FIXING THE NITROGEN PROBLEMS IN SUFFOLK COUNTY, NEW YORK

Water Quality Deterioration in Coastal and Freshwater Systems - - Options and Opportunities

A Background Paper prepared for the
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I. EXECUTIVE SUMMARY

The water quality impact from nitrogen pollution in the coastal surface waters and groundwater of Suffolk County, New York has been 45 years in the making. Fortunately, progress is now underway. This paper reviews how the nitrogen pollution problem reached this point and discusses the many projects and initiatives gearing up from one end of the county to the other.

Numerous studies have reported the water quality problems that have resulted in shellfish losses, fish kills, brown tides and harmful algal blooms, hypoxia, wetlands destruction, habitat loss and unhealthy recreational conditions. High nitrate levels in groundwater discharging into marine waters has added to the nitrate loading from stormwater runoff, poorly treated septic system waste, sewage treatment plant discharges, lawn fertilizers, and atmospheric nitrogen deposition.

The question still remains as to whether advances in wastewater treatment technology and creative approaches to secure the billions of dollars needed to bring sewage management in Suffolk County into the 21th century will be enough. This paper looks at these two ultimate challenges: Technology and Finances.

II. BACKGROUND OF THE PROBLEM

As Long Island, New York evolved after World War II and communities like Levittown grew with the return of veterans, the problem of sanitary wastewater disposal also grew. In Nassau County, a densely developed suburban bedroom county next door to New York City, the obvious solution was to begin the process of connecting houses and businesses to sewage collection systems, and transporting the waste water to coastal treatment plants that discharged their effluent into marine waters and coastal embayments.

Western Suffolk County experienced similar growth to that of Nassau and had the same need for centralized sewage collection and treatment. The high density communities along the south shore in Nassau extended into the south shore towns of Babylon and Islip in Suffolk County. These same areas had groundwater tables only 10-15 feet beneath the land surface. This made the use of cesspools difficult if groundwater quality was to be protected.

The first effort in Suffolk County to install centralized sewers was the Southwest Sewer District. As first designed, the Southwest Sewer District covered 57 square miles in the towns of Babylon and Islip. It was planned to serve 300,000 people (23 percent of the County population at the time).[1] The sewage treatment plant at Bergen Point in West Babylon was designed to treat 30 million gallons of wastewater per day with an ocean outfall pipe extending 2-1/2 miles into the ocean. Construction began in 1975. Suffolk County first applied for federal funds to construct the Southwest Sewer District in 1969 and the estimated cost was $521 million. By 1976, the estimated cost of the project was $1.5 billion. The construction time for the project grew from 5 years to more than 10 years.

As the project proceeded, the first alarm bells were going off due to skyrocketing costs. The early reasons for the rising costs cited increased financing costs, engineering fees, and construction expenses due to design changes. By 1981, law enforcement officials brought civil law suits against Suffolk County politicians, engineering firms, contractors and pipe suppliers for fraud, corruption, kickbacks and substandard construction materials.[2] Individuals went to jail, a principle participant was murdered, and many careers were ruined or seriously damaged. Once the cost of the project grew to over $1 billion, the county expanded the obligation for repayment of the construction bonds used to fund the project to include all Suffolk County residents.

Thirty years later, the plan to extend the original Southwest sewer system "north through Melville and east through Brookhaven and out to the Hamptons," never materialized but a more modest expansion is underway.[3] Mentioning the need to provide centralized sewer service was the "third rail" of electoral politics for over three decades and it condemned Suffolk County to an extreme reliance on antiquated cesspool and septic systems that still define waste water treatment technology in Suffolk County today.

Due to the unfortunate experience with centralized sewering in the 1970s, Suffolk County is presently recognized as the largest community in the U.S. relying on cesspool/septic system waste disposal technology above a sole source aquifer. The County noted in 2014 that it has a population that is dependent on 360,000 sub-standard and non-performing septic/cesspools. These systems are in use by approximately 75% of all the homes in the county.[4] The result is that "excess nitrogen from sewage threatens our valuable natural resources, coastal defenses, and human health."[5]

The Problem with Cesspools and Simple Septic Systems

[1] Comptroller General of the U.S. Report: Suffolk County Sewer Project Long Island, New York: Reasons for Cost Increases and Other Matters. March 22, 1977. CED-77-44. 16 pgs.

[2] McQuiston, John, Sewer Suit Charges Pattern of Corruption over 10-year Period, *New York Times*, 2-1-1981.

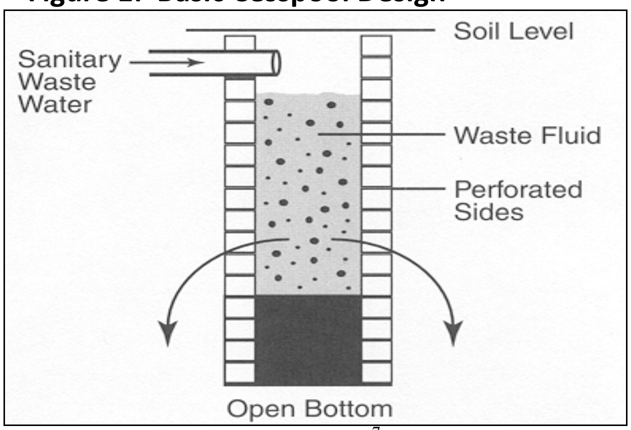
[3] Down the Drain, Long Island Business News, 7-21-2006, libn.com

[4] *Suffolk County Comprehensive Water Resources Management Plan*, Executive Summary, January 2014.

[5] Ibid.
http://suffolkcountyny.gov/Portals/17/Reports/SC%20Comprehensive%20Water%20Resources%20Management%20Plan%20Executive_Summary.pdf accessed 2-17-2015

Cesspools are essentially a simple pit in the ground. They are not substantially different from a latrine except they are usually made of concrete rings with slits in the walls. Treatment consists of settling and bacterial decomposition.[6] Solids settle to the bottom of the cesspool. Liquids escape into the soil by leaking from the bottom and sides of the cesspool. It is bacteria in the cesspool and in the material around the cesspool that decompose the organic (carbon-based) materials in the waste. The liquid waste migrates through the soil until it reaches the water table and then joins the groundwater flow and moves away from the site. Soil does not "filter" or treat wastewater beyond the bacterial activities. Long Island's sandy soil can trap particulate matter but it does not significantly remove the many pollutants dissolved in typical sewage.

Figure 1: Basic Cesspool Design



Source: SJWATERSAVERS.org[7]

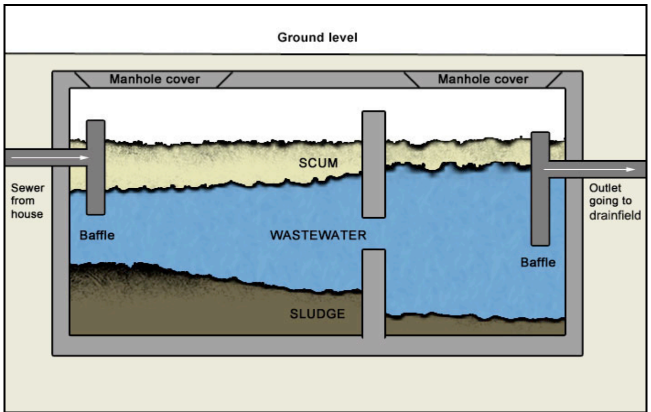
Septic tanks are slight improvements on cesspools. Septic tanks are usually rectangular, concrete containers buried underground. Partitions inside the tank allow waste to buildup and remain in the tank for an extended period of time. This allows solids to settle to the bottom and bacteria in the tank to perform basic decomposition on the waste. After the wastewater moves through all the chambers, it flows out into a leaching field of buried, perforated pipes where it is released back into the environment.[8] Bacteria in the bed of the leaching field continue to degrade organics in the wastewater stream.

Figure 2: Septic Tank Design with two chambers

[6] See E. Dooley, Push for Clean Water, *Newsday*, May 4, 2015. According to Dooley, more than 250,000 cesspools were installed in Suffolk County before 1972, when septic tanks were not required.

[7] SJWaterSavers.org, http://www.sjwatersavers.org/uploads/3/9/6/3/39630307/2213879_orig.gif?280, accessed 5-4-2015

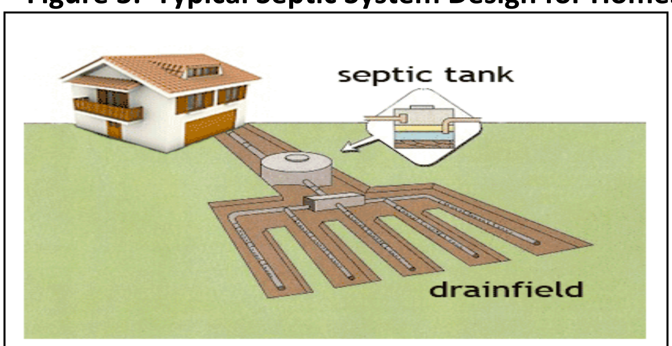
[8] In Suffolk County, many septic systems drain into a cesspool (leaching pool) that then discharges into the ground.



