 hours per day to maintain pressure within the on-site distribution piping. At an average of $0.17/kw-h, the cost to run the pump is approximately $55,000 for an annual savings of $18,000/year. This savings is coupled with up to 36.5 million gallons annually of groundwater that would not be removed from the aquifer to produce this demand by the Riverhead Water District. As water costs rise in Suffolk County, and with the

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higher costs already in Nassau County, this cost to benefit would likely increase and any payback period would decrease.

Potable Reuse – Indirect and Direct

Consideration of re-use systems involves establishing clear regulations for the use of treated wastewater, likely requiring improvements to current standards of treatment. Identifying wastewater treatment limits as it pertains to the emerging contaminants impacting the drinking water treatment industry, as well as re-imagining the water/wastewater treatment interrelation could optimize the volume of water drawn from the aquifer and create a cost effective, sustainable water resources management approach.

Currently, ground water recharge from treated wastewater is performed at or in proximity to the treatment facility. There are potential positive impacts of looking further into the concept of aquifer recharge by direct injection wells, considered indirect potable re-use. This is a method for providing strategic recharge in areas where quantity and/or quality of groundwater has been compromised. This practice requires extensive study of the hydrogeologic makeup of the receiving area. Injection wells must be carefully considered to minimize potential negative impacts based on over saturation, chemical/biological makeup of the injected vs. the receiving waters and the effect on the natural gradients of groundwater movement. This practice could be specifically directed at areas where emerging contaminants may be at elevated levels and it can be proven that treated wastewater does not contain such contaminants. All stakeholders, water suppliers, regulators and consumers would need to embrace this concept, practices used in places like Clearwater, Florida, and the State of Kansas. In the case of the latter, the Kansas Health Institute performed a 2017 health impact study to evaluate water reuse.

Direct Potable Reuse involves the treatment and distribution, as drinking water, of water without an environmental buffer. This is a concept that is being utilized in the more arid states and requires the wastewater treatment facilities to consider such a high level of treatment that the effluent can be piped directly to the drinking water facilities. On Long Island this alternative may seem impractical as it may make more sense to direct the cost of higher-level treatment capabilities to the drinking water facilities to manage the contaminants of the existing groundwater to meet the needs of the public supply.

Water recycling can be categorized by the different levels of treatment. At its simplest, water can be repurposed as greywater, when the water has been ‘gently’ used, such as the discharge from baths, sinks, washing machines or kitchen appliances. This water can potentially be reused for toilet flushing or other non-potable, non-contact usages. Underground drip irrigation systems in residential, industrial or commercial applications are feasible, but consideration must be given to contaminants such as phosphorus and 1,4 dioxane for example. Wastewater treatment facilities have historically reused the treated effluent for the purpose of supplementing the potable water supply for wash-water of various enclosed systems or makeup water for supplying chemicals into the wastewater treatment process. These practices are currently not mandatory and provide a potential legislative opportunity for increased conservation. For example, Riverhead Sewer District reuses 100,000 gallons of water per day for a 1 MGD treatment plant.

Nassau County constructed and unveiled a water re-use project at the Cedar Creek WPCP. In Wantagh in 2019. The project entails reusing screened effluent from the plant and provides additional treatment for solids removal and for high-level, multiple-barrier disinfection using chlorination and ultraviolet (UV) disinfection. The treated effluent replaces potable water which was used for processes, tank and equipment washing. This water re-use project will save 300 million gallons of potable water per year for an annual savings of $350,000 per year.

Photo 2 – Water re-use system and piping installed at the Cedar Creek Water Pollution Control Plant in Wantagh. The system saves 300 Million gallons of potable water per year for an annual savings of $350,000. The treated effluent is used at the plant for process, equipment and tank washing.

The concept of reusing wastewater effluent on Long Island, for applications with potential public contact was investigated by Nassau County in cooperation with the United States Geological Survey during the late 1960's through roughly 1984. Experiments with direct aquifer injection at the Bay Park STP were performed with mixed results while the East Meadow Brook Artificial Recharge Project returned over 840 million gallons of tertiary treated effluent in a 16 month period to the ground water reservoir through a series of recharge basins and injection wells. While demonstrating technical feasibility, the cost of tertiary treatment and operation of the facility were deemed prohibitive. Pilot studies performed by the Town of Riverhead/Riverhead Sewer District to take the treated water from their existing sequencing batch reactor (SBR) and providing additional treatment using membrane ultrafiltration and high strength ultraviolet disinfection, demonstrated that the health impacts of wastewater reuse for public irrigation, by way of sprinklers, can be considered negligible using currently available processes to provide the microbial and nutrient removals for public contact.

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There are precedents and standards from across the country, such as California, Arizona, and Florida, that are in place to govern the level of treatment required for each avenue to ensure that safety is the number one goal in every application. In 1992, the United States Environmental Protection Agency developed a technical document entitled "Guidelines for Water Reuse" which was updated in 2004 and 2012. These standards and precedents can be utilized by regulators in New York State, as well as the local agencies on Long Island, to provide the roadmap for major water consumers to work towards further sustainability and aquifer management. For example, in the case of irrigation, standards for subsurface drip irrigation systems with greywater are very different from sprinkler applications, where highly treated tertiary effluent, to remove pathogens, is required due to the potential health impacts associated with human contact. There are currently no specific regulations for greywater systems in Nassau or Suffolk County. In order to create the standards for public irrigation, the Town of Riverhead had to demonstrate they met levels of treatment identified by the Suffolk County Department of Health Services and the New York State Department of Environmental Conservation, which were compiled based on the strictest standards from the states of Florida, California and Arizona as well as from the United States Environmental Protection Agency. A similar path can be followed for creating local regulations for all types of water reuse opportunities in both Nassau and Suffolk Counties as currently being developed by a workgroup created under the Long Island Nitrogen Action Plan.

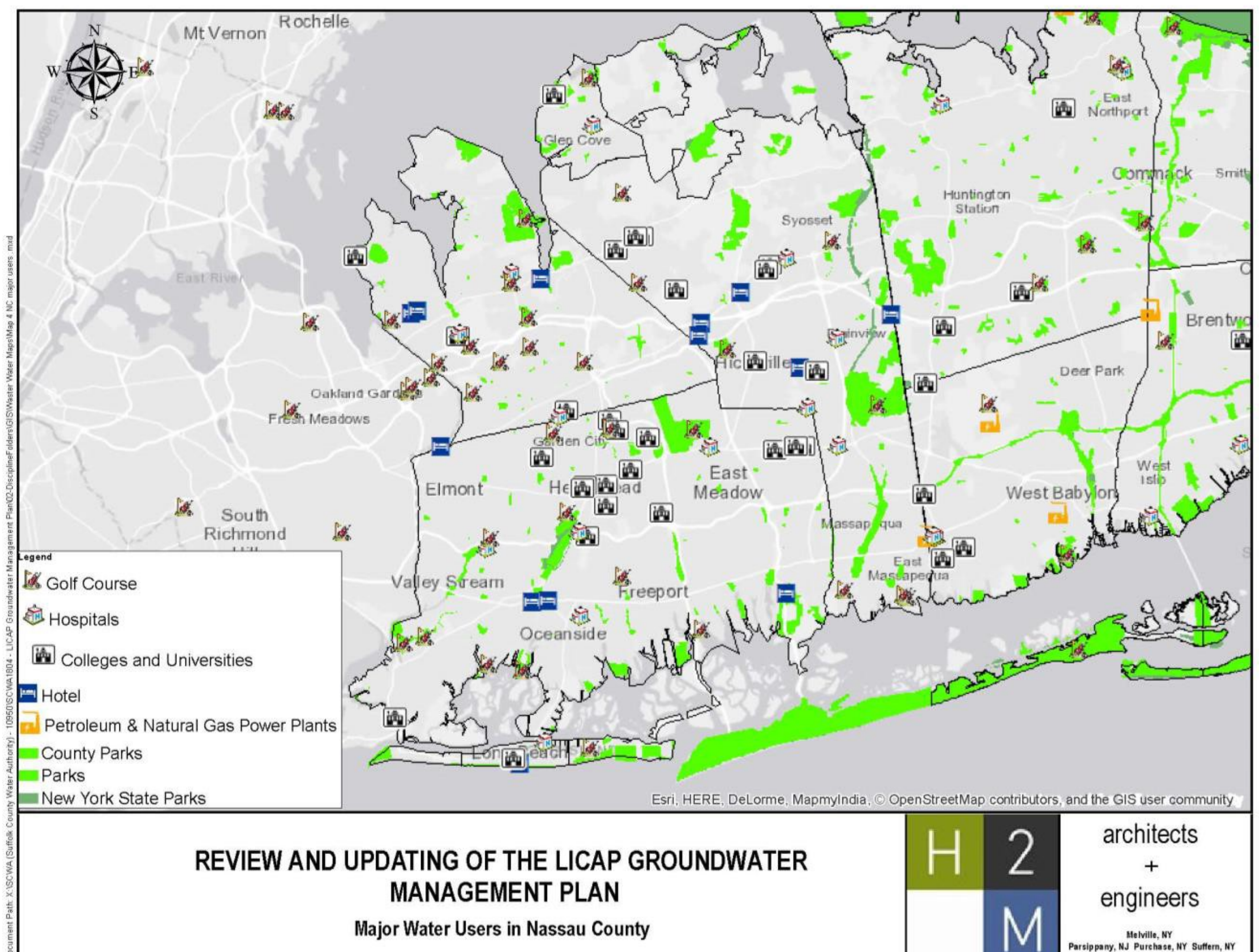
Irrigation

Today's new treatment facilities operate within the limits of technology to produce high quality effluent water which is either discharged to surface waters or recharged into the ground after meeting strict permit limitations for nutrient reduction. With these advancements, the potential for recycling/reusing the treated water to decrease aquifer demands for applications such as irrigation for public use, including green space and golf courses, is increasing with every new project. Long Island is home to many recreational parks and athletic fields, crop farms, wineries and sod farms. There are other alternatives being considered or practiced in some arid areas of the country for reusing treated wastewater for irrigation purposes. These practices generally involve groundwater discharges and avoid direct leaf contact. Appropriate environmental and health studies by the regulatory oversight authorities on Long Island would be required to establish safe practices, etc. before implementation.

A typical 18-hole golf course may use up to 300,000 gallons per day to irrigate all the tees, fairways and greens[10]. This operation is typically started in the early spring months and is completed in the late fall months. If we assume a duration of May 1 – November 16 (200 days) and a daily consumption of 300,000 gallons per day, the average golf course could potentially use up to approximately 60,000,000 gallons per year of either potable or private well water. It is assumed that the majority of the irrigation water for golf courses is produced by private wells and that this reuse option will not have a great effect on the water production industry based on the water not being provided by potable water supplies, but will have a marked impact on aquifer water supply by reducing the amount of groundwater extracted by the private irrigation wells.

A listing of golf courses on Long Island from *LongIslandGolfNews.com* lists thirty-one (31) 9-hole golf courses and one hundred two (102) 18-hole golf courses. With an average of 300,000 gallons per day per 18-hole golf course, this equates to approximately 35 MGD of irrigation water on any given day. For purposes of converting this consumption to a number that is transferable to other types of sites, it is assumed that an average golf course is approximately 65 acres which leads to approximately 4,600 gallons/acre. Using the previous assumptions of 137 MGD and 150 MGD, 287 MGD total, of potential generated wastewater in Nassau and Suffolk Counties respectively, the golf course irrigation demand across Long Island could potentially reuse approximately 12% of the theoretical 287 MGD of effluent generated should it all be collected and treated or 20% of the 178 MGD currently being treated by existing facilities.

When referring to the Town of Riverhead project, irrigation has become a proven method for safe reuse of their treated wastewater. The main purpose of this project is the preservation of the Peconic Estuary as the diversion of treated effluent reduces the nitrogen mass loading during the warmer months when the receiving waters are being used for recreational purposes. The secondary benefit is for reducing the demand on the groundwater supplies being utilized by the golf course by way of private wells. However, the

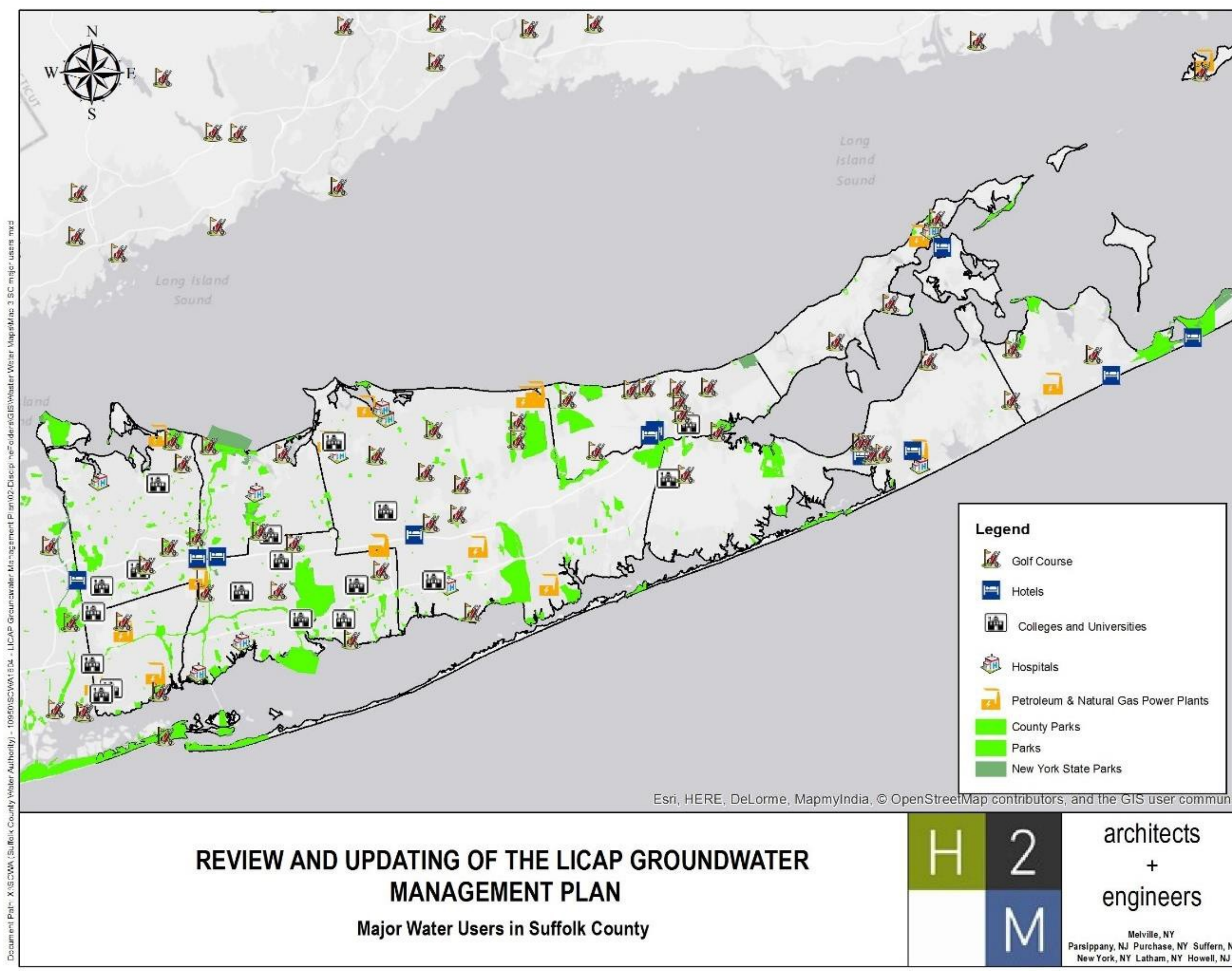


10 Flow data based on Town of Riverhead records of reuse water supplied to the Indian Island Country Club 18-hole golf course.

seasonal shift to the colder months drives the wastewater plant to dispose of the effluent by way of their original outfall or to look for alternative reuse options.

