Executive Summary

Introduction

Water is the single most significant resource for which Suffolk County bears responsibility. As the impact of Superstorm Sandy underscored, more than at any time in our history, we are obliged to come to terms, in every sense, with the water that surrounds us. Suffolk County's water quality is at a tipping point. We face an alarming trend in the quality of the water our families drink, compounded by impairment of many bodies of water in which our families play. Moreover, the source of these impairments has demonstrably degraded the wetlands that serve as our last line of natural defense against storm surge.

While today our drinking water generally meets quality standards, elevating levels of contaminants raise serious concern. Many of our rivers, estuaries and bays are impaired as result of eutrophication. Nitrogen, which primarily spews from residential septics and cesspools, as well as fertilizer, are the principal culprits that spur hypoxia, harmful algal blooms, diminution of sea and shellfisheries, and degradation of our protective natural infrastructure–wetlands and seagrass beds that act as wave and storm surge buffers [1] [2]. Sea level rise, which also contributes to marshland degradation, is projected to raise groundwater levels, increasing vulnerability to saltwater infiltration, and further

[1] Deegan LA, Johnson DS, Warren RS, Peterson BJ, Fleeger JW, Fagherazzi S, and Wollheim WM (18 Oct 2012) "Coastal Eutrophication as a Driver of Salt Marsh Loss" *Nature* : doi:10.1038

[2] Anderson ME, McKee Smith J, Bryant DB, and McComas, RGW. (Sept 2013), "Laboratory Studies of Wave Attenuation through Artificial and Real Vegetation" USACE, "It is generally acknowledged that vegetated coastal features such as wetlands can reduce the effects of surge, waves, and tsunami propagation."

compromising on-site wastewater treatment infrastructure largely composed of cesspools and septic tanks.

Perhaps nowhere have we seen the impact of nitrogen pollution in more stark terms than the Great South Bay. At one time, this bay produced more than half the clams eaten in our country. However, over the past quarter-century, the clam harvest in the Great South Bay has fallen by 93 percent, destroying an entire industry which accounted for 6,000 jobs. While clams were once over-harvested, they have largely failed to recover due to recurrent brown tides fed primarily from nitrogen from septic systems and cesspools. We must decide if this type of impaired surface water body will be our region's future or if we can restore our bays to health.

In advance of the release of the 2014 Suffolk County Comprehensive Water Resources Management Plan ("Comp Plan"), this Executive Summary Update is spotlighting the Comp Plan's critical findings, and relevant post-Superstorm Sandy considerations, in order to spur a critical public dialogue about the scope of the problem and begin to frame near-term solutions. While many environmental issues related to groundwater and surface waters have arisen since the previous Plan (1987), one elemental condition has remained constant: the vast majority of Suffolk residents rely on on-site wastewater disposal systems that discharge to groundwater. In addition, fertilizer use, industrial and commercial solvents, petroleum products, pesticides and a host of other manmade contaminants have had profound and long-lasting impacts on groundwater quality, as well as on fresh surface waters and coastal marine waters into which groundwater and stormwater runoff discharge.

In the face of sea-level rise and extreme weather events, Suffolk County is compelled to devise the means and methods to live and thrive with the water beneath, by and around us.

Critical Findings

*"We have a million and a half people, **approximately 70%,** or roughly a million people, who are **not sewered**. This is probably the only place in the world with that large a density in this tight a space where the waste is going into a sole source aquifer immediately beneath us that we're drinking, and this is **a big concern**."*[3]

Downward Trajectory in Groundwater Quality:

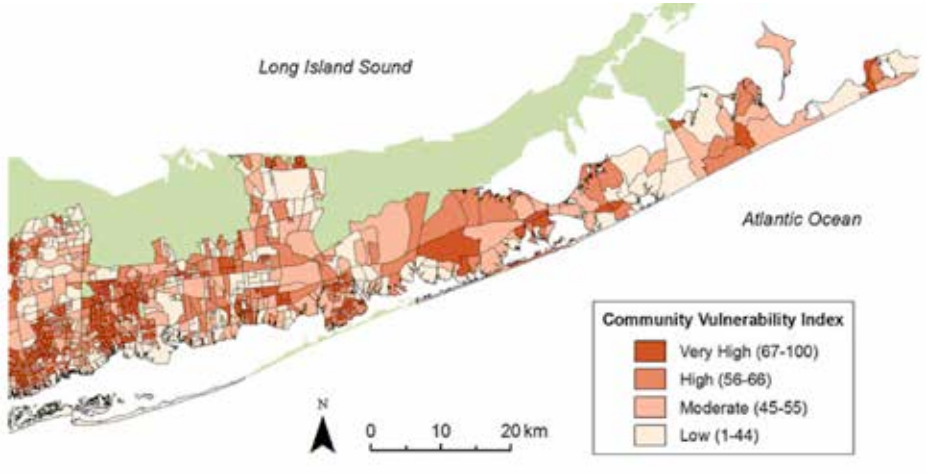
1. Nitrogen is public water enemy #1, as **nitrate contamination** from unsewered housing and fertilizer use poses a threat to both drinking water supplies and coastal marine habitat and resources. Nitrogen-induced nutrient loading and eutrophication can lead to many negative impacts on estuarine environments including harmful algal blooms, hypoxia [little or…], and even anoxia [no oxygen];
2. Volatile organic chemicals (VOCs), another **priority contaminant**, derives from commercial, industrial, and consumer use, impacting large portions of the aquifer, public water supply and private wells;
3. Pesticides pose **a threat,** especially to private wells in agricultural areas; and,
4. Pharmaceuticals and personal care products are an **emerging concern**.

Surface Water Impairments:

5. Long Island's entire 60-miles long South Shore Estuary Reserve was declared impaired by the New York State Department of Environmental Conservation (NYSDEC) in 2008.
6. Brown tide algae invasions have been plaguing Long Island estuaries for nearly a quarter of a century, according to Dr. Chris Gobler of Stony Brook's School of Marine & Atmospheric Sciences (SoMAS) obliterating a shellfish habitat that once provided one half of all hard clams for the nation.
7. There was an 18-36% loss of tidal wetlands between 1974-2001 according to NYSDEC.
8. The NYS Seagrass Taskforce estimates that the 200,000 acres of seagrass in Long Island's bays and harbors in 1930 have shrunk by nearly 90% to 22,000 acres.
9. The Forge River in Moriches is "the worst case of anoxia (absence of oxygen) I have seen," states Dr. Larry Swanson, Associate Dean of SoMAS.

[3] Dawydiak, Walter, Acting Director Environmental Quality, Suffolk County Department of Health Services. Testimony to Health Committee of SC Legislature, March 6, 2012

The costs of redressing water-related issues are significant; the economic consequences of not doing not doing so are ***potentially devastating in property values alone****. Then there is Long Island tourism, producing revenues of $4.7B/yr, with approximately 28% of visitors – 5.1M/yr – visiting parks and beaches.*[4] *"Coastal habitats shield people and property from sea-level rise and storms," reducing their exposure by half, according to marine ecologists at Stanford Woods Institute for the Environment.* [5] [6]



[4] Trust for Public Land, "The Economic Benefits and Fiscal Impact of Parks and Open Space in Nassau and Suffolk Counties, New York," 2010 accessed at http://cloud.tpl.org/pubs/ccpe--nassau-county-park-benefits.pdf
[5] Arkema, K, "Coastal habitats shield people and property from sea-level rise and storms," Nature Climate Change, July 2013
[6] Shepard, C, et al, "Assessing future risk: quantifying the effects of sea level rise on storm surge risk for the southern shores of Long Island, New York," Nat Hazard 2011: 727-745.

Nitrogen from Unsewered Areas

Suffolk County, with a population larger than 11 states and a region that derives its drinking water from the ground, must pay particular attention to the 350,000 sub and non-performing septic/cesspools in Suffolk, accounting for well over 75% of the homes. They are particularly problematic in areas with high water tables and in close proximity to surface waters. When flooded or submerged in groundwater, septic systems do not function as designed and they fail to adequately treat pathogens. Excess nitrogen from this sewage threatens our valuable natural resources, coastal defenses, and human health.

Map of 0-25 Year Baseflow Contributing Areas to Surface Waters

Characteristics of Unsewered Areas in Suffolk County, N.Y.			
	Unsewered Residential Parcels		
	Total	Medium Density (> 1 to < 5 d.u./acre)	High Density *(≥ 5 d.u./acre)*
0-25 Year Baseflow Contributing Areas to Surface Waters	155,939	121,843	34,096
0-50 Year Estimated Groundwater Travel Time to Public Water Supply Wells	55,169	43,967	11,202
Minus Overlap	1,414	1,199	215
Total	209,694	164,611	45,083

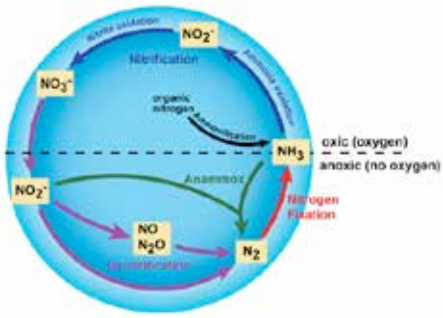
Suffolk County has identified priority high density (greater than 5 homes per acre) and medium density (1 to 5 homes per acre) residential subregions within the contributing areas with the following characteristics:

1. with a depth to groundwater of 10 feet or less; and/or
2. contribute to an area that is listed as a 303(d) impaired water body.

Executive Summary

Contaminant	Manmade Sources
Nitrogen pollution is increasing in our groundwater • While 87% of all community supply wells had nitrogen concentrations less than or equal to 6 mg/L, between 1987 and 2005 there were large changes in nitrogen levels in all of Suffolk County's groundwater aquifers. Nitrogen concentrations in the Upper Glacier aquifer **rose by 40%** while levels in the Magothy aquifer, a deeper aquifer, **rose by 70%**. • Parts of Suffolk County's groundwater exceeds maximum containment levels caused by unsewered, subsized lots, especially in Huntington, Smithtown and northern Brookhaven, with nitrate levels ranging from 8 mg/L to 12 mg/L in Magothy wells in Northport and East Northport. • All 3 major estuaries in Suffolk County are suffering from dissolved oxygen impairments as well as recurring Harmful Algal Blooms, some toxic to humans, diminishing the County's wetlands, which act as a second line of defense for storms. • Wetlands have been scientifically proven to reduce vulnerability from storm surge, reducing wave height by 80% over short distances. Waves lose energy as they travel through vegetation. • Losses of healthy salt marsh have accelerated in recent decades. NYSDEC estimates that there was an 18-36% loss in tidal wetlands in the Great South Bay between 1974 and 2001. In 2008, NYSDEC declared Long Island's entire South Shore Estuary Reserve system, stretching more than 60 miles, an "impaired water body" (under section 303(d) of the Clean Water Act). NYSDEC identifies nitrogen from wastewater as a reason for this unfortunate designation and states that cesspools, septic systems, and sewage treatment plants cause eutrophication, resulting in lower water oxygen levels and persistent algal blooms. According to researchers Kinney and Valiela[1], **69% of the total nitrogen load for the Great South Bay is from septic systems and cesspools**. • Excessive nitrogen has been shown to have a direct effect on seagrass by promoting growth of microalgae which shade it and macroalgae which out-compete it. Thousands of acres have died off in Long Island's Eastern and South Shore estuaries. According to the NYS Seagrass Taskforce, historic photography and records indicate that there may have been as much as 200,000 acres of seagrass in 1930 in Long Island bays and harbors; only about 22,000 acres remain. • A few decades ago, half the clams eaten in this country came from Great South Bay. However, in the past 25 years, the hard clam harvest in Great South Bay has fallen by more than 93% to record lows, resulting in a loss of more than 6,000 jobs.[1] In the 1970s, bay-scallop fishery on Eastern Long Island and hard-clam fishery in the South Shore bays were the two largest in the U.S. The bay-scallop collapse was almost entirely due to the nitrogen-caused algal blooms. While hard clams were over-harvested in the 1970s and 1980s, they have failed to recover largely due to recurrent brown tides.	**350,000 septic and cesspools** 30,250 homes with septic systems or cesspools are within the 0-25 year contributing area to surface water and have less than 10 feet separating their systems from the water table **80% of all fertilizer purchased in Suffolk is for non-farm, residential uses** 25,905 tons of fertilizer were purchased as non-farm uses in 2012, representing 16% of all fertilizer purchased statewide[1]