Source: Farris Septic, California[9]

Nitrogen-based waste is progressively changed in cesspools and septic tanks. Urea waste (CON_2H_4) enters the cesspool/septic tank where it is transformed into ammonia (NH_3) and ammonium (NH_4) by anaerobic bacteria. Ammonia/ammonium is dissolved in water that discharges from the tank and into the leaching field and the local soil. Here, it is converted to nitrite (NO_2) and then nitrate (NO_3) by bacterial action. Once in this form, nitrate does not break down further and can remain unchanged in groundwater for decades or centuries.

Figure 3: Typical Septic System Design for Homes



Source: Alcam Systems, Largo Vista, TX[10]

The key point is that septic tanks and cesspools provide very limited treatment for the many pollutants now present in most domestic and industrial wastewater. Some of the pollutants that are not significantly removed include VOCs, pesticides, consumer products, solvents, cleaners, detergents, shampoos, coffee, and drugs. Urea is transformed into nitrate where it can enter the groundwater at levels of up to 40 mg/L or more.

Growth without Adequate Sewage Treatment

The population of Suffolk County has steadily grown since the end of World War II. When easily available open space disappeared in Nassau County its growth stalled and the population has

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[9] Farris Septic, California, http://farrisseptic.com/wp-content/themes/dynamik/css/images/septic-tank-pumping-diagram.jpg. (also USAplumbing.info) accessed 5-4-2015.

[10] Alcam Services, Largo Vista, TX, http://www.alcamservices.com/images/septic_system.gif, accessed 5-4-2015.

remained relatively static since the end of the 1970s. In Suffolk, with ample room to expand, population growth has continued.

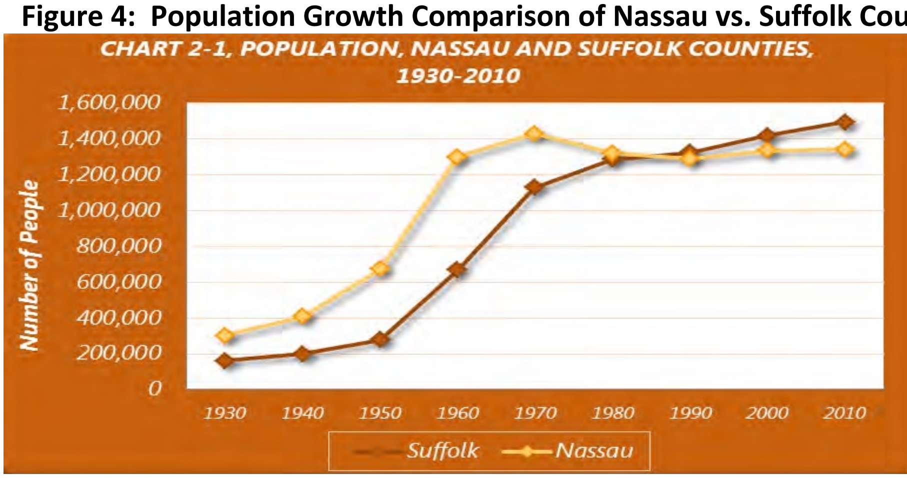
According to the *Suffolk Comprehensive Plan to 2035*,[11] based on the 2010 U.S. Census, the population of the County continues to increase.

- 3% increase in the 1980s
- 7% increase in the 1990s
- 5.2% in the 2000s

The Comprehensive Plan notes that, "Suffolk County ranked 21st in population out of all 3,141 counties in the United States, and was larger in population than 12 U. S. states. The five western towns of Suffolk County - - Babylon, Brookhaven, Huntington, Islip, and Smithtown - - have shown tremendous population growth since 1950. Dramatic growth took place in all five towns between 1950 and 1970, and significant growth continued to occur only in the Town of Brookhaven after 1970."[12] The Suffolk County population in 2010 was 1,493,350 and is predicted to grow by 240,000 people, or 16%, between 2010 and 2035.[13] In 2015, the population has reached 1.5 million people.

The comparison between Nassau and Suffolk population growth is shown in Figure 1. The population of Suffolk County passed Nassau's in the 1990s.

Figure 4: Population Growth Comparison of Nassau vs. Suffolk Counties, N.Y.



Source: *Suffolk County Comprehensive Plan to 2035*, pg. 2-2

It is instructive to consider that the saturation population (the population which can be expected if all available land were to be developed using existing zoning) for Suffolk County has continued to change. In 1962, planners expected it to be 3.4 million. Today, saturation

[11] *Suffolk County Comprehensive Plan to 2035*. Chapter 2 Population. Pg. 2-1. http://suffolkcountyny.gov/Portals/0/planning/CompPlan/vol1/vol1_chpt2.pdf
[12] Ibid. pg. 2-1.
[13] Ibid. pg. 2-2

population is estimated at 1.75 million persons. This figure could be reached by the year 2040 -- an increase of 17% over the 2010 population.[14]

As planners continue to address population growth, the answer to the question of how the wastewater treatment and disposal needs of Suffolk County can be met, is becoming clearer.

Sewer Districts in Suffolk can be divided mainly into two types:

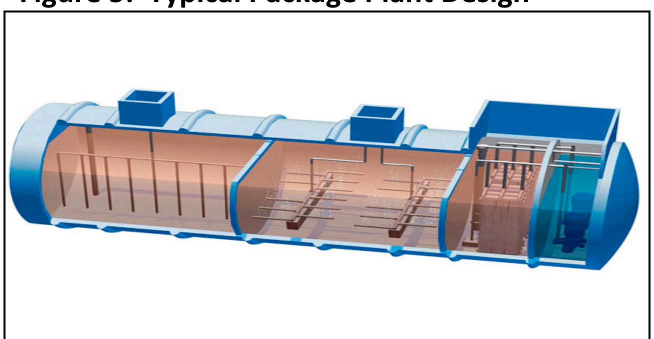
- Those that collect wastewater and transport it to a central sewage treatment plant with effluent discharge to freshwater streams or coastal/marine waters; and
- Those that collect wastewater and treat it by a "package treatment plant" or small treatment system with discharge back to the groundwater.

As of 2012, the approximately 194 Sewer Systems in Suffolk can be categories as follows:

- 24 municipal sewer systems operated by Suffolk County
- 2 community college systems
- 3 operated by the Town of Brookhaven
- 2 operated by the Town of Riverhead
- 2 operated by the Town of Huntington
- 5 operated by Villages
- 4 operated by the federal government
- 152 privately operated systems[15]

The private systems (152) usually use "package plant" treatment technology that discharges to groundwater. The compliance history of these systems is spotty, compounding the issues of groundwater contamination by cesspools and septic systems that predominate in 74% of the county population. Fourteen of the 194 Sewage Treatment Plants discharge to surface water.

Figure 5: Typical Package Plant Design



Source: GE Package Treatment Systems[16]

[14] Ibid. pg. 2-3.
[15] Sewer System Metadata for Suffolk County, 12-21-2012. http://www.suffolkcountyny.gov/Portals/0/planning/Cartography/Sewers/SewerMetadataTables122112.pdf
[16] www.gewater.com/products/packaged-systems-wastewater.html

Package treatment systems are a large single unit, similar to a shipping cargo container. Different treatment steps are divided into compartments that send the sewage through the treatment steps from one end of the container to the other.

Figure 6: Typical Package Plant Exterior View

Source: BMS Blivet Package Sewage Treatment Plant[17]

Package plants serve a wide variety of users. They are used for shopping centers, malls, hotels, housing projects, apartment complexes and condominiums, assisted living communities, nursing homes, hospitals, and businesses.

For all systems that are regulated by the NYS SPDES program, the discharge standard for nitrogen is 10 mg/L.

III. THE SCOPE OF THE PROBLEM

The challenge ahead for Suffolk County is to develop a plan for the problems it is currently experiencing with waste water collection, treatment and disposal while also planning for future growth. The current pollutant of concern is nitrogen.[18]

The water quality problems related to excess nitrogen in Suffolk County include both surface and groundwater.