Commercial/Industrial/Institutional Opportunities for Consideration

Other large water users such as colleges/universities, commercial lots, hospitals, senior care centers, nurseries, industrial facilities or power plants could also benefit from water reuse programs to reduce the demand of potable water supplies for various portions of their daily usage. These types of facilities make up a majority of the top water consumers across Long Island. From an aquifer management standpoint, it would be prudent to evaluate each consumer for whether the discharged wastewater ultimately is recharged to the ground or lost to surface water discharges.



Some examples of the major water users (and what district they are connected to) and their annual usage and average daily usage are:

- Power Utility (Suffolk County Water Authority) – 234 million gallons per year (641,000 gpd)
- Industrial User (South Huntington Water District) – 37 million gallons per year (101,000 gpd)
- Commercial User (Plainview Water District) – 36 million gallons per year (98,600 gpd)
- Commercial User – Irrigation only (Riverhead Water District) – 11.85 million gallons per year (32,500 gpd)
- Laundromat (West Hempstead Water District) – 10.34 million gallons per year (28,300 gpd)
- Hospital (Bethpage Water District) – 9.7 million gallons per year (26,500 gpd)
- Car Wash (West Hempstead Water District) – 7.2 million gallons per year (19,700 gpd)

New facilities can be designed with greywater distribution systems and/or stormwater management systems for use as flushing water or subsurface drip irrigation to offset the potable water use demand. Systems are available for new construction as well as for retrofit of existing buildings. Industrial water users could potentially reuse treated or recycled water for water cooled systems. Examples of this would be power generation facilities such as National Grid and PSEG LI. Additionally, commercial applications such as laundromats and car washes can utilize water recycling as a method of conservation. An example of a current regulation is the Amendment in July 2007 to the Code of the Town of Huntington, Chapter 164-14-F-4 which requires any new car wash or laundromat facility to utilize water recycling systems or equipment which will reduce the water usage by a minimum of 75%.

New or updated residential developments in locations adjacent to or near wastewater facilities could be constructed with potable and water reuse distribution utilities such that a new home could utilize reuse water for seasonal irrigation and flush water for toilets. An example of this possibility would be enhancing the Calverton Sewer District in the Town of Riverhead to incorporate disinfection, storage and secondary reuse outfall to the proposed upgrade which will utilize a membrane biological reactor (MBR) treatment system and groundwater recharge. Although the current facility is permitted for 100,000 gallons per day, projected expansion within the sewer district could be a candidate for a 'purple pipe' network where properties within the district could tap into the reuse water system to reduce their demand on the water supply.

The discussion above is focused primarily on the water volume/recapture potential that may be available in each of the opportunity areas. Planning studies, which would consider any of these options, would need to evaluate the suitability of the re-used water to the actual sector under consideration. For example, how would a laundromat utilize re-use water effectively?

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Conclusion

The opportunities for water re-use on Long Island exist in significant numbers to have a meaningful impact on both the quality and quantity of groundwater drinking water supply. Increased treatment and operations costs associated with emerging contaminants, such as PFAS, PFOA and 1,4 dioxane, suggest that responsible water supply management would be required to consider re-use opportunities to the greatest extent possible. Regulations for re-use applications can leverage experiences from other states and municipalities but must be considered through the lens of what is appropriate for Long Island its sole source aquifer. They must also provide the greatest protection to public health. As more stringent drinking water regulations require more costly treatment alternatives, and as more stringent wastewater regulations create similar impacts and costs, the opportunity to envision a more holistic regulatory regime, one that more closely aligns the requirements of both sectors, becomes worthy of more serious considerations. Both the drinking and wastewater sectors should consider and evaluate the optimization of treatment requirements and consider the overall cost balance across both areas. Rate payers are responsible for both ends of the spectrum currently, so any efficiencies could realize overall rate relief for consumers.

Introduction

New York City delivers one billion gallons of potable water a day to nearly nine million residents of both New York City and upstate Counties from a reservoir system that routinely delivered two billion gallons of water per day a few decades ago. The Long Island Commission for Aquifer Protection (LICAP) conducted a precursory investigation of the potential for delivering water from the New York City system to Nassau County water suppliers. The following section identifies four opportunities that may merit further investigation.

This investigation does not imply that current solutions or needs exist. It simply delineates the engineering opportunities that are available on a "medium-range" forecast schedule, e.g. 10 to 20 years into the future. Beyond the technical issues addressed in this investigation, regulatory and public participation questions need to be addressed as well. The report highlights all three types of challenges, which include, among others:

- The locations and sizes of water mains required,
- Consideration of elevations and pressures
- Interconnection infrastructure,
- The impacts of introducing surface water into a groundwater water system,
- The delivery of fluoridated water to Nassau residents, who currently receive non-fluoridated water
- Corrosion control measures that would need to be implemented

Of equal importance to the above technical challenges is whether the citizens of Nassau County wish to receive some or all of their water from New York City's sources.

Consequently, additional detailed studies would need to be conducted to determine the feasibility of Nassau County water suppliers purchasing water from New York City. Of utmost importance would be guaranteeing that the Nassau supplies could rely and plan their operations to incorporate this infusion of water from the New York City system. Absent institutional measures and assurances, reliance on New York City would be difficult to justify, since the source could not be considered uninterruptible.

Background and Overview

Nassau County's western water suppliers bordering Queens County include New York American Water (Lynbrook District), The Water Authority of Western Nassau (WAWN), and the Manhasset/Lakeville Water District (MLWD). They are presented from south to north along the Queens County boundary of New York City. Each of the above systems have boundaries which either already have, or with proper study and infrastructure improvements could, provide interconnections with NYCDEP's water distribution system (predominantly surface water from their upstate supply system). The Water Authority of Great Neck North (WAGNN) presents opportunity as well, though water would have to move through the MLWD service area.

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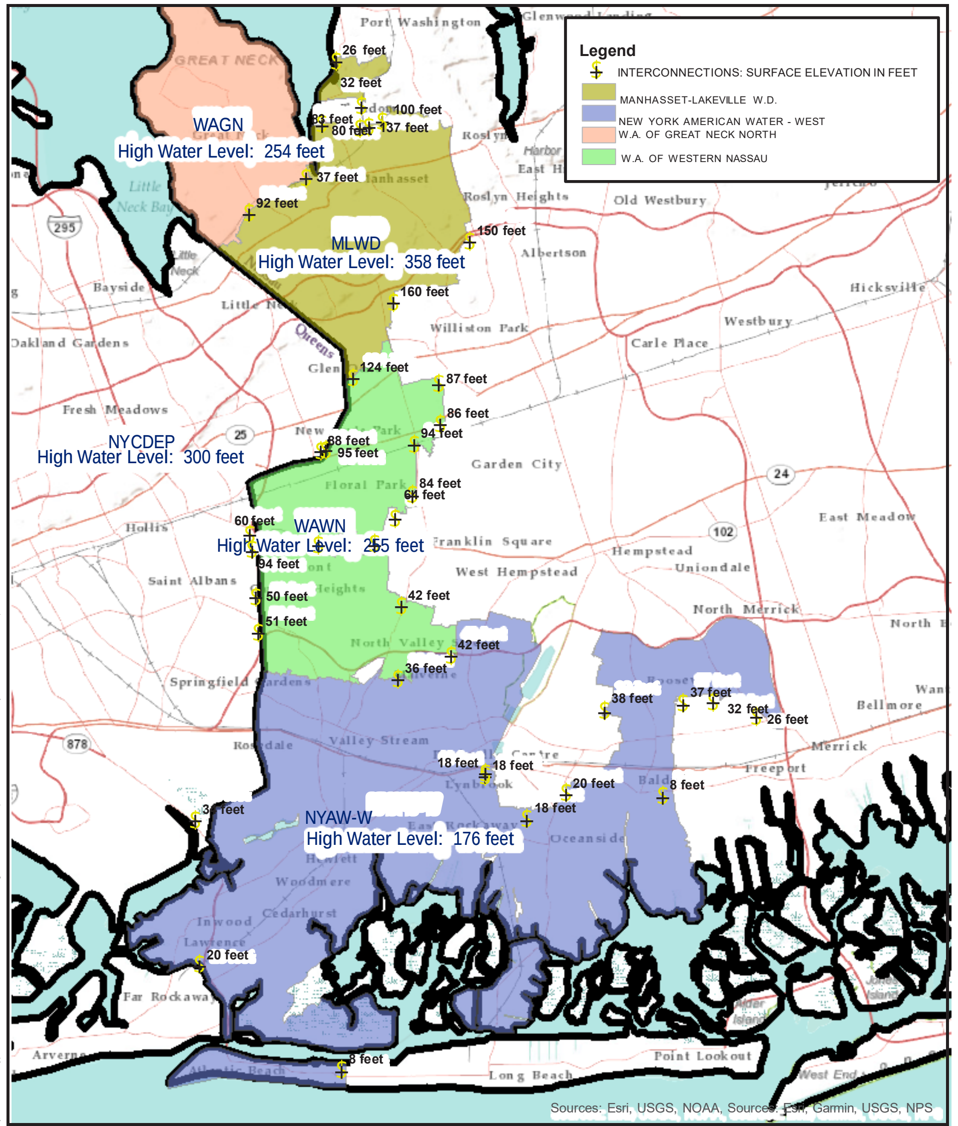

Figure 1
Western Nassau County Water Supplier
Interconnection Locations

H2M architects + engineers

Table 1 Average Daily and Average Annual Demands of Select Nassau County Systems

Supplier	Population Served	Average Daily(MG)	Peak Day(MG)	Total Annual(BG)
NY American Water	220,000	28.8*	46.8*	9.83
WAWN	120,000	10.9	18.3	3.99
MLWD	45,000	6.2	12.1	2.27
WAGN	32,400	4.1	8.0	1.49
Total	417,400	50.0	85.2	17.58

*Estimated

The average daily demand of the four systems is approximately 50 million gallons per day (MGD) (see Table 1). By comparison, NYCDEP serves an average of 1.0 billion gallons per day (BGD) to nearly nine million residents of both New York City and upstate Counties. The scale of the DEP system is in stark contrast to the Nassau County providers and, contingent upon a number of both regulatory and political issues, could provide tremendous opportunity for inter-municipal water sharing agreements.

Through significant focus on conservation and the implementation of universal metering, DEP has reduced the demands on its system, which is capable of delivering in excess of 2.0 BGD to the lowest average daily demands in decades. While assessment of overall transmission capability at potential connection points will require detailed assessment beyond the scope of this assignment, the general premise that flows up to the average daily demand of 50.0 MGD would likely not represent an overall challenge to the supply capabilities of the New York City system; and is reasonable, provided necessary infrastructure were put in place. It is presumed that adjustments to the DEP distribution system would be required at some level.

As improved groundwater modeling and testing provides greater insight into the potential challenges being faced by the Long Island providers, and particularly Nassau County, responsible planning would warrant careful consideration of all practical options, including interconnections with DEP. Importantly, given emerging, yet imminent increased regulatory requirements for Long Island suppliers and anticipated associated costs (capital and operational), the potential ability to partner with New York City on this issue is one that deserves a 360-degree comprehensive review, including prioritization of investments over time. However, it should also be understood that DEP would likely require inter- municipal partners to possess and maintain a separate supply to account for service in the event, either electively or on an emergency basis, DEP were forced to terminate service for any period of time. These are significant issues requiring planning discussions and clear expectations within any established agreement.

Any discussion about the potential to form an inter-municipal relationship with the New York City is best served by beginning with a basic history of the City system and its capabilities. In addition to New York City, DEP supplies water to more than 70 upstate communities and institutions in Ulster, Orange, Putnam, and Westchester counties that consume an average of 110 million total gallons of drinking water daily from New York City's water supply system.

"Water for the system is impounded in three upstate reservoir systems which include 19 reservoirs and three controlled lakes with a total storage capacity of approximately 580 billion gallons. The three water collection systems were designed and built with various interconnections to increase flexibility by permitting exchange of water from one to another. This feature mitigates localized droughts and takes advantage of excess water in any of the three watersheds. In comparison to other public water systems, the New York City system is both economical and flexible. Approximately 95% of the total water supply is delivered to the consumer by gravity. Only about 5% of the water is regularly pumped to maintain the desired pressure. As a result, operating costs are relatively insensitive to fluctuations in the cost of power. When drought conditions exist, additional pumping is required," (source: New York City Department of Environmental Protection).

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The significant takeaway is that DEP harnesses a tremendous stored reserve which was designed and is capable of delivering in excess of 2.0 BGD. The total additional average daily demand of all four Nassau County suppliers is a small fraction of DEP's capacity to deliver water.