Contaminant	Manmade Sources
Volatile Organic Chemicals (PCE, TCE, TCA, and MBTE) • 20% of public water supply wells are treated to remove low-level VOCs prior to delivery to customers • The gasoline additive MTBE, banned in 2004, is detected on a widespread basis but manifests itself in small concentrations of 2-3 parts per billion • Concentrations of dry cleaning and metal finishing solvents doubled in a 20-year period, impacting four times the number of wells. • 70% of community supply wells are rated as high or very high for VOC contamination, due to the widespread use of VOCs	Illegal discharges & spills, leaking underground storage tanks, septic systems, household cleaners, and banned chemicals traveling through the aquifer
Pesticides • Past agricultural practices have significantly impacted private wells on the East End, with 6.5% exceeding pesticide maximum contaminant levels • Over 100 pesticide-related compounds in Suffolk's groundwater have been detected	Agricultural sector and homeowners
Pharmaceuticals and Personal Care Products • Detection of pharmaceuticals and personal care products, like ibuprofen, phthalates, and caffeine, have been found in 0.5% of community public supply well samples, and 4% of (shallower) non-community public supply and private well samples. • The presence of 1,4-dioxane, a chemical in detergents, in over 100 SC Water Authority wells and in a large percentage of its water distribution system is expensive to treat.	Industry and homeowners



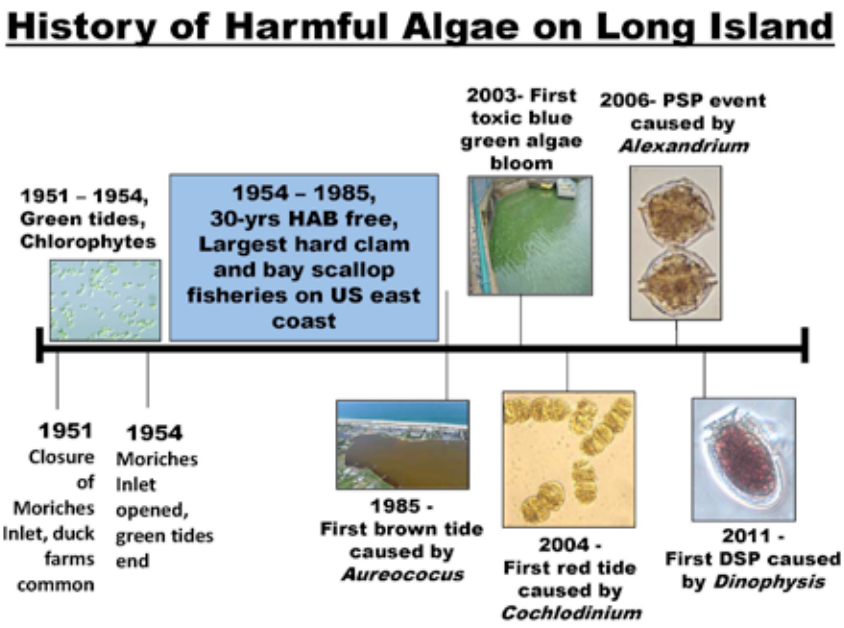
Nitrogen Bomb in Our Bays

Nitrogen is one of the primary nutrients critical for the survival of all living organisms. Since the mid-1900s, humans impact on the global nitrogen cycle via manufacture of fertilizers and burning of fossil fuels has substantially altered the amount of fixed nitrogen in the Earth's ecosystems. Some predict that by 2030, the amount of nitrogen fixed by human activities will exceed that fixed by microbial processes.[7] Nitrogen is arguably the most important nutrient in regulating primary productivity and species diversity in aquatic and terrestrial ecosystems.[8]

Much of the nitrogen applied to agricultural and urban areas ultimately enters rivers and coastal systems. In nearshore marine systems, elevated nitrogen can lead to anoxia or hypoxia (no or low oxygen), altered biodiversity, alterations in the food-web, and habitat degradation. **One common consequence of increased nitrogen is proliferation of harmful algal blooms**.[9] Toxic blooms of certain types of dinoflagellates have been associated with high fish and shellfish mortality. Absent such economically catastrophic impacts, elevated nitrogen can lead to changes in biodiversity, species composition and overall ecosystem function. It has also been suggested that alterations to the nitrogen cycle **may lead to increased risk of parasitic and infectious diseases among humans and wildlife**.[10] Moreover, increases in nitrogen in aquatic systems can lead to increased acidification in freshwater ecosystems.

- Given that Nitrogen forms when microorganisms break down in sewage, manures, decaying plants or fertilizers, millions of pounds of nitrogen are generated on Long Island each year. As Chris Gobler of the Marine Science Research Center at Stony Brook University points out, "and unfortunately most of that, as we all know, is not going to sewage treatment plants, but is going to septic tanks" and eventually seeping into groundwater and surface water, Gobler said. "**We do expect these numbers to rise**."

[7] Vitousek, P. M. *et al.* Human alteration of the global nitrogen cycle: sources and consequences. *Ecological Applications* **7**, 737–750 (1997).
[8] Vitousek, P. M. *et al.* Towards an ecological understanding of biological nitrogen fixation. *Biogeochemistry* **57**, 1–45 (2002).
[9] Howarth, R. W. Coastal nitrogen pollution: a review of sources and trends globally and regionally. *Harmful Algae* **8**, 14–20. (2008).
[10] Johnson, P. T. J. *et al.* Linking environmental nutrient enrichment and disease emergence in humans and wildlife. *Ecological Applications* **20**, 16–29 (2010).



- "The math, via nutrient budgets, that's been done – quantifying the precise amount of nitrogen in pounds per day from different sources including the atmosphere, fertilizers, septic tanks, cesspools, sewage treatment plants – clearly shows that **the large majority is from cesspools and septic tanks**, going from land into these South Shore estuaries," says Gobler. "The groundwater travels through the aquifer, it's going towards the bay. Tainted groundwater flows only a couple of feet a day. So, ironically, the bays may just now be getting hit with the effects of explosive development of the 1960s and '70s."

- Though submerged septic systems have not been thoroughly evaluated, such systems may very well diminish treatment of potentially pathogenic bacteria. "Excess nutrients (nitrogen and phosphorous) from both point and non-point sources from wastewater inputs can significantly impact surface water quality causing anoxia, hypoxia, eutrophication, nuisance algal blooms, dieback of seagrass and corals and reduced populations of fish and shellfish."[11]

[11] Paul, J.H., et al, "Rapid movement of wastewater from on-site disposal systems into surface waters in the Lower Florida Keys," Estuaries, Oct 2000, Vol23, Iss5, pp662-668.

	Suffolk County			New York State		
Year	Total Fertilizer	Farm	Non-Farm	Total Fertilizer	Farm	Non-Farm
2011	34,710.71	20.9%	79.1%	596,891.67	70.1%	29.9%
2012	32,432.19	20.1%	79.9%	590,819.23	72.7%	27.3%

2008-12 Suffolk County non-farm fertilizer sales was **17.5%** of NYS/Agriculture & Markets

- Though the element occurs naturally and is necessary for human health and plant growth, when **ingested in high levels, it can deprive bodies of oxygen in blood**. In infants, excess nitrogen in water used for formula preparation can lead to "blue baby syndrome," where the lack of oxygen turns the skin blue. In adults, high nitrogen levels, in severe cases, can lead to brain damage.

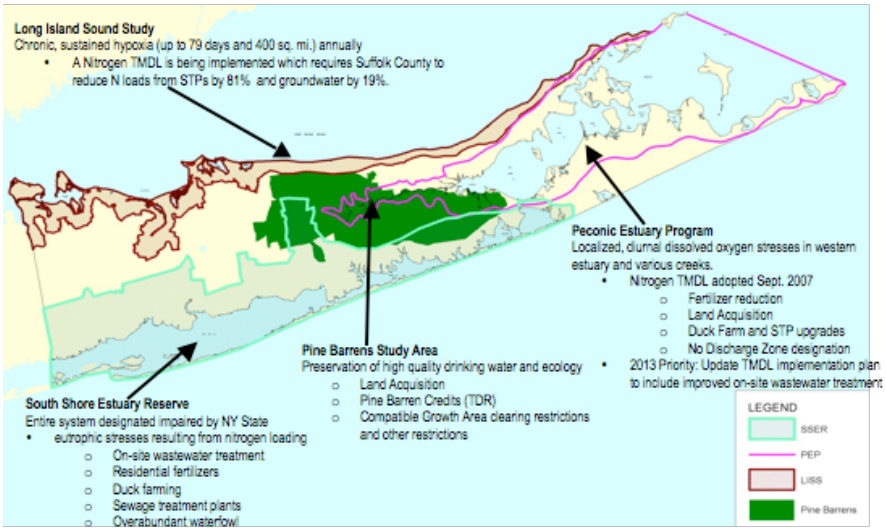
- Excess nitrogen is also harmful to coastal ecosystems. One important impact of nitrogen loading to coastal systems is low dissolved oxygen, or hypoxia. This occurs when decomposition processes outpace oxygen production and consume dissolved oxygen in the water column. Hypoxia can lead to fish kills and displace marine organisms, cause odors, alter sediment chemistry, and impact the food web.

- In 2008 the NYSDEC declared Long Island's entire South Shore Estuary Reserve system, stretching more than 60 miles, an "impaired water body" (under section 303(d) of the Clean Water Act). NYSDEC identifies nitrogen from wastewater as a reason for this unfortunate designation and states that cesspools, septic systems, and sewage treatment plants cause eutrophication, resulting in lower water oxygen levels and persistent algal blooms throughout this important ecosystem.

- But drinking water safety and prevention of hypoxia are only two reasons Long Islanders are concerned about nitrogen loading. Other important impacts include harmful algal blooms (HABs), declining populations of recreationally and commercially important fish and shellfish, and degradation of wetlands and seagrass - important natural defenses against storms.

- The recurrence of nitrogen-caused low oxygen conditions, are the reason many of Long Islands bays are considered "impaired" (under section 303(d) of the Clean Water Act). For this reason alone, federal and state policies have mandated that nitrogen loads be reduced in the Long Island Sound and Peconic Estuary.

- In 2008 the NYSDEC declared Long Island's entire South Shore Estuary Reserve system, stretching more than 60 miles, an "impaired water body" as well and will soon mandated load reductions there. NYSDEC identifies nitrogen from wastewater as a reason for this unfortunate designation and states that cesspools, septic systems, and sewage treatment plants cause eutrophication, resulting in lower water oxygen levels and persistent algal blooms throughout this important ecosystem.



Brown tide – Moriches Bay, LI 2011

The Tides Are Turning on Us[12]

- October 15, 2013 – **Brown tide** algae, the color of coffee, has returned to Long Island's South Shore with concentration 20x what is harmful to shellfish in central Great South Bay and is 4x in other parts of the Great South Bay. Chris Gobler says such algal blooms have been forming in South Shore bays for at least the past 25 years.

- Since the 1980's, the Brown Tide causing algae *A. anophagefferens* has plagued Long Island Estuaries, and has been implicated in the crash of the hard clam population in Great South Bay and the iconic bay scallop population in the Peconic Estuary. In effect, the fate of the shellfish population is forewarning for the surrounding ecosystem of eel grass and marsh, like the proverbial canary in the coal mine.

- Since this particular strain of algae, *A. anophagefferens* can exploit either inorganic or organic nutrients, it can potentially out-compete other co-occurring phytoplankton under some circumstances. As *A. anophagefferens* is adapted to grow under low light conditions and can utilize the available dissolved organic nutrients, it proliferates as the waning algal bloom uses up the inorganic nutrients and shades the water column with its biomass.