Groundwater Quality Problems in Suffolk County

As Suffolk County sees it, nitrogen in the form of nitrate (NO_3) is **public water quality enemy number one**.[19] The nitrogen comes from untreated or poorly treated sanitary waste water and fertilizer. Given the amount of nitrogen loading occurring in unsewered areas, nitrate levels in the groundwater are slowly rising. In the Upper Glacial Aquifer, average nitrogen levels increased from 3.12 mg/L to 4.34 mg/L between 1987 and 2005; a change of 28%. Average

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17 BMS Package Treatment Plants, www.bannow.com/

18 Nitrogen is required by all organisms to perform the basic life processes of making proteins, growing, and reproducing. Nitrogen occurs in many chemical forms. Inorganic forms include nitrate (NO_3), nitrite (NO_2), ammonia (NH_3), and nitrogen gas (N_2).
http://www.suffolkcountyny.gov/stormwater/StormwaterIssues/Pollutants/Nitrogen.aspx#sthash.c91fntVl.dpuf

19 Draft *Suffolk County Comprehensive Water Resources Management Plan*, Executive Summary, 1-2014.

nitrate levels in the Magothy Aquifer increased between 1987 and 2005 from 1.14 mg/L to 3.43 mg/L; a change of 66%.[20]

The significant change in NO_3 levels in the Magothy reflects the groundwater flow process. Pollution that starts in the Upper Glacial Aquifer can slowly migrate into the deeper aquifer system, such the Magothy, over time. Increasing public water supply pumpage is accelerating this downward migration of nitrogen pollution deeper into the aquifers. Presently, only 2-3% of Suffolk County Water Authority water supply wells require treatment for nitrates but if untreated wastewater discharges continue uninterrupted, this will change and more wells will require treatment.

Nitrogen-nitrate levels in groundwater, in this context, are noteworthy because groundwater near the shoreline (an area known as shallow recharge) serves as a transport mechanism conveying nitrogen to coastal estuaries, embayments, and streams.

Areas of particular interest for immediate attention are those communities that are designated as high density (greater than 5 homes per acre) or medium density (1-5 houses per acre), that use cesspools/septic systems and meet the following characteristics:

1. have a depth to groundwater of 10 feet or less; and/or
2. contribute to surface waters that have been listed on the Clean Water Acts 303(d) list for impaired surface waters.

Suffolk County has identified communities that satisfy these two conditions and are located in areas where the groundwater drains to coastal waters or streams within a 25 year travel time. There are 121,843 medium-density homes and 34,096 high-density homes that meet these criteria as of 2010.[21] These are communities that are located relatively near the shoreline, such as the Shirley-Mastic area.

The relationship between groundwater flow and discharges to surface water systems is a major factor in coastal water quality. However, nitrogen entering the coastal water systems comes from a variety of sources that include:

- stormwater runoff carrying fertilizer and septic/animal waste,
- stream discharges under the influence of groundwater and runoff,
- sewage treatment plant discharges,
- groundwater underflow carrying septic/cesspool system waste and fertilizer, and
- atmospheric nitrogen.

Looking at groundwater quality broadly, nitrogen is not the only concern. More wells are affected by Volatile Organic Compounds (VOCs) than are wells requiring treatment for nitrogen.

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[20] *Ibid*. pg. ES-6, Table 3-1.
[21] *Ibid*. pg. ES-5.

Presently, 22% of the water supply wells[22] in the County require treatment for VOCs while 2-3% of supply wells are treated for excess nitrogen.

Surface Water Quality Problems in Suffolk County

The impact of nitrogen-nitrates on coastal water quality and ecosystem health is evident in a number of important and sometimes subtle ways. New York State DEC has listed the entire length of the South Shore Estuary, 60 miles, as an impaired water body under the Clean Water Act, 303(d) program. The cause of impairment is nitrogen and the sources of nitrogen are listed as onsite waste water treatment systems and urban runoff.[23]

Nitrate-nitrogen in coastal water systems is not the same problem it is in groundwater - - it is much more serious. Aquatic systems, both fresh water and marine, are far more sensitive to nitrate than is groundwater. While groundwater is regulated for nitrates in drinking water at 10 mg/L, the background level of nitrate in healthy coastal waters is typically as low as 0.1 mg/L.[24]

Nitrate levels above the natural background in surface water but as low as 2 mg/L, can contribute to serious problems in coastal ecosystem health. These include:

- Brown Tide and other types of algal blooms including Harmful Algal Blooms,
- Loss of wetlands,
- Destruction of seagrass beds and the related growth of competing micro- and macroalgae beds,
- Eutrophication leading to hypoxia (low oxygen levels) and anoxia (no oxygen),
- Loss of shellfishing areas,
- Fish kills and other wildlife deaths,[25]
- Loss of recreational value of coastal waters, and
- Loss of commercial fishing.

Some statistics illustrate the magnitude of surface water impairments:

- Brown tides have caused the loss of shellfish habitat that once produced over 50% of all the hard clams harvested in the U.S.
- Between 18% and 35% of the Long Island tidal wetlands have been lost over the period of 1974-2001. Wetlands are important nurseries for young aquatic organisms; they help improve water quality and help protect shorelines from violent storms, storm surges and erosion.
- Seagrass beds (an important habitat for aquatic animals) have been reduced from 200,000 acres in the 1930s to only 22,000 acres today - - a loss of 90%.[26]

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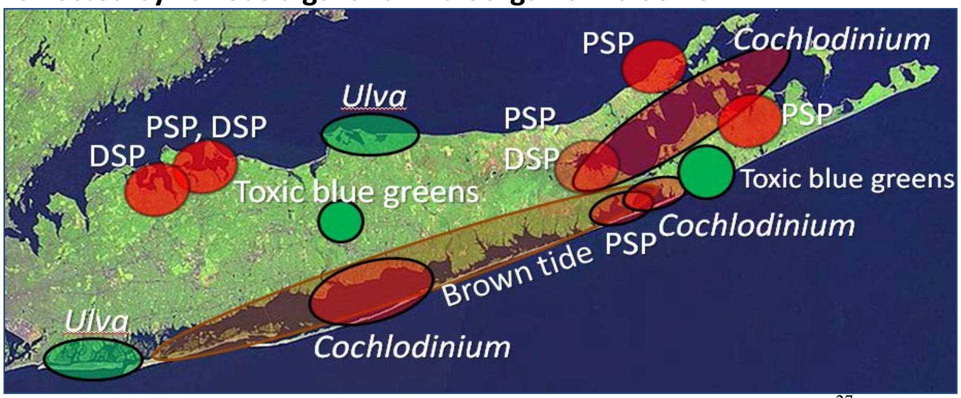
[22] Presentation by Jim Meyers, Suffolk County Department of Health Services, 4-29-2015.
[23] NYS DEC 2014 Section 303(d) List Final, 9-2014. Pg. 34. http://www.dec.ny.gov/docs/water_pdf/303dlistfinal2014.pdf
[24] NOAA discussion of water quality parameters. http://www.nerrs.noaa.gov/doc/siteprofile/acebasin/html/envicond/watqual/wqintro.htm, accessed 2-18-2015
[25] Ellen Yan, "Dead Turtles Wash Ashore," *Newsday*, 5-19-2015. A high concentration of saxitoxin-producing algae was found in the water where 100 diamondback turtles were found dead.
[26] Draft *Suffolk County Comprehensive Water Resources Management Plan*, Executive Summary, 1-2014

- Thousands of homes were damaged along Long Island's south shore by Super Storm Sandy (10-2012). Safeguarding coastal communities from rising sea level and violent storms will include stabilizing natural barriers such as dunes, wetlands, and barrier islands.

Figure 7: Map of Dr. Christopher Gobler's research showing coastal areas affected by various algal and microorganism blooms



Source: *Coastal Resiliency and Water Quality in Nassau and Suffolk County*[27]

Research by Christopher Gobler (PhD, SUNY Stony Brook) and others has demonstrated the damaging impact that high nitrogen levels have on coastal marshland complexes. Elevated nitrogen stimulates marshland plants to grow taller but with shallower roots than normal. The deep roots normally hold the subsurface structure of the wetland together. As the plants and their deep-root systems disappear, erosion gradually destroys the marshland over time. When the marshlands disappear, important coastal habitat is also lost. Without the marshlands as a buffer, human communities are more vulnerable to major storm events, flooding and storm surges, and property damage.

The Price of Controlling Nitrates, Sewage Treatment and Disposal

As anyone knows who has been involved in pollution abatement, capital construction projects, and meeting environmental standards, it is expensive. Solving the sewage problem in Suffolk County is no different.

One thing is different this time, however. The discussion of solving the sewage problem has been taken up by many political leaders as well as environmental advocates, scientists, business leaders and the development industry. The political risk of discussing sewers and other approaches has finally started to fade when compared to the cost of doing nothing.

Suffolk County announced a broad program to meet the needs of the county in 2014.[28] The total cost of the plan could reach $7 billion or more if fully implemented.[29] The plan has three goals for improving water quality and restoring wetlands in Suffolk County. They are:

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[27] *Coastal Resiliency and Water Quality in Nassau and Suffolk County*: Recommended Actions and Proposed Path Forward, 2014, New York State Governor Andrew Cuomo and NYS Department of Environmental Conservation, pg. 13.