More of the history of the New York City system can be found in great part on their website: https://www1.nyc.gov/html/dep/html/drinking_water/history.shtm

Over the years there have been many improvements, including the construction and commissioning of City Tunnel No. 3, which provides significant operational redundancy and security. It does not provide any additional supply. In 1996 New York City purchased the Queens Groundwater System (formerly Jamaica Water Supply; JWS), in South East Queens. In the years immediately following the takeover by the City, DEP committed tens of millions of dollars to improving distribution infrastructure, replacing and upsizing water mains, hydrants, valves, etc. From 1996 until 2000, the City operated the existing groundwater system at reduced levels, blended with the City's surface water supply to serve the constituents of South East Queens. In the walk up to unrealized calamities anticipated by the year 2000 computer clock concern, Y2K (a largely unrealized concern related to computer programming and date systems), New York City tested and implemented operations that provided 100% supply via the surface water system. In the ensuing years, due to water quality and economic considerations, utilization of the groundwater system was reduced further to the point of becoming a back-up supplemental supply. We understand that the Queens wells have not been utilized as a public supply source since approximately 2008.

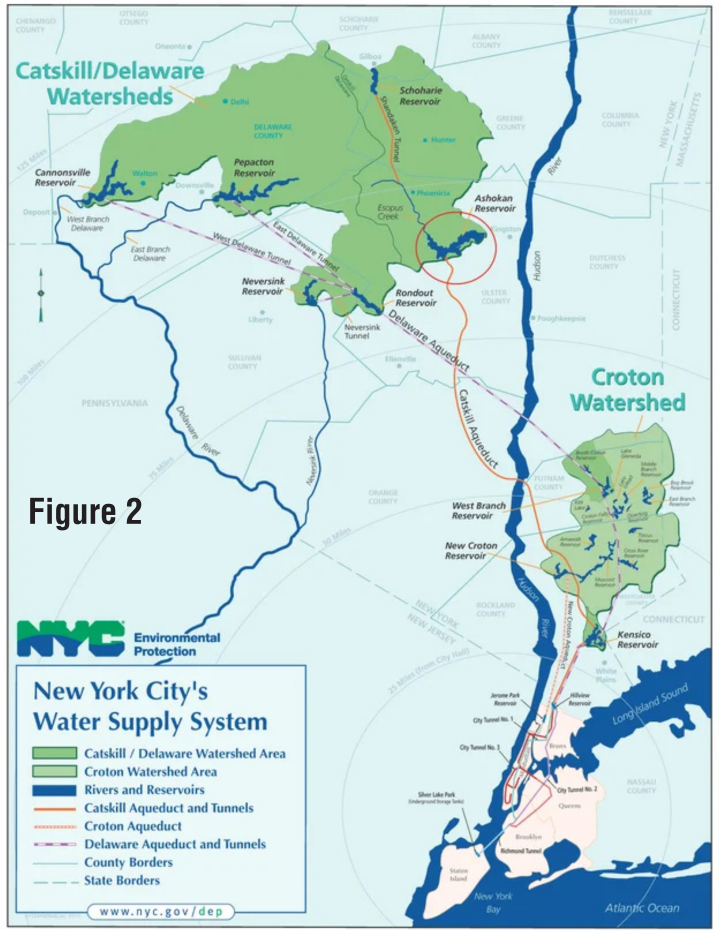

Figure 2

New York City is currently in the process of resolving a serious defect to the Delaware Aqueduct, which is leaking up to 35 MGD, between Roundout Reservoir and West Branch Reservoir on the east side of the Hudson River. Recent presentations by senior DEP engineers project shutdowns of the Aqueduct for repair beginning in 2022 and being completed by 2023. Beyond that horizon, New York City's capacity to support Nassau County would appear of tremendous potential value in consideration of groundwater shortages, water quality, and other impacts such as saltwater intrusion.

Feasibility Considerations for Inter-Municipal Connections

As stated in the previous section, the potential availability of excess water from New York City presents a number of opportunities to provide interconnections to each of the water suppliers along its eastern Queens border. Each individual supplier will be considered below, but attention and consideration should also be given to opportunities to enhance intra-Nassau County interconnections between individual suppliers, allowing greater flexibility and potentially increasing the ability of DEP to supply more average daily supply. These intra-Nassau County interconnection considerations are not part of this report, but are noted here for future consideration. Existing interconnections opportunities are indicated on the map in Figure 1.

New York American Water (NYAW)

All of the DEP service area adjacent to NYAW operates at, or has the potential to operate at, a higher hydraulic gradient then the NYAW system. DEP trunk water mains in the area operate at unregulated pressure under the influence of the nominal 300 foot elevation of Hillview Reservoir at the Bronx/Yonkers border. This suggests that the necessity for additional pumping would be unlikely given appropriately sized transmission mains in the NYAW service area. Interconnection opportunities with NYAW already exist in a number of locations, including a significant (believed to be 20 inch diameter) connection near Central Avenue and Doughty Boulevard at the Queens-Lawrence border. Existing agreements between DEP and NYAW are outdated and consideration of relatively minor additional metering considerations, along with regulatory approvals, present the potential obstacles to water sharing at this location.

The Queens/Nassau boundary traverses a winding path as Rockaway Boulevard passes behind Kennedy Airport becoming Rockaway Turnpike and intersects with the Nassau Expressway as it moves towards Atlantic Beach. DEP operates a 48 inch diameter trunk main that follows along this general path, passing Meadowmere, crossing into Five Towns, through parts of Inwood, and terminating in Lawrence around Broadway and the Nassau County Expressway.

This main is believed to be able to provide additional capacity of up to 10 MGD. This value would need to be validated by DEP during a planning or study phase of consideration. It currently terminates approximately 1.7 miles north of Park Street in Atlantic Beach. Contemplating potential supply to the City of Long Beach for example would entail extending a transmission main across Reynolds Channel to this point. It would then be 1.5 miles across Atlantic Beach to the border of The City of Long Beach, where concerns regarding future saltwater intrusion into its supply are noted. While more detailed analysis would be required to create an optimized design and cost, it is reasonable to consider that a connection from the DEP trunk main to a theoretical point on Park Street in Atlantic Beach with a 20 inch main, including the channel crossing, would entail a capital cost on the order of $3 million - $5 million. From that point, construction of a 16 inch main for the 1.5 mile distance through Atlantic Beach to the Long Beach boundary would potentially cost another $3 million - $4 million.

We understand that DEP continues the build out of its trunk water main system east along the Rockway Peninsula, with plans to complete a loop with its trunk water main system crossing under Jamaica Bay from

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Broad Channel's Cross Bay Boulevard. Upon completion of the construction of the final stages of the trunk water main loop, the DEP system in the area south of the Belt Parkway through Nassau County and into the eastern Rockaway Peninsula will be robust. Both existing and future possibilities along this corridor are significant potentials for additional interconnections.

Additional opportunity lay along Sunrise Highway at the borderline between Queens and Nassau in Valley Stream near the Green Acres Mall. DEP operates a 48 inch diameter trunk main that terminates at the Queens border and would provide an excellent opportunity for interconnection, which in this case would potentially prove mutually beneficial by improving water age for DEP. Estimated supply capability is approximately 5.0 MGD. From the NYAW perspective, the interconnection could provide valuable back-up or redundant supply, even potentially mitigate some planned capital treatment investments; while for DEP, creating demand at the end of this large main would potentially improve overall water quality in the New York City system in this area.

Finally, moving north along Hook Creek Boulevard, opportunity exists for interconnections between DEP, NYAW, and WAWN as all three providers exist in close proximity to each other near the intersection of 129th Avenue and Hook Creek Boulevard, Queens and Cumberland Place and Ocean Avenue, Nassau County. There are also opportunities for either Nassau County suppliers to enter discussions about the potential utilization of DEP well station 36 at this location, which is not currently being utilized by DEP for supply. There are a number of potential opportunities and agreement scenarios that exist here and could allow for the use of what is considered to be a good quality, serviceable well station. Assessment of this well station in the context of the emerging contaminants facing the Nassau County suppliers would have to, if not done so already, be performed, and the potential for any associated treatment investments weighed in conjunction with this assessment.

Potential Interconnection - Nassau Expressway, Lawrence

Potential Interconnection - Sunrise Highway at NYC/Nassau County Boundry

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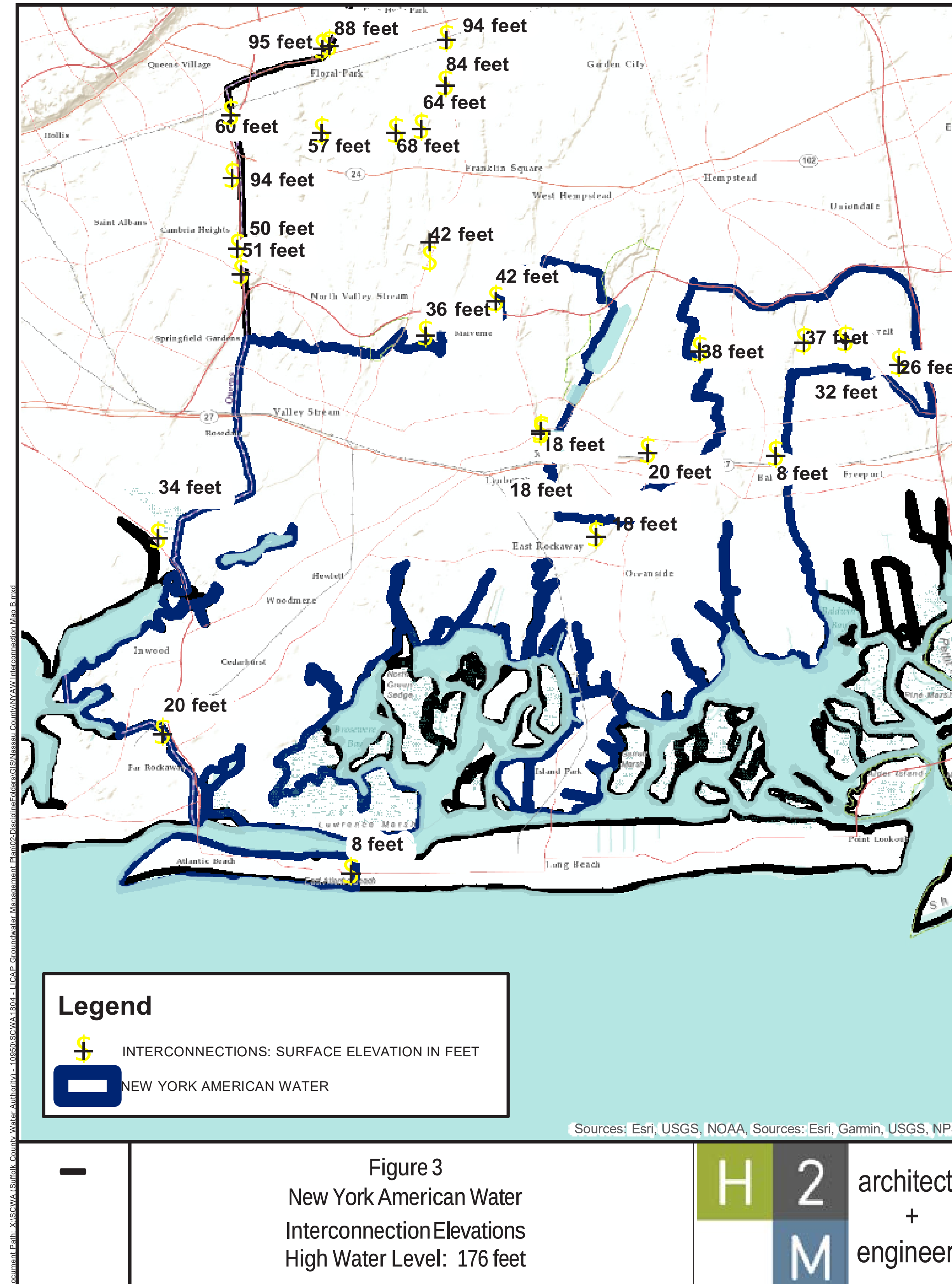

Figure 3
New York American Water
Interconnection Elevations
High Water Level: 176 feet

Water Authority of Western Nassau (WAWN)

There are a number of opportunities for interconnections in the vicinity of 129th Avenue and Hook Creek Boulevard, Queens and Cumberland Pl and Ocean Avenue, Nassau as described above. Additionally, there is opportunity for interconnections or inter-municipal water sharing associated with the existing DEP well station 36. Both DEP and WAWN maintain distribution piping in Hook Creek Boulevard/Ocean Avenue. From an infrastructure standpoint metering vaults and control valves would be required to establish an interconnect. While it would appear to be of significant potential in terms of infrastructure upgrades, the yield in terms of supply would likely be on the order of 3-4 MGD for an 8 inch interconnection with a modest pressure differential. While small for the DEP system, this amount of additional supply would be viewed as significant for any Nassau County supplier, approximating the equivalent of several supply wells. A proper assessment of the ability of the Nassau County suppliers to transport any additional supply throughout their service areas would necessarily have to be weighed to determine cost/benefit.

Similar interconnection opportunities exist along the Cross Island Parkway corridor borders between Cambria Heights/Queens Village and Elmont, Queens Village, and Floral Park, Nassau County and along Jamaica Avenue boundaries between Bellerose and Floral Park Queens and Floral Park, Nassau County (see Figure 4).

Additional opportunities, at larger scale exist along Hillside Avenue near the borders of Glen Oaks/Bellerose Manor and New Hyde Park, Nassau County. WAWN operates an elevated storage tank at an overflow elevation 255 feet above mean sea level (MSL), compared to New York City's Hillview Reservoir nominal operating elevation of 300 feet above MSL. This represents a 45 foot elevation difference between the WAWN tank and DEP's Hillview reservoir. A more rigorous hydraulic analysis, not considered as part of this task, would need to be considered to present a more thorough assessment of any potential need for booster pumping or pressure regulation of any degree. Aside from that potential, interconnection valving, metering pits, and telemetry equipment for both municipalities would be required to allow for water sharing.