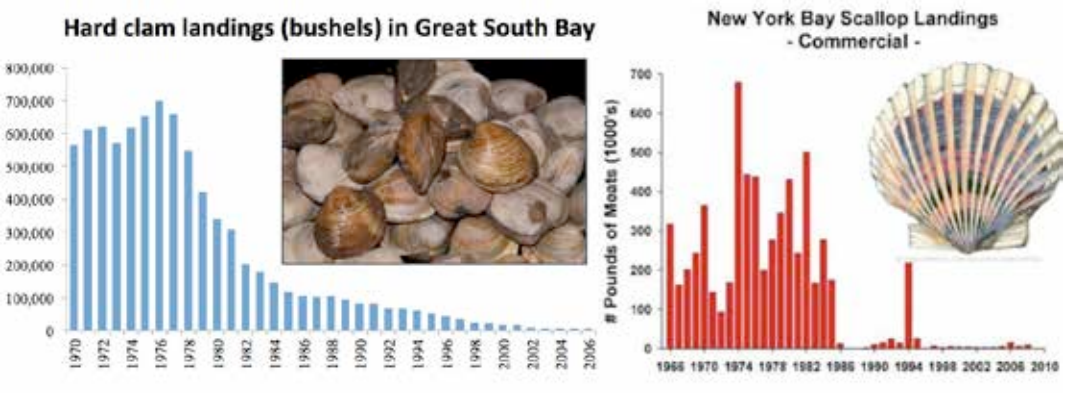
[12] http://www.seagrant.sunysb.edu/articles/t/brown-tide-research-initiative-what-s-new is the source for all material in this section

- Note that the **primary source of dissolved inorganic nitrogen** to many of Long Island estuaries is in fact **groundwater underflow**. Reduced groundwater underflow combined with an organically enriched environment provide ideal conditions for the brown tide, allowing it to out-compete other species that rely on inorganic nutrients alone and higher light levels for photosynthesis.

- When hard clam populations were at their peak in Great South Bay in the 1970s, it has been estimated that the entire volume of Great South Bay was "filtered" through the benthic shellfish once every three days. With the dramatic decline in the hard clam population of Great South Bay, by 1993 the estimated time to filter the bay increased to once every 25 days. Field and laboratory results confirm the importance of these benthic filter feeders in helping to control *A. anophagefferens* populations. In tank experiments, under certain conditions, water filtration by hard clams prevented *A. anophagefferens* from blooming. These results suggest that the reduction in benthic filter feeders, such as hard clams, has caused a shift of the dominant grazers on phytoplankton from benthic filter feeders to the zooplankton grazers in the water column. Accordingly, a combination of a healthy population of benthic filter feeders and pelagic grazers could potentially control *A. anophagefferens* abundance and help prevent a brown tide.

- The red-tide, or **rust tide** organism ***Cochlodinium*** has appeared in Long Island waters every year since 2004,with an earlier than usual appearance in 2013. The Department of Environmental Conservation reported a fish kill reported at Cases Creek in Aquebogue on Aug. 2, finding killifish, snappers, and black sea bass, all with a coating of "orange slime." Gobler said, "Prior research in my lab has demonstrated that these blooms are made worse by increased nitrogen into these bays."

- The **red-tide** algae, *Alexandrium*, produces saxitoxin, which causes *Paralytic Shellfish Poisoning,* which causes numbness and tingling in the face and extremities, followed by headache, dizziness, nausea and a loss of coordination; more severe paralysis, respiratory failure and death can occur (NYS-DEC). Saxitoxin accumulates in the tissues of molluscan shellfish, posing a human health threat which causes shellfish beds to be closed to fishing, and income to be lost. Blooms of this species began to occur annually in north shore bays on Long Island, but now regularly impact eastern and south shore bays including Mattituck Creek, Sag Harbor Creek, and Shinnecock Bay as well.



- The algae *Dinophysis* produces okadaic acid, which causes *Diarrhetic Shellfish Poisoning* resulting in gastro-intestinal symptoms which can be dangerous or even lethal in high-risk populations. This algae has also expanded its range on Long Island in recent years and has occurred in record concentrations in western Peconic tributaries.

- Another group of harmful algae, Cyanobacteria, have created harmful blooms with increasing frequency and extent in Suffolk County's fresh waters.

Why Are Protective Salt Marshes Falling Apart?

Too Many Nutrients[13]

- NYS 2100 Commission's report: "**Tidal wetlands can protect coastal communities** from storm damage by reducing wave energy and amplitude, slowing water velocity, and stabilizing the shoreline through sediment deposition."

- A 2013 report by the US Army Corps of Engineers concluded that **vegetated coastal features** such as marshlands **can reduce the effects of surge, waves**, and tsunami propagation. [14] Researchers have concluded that coastal wetland vegetation serves as a natural defense system against storm surges and waves along coastal regions, reducing wave height by 80% over short distances. Waves lose energy as they travel through vegetation.[15] [16]

- Salt marshes are among the most biologically productive ecosystems on Earth and they perform many ecosystem services that are highly valued by society. "Salt marshes are a critical interface between the land and sea," Woods Hole scientist Linda Deegan says. "They provide habitat for fish, birds, and shellfish; protect coastal cities from storms; and they

[13] Deegan LA, Johnson DS, Warren RS, Peterson BJ, Fleeger JW, Fagherazzi S, and Wollheim WM (18 Oct 2012) "Coastal Eutrophication as a Driver of Salt Marsh Loss" *Nature*: doi:10.1038.

[14] Anderson ME, McKee Smith J, Bryant DB, and McComas, RGW. (Sept 2013), "Laboratory Studies of Wave Attenuation through Artificial and Real Vegetation" USACE, "It is generally acknowledged that vegetated coastal features such as wetlands can reduce the effects of surge, waves, and tsunami propagation."

[15] Jadhav, Ranjit and Chen, Qin, "Field Investigation of Wave Dissipation Over Salt Marsh Vegetation During Tropical Cyclone" Coastal Engineering, 2012

[16] Ysebaert, T, Yang, S.,Zhang, L., He, Q., Bouma, T., Herman, P. "Wave Attenuation by Two Contrasting Ecosystem Engineering Salt Marsh Macrophytes in the Intertidal Pioneer Zone" Society of Wetland Scientists 20 Sept 2011

take nutrients out of the water coming from upland areas, which protects coastal bays from over-pollution."

- Losses of healthy salt marsh have accelerated in recent decades, with some losses caused by sea-level rise and development. The NYS DEC estimates that there was an **18-36% loss in tidal wetlands** in the Great South Bay occurred between 1974 and 2001.[17] As the only South Shore bay with major riverine input, Great South Bay's living resources have been significantly affected by diminished tributary water quality.

- Based upon 36 yrs of nutrient enrichment in replicated field experiments, a team of scientists from LSU's Department of Oceanography and Coastal Sciences, the Coastal Systems Program at U MA, and the Woods Hole Oceanographic Institution drew the following conclusions: "Enrichment reduces organic matter belowground and may result in a significant loss in marsh elevation equivalent to about half the average global sea level rise rates. Sustaining and restoring coastal emergent marshes is more likely if they receive less, not more, nutrient loading…. The salt marshes most vulnerable to changes in elevation will be those organic-rich salt marshes at the low end of their elevation range and exposed to relatively high nutrient loading…. An example of this situation might be in [neighboring] Jamaica Bay, New York, an estuary that has lost much of its salt marsh to fragmentation, and has had significant marsh dieback (near complete loss of vegetation in salt marsh parcels, with subsequent erosion and down-estuary transport of sediment away from the marsh platform).[18] [19]

- Marsh loss through expansion of unvegetated pannes is a widespread phenomenon especially prevalent in northeast estuaries. As these unvegetated areas expand, the vegetated area of marsh and the delivery of ecosystem services from these marshes, like coastal protection from storm surges, are also lost.

- According to Coastal Resilience 2.0, a project of The Nature Conservancy, from '74-'08 Smith's Point marsh diminished by 28.31%, Gardiner Park by 33.67%.

[17] http://www.dec.ny.gov/lands/31989.html
[18] Turner, R. E. et al. Salt marshes and eutrophication: an unsustainable outcome. Limnol. Oceanogr. 54, 1634–1642 (2009).
[19] Hartig, E. K., et al. Anthropogenic and climate-change impacts on salt marshes of Jamaica Bay, New York City. Wetlands 22: 13–31. (2002)

- Excessive nitrogen has been shown to have a direct effect on seagrass by promoting growth of microalgae which shade it and macroalgae which out-compete it. Thousands of acres have died off in Long Island's Eastern and South Shore estuaries. According to the NYS Seagrass Taskforce, historic photography and records indicate that there may have been as much as **200,000 acres of seagrass in 1930** in Long Island bays and harbors; only about **22,000 acres remain**.

- Global decrease in ECEs is known to affect at least three critical ecosystem services (Worm et al. 2006): the number of viable (non-collapsed) fisheries (33% decline); the provision of nursery habitats such as oyster reefs, seagrass beds, and wetlands (69% decline); and filtering and detoxification services provided by suspension feeders, submerged vegetation, and wetlands (63% decline). The loss of biodiversity, ecosystem functions, and coastal vegetation in ECEs may have contributed to biological invasions, declining water quality, and decreased coastal protection from flooding and storm events.[20]

- Like wetland systems, seagrass beds dampen wave energy and stabilize sediment, protecting Long Island's coastal communities from the impact of storms and flooding. "Larger seagrass bed width in the direction of wave propagation results in higher wave attenuation, and relative wave attenuation increases as incoming wave height increases…. A few authors have postulated that seagrass beds could reduce the energy

[20] Barbier EB, et al. "The value of estuarine and coastal ecosystem services." Ecol Monogr 2011;81:169–193.

that reaches shorelines, and potentially protect shorelines from being eroded"[21]

- Wetlands and seagrass beds are also critical to the resiliency of Long Island's marine food web to the impacts of storms and climate change, and ecological threats like eutrophication and harmful algal blooms. By providing the nursery habitat necessary for reproduction of key species at the base of the food web, these habitats are essential to the success of recreationally and commercially important finfish and shellfish.

- Coastal wetlands reduce the damaging effects of hurricanes on coastal communities by absorbing storm energy in ways that neither solid land nor open water can. The mechanisms involved include decreasing the area of open water (fetch) for wind to form waves, increasing drag on water motion and hence the amplitude of a storm surge, reducing direct wind effect on the water surface, and directly absorbing wave energy. Since marsh plants hold and accrete sediments , often reduce sediment resuspension, and consequently maintain shallow water depths, the presence of vegetation contributes in two ways: first by actually decreasing surges and waves, and also by maintaining the shallow depths that have the same effect.[22]

- "Coastal habitats – such as seagrasses, kelp forests, coral reefs, mangroves, wetlands, and dunes – can provide protection from[23] erosion and inundation due to storm surge. Loss of these nearshore habitats can have dire implications, including damage to coastal infrastructure, private property, and loss of human life…. Existing coastal habitat protection laws aimed at reducing eutrophication of receiving waters also keeps in check those same biophysical processes that exacerbate ocean acidification."

- The number of people, poor families, elderly and total value of residential property {exclusive commercial} that are most exposed to hazards can be reduced by half if existing coastal habitats remain fully intact. Coastal habitats defend the greatest number of people and total property value in Florida, New York and California…. Large expanses of coastal forests and wetlands, oyster and coral reefs, dunes and seagrass beds (Supplementary Fig. S4) are critical for protecting the eastern seaboard…. Variation among counties in the value of property now

[21] Chen S-N,et al. "A nearshore model to investigate the effects of seagrass bed geometry on wave attenuation and suspended sediment transport." Estuaries Coasts 2007;30:296–310.
[22] Costanza R, et al. "The valueofcoastalwetlandsforhurricaneprotection." Ambio 2008;37:241–248.
[23] Ruckelhaus, M, et al, "Securing ocean benefits for society in the face of climate change," Marine Policy, Jan 6, 2013

protected by coastal habitats is substantial, ranging from US$0 (for example, Jefferson, Florida), to more than US$20 billion in ***Suffolk*** and Kings, New York." - Arkema, Katie K, et al,"Coastal habitats shield people and property from sea-level rise and storms," Nature Climate Change, July, 14, 2013

- The Community Vulnerability Assessment Tool (NOAA) identifies block groups that are most risk, assessing damages resulting from a category 3 hurricane (*gray*) compounded .5m sea-level rise (*black*),[24] + values of tidal marshes.[25]

Case #1: The Forge

"It's the worst case of anoxia[absence of oxygen] I have seen."
-Larry Swanson, coastal oceanographer, Marine Science Research Center, (New York Times, 2/28/08)

"The **Forge River** has been a distressed estuary since the early part of the 20th century. Extensive duck farming in the 20th century along the banks of the Forge River and high density residential development contributed to the high-nitrogen sediment load that remains. Residential development booms in the Mastic Beach area in the early 20th century and on the peninsula in the mid-20th century added thousands of onsite wastewater treatment systems (cesspools and septic systems) inside the Forge River watershed. Residents of the Forge River watershed continue to report **malodorous conditions and fish kills** while local scientists report hypoxic and anoxic conditions that are inhospitable to aquatic life…

[24] Shepard, C, et al, "Assessing future risk: quantifying the effects of sea level rise on storm surge risk for the southern shores of Long Island, New York," Nat Hazard 2011: 727-745.
[25] Bromberg, K, et al, "Centuries of human driven change in salt marsh ecosystems," AnnRvw Mar Sci 2009; 1-117-141.