1. **Fortify existing wastewater infrastructure**.
   The Bergen Point Sewage Treatment Plant in West Babylon is the largest treatment plant in the county and it is especially vulnerable to the extreme weather events such as Super Storm Sandy. The system serves 80,000 homes and its operational integrity is essential to the county. Along with fortifying the facility, the 6 mile long outfall pipe from the plant to the ocean is leaking beneath the Great South Bay and needs to be repaired.

2. **Sewer three target areas along the South Shore**.
   Four major river systems flow into the Great South Bay: the Forge, Connetquot, Carlls and Patchogue rivers. They carry a high load of nitrogen into coastal waters that affects coastal wetlands vegetation and aquatic organisms. The coastal communities in the river system watersheds in need of sewers are:
   - Deer Pak, North Babylon and Wyandanch,
   - Mastic/Shirley, and
   - Oakdale.

3. **Promote alternative/innovative on-site wastewater treatment technologies**.
   This initiative involves pilot projects to test new techniques and technologies that improve on-site sewage treatment for individual homes and small community systems. As new systems are approved, homeowners may need financial assistance to install and operate them.[30] The cost to upgrade an on-site system is estimated to be $35,000 per home. To hook into sewer systems, the cost per home is estimated to be $50,000.[31]

IV. SOLUTIONS FOR THE 21ST CENTURY

Keeping up with the many needs and plans to solve the nitrogen and wastewater treatment problems of Suffolk County is a full time task. The search for solutions must address two essential considerations: **Technology** and **Financing**.

The primary programs proposed to address nitrogen-based water quality issues offer a mix of technological solutions with funding sources.

A. New York State and the Federal Government

New York State is promoting a number of activities that pass funds from federal agencies such as the Federal Emergency Management Agency (FEMA) and the Department of Housing and

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28 *Suffolk County Water Quality and Coastal Resiliency Action Plan*, W. Hilbert, SCDHS, 3-25-2014 http://Suffolk-County-Water-Quality-Coastal-Resiliencey-Action-Plan-Wlater-Hilbert-Suffolk-County-Dept-of-Health-Services.pdf

29 D. Schwartz, Suffolk Sewering Plan could cost $7B, Consultants Say, *Newsday*, 6-19-2014.

30 *Suffolk County Water Quality and Coastal Resiliency Action Plan*, W. Hilbert, SCDHS, 3-25-2014 http://Suffolk-County-Water-Quality-Coastal-Resiliencey-Action-Plan-Wlater-Hilbert-Suffolk-County-Dept-of-Health-Services.pdf

31 D. Schwartz, Suffolk Sewering Plan could cost $7B, Consultants Say, *Newsday*, 6-19-2014.

Urban Development (HUD) to coastal communities damaged by Super Storm Sandy. Suffolk County will receive $383 million to upgrade and/or install new sewage treatment infrastructure along the southshore of the county. The river watershed areas for North Babylon-Deer Park, Great River and Patchogue will be connected to existing sewer systems. One new treatment plant will be constructed at Brookhaven Town's Calabro Airport or vicinity to serve the Mastic-Shirley area. Collectively, 11,000 homes will be moved from cesspools and septic systems to sewer collection and central treatment systems.[32] Federal and county officials have been very effective in addressing the need for a new sewage treatment plant for this community.

B. Improving On-Site Wastewater Treatment System (OSWT) Technology

There are several initiatives pursuing better on-site treatment technology.

- Southampton Township has initiated a program to speed up the development of advanced and innovative technologies to improve on-site systems. Two million dollars have been dedicated to this initiative in conjunction with SUNY Stony Brook.
- Stony Brook University's new Clean Water Technologies Center will evaluate new technologies that improve wastewater treatment.

C. Extension of the Community Preservation Fund.

State legislators have proposed to build on the highly successful open space preservation fund for the East End adopted in November 1987. The fund would be reauthorized for another 20 years and use $500 million of the money generated to help pay homeowners as they install community systems or individual on-site systems.

D. The *Suffolk County Water Quality and Coastal Resiliency Action Plan*.

Suffolk County announced this new program in March 2014. It is the comprehensive plan that fits all the various initiatives into an organized program of improvement. It fills in many of the details on how individual efforts will work together. It includes additional wastewater projects such as:

- Replacement of a portion of the Bergen Point (Babylon) STP's outfall pipe that runs beneath the Great South Bay for 2.5 miles. The cost for this program is estimated at $242 million.
- A Pilot Program to field test on-site systems at 19 volunteer sites around the county. Both home systems (1,000 gpd) and small commercial systems (1,000 gpd to 30,000 gpd) are being tested. Volunteers were selected by a lottery in December 2014 to participate in the technology trials.
- Groundwater modeling will examine the sources of nitrogen in the aquifer systems beneath Suffolk County and will evaluate nitrogen load reductions to achieve the desired improvements in surface water quality.

[32] Serious about clean water, *Newsday* Editorial, November 16, 2014.

- Conduct a house-by-house inventory of all households in the county that use on-site systems to help determine areas of greatest need and which types of new systems would best service different parts of the county.[33]
- In a related effort, the Bergen Point STP is examining a new technology to collect and dispose of sewage sludge generated by the plant. A pilot program will test the feasibility of converting the sludge into No. 6 industrial oil. RDX Technologies, an Arizona company, will perform the test.[34] If successful, the program may save $5.2 million annually in operating costs spent to truck the sludge to landfills in Connecticut and upstate New York.

Table 1: Projects and Funds Allocated, Authorized or Proposed for Suffolk County

Watershed/Region/ Project	Projects Involved & Cost	Totals & Subtotals & Source of Funds	Comments
Suffolk Cty Resiliency and Water Quality	1. Forge River – Mastic/Shirley -Brookhaven ($196 M)	$383 Million for 4 projects: $300 M from FEMA Community Devel Block Grants Disaster Funds; and $83M Loans (CWSRF - EFC)	New STP at Brookhaven Airport or vicinity
	2. Carlls River – N. & W. Babylon	$136 M of the $383 M	Connect to Bergen Pt.
	3. Connetquot River - Islip (Great North River)	$33 M of the $383 M	Connect to Bergen Pt.
	4. Patchogue River - Brookhaven	$18M of $383 M	Connect to Patchogue STP
NYS Clean Water Technology Center, SUNY Stony Brook	$2M	NYS Budget allocation for seed money to begin the project.	Future funding on 50/50 share between NYS & Suffolk Cty
Transition from old septic systems to new technologies as newer systems become available	Cost Unknown	NYS DEC Proposes EFC develop a new program to offer low/no cost loans to homeowners as they install new on-site treatment.	EFC looking at $5 – 15M pilot loan program
Bergen Point STP – Southwest Sewer District	$14.5 M to upgrade outfall pumps and expand capacity for Sewage Treatment Plant	$13.6 M from NYS $1.3 M from Suffolk Cty bonds $510,000 in municipal contributions	
	Replace portion of 6 mile outfall pipe under GSB; increase treatment capacity from 30.5 mgd to 40.5 mgd	Recommended by NYS: $242 M to be funded by low/no cost loans from EFC.	No commit-ments yet on pipeline project
Fire Island Sewer Line	Project not yet approved;	Fire Island to Montauk Point (FIMP)	100% of cost

33 *Suffolk County Water Quality and Coastal Resiliency Action Plan*, W. Hilbert, SCDHS, 3-25-2014 http://Suffolk-County-Water-Quality-Coastal-Resiliencey-Action-Plan-Wlater-Hilbert-Suffolk-County-Dept-of-Health-Services.pdf

34 R. Brand, Sludge fuels project, *Newsday*, February 16, 2015.

Extension	Cost not yet announced	project of Army Corp Resiliency Project to connect all Fire Island buildings.	would be paid by ACE
Ronkonkoma Hub STP	$21 M to bring sewage to Mac Arthur airport or vicinity	Suffolk County	Part of a $245 M Project
Sewer Capacity Study for 8 areas	1. Bellport – North Bellport	$2.1 M Suffolk County	CP-8189
	2. Lake Ronkonkoma Hub		
	3. Mastic - Shirley		
	4. Middle Island – Rt 25 Corridor		
	5. Sayville – Bayport - Islip		
	6. Southampton Village		
	7. Suffolk Center - Yaphank		
	8. Flanders/Riverside		CP-8192
Southwest Sewer District Expansion	Projected Costs based on Feasibility Report (9-2012)	Funding source not yet identified; project is implemented in phases.	CP-8139
	Total cost: $2.076 Billion		
Islip Sewer Study for Bayport to Great River (Sayville)	$200,000	New York State and Town of Islip	
Upgrade various STPs e.g., Riverhead, Northport	Riverhead: needs $23.5 M; has $14 M so far. Northport: needs $9.2 M; has $4.68M so far.	Riverhead: funds from Suffolk Cty, NYS, and reserve funds. Northport: funds from Suffolk Cty, and NYS.	