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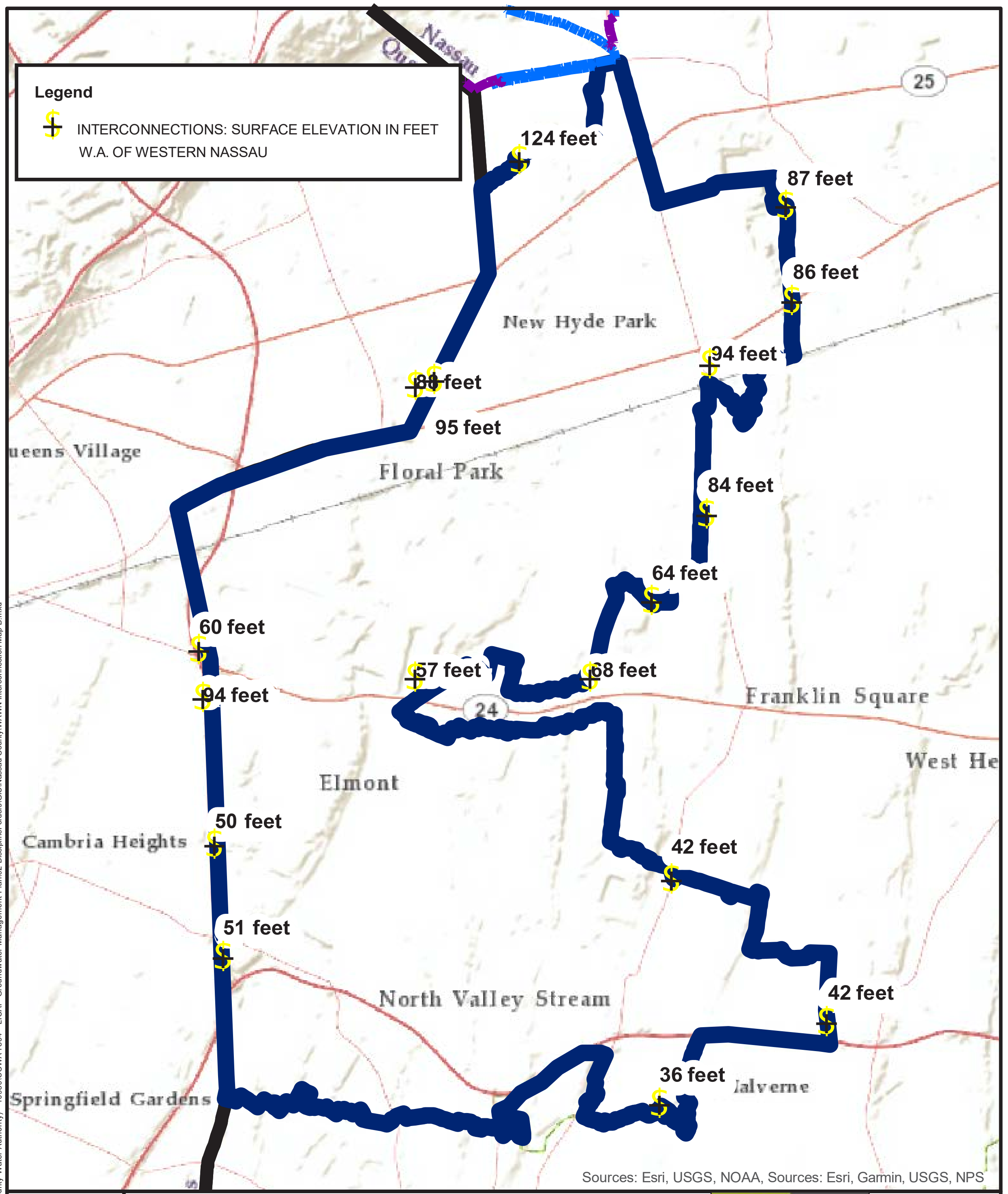

Figure 4
Water Authority of Western Nassau
Interconnection Elevations
High Water Level: 255 feet

H2M architects + engineers

Manhasset/Lakeville Water District (MLWD)

Similar to WAWN, there are some clear opportunities for direct connections to the DEP system, but as the topography changes and elevations rise in both Nassau and Queens, more hydraulic analysis is warranted. However, preliminary assessment of select locations suggest viable alternatives. It is believed that DEP operates a 20 inch diameter main along Northern Boulevard. Extending a 12 inch main, for example, from Glenwood Street at the Queens line to Merrivale Rd, in Great Neck, could manage up to 3.0 MGD of additional supply efficiently if available from DEP. Moreover, replacing the section from Greenwood Street to Lakeville Road with a 16 inch or larger main could present yet greater opportunity. It would provide a strong loop into the existing MLWD transmission mains already in Lakeville Road, but as importantly, with additional supply and stronger transmission capability MLWD would be better positioned to potentially share additional supply with WAGNN. These two scenarios would represent capital expenditures on the order of $2 million-$4 million plus engineering, planning, and permitting efforts.

Another connection point of consideration for MLWD is along Union Turnpike near the Queens/New Hyde Park border. DEP operates its distribution system, comprised of 12 inch and 20 inch mains in this area, at a gradient of approximately 210 feet. This would appear to present opportunity in much of the MLWD service areas except the highest elevations. The MLWD system has a transmission corridor along Lakeville Road, with mains of 16 inch, or in some cases larger diameter pipes. Hydraulic modeling could be performed to consider the value of a capital improvement to replace 10 inch diameter mains with 16 inch or larger diameter mains for approximately 3,000 feet from Union Turnpike to Marcus Avenue along Lakeville Road. At a budgetary estimate of $350/linear feet (LF), this would represent an investment of approximately $1 million, but would substantially increase the delivery capacity from a theoretical DEP connection at Union Turnpike. The additional demand on the DEP system would similarly warrant analysis to ensure that head losses remain acceptable with any projected flows. This could be independent or coupled with additional connections along Northern Boulevard. The cost benefit of this investment would be largely dependent upon the degree to which it might be utilized. Essentially, how much water would MLWD, or other Nassau County providers who could benefit, consider using, and how much would DEP reliably commit to supplying, understanding all the agreements, and other drivers. The value of such a redundancy or sharing agreement would appear greatly enhanced if the more southern supply wells became impacted by emerging contaminants or other problems.

The MLWD distribution system south of Union Turnpike, adjacent to the DEP system, contains distribution assets of 12 inch diameter or larger. This provides opportunity from a hydraulic perspective; however, more in-depth analysis of the demands here are needed, to assess the value of the connection. Initially this connection appears less significant for this area.

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LICAP
Long Island Commission for Aquifer Protection

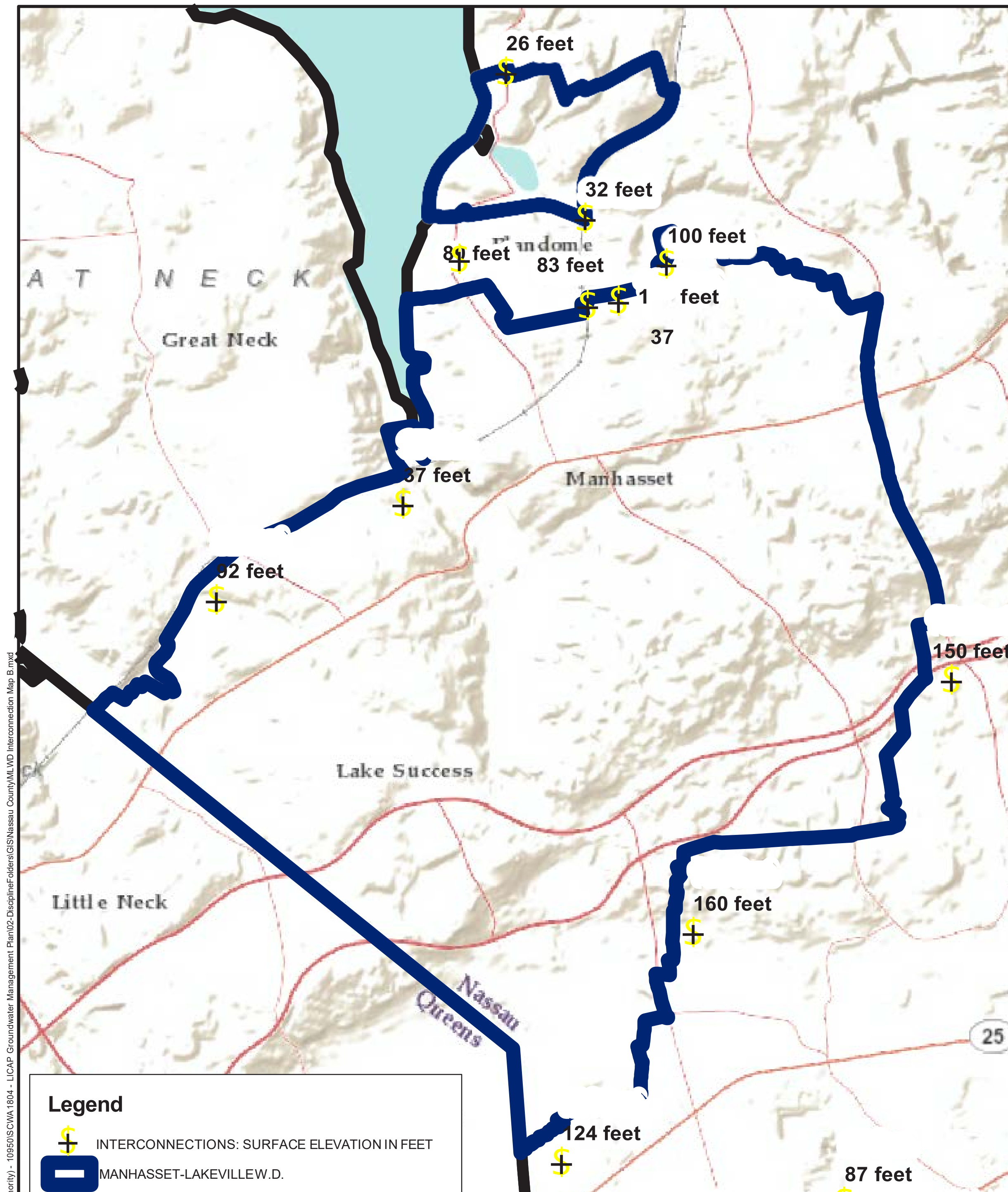

Figure 5
Manhasset Lakeville Water District
Interconnection Elevations
High Water Level: 358 feet

Sources: Esri, USGS, NOAA, Garmin, USGS, NPS

H2M architects + engineers

Water Authority of Great Neck North (WAGNN)

While there are no direct interconnection locations between the DEP system and the WAGNN, it is feasible to envision a cooperative approach with the MLWD as described above, or an independent initiative that is structured similar to the approach laid out for MLWD along Northern Blvd. From a practical and economic standpoint, collaboration with the MLWD on an initiative would seem to provide the most overall value. There would be a need to assess metering arrangements between the two water suppliers, as there would obviously need to be done with NYCDEP, but these costs would be fractional incremental expenses from the more macro level consideration of the long-term value of potentially having access to an alternate supply.

Consideration of Potential Costs

The discussion above presents an overall view of the feasibility of the potential for western Nassau County water suppliers to consider inter-municipal supply connections with the NYCDEP. The concept at some levels is basic, but in order to make judgments beyond the macro level planning viewpoint, far more detailed engineering and water quality analysis would need to be provided. Either a comprehensive hydraulic modeling effort for the several suppliers or a series of discrete sub-models for individual suppliers would provide great utility. Considering the overall opportunity, the argument for a comprehensive modeling effort would be compelling. Beyond the immediate direct interconnections, the prospects for neighboring suppliers, east of the four districts mentioned above, to share additional supply would appear to offer great opportunities. When further consideration is given to issues like the impact of emerging contaminants and over stressed demands on existing well supplies, regional water sharing conceptually suggests significant merit.

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Figure 6
Water Authority of Great Neck North
Interconnection Elevations
High Water Level: 254 feet

H2M architects + engineers

In several areas discussed above, budgetary values provide an order of magnitude cost for select conceptualized water main installations. Presented below is a planning level view of the Potential supply capacities of theoretical connections based on size and pressure differentials. Further, we provide typical schematics and estimates for potential infrastructure improvements that would typically be required, such as bi-directional metering pits of various sizes, connection costs and a typical booster pump station should one be necessary. Coupled with specific water main installations or upgrades, a budgetary costing could be assembled for any or all connection opportunities (see Table 2). Planning and permitting costs would also need to be considered. In addition to capital improvement costs, operation and maintenance costs (O&M) and the cost of purchasing water from New York City would have be built into the cost benefit analysis. Assuming that the O&M costs are minor additions to existing Nassau County distribution O&M costs, the budgetary cost of water purchasing should be considered. New York City currently provides bulk water to upstate communities at a rate of $1.73 per 1,000 gallons, and provides in-city customers with water at a rate of $5.21 per 1,000 gallons. The in-city customers are receiving water that benefits from all the in-city treatment and capital investments. It is important to ensure any analysis in this areas considers “apples to apples” scenarios.

By contrast, western Nassau County suppliers have rates that range from $2.64 per 1,000 gallons to $6.47 for the same volume. A more in-depth cost evaluation than what is presented here should be performed to ensure that the assessments are comparable and inclusive of consistent variables effecting overall cost.