"Nitrogen loading, in order of quantity delivered to the estuary, is from residential septic systems, the duck farm, private treatment plants, release from the sediments, residential and agricultural fertilizer use, and to a lesser extent atmospheric deposition and stormwater. The Characterization report concludes that the severe dissolved oxygen depletion in the Forge River is primarily due to algal blooms fed by exceptionally high nitrogen. The majority of the nitrogen entering the estuary is from groundwater that is years or tens of years old and therefore reflects historic inputs. Groundwater continues to receive nitrogen from septic systems and fertilizer use. Dense algal blooms will recur annually, particularly during the summer, as long as new and historic nitrogen loading and circulation remains unchanged…. The **Forge River has a history of water quality impairments** and has experienced chronic hypoxia and fish kills. In 2006, using methodology established by the Federal Clean Water Act, the river was categorized as a waterbody that did not meet water quality standards, and was placed on **New York State's "303(d) list**." –Cameron Engineering/CH2MHill, Forge Watershed Management Plan, March 2012

"The sheer volume of groundwater that feeds the Forge River and its tributaries, especially in high-density areas, delivers a tremendous nitrogen load, likely far more than, say, a concentrated amount from a point-source discharge," -Robert Waters, supervisor, Suffolk County Department of Health Services' Bureau of Marine Resources (2/28/08)

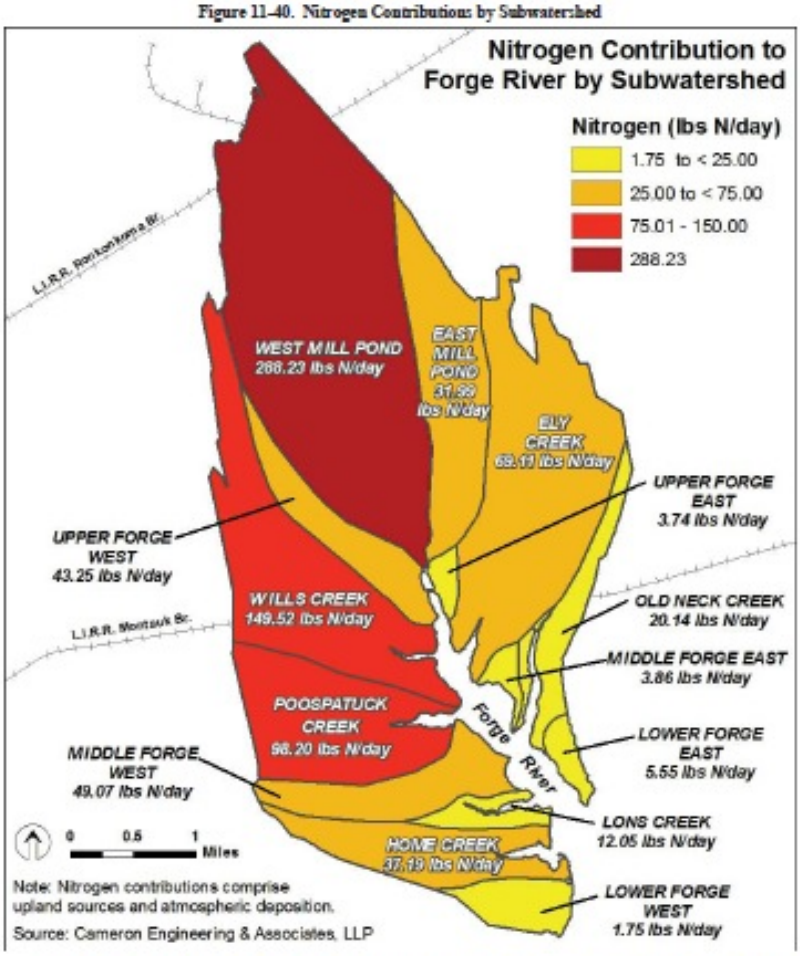
"The eastern boundary of the study area consists of the Forge River and its tributaries. The River is an estuary that has been identified as an impaired water body and is included in the New York State Department of Environmental Conservation (NYS DEC) 303 (d) list for pathogens, nitrogen and dissolved oxygen/oxygen demand. Incorporation of the densely developed residential area in the western part of the Forge River watershed to **the potential Sewer District boundary provides a significant environmental benefit** which helps to satisfy the stakeholder goals associated with improving the water quality of the Forge River."

"Many homes close to the estuary are at elevations so low that there is little unsaturated soil between the on-site system and groundwater. Here there is no opportunity for soil bacteria or roots to act on the nitrogen prior to its release to groundwater and then the estuary. Several hundred homes are less than nine feet above groundwater, the minimum currently required by the County for on-site wastewater treatment systems (11-54)."

"If groundwater nitrogen were significantly reduced, algal blooms would be less frequent and less intense. Less intense and fewer algal blooms would reduce

the deposition of organic matter to the sediments. Activity by aerobic sediment bacteria would slow, releasing less nitrogen back to the water table. Anaerobic bacteria located deeper in the sediment where oxygen is depleted, would denitrify remaining organic material and release nitrogen to the atmosphere. Reducing groundwater nitrogen inputs to the estuary is one of the most effective ways to improve water quality in the Forge River (11-57).

Figure 11-40. Nitrogen Contributions by Subwatershed



Note: The Jurgielewicz Duck Farm ceased operations just prior to the publication of this report. Nitrogen loading will be re-calculated as part of the formulation of the TMDL without the input from the duck farm.

Source Water Assessments

Recognizing that activities in a water supply's source water area have a significant potential to affect quality of the potable supply, the New York State Department of Health (NYSDOH) directed the development of Source Water Assessments for all public supply wells that existed in Suffolk County in 2003.

As part of this project, updated source water assessments were completed for all existing and planned community supply wells identified by Suffolk County water suppliers. The source water assessments have three major components:

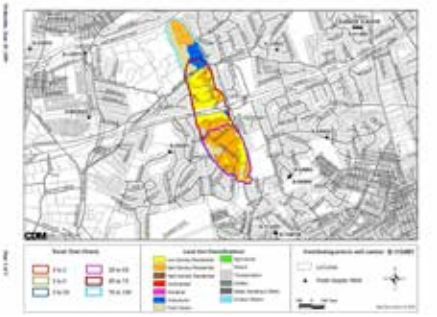
- *Use of three dimensional groundwater flow and contaminant transport models to delineate the area contributing recharge to each well (source water area), and to estimate the time of travel from the water table to the well screen;*
- *Use of GIS and extensive databases to identify the prevalence of each contaminant category within the source water area, based upon land uses and the presence of potential point sources of contamination;*
- *Evaluation of the susceptibility of each well to potential contamination, based upon contaminant prevalence, contaminant fate and transport characteristics, and travel time to the well screen.*

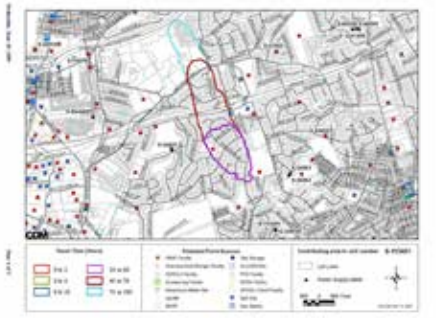
Groundwater Quality

Groundwater throughout most of the County is of high quality. The ***1987 Comp Plan*** identified only four inorganic constituents – chlorides, sulfate, iron and manganese – that exceed drinking water standards in native groundwater in some parts of the aquifer system. Although Suffolk County's 1.5 million residents live directly above the sole-source aquifer, the quality of the County's groundwater remains remarkably good due to the concerted efforts of water resource managers. Water quality data reveals that concentrations of many contaminants introduced to the groundwater by human activity have increased over the past two decades since the ***1987 Comp Plan*** was completed.

Suffolk County has long recognized that land uses and activities occurring above ground can have a direct impact upon groundwater quality, as recharging precipitation can transport dissolved contaminants from materials used, stored or disposed of at the ground surface down through the unsaturated zone to the underlying aquifer. The sands, silts, gravels and clays that make up the unsaturated zone and the aquifer system function as a large sand filter that has helped to limit the impact of many of these contaminants on groundwater quality. While implementation of regulations and management activities protecting groundwater quality have been effective in reducing the impacts of human development, the continued effects of overlying land uses on groundwater quality in the County are evident.

New York State Department of Environmental Conservation (NYSDEC) has established groundwater quality criteria for over one hundred contaminants, and improved analytical capabilities allow detection of hundreds of additional contaminants, at increasingly lower concentrations. This study focused on contaminants that have been identified in Suffolk County groundwater – nitrate, which has long been identified as the inorganic parameter causing the most widespread concern; volatile organic compounds (VOCs) and pesticides, which have previously been identified as a serious threat to groundwater quality, and additional contaminants of concern, whose occurrence and health impacts are still being studied, such as perchlorate and pharmaceuticals and personal care products (PPCPs).





Source Water Assessments Used Computer Models, Land Use Data, Potential Point Source Locations, and Contaminant Fate and Transport Characteristics to Assess the Susceptibility of Each Community Supply Well to Contamination.

A comparison of water quality data collected from community supply wells that were sampled in both 1987 and in 2005 reveals that concentrations of nitrate are slowly increasing in all three aquifers, as a result of sanitary wastewater discharges and fertilization practices. A comparison of average nitrate concentrations from all community supply wells that existed in 1987 and all community supply wells that existed in 2005 shows that nitrate concentrations, on average, have increased by more than 1 mg/L in both the upper glacial and Magothy aquifers. Overall, average nitrate concentrations remained less than or equal to 6 mg/L in nearly 87 percent of all community supply wells in 2005. Only two percent of all raw water samples of community supply wells exceeded the 10 mg/L drinking water Maximum Contaminant Level (MCL). Private well sample results showed that almost one third of the private wells tested contained less than 1 mg/L nitrate, approaching native groundwater quality, and nitrate concentrations in nearly 75 percent of the private wells were less than or equal to 6 mg/L. However, nitrate levels in nearly ten percent of the 10,277 private wells sampled exceeded the 10 mg/L MCL; these impacted wells were primarily located in agricultural areas of the north and south forks and in pockets of the more densely developed unsewered areas of the north and south shores. In summary, while groundwater throughout most of the County continues to comply with the nitrate MCL, the data indicates that the quality of the aquifer has been gradually deteriorating as a result of overlying land uses. These impacts are particularly evident in the shallow zones of the aquifer that are utilized by private wells.

SCDHS routinely tests groundwater for over 80 VOCs – most are never detected. A more detailed assessment of the VOCs that have been most commonly detected in the County in the past (tetrachloroethene or PCE; trichloroethene or TCE; 1,1,1-trichloroethane or TCA, and MTBE) was conducted. Raw water quality data confirms that these most commonly detected VOCs were not found in raw water samples from nearly 90 percent of Suffolk County community supply wells in 2005, and that untreated water pumped from about 98 percent of the community supply wells complied with applicable MCLs for VOCs. Nevertheless, a careful review of contaminants such as PCE in public supply wells that were sampled in both 1987 and 2005 showed that PCE was detected in four times as many wells in 2005 as in 1987, that average PCE concentrations from the same set of both upper glacial and Magothy wells doubled from 1987 to 2005, and that untreated water exceeded the 5 μg/L MCL in one well in 1987, and in nine wells in 2005. Similarly, TCE data from untreated water from public supply wells that were sampled in both 1987 and 2005 showed that average TCE concentrations from the same set of both upper glacial and Magothy wells doubled from 1987 to 2005, and that untreated water from nine wells exceeded

the 5 μg/L MCL in 2005 (only one of the nine did in 1987). Considering untreated water quality data from the same set of public supply wells that were sampled in both 1987 and 2005, the average TCA concentration decreased in the upper glacial wells, but increased slightly in the Magothy wells. Increased detections of VOCs throughout the County, albeit at low concentrations, indicate widespread use and release to the environment. Isolated areas of higher levels of VOC contamination are associated with industrial, commercial, transportation or institutional land uses.