E. The *Suffolk County Comprehensive Water Resources Management Plan*, 2015[35]

Adding to the list of programs to correct and improve overall water quality, Suffolk County finalized and adopted the new Comprehensive Water Resources Management Plan in 2015. The plan describes groundwater and surface water quality in detail, updating the earlier 1987 plan. It is especially important that the 2015 plan provides a table (Water Resources Management Plan Framework) of detailed implementation and funding recommendations and commitments. First though, the plan lists key management strategies that must be addressed in the near term including:

- Develop a comprehensive database and water monitoring program
- Engage a diverse stakeholder group to support implementation strategies
- Establish a responsible management entity (RME) and a County-wide wastewater management district to oversee advanced wastewater system infrastructure
- Identify financial incentives and financing mechanisms necessary to generate the funds required to implement the plan recommendations
- Increase staffing levels to implement and administer key programs and goals.[36]

[35] *Suffolk County Comprehensive Water Resources Management Plan*, 2015. Principle contributors to the plan include the Suffolk County Department of Health Services, SC Department of Public Works, SC Department of Economic Development and Planning, SC Water Authority, and CDM Smith Consultants. (1,040 pgs)

[36] Suffolk County Comprehensive Water Resources Management Plan, 2015., *Executive Summary*, pg. 51 (67 pgs)

The 15-page Management Plan Framework is organized by water quality problems and management challenges which include:

1. Nitrogen
2. Volatile Organic Compounds (VOCs)
3. Pesticides
4. Pharmaceutical and Personal Care Products (PPCPS)
5. Potable Supply
6. Project Management and Date Collection
7. Coastal Resiliency and Surface Water Quality

Each topic area lists recommendations, their priority, collaborators, time line, milestones & actions, and funding sources and/or commitments. A number of the programs already mentioned are contained in the Framework.

For example, in the Nitrogen section, one recommendation 1.2 is: "Develop a range of approvable advanced alternative on-site wastewater treatment options available for residential and non-residential applicants in Suffolk County. Gain acceptance and encourage participation." The funding source is identified as: "**To be determined** - could include Watershed Improvement Districts, State Revolving Loan Fund, NYS Water Quality Improvement Program, the Suffolk County Water Quality Protection and Restoration Program, a proposed Aquifer Protection Fee by the public water suppliers, and the Community Preservation Fund for the East End, if supported at the local and state levels."[37] This list is repeated for a number of recommendations.

Some programs are already underway and outside funding is being provided. For example, the Health Impact Assessment Program is evaluating various options under consideration to the Sanitary Code to replace failing septic systems. The US EPA is conducting the assessment and funding it. Many other programs are underway using existing county resources. The NYS DEC and pesticide manufacturers are identified as funding sources for the pesticide programs. For the PPCP problem, the SCDHS will begin testing for 1,4-dioxane and has entered into an agreement with the Suffolk County Water Authority to test 50 water samples from small public supplies and private wells for seven other PPCPs.

New Technologies and Regulations Are Part of the Goal to Protect Water Quality

The use of better technology to solve Suffolk County's wastewater treatment problem is at the heart of the county plan. Which technology will be the answer and at what cost is the big unknown.

Sewage Treatment Technologies range from conventional to unconventional, advanced and alternative systems. The following list is wastewater treatment technologies that may play a

[37] *Ibid*, pg. 53.

role in meeting the needs of Suffolk County. It is generally agreed that continuing the use of cesspools and simple septic systems is unacceptable and all these systems must eventually be replaced with better treatment technology. This is the opportunity to move sewage treatment in Suffolk County from the 19th to the 21st century and take advantage of new innovations in the field.

Sewage Treatment Options:

1. Conventional sewage collection conveyed to a Centralized STP with Tertiary Treatment (denitrification)
2. Small decentralized community cluster systems
3. Package Plants with sewage collection
4. Marsh Pond Systems and Constructed Treatment Wetlands (CTW)
5. Living Machines
6. Advanced/Innovative On-Site Wastewater Treatment (Decentratized):
    - BUSSE Green Technologies
    - Norweco
    - Orenco Systems
    - Hydro-Action Industries
7. Zero Discharge (e.g. Waterless and Composting) Toilets
8. New Treatment Technologies; Nitrasis, Electrolysis,
9. Sludge Treatment Issues and Disinfection of Wastewater

A summary of some of these systems is presented in **Appendix A**.

Under the Clean Water Act, sewage treatment plants (STPs) must obtain a discharge permit that establishes the plant's discharge effluent quality. All plants are required to treat to at least secondary treatment levels. The standard discharge limits in the U.S. address four parameters of effluent quality. Additional parameters are permit-specific for each plant.

Table 2: Sewage Treatment Standards for Conventional Systems

Parameter	Maximum Allowable Value
BOD_5 (biochemical oxygen demand)	30 mg/L
TSS (total suspended solids)	30 mg/L
pH	6.0 – 9.0
Fecal Coliforms	200 per 100 ML

Source: Nathanson, 2008, Table 10.1

The nitrogen-nitrate effluent limit for conventional plants is 10 mg/L.

Article 6 of the Suffolk County Sanitary Code

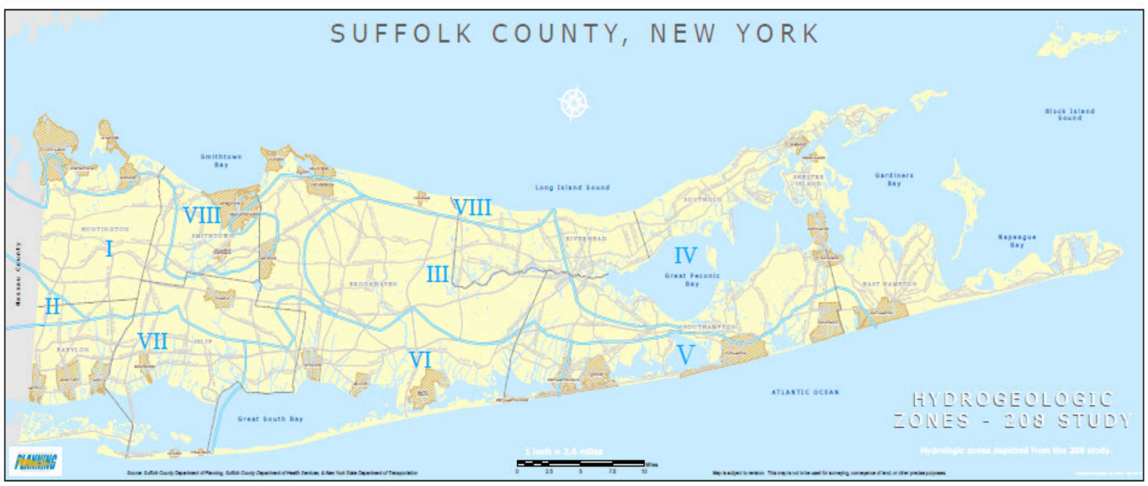
In 1980, the Suffolk County Sanitary Code was amended to regulate small community and on-site wastewater treatment systems. The standards are based on the location and volume of the discharge.

1. Individual On-Site Systems are allowed for residential parcels **greater than or equal to one acre** in the **deep recharge zone** (Hydrogeologic Zones III, V, and VI - - in the center of the county).

2. Individual On-Site Systems are allowed for residential parcels **greater than or equal to one-half acre outside the deep recharge zone** (Hydrogeologic Zones I, II, IV, VII and VIII), areas that ring the shoreline of the county.

3. Residential lots **smaller than one-acre** within the deep recharge zone and **lots smaller than one-half acre** outside the deep recharge zone require the use of community sewage treatment systems.

Figure 8: 208 Study - Hydrogeologic Zones in Suffolk County



Source: Swanson, L. et al., Long Island History Journal, 2011[38]

County surveys found that over 60% of residential parcels using on-site systems are on less than one-half acre lots. In the towns of Brookhaven, Huntington, Islip and Smithtown, approximately one-third of residential lots using these systems are less than one-quarter of an acre.[39]
For individual on-site systems, there is not a specific discharge standard that they are required to meet for nitrogen or other pollutants.

Article 7 of the Sanitary Code of Suffolk County
For larger flows than that of individual on-site systems, the County and the NYS-DEC allow the use of "alternative treatment systems" for flows up to 15,000 gallons per day. Such systems must meet an effluent nitrogen limit of 10 mg/L.[40] This generally means the use of package plants. Two technologies were authorized: one using sequencing batch reactors (SBRs) or the other, Cromaglass systems. Suffolk County documented that in 2006, less than 50% of these

[38] Swanson, L. et al., Long Island History Journal, Suffolk County a Leader in Environmental Initiatives, 2011, Vol. 22, Issue 2. https://lihj.cc.stonybrook.edu/wp-content/uploads/2011/09/SwansonElevation.jpg
[39] Draft *Suffolk County Comprehensive Water Resources Management Plan*, 2010, pg. 3-31.
[40] *Ibid*, pg. 3.28.

systems were able to maintain an average effluent nitrogen concentration of 10mg/L or less.[41] The average level of nitrogen in Cromaglass effluent was 22.3 mg/L. System treatment quality has improved but a substantial number of these systems still did not meet the 10 mg/L nitrogen standard as of 2008.