Table 2 Select Interconnection Capital Cost Estimates

Interconnection Type	Vault Size	Power Required	Construction Cost
2-Way	11’ x 8’	no	$175,000
1-Way w/ Booster	11’ x 8’	yes	$250,000
WM extension/LF	12”	No	$300.00
WM extension/LF	20”	No	$350.00

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Interconnection Capacity

The potential capacities of individual interconnections can be estimated using a method developed by Hardman and Cheremisinoff (1), with modifications by H2M (2) (see Table 3). The equations used is:

$$Q = 0.0215 \left[\frac{\Delta P \, D^{5.33}}{D^{1.33} + 0.285\, L} \right]^{0.5}$$

Where

Q = flow through interconnection in cfs

ΔP = pressure differential across the interconnection in psi

D = inside pipe diameter in inches

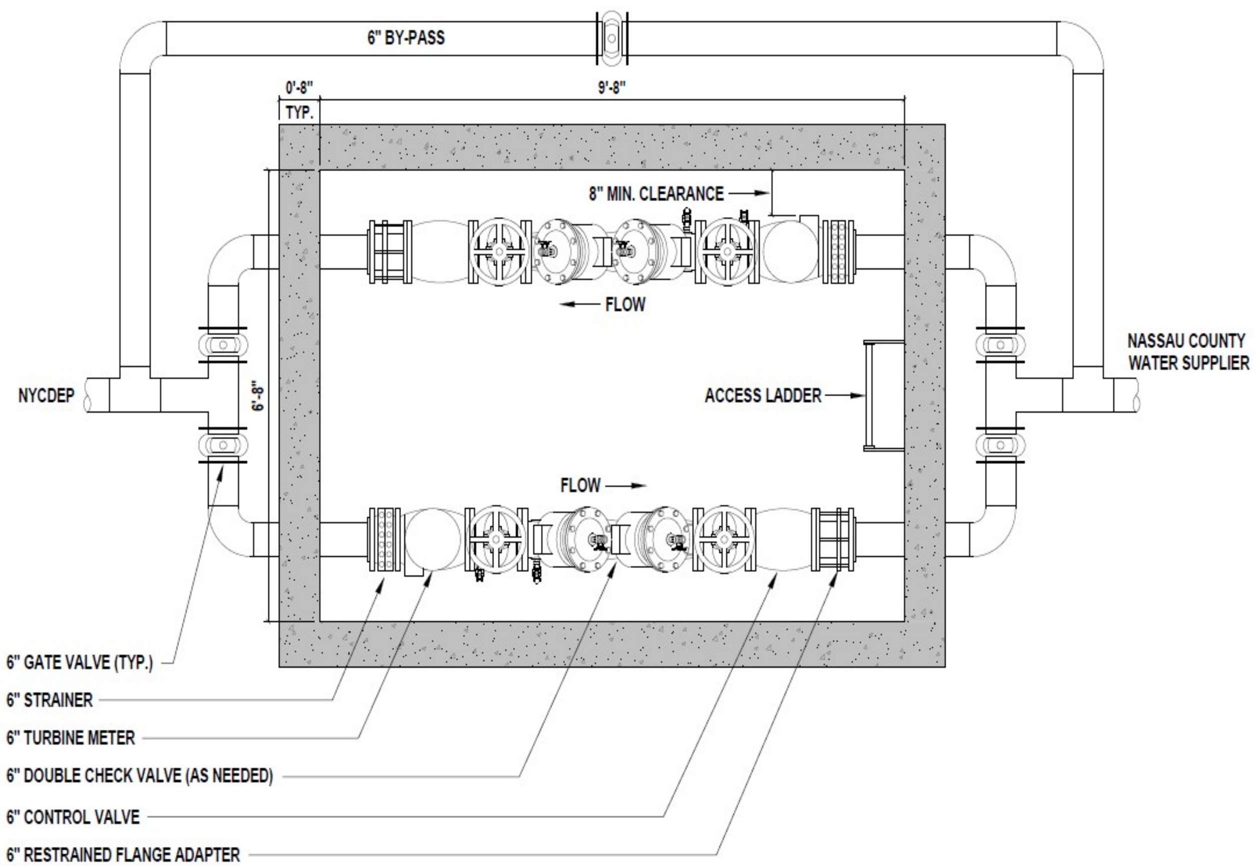
L = length of interconnection in feet, but not less than a minimum value of 100

(1) Hardman, J.L. and P.N. Cheremisinoff. “Determining the Utility Value of Water-Supply Interconnections, Part I, II and III.” Water and Sewage Works, December 1978, January 1979 and February 1979.
(2) Holzmacher, McLendon and Murrell, P.C. “Master Water Plan - Nassau County, State of New York.” September 1980.

Table 3 Potential Capacity at an Interconnection with Respect to Main Size and Pressure Differential

Main Size [inches]	Pressure Differential [psi]	Flow [gpm]
6	5	40
6	10	577
8	5	826
8	10	1168
10	5	1413
10	10	1998
12	5	2172
12	10	3072

These values represent theoretical estimates. More refined analysis, with the input of NYCDEP’s engineering staff, to determine feasibility and identify any flow limitations would be necessary as part of a deeper study.



Typical 2-Way Interconnection Vault Plan

Discussion of Potential Water Quality and Hydrological Impacts

The final area of high-level consideration for this assessment will touch on potential pros and cons of issues surrounding water quality and hydrology. Starting with the issue of water quality, overall compliance implications should be foremost in the evaluation. The experience of NYCDEP after the takeover of the former JWS provides valuable insight. Upon assuming responsibility for the JWS service area in 1996, NYCDEP increasingly provided blended water from its surface water system to the existing groundwater service area. Overall, compliance issues presented little concern. Adjustments to operations of the groundwater system were made, including the introduction of both fluoride and orthophosphate delivery systems to match the surface water chemical compositions. During the period of time from 1996 to 2000, when blended water was more prevalent, the challenges most frequently encountered were around aesthetic issues like color and iron. These issues were mostly associated with groundwater and the older tuberculated piping in the JWS distribution system. As water main replacement increased, the strength of the surface water transmission capabilities increased and the need for well supply decreased. There were also a number of wells that had become impacted by contaminants, mostly volatile organic compounds (VOC) like Tetrachloroethene (PERC) and Methyl Tertiary Butyl Ether (MTBE), that lead to decrease utilization of well supply. As noted above, during the walk up to the Y2K technology concerns, New York City tested and demonstrated its

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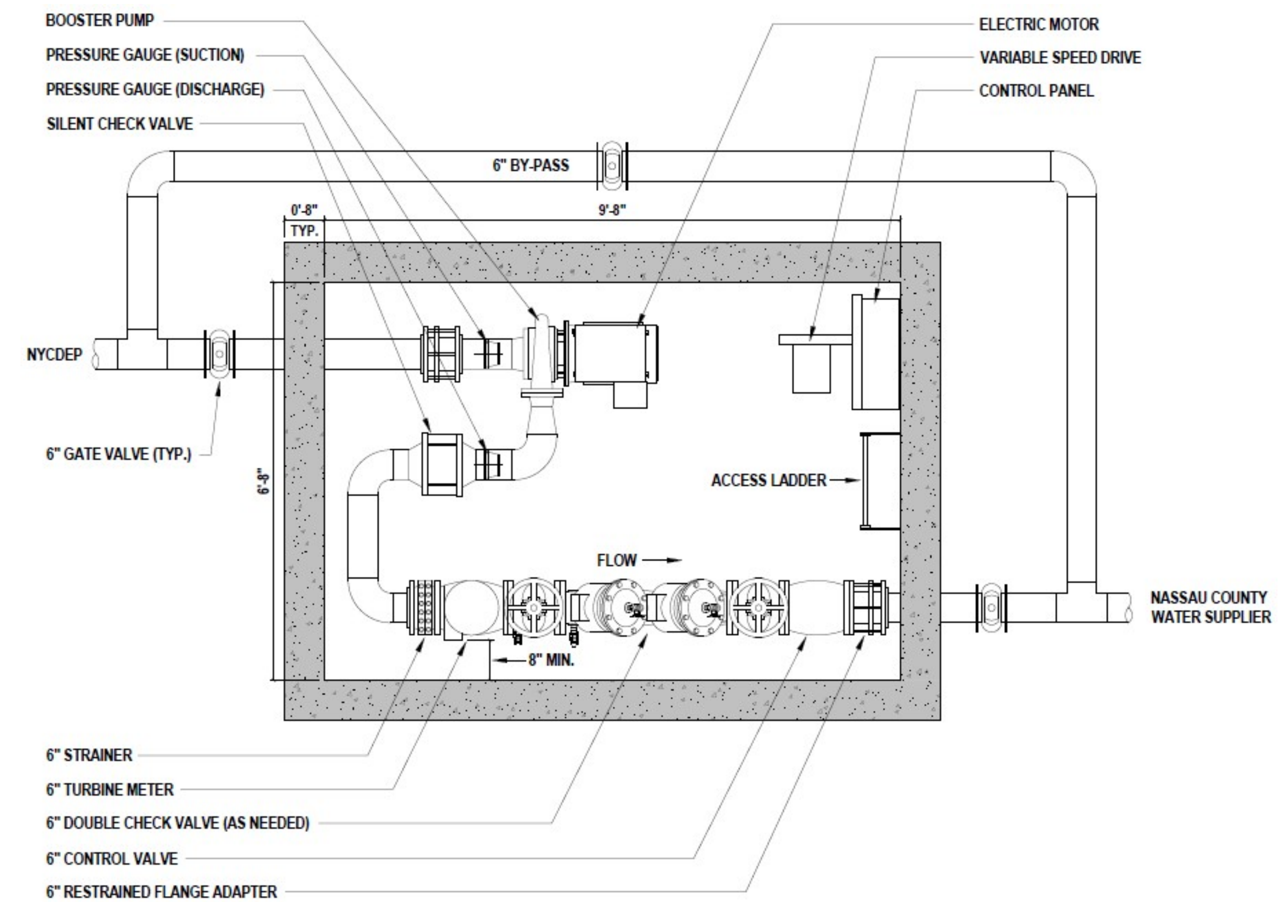

Typical 1-Way Interconnection with Booster Vault Plan

ability to provide surface water to the entire former JWS service areas. Thereafter less groundwater supply was delivered, to the point where it was essentially ceased entirely in the mid 2000's. As such, from the standpoint of concern about the blending interaction between the New York City surface water supply and groundwater supply, there is valuable history to draw from and overall regulatory compliance is not thought to be a concern. Proper due diligence would suggest however that proper testing be performed as part of any planning study.

Generally, New York City's surface water system does not face the same challenges as the Long Island suppliers with regard to volatile organics or issues like 1,4-Dioxane and perfluorinated compounds (PFAS). There are however a few other considerations, most notably the utilization of fluoride by New York City. First, it should be noted that New York City has a Legislative requirement to provide fluoride in its distribution system. That said, in May 2016, DEP lowered its fluoride application dosage to 0.7 milligrams per liter (mg/L) which is the recommended value by the U.S. Department of Health and Human Services. Nassau County suppliers do not apply fluoride, and this has been considered a major point of contention in consideration of inter-County water sharing. The merits and concerns of fluoride are a topic of study and debate far outside the scope of this report, but clearly an issue which would need to be resolved before further advancement of planning for inter- municipal water sharing. However, there are an estimated 350,000 Long Island non-resident commuters consuming New York City supply on a regular basis. The need for the various public health agencies to provide appropriate guidance will be critical to either the success or failure of any future initiatives in this area.

Fluoride can be removed from water through several processes. According to the United States Environmental Protection Act (USEPA), reverse osmosis and activated alumina are the best available technologies for the removal of fluoride from drinking water. Other treatment technologies include ion exchange, lime softening, electrodialysis, and adsorption with media, including activated carbon, bone chars, and clays. Adsorptive media is the most common method for fluoride removal. Efficiency is affected by initial concentration, water pH, contact time, and presence of competing ions. Removal is most efficient at a slightly acidic pH.

Another item of discussion is that New York City applies orthophosphate for corrosion control, while few Nassau County suppliers use it. NYAW is currently experimenting with its usage. While orthophosphate usage is not believed to be a large challenge to overcome, testing would be necessary to ensure that there are no adverse impacts, especially related to lead and copper compliance. If fluoride removal were considered, it could have implications on this process as well.

In light of the New York City system being surface water, a thorough understanding of the implications of disinfection by-products (THHM's and HAA's) should be realized. Water age and disinfection by- products (DBP) development are related and as the New York City water potentially travels further beyond its borders, careful analysis and testing of this and other water quality parameters is required.

Finally, there are potential pros and cons of reducing pumping requirements for the Nassau County suppliers. On the positive side, reduced pumping will allow for the groundwater levels to rebound and the aquifer to be subject to less stress. On the potential negative side, assessment of potential negative impacts of reduced pumping, including rising groundwater table, localized basement impacts, and plume migration should be assessed in the Southeastern Queens and Nassau County areas.

CHAPTER 14:
REGIONAL CONTAMINATION THREATS

Regional Contamination Threats

The discussion of Regional Contamination Threats in the draft Groundwater Resources Management Plan (GRMP) focused almost exclusively on Nassau County. Suffolk County has experienced similar contamination from specific sites, along with Regional contamination from pesticides (such as aldicarb) and other widely used chemicals. A characterization of Regional contamination events is complex, as some threats may be localized, as in the case of hazardous waste sites, while other threats are multifocal and dispersed, as is often the case with the new emerging contaminants 1,4- Dioxane and per- and polyfluoroalkyl substances (PFAS).

More than 250 Inactive Hazardous Waste Sites have been identified on Long Island. The United States Environmental Protection Agency (USEPA) and the New York State Department of Environmental Conservation (NYSDEC) have identified approximately 145 inactive hazardous waste sites in Nassau County and 109 sites in Suffolk County. The following assessment expands upon the previous Long Island Commission for Aquifer Protection (LICAP) report by looking more closely at Regional contamination events in Suffolk County.

It is acknowledged, however, that except for PFAS-related sites, listing of major new superfund sites and spills have declined significantly over the past several years. At the same time, low-level volatile organic compound (VOC) contaminant occurrence has increased. In addition, pesticides and pharmaceuticals and personal care products (PPCPs) have become a growing concern. In 2015, Suffolk County completed a Comprehensive Water Resources Management Plan, which should be regarded as an incorporated reference. This management plan has been an invaluable tool to Suffolk County and may similarly serve as a basis for LICAP Plan recommendations.

Suffolk County

Of the NYSDEC listed sites[1] in Suffolk County shown in Table 1, 31 have been categorized as Class 2, defined as constituting a significant threat to the public health or environment. Four of these are among the 16 USEPA Superfund sites listed in Suffolk County. Among the largest sites are sites No. 3, 5, 17, and 32*, located in Upton, Port Jefferson Station, Riverhead, and East Setauket, respectively. Site No. 32* is not classed as a hazardous waste site by NYSDEC, but rather as a bulk storage site. In addition, two of these four sites, along with two others (No. 18 and 31) have been identified as sites where the emerging contaminants perfluorooctane sulfonic acid (PFOS) and perfluorooctanoic acid (PFOA) were detected. PFOS and PFOA are currently known to be impacting groundwater. These six numbered sites are the "Featured Sites" shown on Figure 1 and are discussed in this task report.