Pesticides also continued to be detected in groundwater downgradient of agricultural areas. In recent years, extensive investigations conducted by SCDHS, including sampling of public, private and monitoring wells, have identified the presence of over 100 pesticide-related compounds in Suffolk's groundwater. SCDHS found that 140 community supply wells were impacted by pesticide-related contaminants during the period from 1997 through 2006.

Perchlorate has been detected in raw, or untreated water samples obtained from eight percent of community supply wells screened into the upper glacial aquifer and five percent of wells screened into the Magothy aquifer. Wells with perchlorate detections generally include existing or historical agricultural land within their contributing areas.

New, more sophisticated analytical techniques have enabled the County to detect the presence of contaminants at parts per trillion levels, much lower concentrations than could previously have been identified. SCDHS has closely monitored available information on emerging contaminants and has analyzed thousands of samples from community, non-community and private wells over the last decade. SCDHS monitoring has identified the presence of trace levels of PPCPs in less than 0.5 percent of the samples collected from community supply wells and in nearly four percent of the samples collected from the shallower non-community and private wells. As new information on the detection, fate and transport characteristics, or potential effects of PPCPs is published nearly every day, SCDHS continues to monitor the literature and regulatory initiatives to assess the need to respond to any potential public health concerns.

Groundwater Quality and Land Use Compared to many sources of water supply throughout the country, Suffolk County's groundwater supply remains for the most part, a high quality source of potable water, despite the impacts of the 1.5 million people who live in the watershed. The combined efforts of programs to protect the aquifer system at the federal, state, county and town levels have been very successful in controlling the impacts of development on groundwater - although the continual gradual decline of groundwater quality indicates that additional efforts are required.

As part of this study, the County's calibrated groundwater models were used to delineate the ground surface area contributing recharge or source water for each of the County's 704 existing and planned community supply wells, shown on **Figure ES-1**. Using Geographic Information Systems (GIS), these contributing areas were overlain upon land use mappings provided by the SCPD as well as mappings of potential point sources of contamination developed from databases maintained by SCDHS, NYSDEC and the Environmental Protection Agency (USEPA). These potential point sources are facilities or properties that have the potential to release contamination to groundwater based on knowledge of the materials used, stored, or disposed of on-site. Based upon the fate and transport characteristics of contaminants commonly associated with the land use types and facilities present within each well's contributing area, and the simulated time of travel from the water table to the supply well's screen, each public supply well's susceptibility to contamination by microbials, nitrates, VOCs and pesticides was assessed and documented.

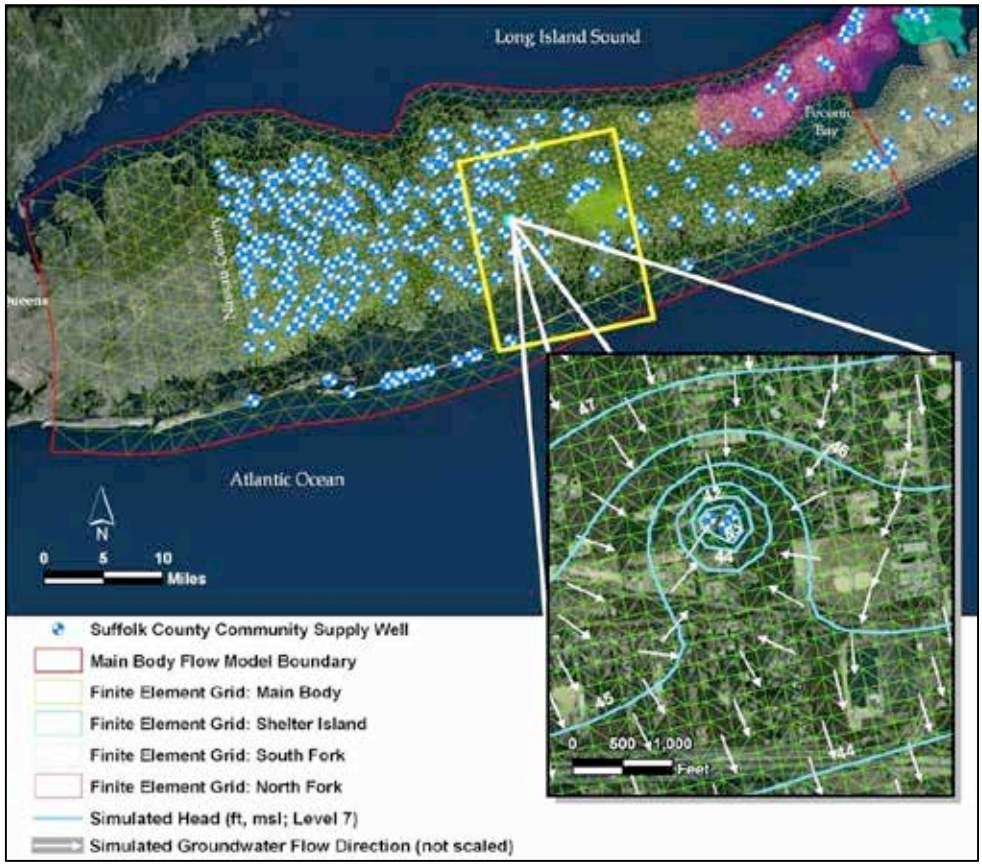


Figure ES-1
Calibrated three-dimensional groundwater and salt water intrusion models were used to develop source water assessments for each community supply well, to help to understand the relationships between land use and groundwater quality and groundwater and surface water resources.

The susceptibility ratings resulting from the updated source water assessment analyses show that the majority of Suffolk County community supply wells are vulnerable to nitrate contamination; this demonstrates a need for additional groundwater protection measures. Due to the widespread use of VOCs in the County, the susceptibility of nearly seventy percent of community supply wells is rated as high or very high for contamination by VOCs. Susceptibility to pesticides is rated at low to medium throughout most of the County, except on the North Fork, where community supply wells are highly or very highly susceptible to pesticide contamination introduced to the aquifer by the agricultural lands present. Because it takes years – or decades in some cases –

Historical land uses within a community supply well's contributing area and travel times from the water table to the well screen were used to relate land use to groundwater quality.

for recharging groundwater to reach a supply well screen, historical land uses can also have a significant impact upon water quality at a well. The relationship between historical land use types within supply well contributing areas and well water quality was also evaluated as part of this study.

On a County-wide basis, sanitary wastewater disposal and fertilization are the two most significant sources of nitrogen loading to the groundwater system. Sanitary wastewater management is one of the most important groundwater resource protection issues facing Suffolk County in both existing developed areas and in currently undeveloped areas. Prior to extensive development, private wells were used to withdraw potable supply from the aquifer; most of the water withdrawn was returned to the aquifer system via on-site cesspools or septic systems. The recharging sanitary wastewater introduced nitrogen and bacteria to the aquifer system, but this was successfully diluted by the greater volume of recharging precipitation and did not cause widespread impacts. Eventually, the sanitary wastewater recharged by more and more residents exceeded the assimilative capacity of the resource in densely developed areas, causing noticeable impacts to the aquifer, drinking water supply, and surface water ecology, and prompting implementation of wastewater collection and treatment systems.

Recognizing the impacts that densely developed unsewered areas have on groundwater and surface water quality, Suffolk County has implemented sanitary sewering programs, and through Article 6 of the County Sanitary Code, established maximum allowable residential densities of one acre in Groundwater Management Zones (GMZ) III, V and VI and ½ acre in GMZs I, II, IV, VII and VIII for new developments that do not include wastewater treatment and disposal facilities. Water quality data and groundwater model simulations show that unsewered areas where property sizes are smaller than one acre are likely to cause groundwater nitrogen concentrations that exceed GMZ target levels of 6 mg/L. Water quality data and groundwater modeling also show that property sizes of ¼ acre or smaller significantly increase the risk of exceeding the 10 mg/L nitrate MCL as shown by **Figure ES-2**. These model simulations of nitrogen levels are higher than previously planning studies because roadways (which would have covered twenty to twenty-five percent of the land area) were not incorporated into the evaluation. Incorporation of roadways would have reduced the overall nitrogen load included in the model, as well as the resulting nitrate concentration.

An evaluation of the impacts of historical land use and nitrate concentrations revealed that:

Nitrate levels were lowest in wells with contributing areas comprised primarily of open space.

Nitrate levels in wells with sewered contributing areas were lower than nitrate levels in unsewered areas.

Groundwater nitrogen levels increase in unsewered areas as housing density increases.

Wells with contributing areas that comply with the density requirements established by Article 6 of the County Sanitary Code complied with target nitrate concentrations.

Agriculture remains a major source of nitrate contamination, particularly on the North Fork; nitrogen loadings are crop-specific.

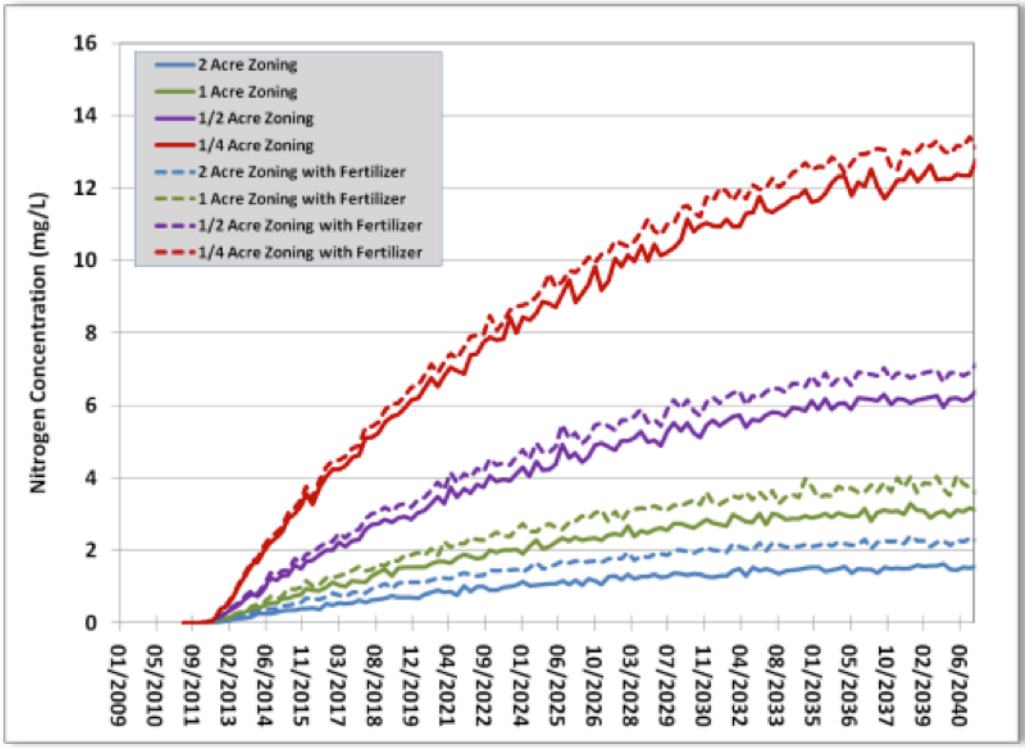


Figure ES-2 Groundwater models were used to assess the impacts of hypothetical unsewered residential areas of various densities upon nitrate concentraions in downgradient groundwater.

Data provided by the SCPD shows that over sixty percent of residential parcels in the County are less than or equal to the minimum ½ acre size required by Article 6, and indeed, many existing residences with on-site wastewater disposal systems had already been constructed on smaller parcels prior to 1980 when Article 6 was enacted. The observed nitrogen levels in groundwater, which have continued to increase since the ***1987 Comp Plan***, result from a combination of the Article 6-compliant and the older non-compliant parcels.

Sources of VOC contamination can include both point sources, such as leaking underground storage tanks, illegal discharges and spills, and non-point sources such as septic system discharges. Relating the presence of VOCs in groundwater to overlying land use is not straightforward, given the widespread use of VOCs, the detections of low levels of VOCs in shallow groundwater throughout the County, and the myriad of potential pathways by which low levels of the contaminants can be introduced to the aquifer system. Water

Prior to extensive development, precipitation infiltrating down through the ground surface travelled through the aquifer system to discharge to one of the County's streams, or to one of the surrounding salt water bodies. In fact, approximately 95 percent of stream baseflow was derived from groundwater.