Changing Regulatory Conditions and Finding Solutions

The Town of Brookhaven has stepped forward to change the way it regulates sewage discharges into fragile watersheds and ecosystems. The Carmans River and its 18,000-acre south shore watershed has been the focus of local efforts to protect it from developmental encroachment and the impacts to water quality that come with increased growth without centralized sewers. On February 3, 2015, the Town adopted discharge standards for wastewater that are stronger than those of the county. The town now requires septic systems that process between 1,000 to 30,000 gallons per day (gpd) to meet an average nitrate **discharge standard of 3 million parts per million (3 mg/L).** The county nitrate standard is 10 mg/L.[42]

In addition to changing the discharge standard, many advocates support an additional requirement to enforce total loading limits for nitrogen into coastal waters and groundwater. This is the approach Massachusetts has used in its regulation of greywater systems.[43] For example, sewage from typical septic systems going into the Forge River is 229 pounds per day. The load would be reduced to 69 pounds per day with the installation of sewers. [44]

V. TECHNICAL AND FINANCIAL SOLUTIONS TO CONSIDER

Changes in Technology, Policies and Practices

As more participants join the search for better solutions to the nitrogen – water quality challenge, the list of interesting ideas addressing technology, policy and practices continue to grow. They include:

- **Revise surface and groundwater nitrogen-nitrate discharge standards**.
  - Encourage other Towns and Villages to follow the Carmans River approach and implement discharge performance standards such as 2 mg/L for both community and individual on-site systems.
  - Change and clarify Department of Health Services restrictions on zero discharge toilets and speed up the approval process for such systems;

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41 *Ibid*. pg. 3-29.

42 MacGowan, Carl, Law to Protect Waters, *Newsday,* February 4, 2015.

43 Greywater is the wastewater from sinks, showers, washing machines, dishwasters, clothes washers, ect. Massachusetts allows nitrogen loading for residential facilities of 660-770 gallons per acre. New construction is limited to 440 gallons per acre. http://www.mass.gov/eea/agencies/massdep/water/wastewater/regulatory-provisions-for-compost-toilets-and-greywater.html ;

44 Rossin, Steven, Could Sewers Help the Mastic-Shirley Community?, The Foggiest Idea, May 16, 2014. http://www.thefoggiestidea.org/2014/05/16/rossin_can_sewers_help_mastic/, accessed 2-15-2015

- Reduce SPDES discharge standards to 3 mg/L or less based on discharge location;
- Calculate mass loading limits on nitrogen-nitrate discharges and include them in discharge permits as total pounds of nitrogen released to the environment;
- Include limits of total pounds of nitrogen released within a watershed coupled with carrying capacity calculations;
- Adopt new ambient surface water standards to include numeric nutrient standards for various surface water environments; [45] and
- Mandate the phase out of cesspool use in on-site systems for treatment and end their grandfathered status.

- **Update building codes and local regulations to minimize future nitrogen loads**.
  - Continue to improve stormwater management and mitigation programs;
  - Establish setbacks and vegetation buffers along waterways to enhance runoff capture and storm surge protections;
  - Change building codes to allow and encourage new systems such as no-discharge toilets;
  - Improve nutrient management for the agriculture community, golf courses, sod farms, and residential communities to address fertilizer applications and other chemicals such as pesticides. The Agricultural Stewardship Program training program being championed by the Long Island Farm Bureau deserves support and has been effective in other parts of New York State.[46]
  - Promote organic methods of farming and residential lawn care;
  - Extend the Community Preservation Fund to all Towns in Suffolk County and use the extra revenue to assist homeowners to install new on-site and community treatment systems;
  - Revise state and local building codes to reflect best practices in water use and wastewater treatment systems;
  - Revise Article 6 of the Suffolk Sanitary Code to require all new construction (residential) to have a minimum lot size of 1-acre, whether inside or outside the deep recharge zone; and
  - Establish Wastewater Management Districts for on-site and decentralized Wastewater treatment systems.

- **Implement monitoring and testing of residential systems to ensure treatment performance meets discharge requirements**.
  - Monitor, test and pump septic systems every 5 years for discharge quality performance and require all wastewater systems (categorized by type) to be registered with the County;
  - Continue research on on-site systems and require better treatment for other pollutants that may be discharged back to the groundwater such as solvents,

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[45] For example, 0.69 mg/L for wadable streams, and 0.5 mg/L for coastal waters. This should be consistent with guidance from the US EPA and on-going efforts at the DEC.

[46] *Nitrogen and Pesticide Reduction Plan for Long Island Agriculture*, Long Island Farm Bureau, 2015.

household chemicals, pesticides and insecticides, and PPCPs (pharmaceuticals and personal care products); and
    - Require discharge quality compliance of treatment systems at the point of discharge for all systems discharging to groundwater;

- **Promote beneficial reuse of treated wastewater and alternative treatment technologies**.
    - Conduct feasibility studies and encourage wastewater reuse at appropriate locations to promote water conservation and to reduce the generation of additional wastewater requiring treatment;
    - Support projects to reuse treated effluent for irrigation purposes such as the Riverhead STP project.
    - Promote alternative treatment systems such as marsh-pond, constructed wetlands (surface and subsurface flows), solar ponds, and others;
    - Develop programs to replace lost wetlands along coastal margins; and
    - Support programs advancing decentralized community systems, enhanced treatment and tertiary systems.[47]

- **Implement water conservation practices to reduce water demand, treatment and discharge**.
    - Promote education programs in the Building Trades and Continuing Ed certifications to teach green building design and construction practices that compliment and support land use that has the smallest environmental impact including water quality impacts and conservation;
    - Promote programs to improve soil health and increase the ability of soils and plants to capture nutrients and retain moisture thereby reducing the need for irrigation; and
    - Implement water conservation throughout Suffolk County to reduce both water demand and reduce wastewater discharges through any treatment system.

Financing the Change to Better Water Quality

The transition from the 360,000 primitive on-site systems in Suffolk County to the systems of the future will take time - - perhaps 20 years or more. The initial steps are being taken now to create a road map for getting there. Along with having the vision, the County will need help to secure the funding. All the money to do the job does not have to be raised now. It can be phased in as programs evolve over time.

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[47] For example, see the reports from Peconic Green Growth, Inc. such as the *Plan for Decentralized Wastewater Treatment, North Fork , NY*, Glynis M. Berry, March 2014; *Pilot Study of Clustered Decentralized Wastewater Treatment Systems in the Peconic Estuary*, G. Berry, September, 2014; www.peconicgreengrowth.org .

Funds now available from the Federal, State and County will allow the programs to get underway. The work to find other funding sources will need to continue. Ideas for additional financial resources and ways to lower the cost of the programs include the following:

- **Federal and State Funds**
  - Continue to secure additional funds from the Clean Water State Revolving Loan Fund as grants and/or loans for water-related infrastructure projects;
  - Maximize the use of federal FEMA funds related to Super Storm Sandy and Coastal Resiliency efforts;
  - Seek grants from the US EPA for green infrastructure projects such as implementing alternative treatment technologies ;
  - Encourage the Environmental Facilities Corporation to develop a new program to aid home-owners as they replace cesspools and old septic systems with advanced treatment systems; and
  - Use the Regional Economic Development Councils to promote and fund continued research into low-cost technologies that effectively remove/treat nitrogen in wastewater.

- **Local Financing Initiatives**
  - Expand the Community Preservation Fund and/or the ¼-cent program to be used to assist with infrastructure and new technologies funding;
  - Require the private builders/development sector to financially support (through fees or other revenue plans) and help pay the cost of infrastructure that will benefit future construction and growth in the County;
  - Analyze and implement small increases in sales charges on commodities such as toilet paper, fertilizer and other products associated with nitrogen loading into local waters; [48] and
  - Consider a nitrogen-loading discharge fee for on-site systems similar to programs proposed for carbon-based CO_2 discharge fees to curb climate change;

- **Management Opportunities**
  - Develop long-term annual revenue requirements and goals for individual programs and over-all upgrades to guide planning at all levels of government;
  - Establish Wastewater Management Districts among residential communities to help install and maintain on-site and community systems with bonding authority; and
  - Consolidate the entire county into a single sewer management authority;[49]

[48] According to the Draft *Suffolk County Comprehensive Water Resources Management Plan*, 80% of all fertilizer purchased in Suffolk County is for non-farm residential uses. *Suffolk County Comprehensive Water Resources Management Plan*, Executive Summary, January 2014. pg. ES-6.
[49] See W. James, Suffolk Sewer Shortage, *Wall Street Journal*, August 27, 2012, discussion of Bellone proposal to consolidate the 22 sewer districts into a single district run by the Suffolk County Water Authority.