All of these sites have posed a groundwater contamination threat in the past, and some of the sites continue to contaminate groundwater. Among the most prevalent contaminants are industrial solvents and fuels, such as perchloroethylene (tetrachloroethylene, PERC, or PCE) and its degradation products, as well as gasoline, diesel or jet fuel. Radioactive elements and heavy metals are also found at some of these sites. Perfluorinated compounds (PFOS, PFOA), are known to have extensively contaminated sites where they were utilized in the form of aqueous film forming foams (AFFF) to extinguish fires. The extent to which these may be found at any of the contaminated sites in Suffolk County remains under review and assessment. The

New York State Department of Health (NYSDOH) is currently utilizing an EPA lifetime Health Advisory Level (HAL) in evaluating drinking water source contamination findings relating to PFOS and PFOA. In the July 24, 2019 New York State Register, NYSDOH published a proposed regulation which includes a 10 part per trillion (ppt) Maximum Contaminant Level (MCL) for each of these perfluorinated compounds. Pesticides also constitute a significant threat to groundwater quality and human health and are found most extensively near farms and greenhouses predominantly in eastern Suffolk County.

The most extensive impacts to groundwater in Suffolk County are from the oldest sites, many of which became active prior to World War II. These sites produced weaponry, aircraft, and other wartime products, and continued operations for many decades afterward. Disposal practices during that period often consisted of pits, trenches, drains, and similar structures, allowing these chemicals to infiltrate into the soil, eventually reaching and contaminating the groundwater. Some of the compounds sank deep into the aquifer system, while others floated on the water table. In both instances plumes of contaminants eventually migrated away from their disposal site, moving in the direction of groundwater flow.

Most of the contaminant plumes are situated within the Upper Glacial Aquifer, which is the shallowest aquifer in most of Suffolk County and the source for many residential wells. The underlying Magothy Aquifer is also contaminated by plumes, with some extending as deep as the Raritan Clay (approximately 900 feet below land surface, depending on location). These plumes change in extent, both vertically and horizontally, as they are influenced by factors such as chemical reactions in the subsurface, pumping of wells, and even tidal forces near the shoreline. Six large legacy sites in Suffolk County, which are undergoing continuing study and remediation, were chosen for discussion in this report. These six sites and the agencies providing oversight for their remediation are listed below:

- Brookhaven National Lab (NYSDEC and USEPA)
- Lawrence Aviation Industries (NYSDEC and USEPA)
- Calverton Naval Weapons Industrial Reserve (WIRP) Plant (NYSDEC)
- Gabreski Air National Guard Base (NYSDEC)
- Suffolk County Firematics (NYSDEC)
- Northville Industries (NYSDEC)

1 A "Registry of Inactive Hazardous Waste Disposal Sites" was created by the NY State Environmental Conservation Law Article 27. Sites listed in the Registry are commonly said to be sites in the "State Superfund Program." Sites are classified 1 through 5 based on its characteristics. Details of the Classification Codes may be found online at https://www.dec.ny.gov/chemical/8663.html

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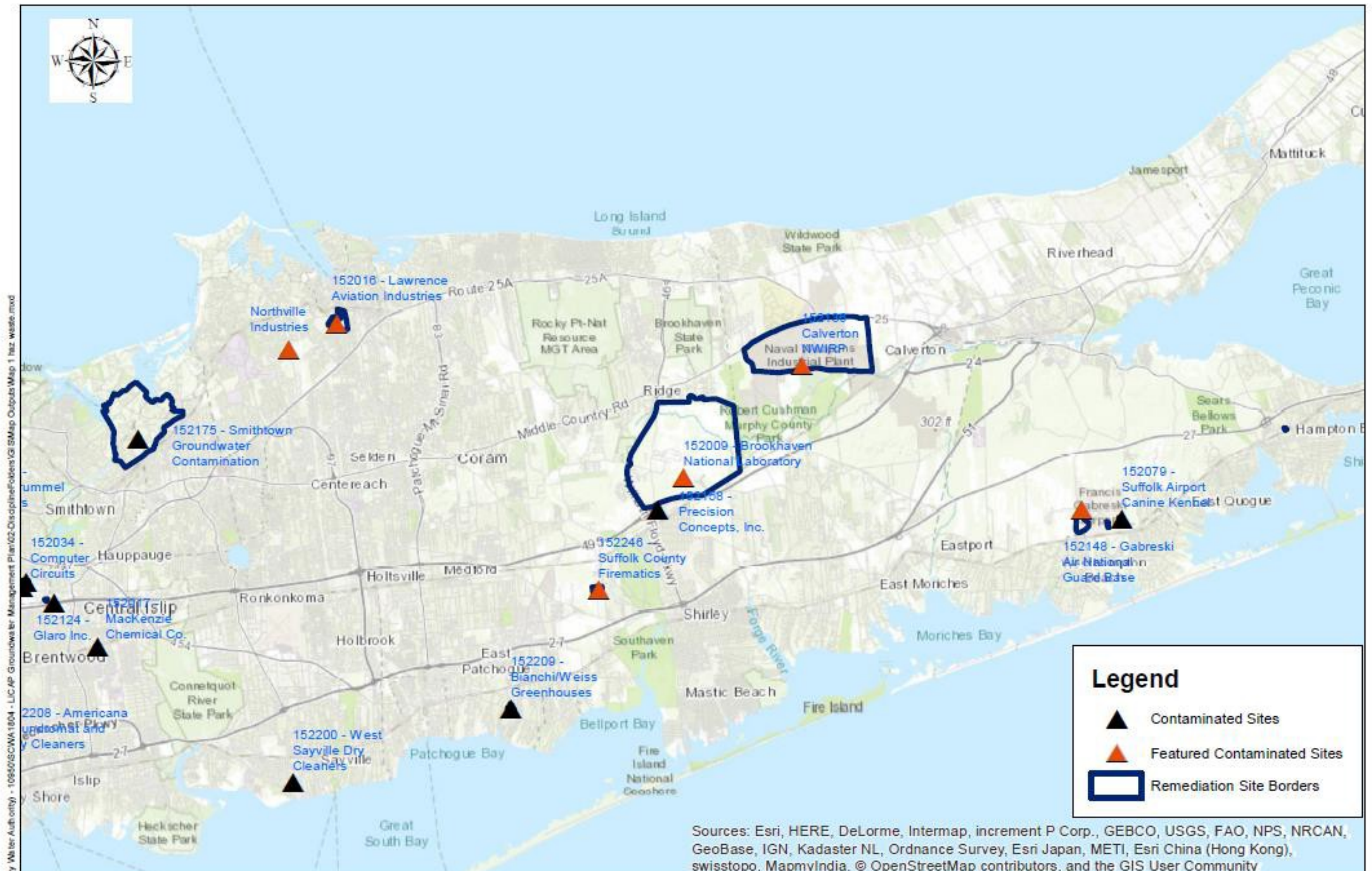

Figure 1
Suffolk County Active Hazardous Waste Sites

H2M architects + engineers
Melville, NY
Parsippany, NJ Purchase, NY Suffern, NY
New York, NY Latham, NY Howell, NJ

In Figure 1 above, borders are shown for geographically larger sites.

Table 1 Suffolk County NYDEC Class 2 Hazardous Waste Sites

	Site Code	Site Name	City/Town	Address
1	152003	Deutsch Relays, Inc.	East Northport	65 Daly Road
2	152004	Fairchild Republic Aircraft; Old Sump	East Farmingdale	Route 110 (Broad Hollow Road)
3	152009	**Brookhaven National Laboratory**	**Upton**	**William Floyd Parkway**
4	152015	Chemical Pollution Control	Bay Shore	120 South 4th Street
5	152016	**Lawrence Aviation Industries**	**Port Jefferson Station**	**Sheep Pasture Road**
6	152017	MacKenzie Chemical Co.	Central Islip	One Cordello Avenue
7	152025	Pride Solvents and Chemical Co.	Babylon	78-88 Lamar Street
8	152033	Dzus Fastener Co., Inc.	West Islip	425 Union Boulevard
9	152034	Computer Circuits	Hauppauge	145 Marcus Boulevard
10	152036	Astro Electroplating, Inc.	East Farmingdale	170 Central Avenue
11	152039	Babylon Landfill	West Babylon	Gleam Street
12	152079	Suffolk Airport Canine Kennel	Westhampton Beach	Old Riverhead Road
13	152119	Target Rock Corp.	East Farmingdale	1966 East Broadhollow Road
14	152124	Glaro Inc.	Hauppauge	735 Old Willets Path
15	152125	Active Industrial Uniform	Lindenhurst	63 West Merrick Road
16	152130	Fairchild Republic Main Plant	East Farmingdale	1000 Conklin Street
17	152136	**Calverton NWIRP**	**Riverhead**	**Swan Pond Road**
18	152148	**Gabreski Air National Guard Base**	**Westhampton Beach**	**Old River Head Road**
19	152158	Precision Concepts, Inc.	Shirley	26 Natcon Drive
20	152162	100 Oser Avenue	Hauppauge	100 Oser Avenue
21	152175	Smithtown Groundwater Contamination	Smithtown	Moriches Road and Fifty Acre Road
22	152183	Brandt Airflex	East Farmingdale	937 & 965 Conklin Street
23	152187	Country Cleaners	Huntington	410 West Main Street
24	152188	Villa Cleaners	Deer Park	1887-1899 Deer Park Avenue
25	152200	West Sayville Dry Cleaners	West Sayville	61 West Main Street
26	152201	Levey Property	Copiague	1305 South Strong Avenue
27	152208	Americana Laundromat and Dry Cleaners	Bay Shore	1572 North 5th Avenue
28	152209	Bianchi/Weiss Greenhouses	East Patchogue	Orchard Road
29	152211	Beau Brummel Cleaners	Commack	2049 Jericho Turnpike
30	152239	Former Elka Chemical Company	Lindenhurst	340 West Hoffman Avenue
31	152246	**Suffolk County Firematics**	**Yaphank**	**676 Maple Street**
*32**	1-1720	**Northville Industries**	**East Setauket**	**19 Belle Meade Road**

Sites in the discussion to follow are shown in **bold.** * The Northville Industries Site is a Petroleum Bulk Storage Site and is addressed under the NYSDEC Spills Program, rather than the NY State Superfund Program. : Source- NYSDEC Environmental Site Remediation Database Search Website,: https://www.dec.ny.gov/cfmx/extapps/derexternal/index.cfm?pageid=3, accessed 2/28/19

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Discussion and Status of Suffolk County Legacy Sites

Brookhaven National Lab (BNL) (EPA ID: NY7890008975)

This site covers approximately 5,265 acres in area and has 10 Operable Units[2] (OUs). Most of BNL's facilities are located near the center of the site, in an area covering about 1,700 acres (Figure 1). Remediation began at the site in 1992. The 10 OUs account for various types of contamination, any of which may have impacted the groundwater. These include radiological contamination, VOCs, semi- VOCs, metals, and ethylene dibromide (EDB). Many techniques have been utilized to contain or remediate groundwater contamination at BNL, including groundwater pump and treat systems, groundwater containment, leachate collection, subsurface barriers, and alternative water supplies.

The Upper Glacial and Magothy aquifers are most prone to contamination beneath BNL, since they are found at shallow depths below surface. The Lloyd aquifer is much deeper and surface contamination may take decades or longer to reach it. One unique aspect of BNL's location is that it is situated within the headwaters of the Peconic River. Therefore, contaminants emanating from BNL have the potential to contaminate surface water as well as groundwater.

BNL has constructed numerous disposal areas, including tanks, cesspools, pits, and landfills; most of which either have been or currently are in remediation. Groundwater has been contaminated with VOCs, radionuclides, and pesticides, both on and off the BNL property. There has been ongoing monitoring of both groundwater plumes and the Peconic River. The site is served by BNL's own public drinking water supply.

Among the contaminants of concern at BNL is tritium. Since 1997, on-site management of the tritium plume has been achieved through hydraulic containment. Approximately 335 million gallons have been processed. Another 650,000 gallons were directly removed from the reactor source. Tritium undergoes radioactive decay with a half-life of 12.3 years. It is estimated that of the tritium mass that was present in the groundwater plume in 1997, approximately 29% remains in the groundwater at BNL as of 2019.

VOC and strontium have also contaminated groundwater extensively at BNL. Remediation of these contaminants is ongoing using 11 pump-and-treat systems. These systems have extracted approximately 23 billion gallons of groundwater contaminated by VOCs (approximately 7,300 pounds) and approximately 143 million gallons of groundwater contaminated by strontium (30 millicuries).

Some source areas, such as the interim landfill, chemical/animal pits and glass holes, and the carbon tetrachloride tank have each been addressed successfully and are no longer considered to be threats to groundwater. This was achieved by the late 1990s mostly via soil removal and disposal (for the chemical/animal pits and glass holes), and via a pump-and-treat system for the carbon tetrachloride tank plume. Once cleanup goals were met, the remediation equipment was dismantled.

[2] An administrative term used to identify a portion of a site that can be addressed by a distinct investigation and/or cleanup approach. For example, groundwater contamination at a site may be considered as one operable unit, and soil contamination at the same site may be dealt with as a second operable unit. An operable unit can receive specific investigation, and a particular remedy may be proposed. A Record of Decision is prepared for each operable unit.

In the headwaters of the Peconic River, mercury-contaminated sediment, along with other metals, has been an ongoing issue. Through 2015, approximately 21,000 cubic yards of contaminated sediment were removed from both on-site and off-site areas along the Peconic River. Additional sediment removal was planned for 2016.

Additional groundwater testing performed by BNL has indicated the presence of PFAS compounds and 1,4-Dioxane in groundwater monitoring wells and in the effluent of remedial treatment systems both on and off-site. A concentration of 18 parts per billion (ppb) of 1,4-Dioxane was reported by BNL in an off-site monitoring well in 2017. PFOS and PFOA have been detected in on-site groundwater monitoring wells in concentrations more than 75 times the USEPA's HAL of 70 ppt. As reported in the BNL 2018 Annual Water Quality Report, results from BNL's own compliance sampling of their on-site public water system wells confirmed results of samples collected by SCDHS indicating the presence of six specific perfluorinated compounds (PFOS, PFOA, PFBS, PFHpA, PFHxS, and PFNA). The concentrations did not exceed EPA's 70 ppt HAL for PFOS and/or PFOA for drinking water or the NYSDOH regulatory MCLs of 50 ppb (for the balance of these PFAS, recognized as Unspecified Organic Compounds under Section 5-1-1 (ce) of the NY State Sanitary Code), All of the detected compounds but one are related to the use of firefighting foam. The sixth detected compound, PFBS, is classified as a surfactant used in plastic production.