Although water supply pumping, sanitary wastewater management and stormwater management have all modified the County's predevelopment water budget, groundwater continues to be a significant source of baseflow to streams and wetlands, and discharges millions of gallons to coastal waters each day. Consequently, groundwater quality can have a significant impact upon surface water quality.

quality data has revealed that the highest levels of VOCs are found in wells with industrial, commercial, transportation or institutional uses within their source water areas. Nevertheless, low levels of VOCs were widely detected in groundwater throughout the County, indicating a more widespread low-level source of the observed contaminants, such as residential septic systems. Before targeted recommendations to reduce the release of VOCs to the County's groundwater can be developed, a better understanding of the potential sources of the observed contamination is required.

SCDHS has been a pioneer in the investigation of pesticide impacts to ground and surface waters. The results of their early investigations led to expanded pesticides monitoring in Suffolk County and throughout the nation, to the ban of some pesticides found to leach to groundwater, and to changes in the federal and state pesticide registration processes to prevent similar contamination from occurring. Pesticide contamination in Suffolk County is primarily associated with agricultural land use.

The public health implications of low concentrations of PPCPs in water are only now being studied and are not yet well understood. PPCPs in groundwater are of most concern in densely developed unsewered areas where sanitary wastewater is discharged directly to the ground via on-site septic systems, cesspools or leaching fields. SCDHS continues to assess the potential presence of PPCPs in groundwater, and monitors literature and regulatory initiatives pertaining to potential public health implications.

Surface Water Quality

Suffolk County's surface waters are renowned for their beauty and their ecological, recreational and economic significance. Both the Long Island Sound and the Peconic Estuary have been designated as estuaries of national significance, two of the County's south shore beaches have been included on the 2010 list of the "Top 10" beaches in the United States and the County's streams, harbors and estuaries have great ecological value and significance. The Long Island Sound (LIS), Peconic Estuary and South Shore Estuary Reserve (SSER) have been the subjects of focused studies for years; the LIS Comprehensive Conservation and Management Plan (CCMP), the Peconic Estuary Program (PEP) CCMP and the SSER Comprehensive Management Plan (CMP) all identify a number of strategies and recommendations to improve water quality, reduce use impairments, and protect and restore habitat and ecosystems in the marine systems and the fresh surface waters that feed them.

This Plan focused on the water quality of the County's fresh surface water features, particularly as they are impacted by the quality of groundwater baseflow. **Figure ES-3** below illustrates the relationship between groundwater and stream baseflow.

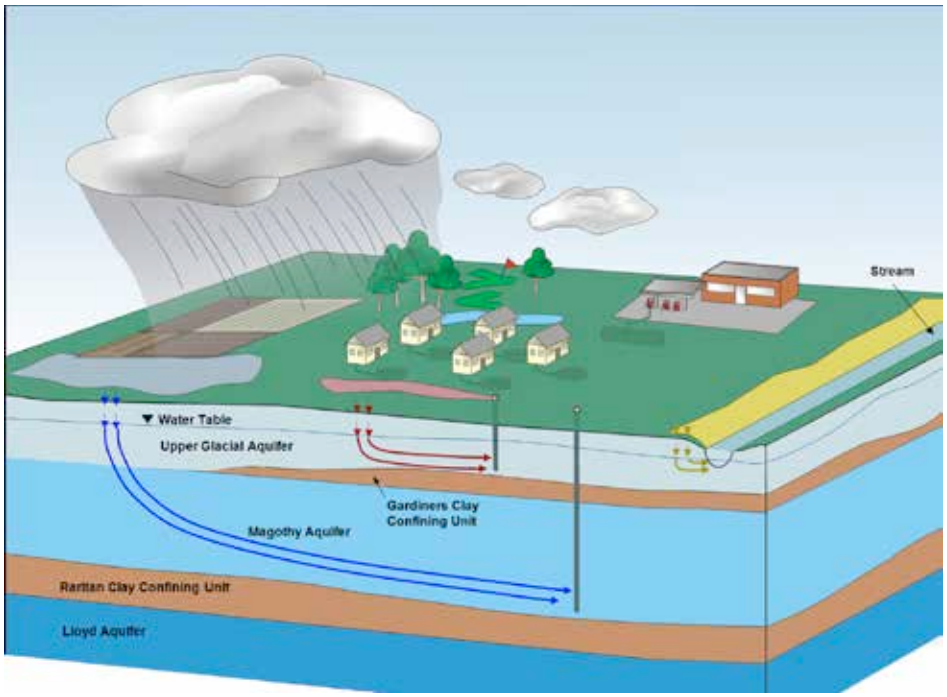
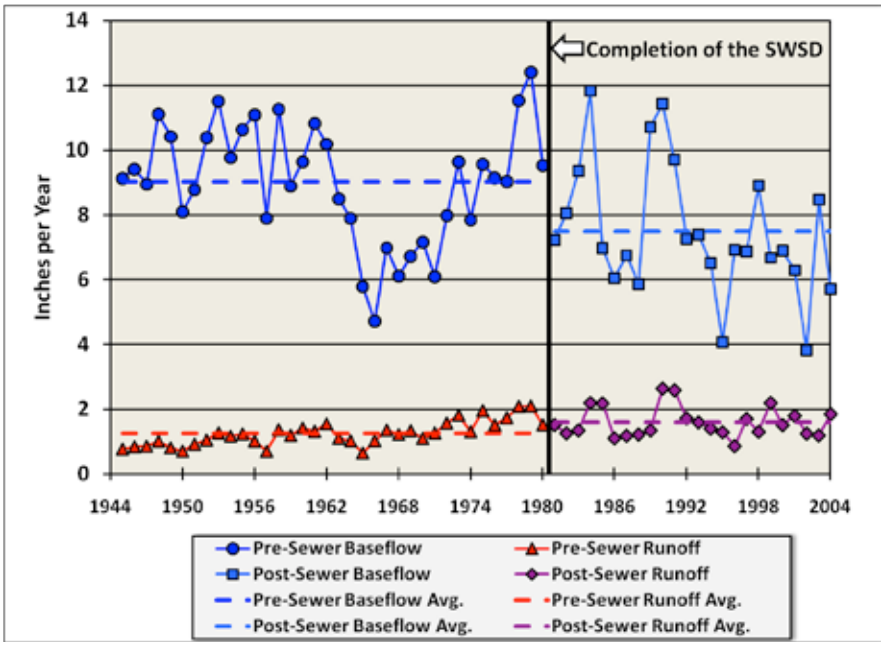


Figure ES-3 - Hypothetical watershed showing how land use can affect groundwater and surface water quality

Within Suffolk County, New York State has classified more than 200 freshwater streams and ponds, identified over 50 coastal plain ponds distinguished by ecological communities that support rare and unusual plant species, and regulates over 1,050 freshwater wetlands covering nearly 24,000 acres (NYSDEC, 2006). Only 13 of the fresh water bodies have been included on the New York State Draft 2010 Section 303(d) List of Impaired Waters – an indication that the quality of most streams, lakes, and ponds supports their best use. NYSDEC has identified pathogens, metals, dissolved oxygen, phosphorus, ammonia, pesticides and silt/sediment as the primary contaminants causing impairment of the fresh surface waters, and storm water runoff as the source of these contaminants. A review of water quality data characterizing twelve of the larger fresh streams in the County revealed that streams in the more densely



Even after sanitary sewering was completed in the County's Southwest Sewer District, groundwater baseflow is the major source of streamflow.

developed western part of the County showed higher levels of VOCs than streams located farther to the east, and that pesticides were primarily detected in streams in the agricultural eastern areas of the County. In general, as would be expected based upon their properties, VOCs have a lower rate of detection, and lower reported concentrations, in surface waters than in groundwater. Levels of MTBE, the most frequently detected VOC**,** appeared to be declining in recent years, probably because sale of gasoline containing MTBE as an additive has been prohibited in New York State since 2004.

The coastal waters bordering Suffolk County are impacted to varying degrees by contaminants introduced by point and primarily, non-point sources. Of the 38 classified saline waters in Suffolk County that discharge to the Long Island Sound, only one, West Harbor Fishers Island, is identified as impaired according to the NYSDEC 2010 draft 303(d) list. Of the 67 classified saline waters along the south shore including Great South Bay, the Atlantic Ocean, and those that drain to either of these waters, 14 are considered to be impaired. The estuary programs have demonstrated that nutrients (particularly nitrogen) and pathogens are primarily responsible for use impairments and for stressing the living marine resources.

Within the Suffolk County watershed area, nonpoint sources are the major contributors of nutrients and pathogens. Recommendations identified by each of the estuary programs focus on reducing nitrogen loading from sanitary wastewater and fertilization, implementation of best management practices (BMPS) to improve stormwater quality, and open space preservation to improve water quality and reduce impacts on the ecology of Suffolk County's coastal waters. The cumulative impacts of these stresses on the overall health of the aquatic ecosystem are not well understood. Little is also known about the impact of emerging contaminants such as PPCPs on the marine resources; the

cumulative impacts of pesticides and PPCPs on the aquatic ecosystems have not yet been well defined, and are currently under study.

Non-point source contributions of nutrients, pathogens and other contaminants have been identified as the primary causes of surface water quality impairments in Suffolk County. Groundwater continues to provide close to ninety percent of baseflow to most streams in the County, and groundwater discharge is one primary source of nutrient loading to fresh and coastal surface waters. The groundwater models were used to delineate the land surface area contributing groundwater baseflow to the County's streams and coastal waters at time of travel intervals ranging from less than one year to fifty years as shown by **Figure ES-4.** Understanding the land use types within the groundwater contributing areas to a stream can help to identify the sources of any observed

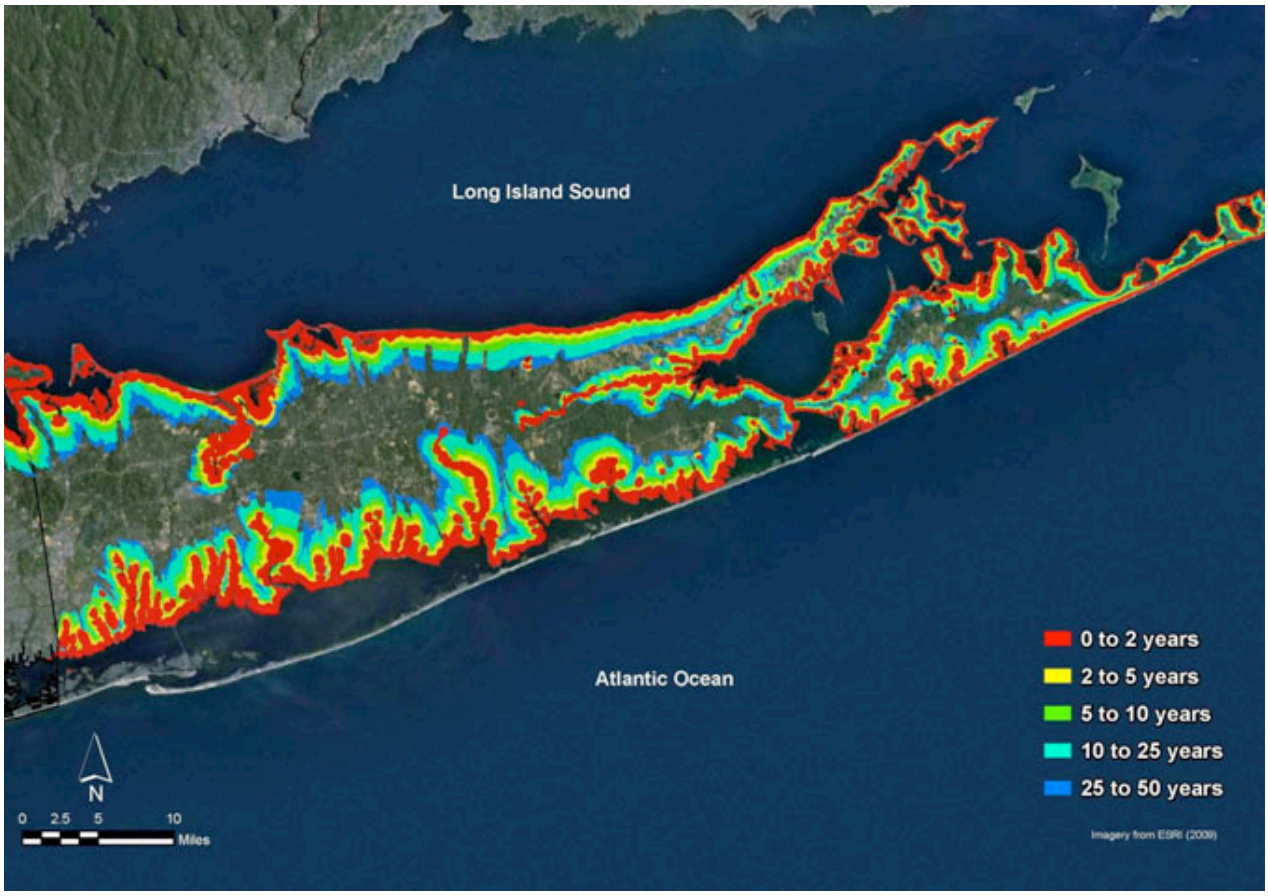


Figure ES-4 Precipitation falling upon the ground surface in the highlghted areas travels through the aquifer system to discharge to County streams, harbors, and other coastal waters. The time that it takes the water to travel from the water table to surface water discharge provides an indication of the time it will take for the effects of management actions to be reflected in the surface water quality.

contamination and to guide identification and evaluation of management options to improve water quality, as illustrated by **Figure ES-5.** Management actions implemented to reduce nutrient and contaminant loads to groundwater within the areas contributing to the County's surface water features will reduce these non-point source loads to the surface waters. Protecting the quality of recharge in these areas will help to protect and improve surface water quality. Based on estimated travel time from the water table to surface water discharge, it may take years for the benefits of improved water quality to be fully realized.