VI. CONCLUSION

Suffolk County is off to a good start in an effort that will require strong local, state and federal support for a decade or more. A recent development along the path to success was the announcement on May 5, 2015 that Peter Scully, the Region One Director of the New York State DEC, would be joining the county as the new "sewer czar."[50] He will help oversee the funds and projects related to nitrate pollution problems in the county.

Every great journey begins with the first steps. The first steps of this process for Suffolk County are impressive.

APPENDIX A:

Treatment Technologies

1. Conventional Centralized Biological STPs with ocean outfalls - - on Long Island.
The conventional biological sewage treatment plant is used by most major cities and urban/suburban areas including Long Island treatment plants such as Bay Park, Cedar Creek, and Bergen Point. All sewage treatment in the U.S. is required to achieve secondary treatment levels. This is typically one of the major design aspects achieved by biological or activated sludge treatment plants. Water quality treatment typically must meet waste reductions of Biochemical Oxygen Demand (BOD) and Total Suspended Solids (TSS) of 85%.

In these plants, the treatment steps are divided into primary and secondary. Primary treatment is simply a first step that allows wastewater entering the plant to sit while larger particles of waste material settle to the bottom of the holding tank. The material that settles out is called "solids" or "sludge." Primary treatment removes 60% of suspended solids and about 35% of BOD.[51] The liquid portion of the wastewater is then sent to the second stage or secondary treatment. Here, again, large holding tanks store the liquid and a thick concentration of bacteria (activated sludge) is grown that consumes the organic waste in the wastewater. The bacterial soup is supplemented by bubbling oxygen into the tanks, enhancing the growing conditions for the bacteria which are actively consuming the organic matter as a food source. The wastewater is held in the activated sludge tanks for up to 6 hours.[52] The treated water then flows into a clarifier tank where final settling of remaining particles occurs and the finished product is the wastewater effluent. It is treated with disinfectants and then able to be discharged.

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[50] R. Brand, Sewer Czar Named, *Newsday,* May 5, 2015.
[51] Nathanson, J., *Basic Environmental Technology*, Prentice Hall, 5th Edition, 2008.
[52] An alternative design uses trickling filters (a bed of rocks that support the growth of biological slime of bacteria) that serve the same purpose as activated sludge tanks. Bacteria are exposed to the wastewater and consume the organic materials in the sewage.

Conventional treatment plants can treat large volumes of wastewater. Bay Park STP (Nassau County) treats an average of 50 million gallons per day of wastewater. Bergen Point STP, the largest plant in Suffolk, treats an average of 30 million gallons per day. The wastewater from such large systems is discharged into coastal waters, in this case the Atlantic Ocean or estuarine systems connected to the ocean. The construction of centralized systems is millions of dollars and operation costs run into the millions of dollars also.

2. Small Decentralized Community-Clustered Treatment systems serving multiple homes

The idea of small community treatment systems is to collect wastewater so it does not discharge through individual septic systems, but rather is sent to a more effective treatment process before discharge within a given community. Such systems can serve a small cluster of homes up to several hundred homes. They are usually identified by the amount of flow they can process, being between 1,000 and 30,000 gallons per day.

Another aspect of the system is that the collection pipes can be smaller than a conventional system. This makes installation easier, less expensive, and less disruptive to the community. The solids that are part of wastewater are filtered out and stored at the individual home where they can be pumped out periodically. The liquid portion of the wastewater is sent to the treatment plant. The treatment technology can use a wide variety of systems, including constructed wetlands and similar natural systems, as well as more conventional approaches. Discharge can be to groundwater or to coastal/ surface water. The goal is to use technology that will achieve a higher level of treatment than a conventional system, septic or package plant system. The construction cost of small community systems is much lower than centralized systems as are the operational costs.

3. Package Plants

As discussed earlier, Package Plants are single unit treatment systems that combine several treatment sets in one, pre-built package or unit that is trucked to a location requiring treatment services. The treatment plant can discharge to groundwater or surface water. The system is automated so that operators are not required on a daily basis. The system is checked periodically by maintenance personnel and it has alarms if malfunctions occur. Suffolk County uses these systems extensively. They have become the substitute for larger centralized systems. Nearly all these systems are located in the middle of the county and discharge to groundwater. The quality of the discharge frequently does not meet permit discharge standards. Package plants are not allowed in Nassau County.

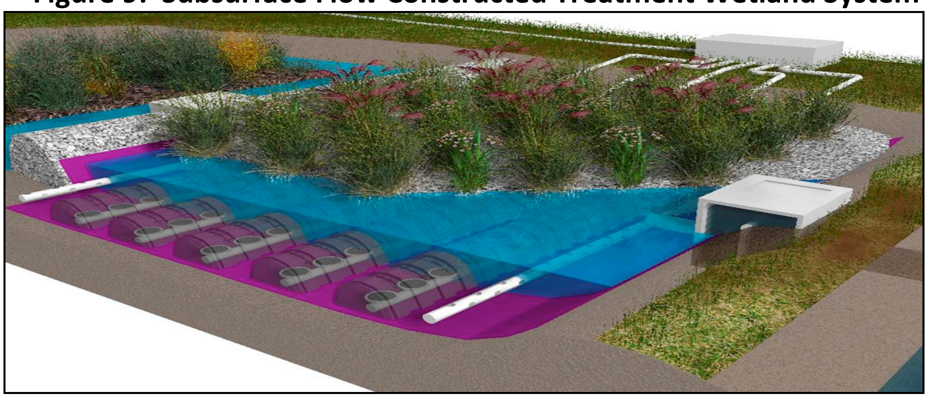
4. Marsh-Pond Surface Flow (SF) Constructed Treatment Wetlands

These systems are usually categorized as alternative treatment but their great value is that they mimic nature to achieve a high quality of water treatment at a very low construction and operational cost. The marsh-pond systems are used for tertiary wastewater treatment. Often, they are largely self-sustaining if set up properly. In essence, these systems use a series of plantings that allow wastewater to move slowly over and through the planted areas. The plants and the bacteria living within the areas, in the soil and plant roots, provide removal of solids and organic materials and also treat other pollutants with minimal technology, chemicals or energy inputs. At first glance, the systems look like an open field or wetland. Systems built along a coastal margin can allow the treated water to drain back into the local water body. Like the small community system, solids are removed from the liquid wastewater and only the liquid is treated.

5. Subsurface Flow (SSF) Constructed Treatment Wetland (CTW) Systems

A modification of the marsh-pond system is the subsurface flow (SSF) constructed wetland approach (CTW) which can be used for secondary wastewater treatment. Small lined basins are constructed and planted with plants. Water flows through gravel, with no visible water at the surface. These systems achieve the removal of TSS, through filtration and sedimentation, biological reduction of BOD and nitrogen, and microbial destruction of pathogens. Engineering enhancements of the SSF CTW design include the incorporation of subsurface aeration to encourage aerobic destruction of contaminants. A piping network of diffusers oxygenates the sub-surface area supporting the plant roots and bacteria that perform the water treatment. These aerated systems perform throughout the year and in cold as well as warm climates. They can be built in stages to meet a wide range of wastewater flows.

Figure 9: Subsurface Flow Constructed Treatment Wetland System



Source: Roux Associates

6. Living Machines and Aquatic Greenhouse Systems

Another type of natural system has been developed that the US EPA refers to as the "Living Machine." Modeled on natural wetland systems that are nature's own water treatment system, the Living Machine uses a sequence of planted cells of various plants. Water slowly moves from one cell to another and a combination of plants, bacteria and small animals systematically remove water pollutants. By the end of the flow path, water quality has been restored to a high level of quality.

A further refinement is the Aquatic Solar Greenhouse System. In this approach, the treatment process has been enclosed in a greenhouse system. Again, water moves through a series of tanks filled with plants specifically selected to perform water treatment. Small animals, snails, fish, and others aquatic organisms can also be part of the process. At the end, both solids and water pollutants are eliminated so that a high quality effluent is produced that is comparable to tertiary treated wastewater. Nitrate levels in the order of 2 mg/L are achievable. These systems can be located anywhere there is a need and they are scalable for low as well as high volume flows. Tests have shown that these systems may also remove other pollutants of concern in wastewater.

Figure 10: Solar Aquatic Greenhouse System

Source: Kootenany Boundary, British Columbia[53]

Figure 11: Inside a Living Machine

Source: YMCA Camp Seymour Living Machine[54]

7. Advanced/Innovative On-Site Wastewater Treatment (Decentratized):
New technologies that improve on the basic septic tank and drainage field concept are generating increased attention by Suffolk County and other areas of the U.S. The approaches generally include modifications of the standard septic tank design to include some type of active treatment such as chemical additions, aeration, and pumps to move the liquids through the process.