Table 2 BNL: SCWA Well Fields Downgradient

SITE NAME	ADDRESS	COMMUNITY
Sally Lane Future Well Field & Pump Station	Sally Lane	Ridge
William Floyd Parkway Well Field & Pump Station	William Floyd Parkway	Yaphank
Country Club Drive (Pine Hills) Well Field & Pump Station	Country Club Drive (Private Community)	Manorville
River Road Future Well Field & Pump Station, E/S of River Road	River Road	Shirley
Lambert Avenue Well Field & Pump Station	Miramar Street	Mastic
Main Street Well Field & Pump Station	Main Street	Mastic
Margin Drive East Well Field & Pump Station	Margin Drive East	Shirley
Old Neck Road Well Field & Pump Station	Old Neck Road	Center Moriches
Middle Country Road	Middle Country Rd.	Ridge

3 Studies designed to gather the data necessary to determine the type (nature) and extent (location) of contamination at a hazardous waste site. The RI is usually performed at the same time as a Feasibility Study in a process known as the "RI/FS."

4 A document which provides the definitive record of the cleanup alternative that will be used to remediate a hazardous waste site. The ROD is based on the Remedial Investigation / Feasibility Study and public comment.

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For most of the SCWA well fields listed in Table 2, their groundwater contributing areas identified in the 2003 Source Water Assessment Program (SWAP) indicate no likely impact from BNL contamination within the 100 year time of travel contributing area. The Lambert Avenue well field is the one exception. Its SWAP analysis shows groundwater being drawn in from within BNL's property in the range of 50-100 years. As of December 2018, BNL's community advisory council had urged BNL to test off-site residential wells for perfluorinated compounds, specifically PFOS and PFAS. SCDHS has identified approximately 90 properties potentially served by 92 private/ on-site wells downgradient of the BNL site, based upon a hydrogeological evaluation that considered a groundwater flow travel time of approximately 50 years from the site boundary. Other private wells are significantly further away. Private well sampling by Suffolk County Department of Health Services (SCDHS) was initiated in 2019 with notices offering free testing. This effort is ongoing.

Following the completion of a Remedial Investigation/ Feasibility Study3 (RI/FS), a Record of Decision4 (ROD) was issued. It is on file with the EPA and can be found at: https://www.bnl.gov/gpg/files/B96/B96_Final_ESD_07-16-09.pdf

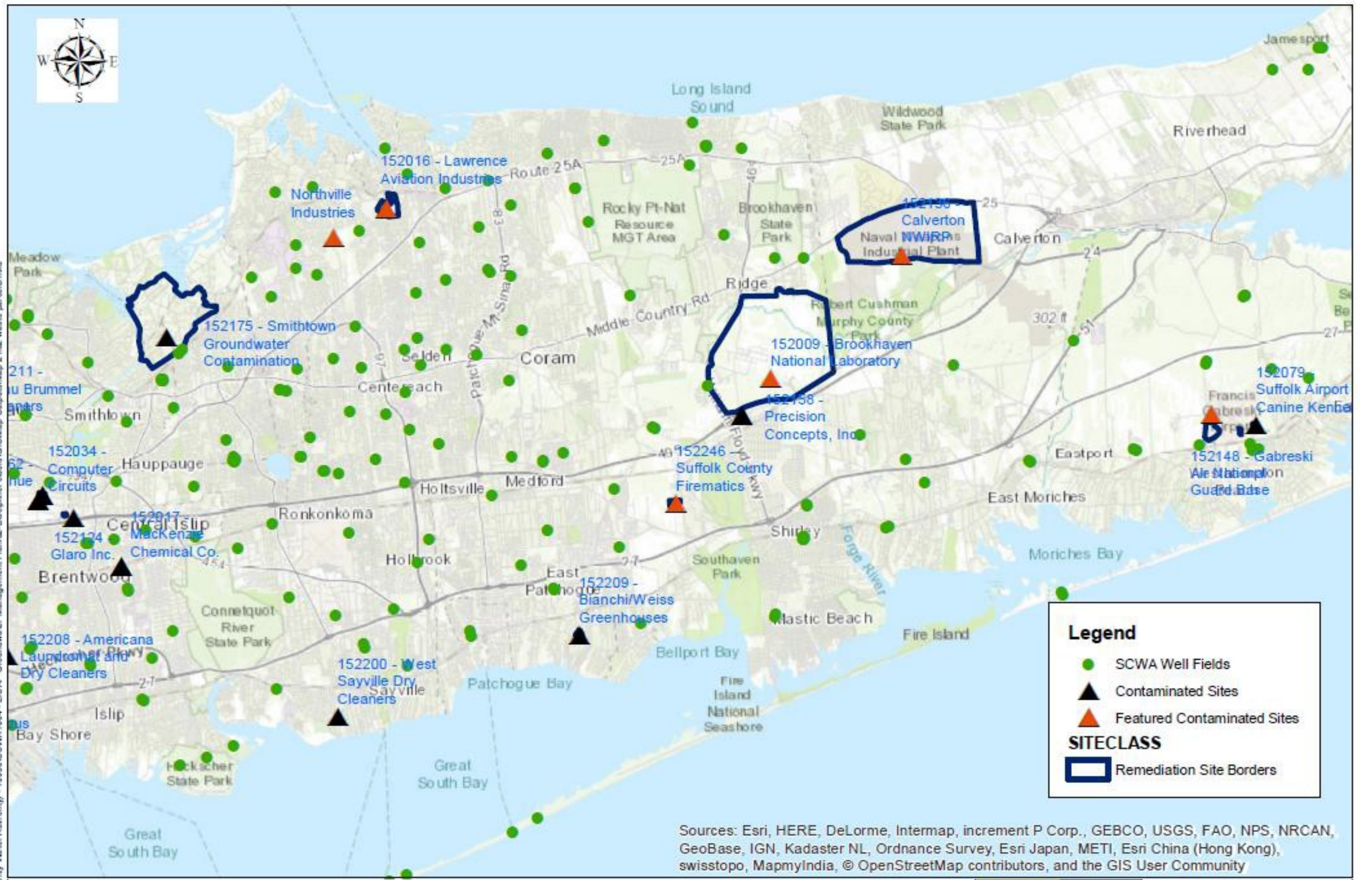

Figure 2
SCWA Well Field Sites

H2M architects + engineers

Lawrence Aviation Industries (LAI) (EPA ID: NYD002041531)

LAI (Figure 1) is located on approximately 125 acres in the unincorporated Hamlet of Port Jefferson Station in the Town of Brookhaven. From 1959-1991 this facility produced titanium sheet metal for use in the aviation industry. Its waste stream included fluorides, sludges, caustic acids, and halogenated solvents. Wastes were disposed of in on-site lagoons and cesspools, eventually leading to significant groundwater contamination.

In 1991, SCDHS installed and sampled 12 profile wells downgradient of the subject site. Trichloroethene (TCE) was detected in 5 of these wells, with concentrations ranging up to 2,600 ppb. TCE was also identified by SCDHS in stream samples that were collected in Port Jefferson Creek in concentrations exceeding 500 ppb.

The site was initially placed on the National Priorities List (NPL) in 2000 under USEPA. A 2001 preliminary remedial investigation/feasibility study (RI/FS) through the New York State Superfund identified several contaminated and potentially contaminated private wells. Additionally, a pond and a creek located downgradient from the site have been contaminated from groundwater emanating from Lawrence Aviation. A record of decision (ROD) was issued in 2006. This ROD:

- Required groundwater extraction and treatment through pump and treat and chemical oxidation
- Directed further identification of private wells impacted by site related contamination and their connection to public water
- Required installation and operation of an off-site groundwater extraction and treatment system located at the downgradient edge of the VOC plume

TCE and PCE were detected at multiple depths in groundwater at concentrations exceeding the clean- up criteria. The ROD groundwater remedy called for the plume and source containment and treatment of contaminated groundwater, which included, in part:

- Construction of two groundwater extraction and treatment systems
- Long-term groundwater and surface water sampling to monitor changes in contaminant concentrations and distribution over time
- Investigation of vapor intrusion into structures within the plume area and implementation of an appropriate remedy (such as sub-slab ventilation systems) based upon the investigation results

On-site and off-site pump and treat has been operational since the end of 2011. Removing all oils in the on-site building press pit sumps and additional actions were ongoing as of 2014. EPA's consultant now submits a monthly operation, maintenance, and monitoring report on the pump and treat systems and a five year review report was completed by EPA in July of 2015.

In order to minimize risk to human health, the site is fenced and posted with signage informing people that nearby surface waters (Old Mill Creek Pond) are contaminated and not safe to drink. Public water

serves the area, private well surveys have been conducted on multiple occasions, and no nearby private wells are believed to be utilized. As indicated in the Task 2 Private Well evaluation, data suggests approximately 21 private wells are in the general groundwater flow direction, further offsite.

The ROD for this site can be found at: https://semspub.epa.gov/work/02/108509.pdf

Northville Industry Corporation: East Setauket Terminal Gasoline Leak

Approximately 1.2 million gallons of gasoline leaked into the ground and groundwater beneath the Northville Industry Corporation's East Setauket Terminal (Figure 1). This was originally discovered in 1987. The source was underground piping within the terminal. It is unknown when the leaking began but it is believed to have possibly occurred over several decades. After repairs to the leaking pipe and further inspection of the fuel storage tanks and other pipes, Northville Industries took steps to quantify the extent of contamination and to recover gasoline from the groundwater and prevent further spread of the contamination. On October 13, 1994, Northville Industries entered a Consent Order with New York State. The Consent Order defined actions necessary for the completion of site remediation and closure.

There is one Suffolk County Water Authority Well Field (Figure 2) and approximately 11 private wells downgradient of the East Setauket Terminal.

Table 3 Northville Industries I-1720: SCWA Wellfields Downgradient

SITE NAME	ADDRESS	COMMUNITY
Sherry Drive Well Field & Pump Station	Sherry Drive	Setauket

Groundwater beneath the Northville site flows toward the north. Given groundwater flow conditions, the geologic complexity beneath the site, and the long period over which the release may have occurred and the nature of the contaminant (floats on water and chemically degrades over time), it can be stated that a release of this size may have posed some level of concern at a prior point in time. Based on action taken, there appears to be no evidence that groundwater contamination still exists at this site.

Calverton Naval Weapons Industrial Reserve Plant (NWIRP) (NYSDEC Site Code:152136), (EPA ID: NYD003995198)

The Calverton NWIRP site, located near Riverhead is shown in Figure 1. A portion of the site was used as an aircraft parts and sub-assembly plant by Northrop Grumman Corporation through 1996. Active hazardous waste disposal took place during the period of 1952-1984. Operations originally occupied more than 3,000 acres in size; the current site today is smaller, consisting of 209 acres across three disconnected parcels where environmental investigation and remedial activities currently are taking place. The Calverton site is situated on a groundwater divide, and so groundwater flow is highly variable. Groundwater beneath the site can move either to the north and south away from the divide, as well as to the east, toward the Peconic River. For this reason, the fate and transport of contaminants beneath the Calverton facility is highly dependent on the source location. There are private wells downgradient of the site.

Contamination from the site is found primarily in the Upper Glacial aquifer. Groundwater beneath the northern half of the facility flows to the northeast, while groundwater beneath the southern half of the facility flows southeastward toward the Peconic River.

The contaminants of concern (COCs) at the site include toluene, 1,1,1-trichloroethane and methyl ethyl ketone. Many different operable units have been established in order to address groundwater contamination. Within OU2 designed Site 7, a former fuel depot, a full-scale air sparging/soil vapor extraction system was approved and implemented in 2006. Site 10A was a jet fuel systems laboratory. Contamination at this site includes VOCs and petroleum products. A skimmer system to recover free product fuel from the water table operated at this location until 1996. OU3 was used for testing of aircraft engine and fuel systems. Groundwater contaminants found included free product fuel. Groundwater contamination consisting of chlorinated fuel components and VOCs are considered to relate to spills of chemicals used to clean the aircraft engines and fuel systems. Ongoing groundwater contamination migrating from the OU3 source area has been documented.

An on-site public supply well (Riverhead Water District well 12-1, emergency use only) became contaminated with chlorinated solvents above drinking water standards was formerly treated and is currently not in service. No other public water supplies are known to be impacted by the site, although no information could be found regarding the extent of emerging contaminant impacts.

The 11 acre OU4 Site 2 area was a fire training area used to simulate plane crashes. For 30 years through the mid-eighties, 450 gallons of waste solvents per year were used in the training exercises. Free product was removed from wells. Although not addressed in the earlier investigations, the Department of Defense is currently investigating its current and former facilities including Calverton relative to possible PFAS, PFOS, and PFOA from aqueous firefighting foams associated with firefighting and fire training activities at its locations.

The ROD for this site can be found at: https://www.navfac.navy.mil/products_and_services/ev.html

Suffolk County Firematics, (NYSDEC Site Code: 152246)

Located on approximately 28 acres in Yaphank, New York, Suffolk County Firematics (Figure 1) is owned by Suffolk County. It has been used as a firefighting training facility since 1959. Groundwater in the upper Glacial aquifer flows toward the southeast and is contaminated with PFOS and PFOAs. While there is currently no specific enforceable DrinkingWater Standard for these two chemicals, EPA has issued a lifetime Health Advisory Level (HAL) of 70 ppt, either alone or in combination. New York State standards are under development.

There is one SCWA wellfield (Figure 2) in the vicinity of the Firematics site. The 25- and 50-year contributing areas for these public supply wells do not intersect the Firematics facility, and so there are not believed to be any anticipated groundwater impacts to these public supply wells. There are private wells generally located downgradient, some of which are in proximity of the site. Most of these wells are screened in the Upper Glacial Aquifer and are relatively shallow.

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Table 4 Suffolk Firematics (NYSDEC Site Code: 152246): SCWA Wellfield Located Downgradient

SITE NAME	ADDRESS	COMMUNITY
Margin Drive East Well Field & Pump Station	Margin Drive East	Shirley

The SCDHS Office of Water Resources initiated a groundwater investigation in July 2016 to evaluate the potential for PFOS/PFOA groundwater contamination. Groundwater profile samples from 12 temporary wells on-site and immediately downgradient (between the site and the private wells) were collected. PFOS/PFOA detections were reported in all 12 profile wells:

- Sixteen well water samples in seven different wells exceeded the USEPA Health Advisory Limit (70 ppt, PFOS + PFOA or individually).
- Five wells had PFOS/PFOA detections below the HAL.
- On-site detections exceeding the HAL were as high as 418 ppt of PFOS/PFOA combined.
- Off-site detections exceeding the HAL ranged up to 986 ppt of PFOS/PFOA combined.