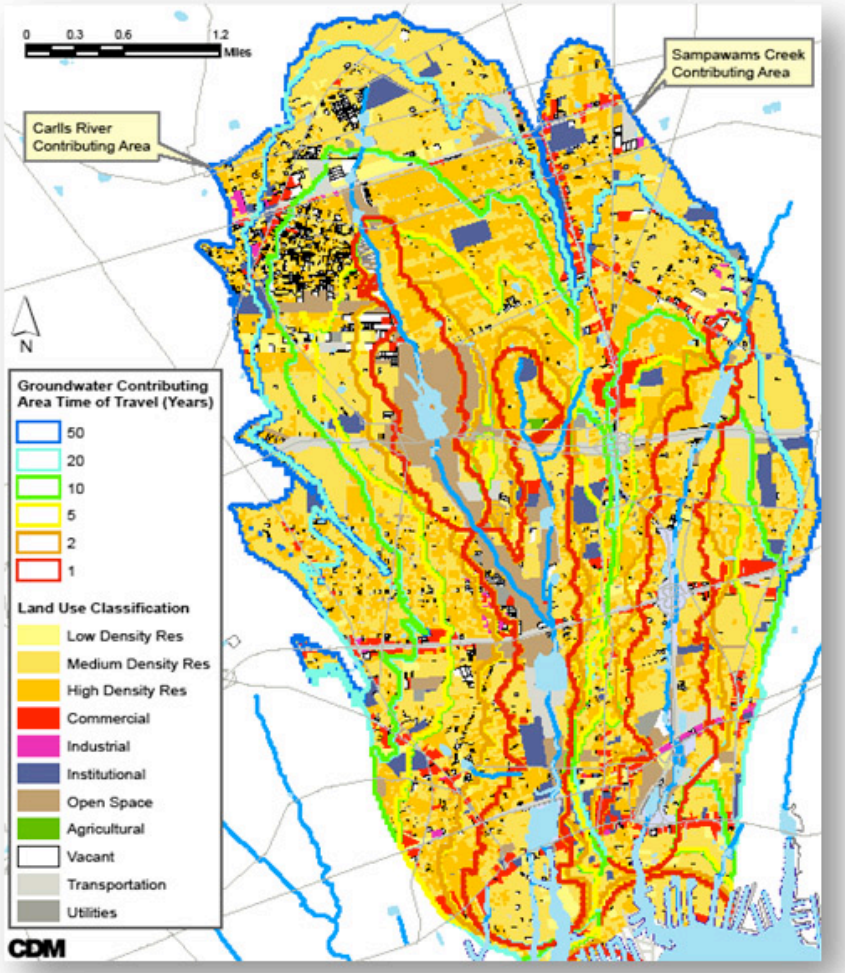


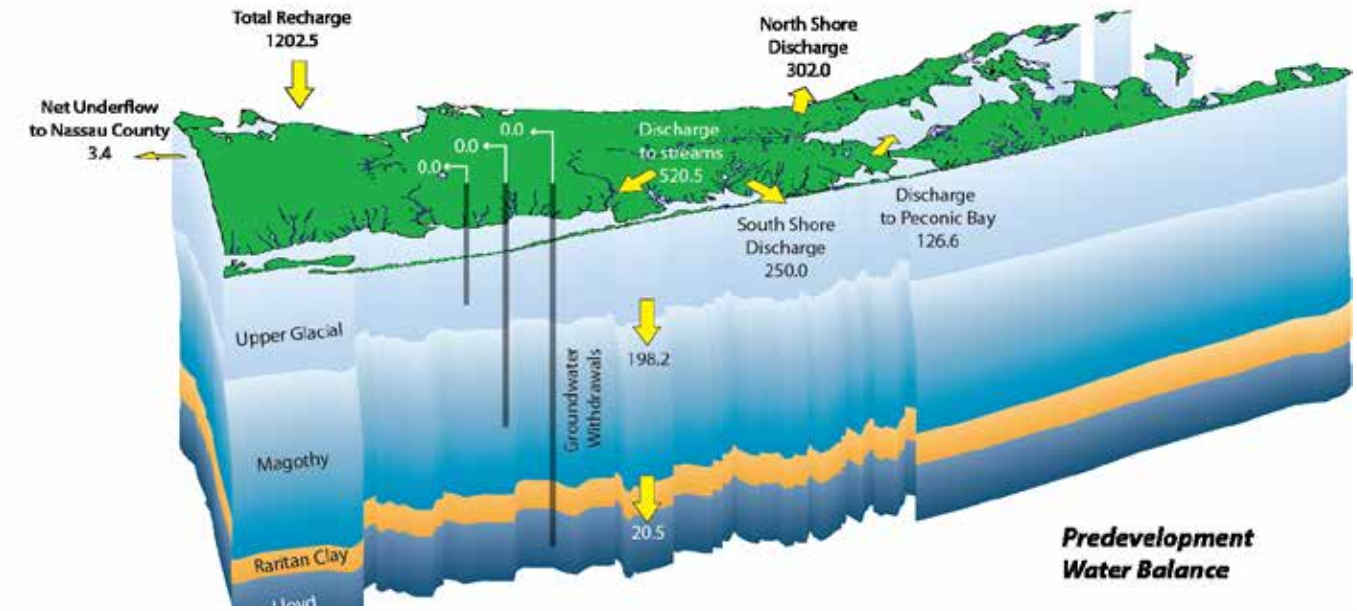
Figure ES-5 *The delineation of groundwater contributing areas to the County's surface waters has aided in the understanding of the impact of land use types on surface water quality and will help select and prioritize management and protection alternatives.*

Groundwater Quantity

Suffolk County's extensive and productive aquifer system that provides the sole source of potable water supply for the County's 1.5 million residents has been studied for decades. All of the County's groundwater originates as precipitation that recharges the island - the County is fortunate to receive an annual average of approximately 48 inches of precipitation, relatively evenly distributed throughout the year. While the amount of precipitation that recharges the aquifer varies by season and location, on average, it is estimated that approximately 50 percent of the precipitation recharges the aquifers to provide an annual average of approximately 1367 million gallons each day of recharge to the aquifer system. The calibrated Main Body, North Fork, South Fork and Shelter Island groundwater models were used to develop water balances to better understand the County's aquifer system and to begin to assess the magnitude of the impacts that could result from predicted increases in sea level for long term planning purposes.

The water balances compared aquifer conditions that would have existed at the turn of the century prior to extensive development to current conditions, including contemporary levels of public water supply pumping and the operation of stormwater and wastewater management facilities. Long term average recharge rates were based on precipitation records obtained from gauges at Mineola, Brookhaven National Laboratory, Riverhead and Bridgehampton. Recent levels of public water supply pumping assigned in the model simulations were based on the average annual pumping rates used for the Long Island Source Water Assessment Program evaluations (SWAP, 2003). The predevelopment and present day water balances are summarized by **Figure ES-6**.

Under predevelopment conditions, precipitation, the only source of recharge to the groundwater system, traveled down through the aquifer system, until it was ultimately discharged to surrounding coastal waters, either as stream baseflow or as underflow. Construction and operation of sanitary sewering systems that discharge to surface waters results 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.



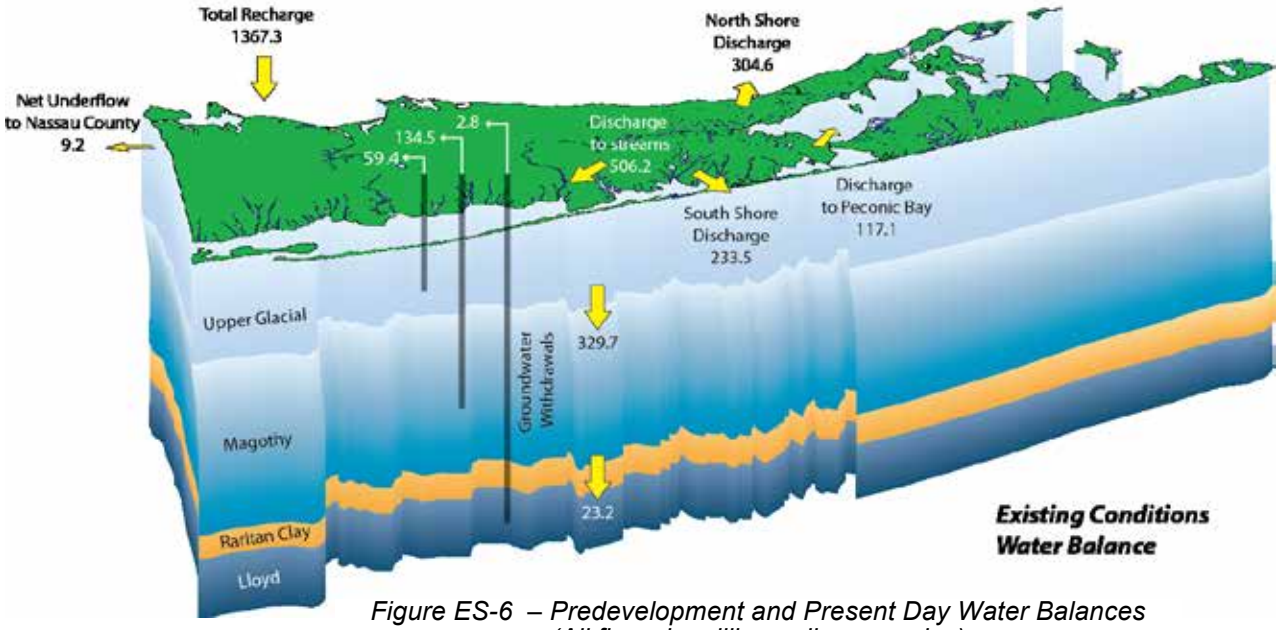


Figure ES-6 – Predevelopment and Present Day Water Balances
(All flows in million gallons per day)

The construction of stormwater recharge basins in many parts of the County has increased recharge during the growing season, so that on an annual basis, recharge to the aquifer is actually slightly higher than during pre-development conditions.

The water balances confirm that on a County-wide basis, the aquifer system can sustain current and projected rates of water supply pumping. A comparison of pre-development and current water balances also identifies a 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 via on-site septic systems or small sewage treatment plants discharging to recharge beds. Suffolk County has evaluated the impacts of sanitary sewering in the Southwest Sewer District (SWSD) on streams and wetlands areas within that district. Potential impacts of development on streams, ponds, wetlands and inter-tidal areas are best considered on a localized basis, considering area water supply pumping, development, and stormwater and sanitary wastewater management approaches.

Global Climate Change Model Projections of Sea Level Rise in the New York Area

Decade	Predicted Increase in Sea Level
2020s	2 to 5 inches
2050s	7 to 12 inches
2080s	12 to 23 inches

Sea Level Rise

In the past, sea level had been rising along the East Coast at a reported rate of between 0.34 and 0.43 inches per decade (**Climate Risk Information**, 2009). Over the past century, the rate of sea level rise has been increasing, with the average rate 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 as shown on the table to the left, and as a result of ice melt. Rapid ice melt scenarios incorporated into other model simulations predict even more significant increases in sea level in the coming years than are shown in the table.

The groundwater models were used to estimate the potential impacts of sea level rise on the aquifer system. The sensitivity of model results to future sea level increases of 1.0 and 2.0 feet above mean sea level was assessed. The predicted increase in upper glacial water levels on the main body of the County, assuming a 2 foot rise in sea level, varied from less than 0.25 feet to 2 feet, with groundwater levels predicted to increase by less than 1 foot in most areas as shown by **Figure ES-7**. The predicted water table increase is much lower along the south shore compared to the north shore, because increases in stream baseflow limit the increase in the water table in the vicinity of the south shore streams.

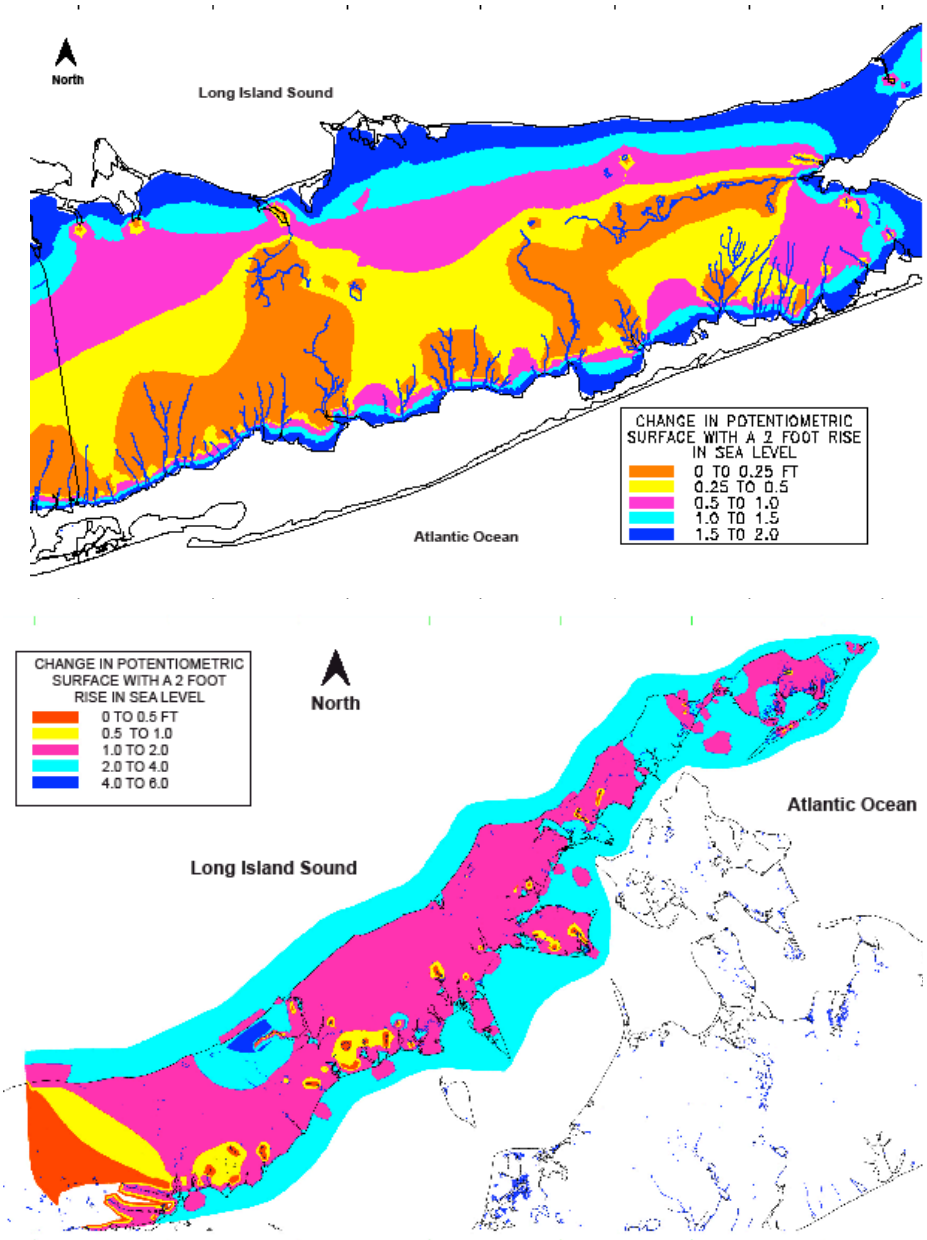


Figure ES-7 The predicted impacts of a two foot rise in sea level on the groundwater table on the main body of Suffolk County and on the North Fork were simulated using groundwater and salt water intrusion models.

The impacts of rising sea level are predicted to be more significant on the forks and Shelter Island. For example, over most of the North Fork, the projected increase in water level elevation varies from 1 to 2 feet, and the impact is markedly more extensive than projected for the main body of the County. Similar results were projected by the South Fork and Shelter Island models. The simulated rise in the freshwater/saltwater interface position was also assessed for the North and South Forks and Shelter Island; localized increases in the elevation of the salt water interface will result in a reduction in the thickness of the freshwater aquifer systems.

In the coming decades, Suffolk County will need to address the impacts of projected increases in sea level elevation. While there are many uncertainties associated with the impacts of climate change, published research and the results of Global Climate Models consistently indicate that sea level will continue to rise at an accelerated pace. Additional evidence indicates that precipitation is increasing in this part of the world, and that the number of extreme precipitation events is also increasing in the northeastern United States, including Suffolk County. Sea level rise may have profound impacts on low lying coastal areas, particularly along the south shore and on the forks, with significant implications for infrastructure such as stormwater and wastewater collection and disposal

systems and water supply. The impacts of sea level rise and more frequent extreme precipitation events should be monitored so that wastewater and stormwater runoff management strategies can be developed if required. The impacts of sea level rise on the location of the salt water interface must also be monitored and addressed from a water supply perspective. Extreme precipitation events will exacerbate existing drainage problems; reliable solutions can only be developed based upon data characterizing the magnitude of increased water levels and flows.

Drinking Water Supply

From a County-wide water quantity perspective, Suffolk County's aquifers can readily provide the average annual 292 million gallons per day (mgd) required to satisfy projected future (2030) water supply demands. However, as additional wells are sited to meet projected future needs, the effects of water supply pumping on groundwater-fed streams, ponds and wetlands must be considered, and in localized coastal areas, projected water supply demands may exceed the capacity of the limited shallow fresh water aquifer. From a water quality perspective, most untreated groundwater in the County continues to comply with existing drinking water quality criteria, and community supplies are treated to remove the low levels of VOCs or other contaminants that source water monitoring may identify. Community supplies currently provide potable water to more than 87 percent of Suffolk County residents; approximately 72 percent of the population is served by the SCWA. Community supplies are generally the best means of providing a reliable supply of potable water that complies with all applicable drinking water criteria or MCLs.

Several potential issues of concern that affect some residents' access to a reliable and safe supply of water have been identified. These concerns result both from the ability of the aquifer resource to supply sufficient water that complies with all applicable drinking water criteria, and the ability of existing infrastructure to meet water supply demands, now and in the future.

Resource Constraints - Two areas of the County where existing groundwater quality has affected the ability to utilize the existing groundwater supply have been identified during this study:

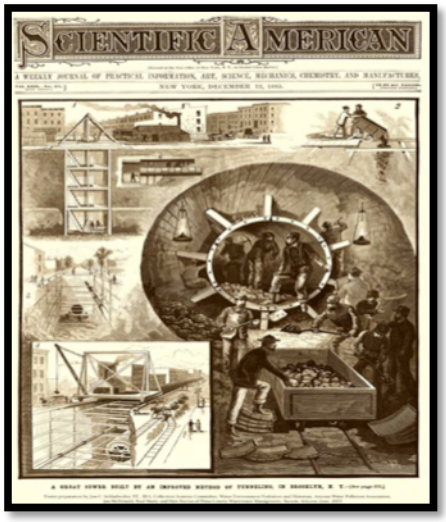
- Northport and East Northport, where nitrate levels measured in untreated water from existing SCWA Magothy wells have ranged from 8 mg/L to 12 mg/L, and

- Southold, where the extent of the shallow aquifer is limited by underlying and surrounding salt water, and where agricultural contaminants such as nitrates and pesticides have caused widespread groundwater contamination.

Infrastructure Limitations - Infrastructure limitations also affect the reliable provision of potable supply. Customers of some smaller, aging community and non-community supply systems would be served more reliably by a larger community supplier such as the SCWA. A GIS analysis completed as part of this study concluded that approximately 47,000 private wells continue to provide potable supply to Suffolk County residents. Shallow private wells are more susceptible to contamination from near surface activities and are not tested with the same frequency as community supply wells; in fact less than 2 percent of private wells are tested by the SCDHS each year. A sampling effort conducted by the SCDHS between 1997 and 2006 found that almost 10 percent of the samples collected from private wells exceeded the drinking water standard for nitrate and approximately seven percent showed VOCs above 5 μg/L.

While there are adequate supplies to meet all existing and projected potable water needs on a Countywide basis, existing infrastructure in some parts of the County is not adequate to respond to the increased water supply demand resulting from the early morning use of automatic irrigation systems during hot, dry summer periods, as illustrated during the summer of 2010. Community supply pumping during the winter months has only increased by approximately 15 mgd since 1987, while pumping during the summer has increased by 100 mgd or more as shown by **Figure ES-8**. Much of this increase is attributed to the installation and use of automatic irrigation systems.

Projected water supply demands for the year 2030 were based on population projections provided by the SCPD and provision of community supply to all residents currently using private wells. Considering peak water supply pumping demands that are based on existing observed peak demand factors, the 2030 projections indicate that additional wells will be required in most Towns in the County. In fact, over one hundred new supply wells would be required in the County based upon projection of current peak water demand patterns. Alternatives to provide potable water to County residents, considering treatment, conveyance from the Pine Barrens, and conservation were identified and evaluated.



Wastewater Treatment – Historical Context

- "**The cesspool is basically wrong** in principle and leads to ground water pollution and unsatisfactory surface conditions…. Septic tanks provide a more desirable form of sewage disposal but are at best an inefficient unit which require periodic cleaning and relatively large areas for disposal of the liquid fraction through seepage trenches. In all instances of inefficient or ineffective treatment, partly treated sewage from source may reach the ground water…. The hazard of this condition is the possibility of transmitting water-borne diseases, such as typhoid, cholera, dysentery or other organism of intestinal…. Presently being discharged into the ground waters are wastes totaling some 60,000,000 gallons a day…. Shore areas are not conducive to the use of individual disposal systems, with the result that overflow from cesspools, seepage of polluted ground water and illegal direct discharges of sewage find their way into the surrounding water."-Public Hearing, Sewer district No.1, Bowe, Alberston & Walsh, 1966

- 1969: 1) 98% of the homes in Suffolk County were not served by sanitary sewers; 2) No Suffolk County Sewer Districts or STPs have been established; and 3) there were, however, 20 municipal and 20 private STPs in-place. -*Utilities Inventory & Analysis*, Nassau-Suffolk Regional Planning Board.

- On January 21, 1975, the Environmental Defense Fund petitioned the U.S. Environmental Protection Agency (EPA) Administrator to designate the aquifers underlying Nassau and Suffolk Counties, Long Island, New York, as a sole source aquifer under the provision of the Act.

- EPA '75: The Suffolk County Water Authority has indicated that nitrate concentrations have been increasing…. Although the problem is less severe in this more sparsely populated county, parallel trends of development indicate that nitrate contamination will approach that of Nassau County in the future…. The **NassauSuffolk Aquifer System is highly vulnerable to contamination**.

- **Vote Propostion #1:** "Shall Resolution No. 348-1969, adopted by the Board of Supervisors of the County of Suffolk, New York, on June 9, 1969, making certain affirmative findings and determinations relating to the establishment of a county sewer district, to be known as the Southwest Sewer District…at a cost of $291,750,000"
  65,000,000 – Federal & State Grants
  226,000,00 – Funding required
  229,623,750 – Interest on bond over 40yrs
  $**456,373,750** – Total cost to SWSD ['69 $]
  Houses with assessed valuation of $3,800 in Babylon and $5,000 in Islip would have an annual charge of $170.

- In 1969 the avg. life of a cesspool was 8-14yrs and one in four was failing. A new one cost $420