Significant investigation is continuing. A full remedial investigation is being conducted on and around the site in order to determine the extent and magnitude of the PFOS/PFOA contamination in the groundwater. Forty-one downgradient private wells have indicated PFOS and/or PFOA detections, with 18 of those wells exceeding the HAL. As a result of these findings, 45 homes were connected to public water and three point of entry treatment systems were installed by the county at properties that had been served by private wells. Lastly, aquatic biota studies are underway to evaluate the potential PFOA/PFOS impacts to the coastal environment.

Gabreski Air National Guard Base (NYSDEC Site Code 152148)

This site is an Air National Guard (ANG) base located at the Gabreski Airport in Westhampton (Figure 1). The ANG leases 88.5 acres of runways, aviation facilities, a former fire training area, and an additional 0.5-acre Airport Fire Training Area has also been used. Operations at the base include aircraft and ground vehicle maintenance, which historically involved the disposal of many hazardous materials used in routine` activities. Additionally, the firefighting agents used at crash sites and fire training areas contained both PFOA and PFOS. Operable units were established at the site to address the former septic systems, perfluorinated compounds and other hazardous compounds separately.

The direction of groundwater flow beneath the airport is generally toward the south-southeast. There are two SCWA well fields (Figure 2) located downgradient of the site (located as close as one mile southeast). Private wells are in some downgradient proximity to the airport as a whole. A 1994 site investigation was conducted to determine if the contaminants detected in the septic systems had migrated to soil and/or groundwater, but did not address PFOA and PFAS, since at that time these compounds were not considered to be threats to groundwater and human health. The SCDHS has conducted private well sample collection downgradient of the ANG base. Approximately 75 properties were identified as being served with a private well. About 60 were sampled and eleven indicated PFOS and/or PFOA concentrations exceeding the USEPA health advisory level. Public water was extended to 65 properties.

SCWA has sampled its public supply wells and has provided analytical assistance for private well samples collected by SCDHS in 2016 near the site and downgradient of contaminated areas. The sampling showed groundwater impacts by PFOS and PFOA downgradient of the base. Granular activated carbon (GAC) treatment was installed for some of the contaminated wells as recently as 2016. In 2018, significant groundwater (and soil) contamination were found at the Fire Training Area. The results of the sampling effort show that both Fire Training Areas appear to be contributing significantly to a PFOS and PFOA plume.

Table 5 Gabreski Air National Guard Base (NYSDEC Site Code 152148) SCWA Wellfields Downgradient

SITE NAME	ADDRESS	COMMUNITY
Meeting House Road Well Field, Pump Station & Elevated Tank	South Country Road	Quogue
Gus Guerrera (C.R. 31 South) Well Field & Pump Station	Permanent Easement	Village of Westhampton Beach

Emerging Contaminants 1,4-Dioxane and PFAS

In addition to the NYSDEC Class 2 and EPA Superfund Sites discussed above, the emerging contaminants 1,4-Dioxane, PFOS and PFOA have some likelihood to be found at any of the listed sites, given their extensive use by industry over the last century. This is likely to be the case for some Brownfields and other NYSDEC legacy sites as well (see Tables 6 and 7).

1,4-Dioxane is a chemical that was used to stabilize chlorinated solvents including 1,1,1- trichloroethane (TCA), which is among the most widely used of all solvents. Because of this, 1,4- Dioxane is often found at many of the most contaminated sites across the United States.

PFAS have been manufactured and used in a variety of industries since the 1940s. PFOA and PFOS have been the most extensively produced and studied of these chemicals. PFOS (also known as perfluorooctane sulfonic acid) was the key ingredient in Scotchgard, a fabric protector made by 3M, and numerous stain repellents. Their association with certain aqueous firefighting foams (AFFS) is well documented. "Per"- and polyfluoroalkyl substances (PFAS) are a group of man-made chemicals that includes PFOA, PFOS, GenX and many other chemicals.

Both chemicals are very persistent in both the environment and in the human body, since they don't easily degrade, and they bio-accumulate (in proteins) over time. All the active hazardous waste sites in Suffolk County as well as most of the legacy sites will likely require groundwater testing for these compounds.

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Table 6 Suffolk County Brownfields Sites

CLEANUP NAME	LOCATION ADDRESS	CITY NAME
5 North 15th Street	5 North 15th Street	Wheatley Heights
Hubbard Power & Light Inc. Property	1600 Fifth Avenue	Bay Shore
8 Andrews Avenue	8 Andrews Avenue	Wyandanch
Former Bellport Gas Station	1401 Montauk Highway	East Patchogue
William Kubach	70 Moffitt Boulevard	Bay Shore
Municipal Parking Lot	Railroad Street And New York Avenue	Huntington
37 Commonwealth Drive	37 Commonwealth Drive	Wyandanch
Rotundo	1345 New York Avenue	Huntington Station
In and Out Food Mart	1491 & 1499 Straight Path	Wyandanch
Blue Point Laundry	1 Park Street	Blue Point
1617 Straight Path	1617 Straight Path	Wyandanch
SCSD Gabreski Airport STP	County Road 31	West Hampton Beach
7 North 15th Street	7 North 15th Street	Wheatley Heights
Lawrence Junkyard	156 Grant Avenue	Islip
Medigen Of New York	95 Eads Street	West Babylon
Former Central Islip Psychiatric Center	Carleton Avenue	Islip

NYSDEC is currently contacting site owners to schedule sampling for these chemicals in groundwater. Samples will be analyzed for a NYSDEC selected PFAS target analyte list to understand the nature of contamination. It also may be necessary to discriminate between various PFAS compounds based on association because of the variety of PFAS uses in consumer products.

A 2017 amendment to the NY State Public Health Law created a 12-member Drinking Water Council as a science based advisory board. The Law charged the Council with providing NYSDOH with guidance as the selection of unregulated contaminants for monitoring, notification levels for unregulated contaminant public reporting, and the establishment of MCLs as appropriate. The amendment directed the Council to initially focus on 1,4-Dioxane, PFOS and PFOA. The Council met five times in 2017-18 and recommended the establishment of a 1 ppb MCL for 1,4-Dioxane, and a 10 ppt MCL for PFOS and for PFOA. The State Commissioner of Health accepted these recommendations. On July 24, 2019, NYSDOH proposed amendments to Part 5 NY State Sanitary Code incorporating these MCLs and monitoring requirements for public water suppliers. Final Code adoption may be completed late in 2019 or early 2020.

Table 7 NYSDEC Class 4 Sites in Suffolk County

SITE CODE	SITE NAME	CITY/TOWN	ADDRESS
152002	Blydenburgh Landfill, Town of Islip	Hauppauge	600 Blydenburgh Road
152006	Jameco Industries, Inc.	Wyandanch	248 Wyandanch Avenue
152011	RCA Rocky Point	Rocky Point	Rocky Point-Middle Island Road
152013	Sonia Road Landfill	West Brentwood	Sonia Road
152021	Cantor Brothers, Inc.	East Farmingdale	50 Engineers Lane
152022	Goldisc Recording	Holbrook	Broadway Avenue
152029	Spectrum Finishing Corp.	West Babylon	50 Dale Street
152030	Preferred Plating	East Farmingdale	32 Allen Boulevard
152031	Peerless Photo Products	Shoreham	4 Randall Road
152035	Cardwell Condenser Corporation	Lindenhurst (V)	80 East Montauk Highway
152040	Huntington Landfill	Huntington	Town Line Road
152052	North Sea Landfill	Southampton	Majors Path
152077	ServAll Laundry	Bay Shore	8 Drayton Avenue
152082	Circuitron Corp.	East Farmingdale	82 Milbar Boulevard
152102	I.W. Industries, Inc.	Melville	35 Melville Park Road
152103	Commercial Envelope Mfg. Co., Inc.	Deer Park	900 Grand Boulevard
152106	Rowe Industries, Inc.	Sag Harbor	Bridgehampton Turnpike
152108	Liberty Industrial Finishing Products	Brentwood	500 Suffolk Avenue
152123	B.B. & S. Treated Lumber Corporation	Speonk	1348 Speonk-Riverhead Road
152139	Bulova Watch Factory	Sag Harbor	15 Church Street
152140	National Heatset Printing Co.	East Farmingdale	1 Adams Boulevard
152147	Minmilt Realty (Hygrade Metal Moulding)	East Farmingdale	540 Smith Street
152157	Eugene's Dry Cleaners	Babylon	54 East Main Street
152159	K - Sag Harbor MGP	Sag Harbor	Bridge Street
152169	New York Twist Drill (Loading Dock Area)	Melville	25 Melville Park Road
152184	Mom's Cleaners	West Islip	556 Union Boulevard

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Pesticide Monitoring

NYSDEC implements a groundwater monitoring program to determine if the use of pesticides impairs groundwater quality beneath Long Island. Results from this program provides information for NYSDEC decisions on pesticide approval and use regulation. Since 1997, under contract to NYSDEC, SCDHS has collected and analyzed samples from groundwater monitoring wells, private water supply wells, and both community and non-community public supply wells located in both Nassau and Suffolk Counties. Samples are submitted to the Suffolk County Public Environmental Health Laboratory (PEHL) for pesticide analysis. Approximately 1,200 groundwater samples have been collected per year. Each year new pesticide products are brought to market, and this points out the need for continued improvement to available analytical capabilities.

NYSDEC maintains a webpage that documents its ongoing efforts implementing the Long Island Pesticide Pollution Management Strategy (https://www.dec.ny.gov/chemical/87125.html). NYSDEC reports that the SCDHS cooperative program consists of more than 24,000 samples, which includes analytical results for as many as 300 parameters, including 150 pesticides, pesticide metabolites, and other agricultural chemicals. Sampling locations have included as many as 200 monitoring wells. The most recent public summary of water quality monitoring analytical data was assembled by NYSDEC in 2014. Annual work plans for this monitoring program were not available for release/review, to ensure the privacy of cooperating private parties. Table 8 summarizes the core elements of the SCDHS workplan monitoring well commitment for 2019-2020.

Table 8 SCDHS Pesticide Workplan Monitoring Well Program Summary

2019-2020 Pesticide Work Plan Summary		
Project	# of Sites	# of Wells
Vineyard Monitoring	8	23
Golf Course Monitoring	12	15
Row/ Field Crop Monitoring	6	19
Greenhouse Monitoring	8	23
Sod Farm Monitoring	2	6
Residential Turf Monitoring	3	7
Nursery Monitoring	4	11
Public Utilities Right of Ways	3	9
Mixed Use/Transitional Use Monitoring	7	8
Trend Analysis	5	24
Total	58	145

This monitoring program and a further discussion of findings also is discussed in Chapters 3 and 4 of the LICAP Groundwater Resources Management Plan.

following authors for their contributions of reports on the quality and quantity issues facing the Long Island aquifer system, presently and in the future. The authors' time and efforts are appreciated and assisted in creating an overall plan for groundwater resource management on Long Island:

Michael J. Alarcon, P.E., MSCE, Director, Bureau of Environmental Engineering, Nassau County Department of Health *Water Use and Regulation of the Lloyd Aquifer on Long Island, New York.*

Richard Bova, P.G., Deputy Director, Strategic Initiatives, Suffolk County Water Authority *Climate Change and Impacts to Groundwater Resources and Supply on Long Island, New York.*

Stan Carey, Superintendent, Massapequa Water District *Cross County Water Transmission on Long Island, New York; Water Supply Alternatives on Long Island, New York.*

Steven Colabufo, CPG, Water Resources Manager, Suffolk CountyWater Authority *Climate Change and Impacts to Groundwater Resources and Supply on Long Island, New York; Water Supply Alternatives on Long Island, New York.*

Dorian Dale, Director of Sustainability, Chief Recovery Officer, Suffolk County Department of Economic Development and Planning *Wastewater Management in Nassau and Suffolk Counties, New York.*

Joseph DeFranco, Director, Bureau of Environmental Protection, Nassau County Department of Health *Regional Groundwater Contamination Events on Long Island, New York.*

Douglas J. Feldman, P.E, Principal Engineer, Office of Water Resources, Suffolk County Department of Health Services *Chloride Contamination of Potable Supply Wells in Nassau and Suffolk Counties, New York.*

Michael Flaherty, Hydrogeologist III, Nassau County Department of Public Works *Regional Groundwater Contamination Events on Long Island, New York.*

Tyrand Fuller, CPG, Lead Hydrogeologist, Suffolk County Water Authority *WaterTraq - Water Quality Mapping and Database.*

Paul Granger, P.E., Superintendent, Port Washington Water District *Cross County Water Transmission on Long Island, New York; Water Efficiency, Conservation and Reuse in Nassau and Suffolk Counties, New York.*

Julie Hargrave, Principal Environmental Planner, Central Pine Barrens Joint Planning and Policy Commission: Land Preservation *Needs for Future Water Quality and Drinking Water Infrastructure on Long Island, New York; The Pine Barrens: Safe Yield, Quantity Impacts and Permitting Restrictions on Long Island, New York.*

Jason Hime, P.E., Associate Public Health Engineer, Suffolk County Department of Health Services. William J. Merklin, P.E., Senior Vice President, D&B Engineers and Architects *Cross County Water Transmission on Long Island, New York; Water Supply Alternatives on Long Island, New York.*

Sarah J. Meyland, M.S., J.D., Associate Professor, Director, Center for Water Resources Management, School of Engineering and Computer Sciences, New York Institute of Technology *Groundwater Quantity and Competing Uses on Long Island, New York; Water Use and Regulation of the Lloyd Aquifer on Long Island, New York.*

John Pavacic, Executive Director, Central Pine Barrens Joint Planning and Policy Commission *The Pine Barrens: Safe Yield, Quantity Impacts and Permitting Restrictions on Long Island, New York.*

Paul J. Ponturo, P.E., Senior Water Resources Engineer, H2M architects + engineers *Regulatory Framework for Groundwater Management on Long Island, New York.*

John Rhyner, P.G., Vice President, Geothermal Services, P.W. Grosser Consulting, Inc. *Use of Long Island's Groundwater Resources for Geothermal Heating and Cooling.*

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