Suffolk County Pilot Program for Advanced Wastewater Treatment Systems
Four manufacturers have donated systems for demonstration testing in 19 homes in Suffolk County. They are:

- BUSSE Green Technologies
- Norweco
- Orenco Systems
- Hydro-Action Industries[55]

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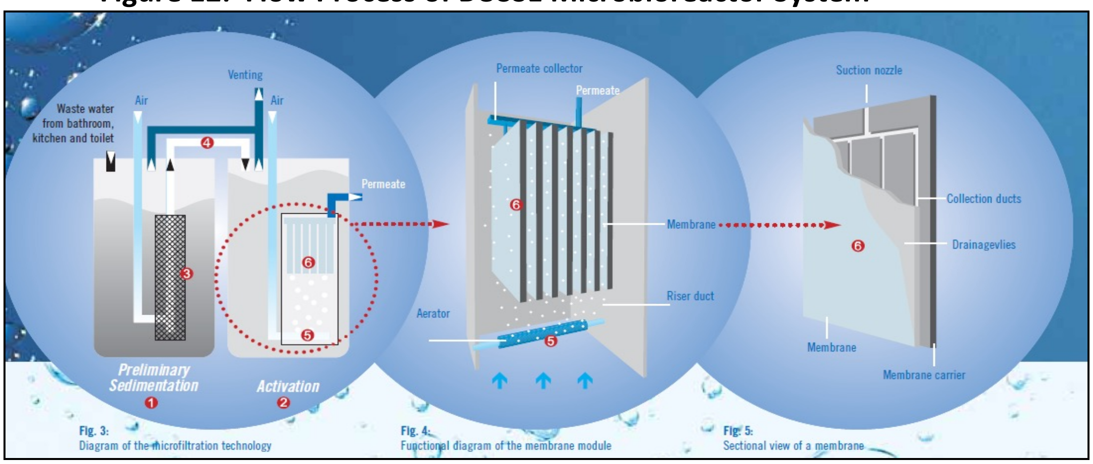
[53] Christina Lake Solar Aquatic System, British Columbia, www.rdkb.com/Services/EnvironmentalServices/WasteManagement/Living_Machine
[54] YMCA Camp Seymour Living Machine, Washington State, organiconlygarden.blogspot.com/2011/04/ymca-camp-seymour-livining_machine

BUSSE Green Technologies uses small scale membrane bioreactor technology. It is a modular system that can be installed above ground or partially underground as well as inside buildings, boats, cargo crates and other applications. There are three steps and four chambers to the system. Inflowing wastewater is first held in a tank that is aerated. The wastewater is then sent through a mesh filter to a second identical holding tank. The wastewater is again sent through a filter and evenly divided between two membrane tanks. The membrane bioreactor tanks each hold 24 flat sheet membranes covered with bacteria that perform water treatment. Air bubbles in the bioreactor tank keep a flow of water moving over the membranes that prevents the membranes from fouling and provides ample oxygen to promote microbial degradation of the wastewater organics. Water pressure moves the treated water across the membrane where it is collected on the other side as treated effluent.[56] A final microfiltration polishes the final discharge water to produce reusable quality water. Sludge in the system is re-circulated and used to sustain the bacteria and further degrade organic particular matter.[57] The modular design allows the systems to meet flows from several homes to large applications.

Figure 12: Flow Process of BUSSE Microbioreactor System



Source: BUSSE GT Brochure

Norweco produces a wide range of products for wastewater treatment. A unit designed for residential treatment conditions is the **Hydro-Kinetc FEU** system. The system is installed below ground and has five tanks in the treatment process.

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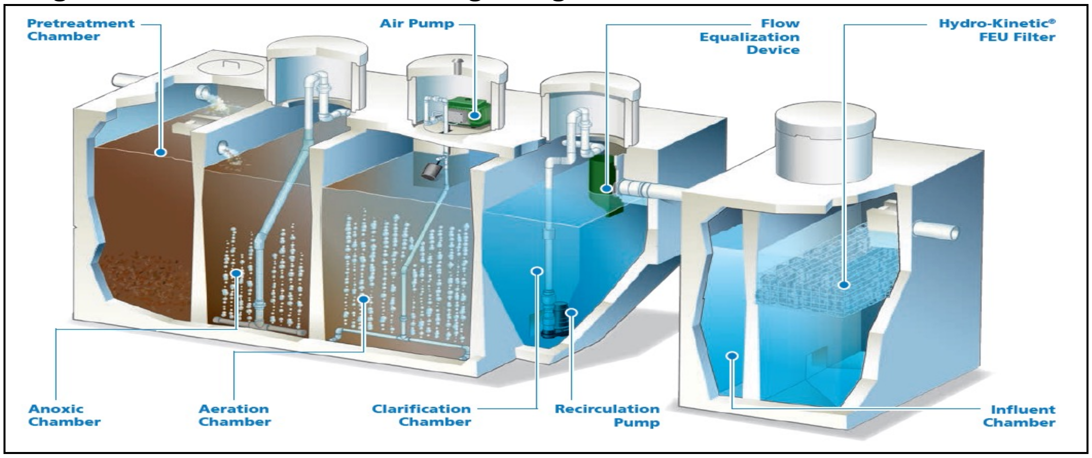
55 Suffolk County Announces Lottery for Free Advanced Wastewater Treatment Systems for Single Family Homeowners, Long Island Exchange, 10-27-2014, https://www.longislandexchange.com/press-releases/suffolk-county-announces-lottery-for-free-advanced-wastewater-treatment-systems-for-single-family-homeowners/

56 Small Scale Sewage Treatment System with Membrane Bioreactor Technology, BUSSE GT. http://www.busse-gt.com/download/brochurebussegt.pdf

57 Annual Report to the New Jersey Pinelands Commission, Alternate Design Treatment Systems Pilot Program, Aug. 2012, http://www.nj.gov/pinelands/landuse/waste/2012_Annual_Septic_Pilot_Program_Report.pdf

Figure 13: Norweco Interior Design Diagram

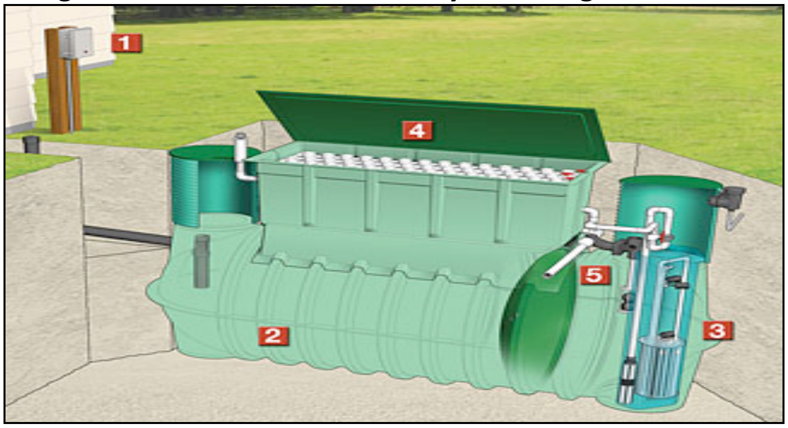


Source: Norweco

Pretreatment occurs in the first tank where anaerobic bacteria begin to breakdown organic waste. In the **Anoxic Chamber** water from the pretreatment tank is mixed with water from the clarification tank to promote nitrogen removal in an anoxic, low oxygen environment. In the **Aeration Chamber**, treated water is aerated to achieve aerobic (oxygen-rich) bacterial decomposition. The Clarification Chamber recirculates some liquid to the Aeration Chamber and sends the rest to the Influent Chamber for the final stage of treatment. Water flows into the **Hydro-Kinetic FEU** (Flow Equalized Upflow) Chamber. Water is pushed upward through a filter media rich with microorganisms that perform the final treatment process and then the water leaves the system and is ready for discharge. The entire process involves a 70 hour retention time and produces an effluent of 1.8 mg/L of TSS and 7.95 mg/L of Total Nitrogen.

Orenco System is a modification of a traditional septic system that provides a secondary treatment stage prior to discharge to a leaching field. The system can come in a single unit with a large holding tank functioning like a simple septic tank. Water is pumped from the holding tank to a small tank above the holding tank where fabric sheets are suspended from the top of the tank and wastewater is sprayed over the fabric which is rich in bacteria. Once the water has slowly drained down across the fabric, treatment is completed. One option is for the secondary treatment tanks to be located away from the holding tank and arrays in a suitable location depending on the application. Water is re-circulated between treatment tank and holding tank to progressively improve effluent quality. All operations are automated. Annual maintenance is provided by the installation company. The system uses one small pump so electrical consumption is low. The quality of the treated effluent varies with influent quality but the manufacturer claims that Total Nitrogen can be reduced to 25 mg/L for concentrated influent and 5-15 mg/L for weaker influent.

Figure 14: Orenco Treatment System Diagram

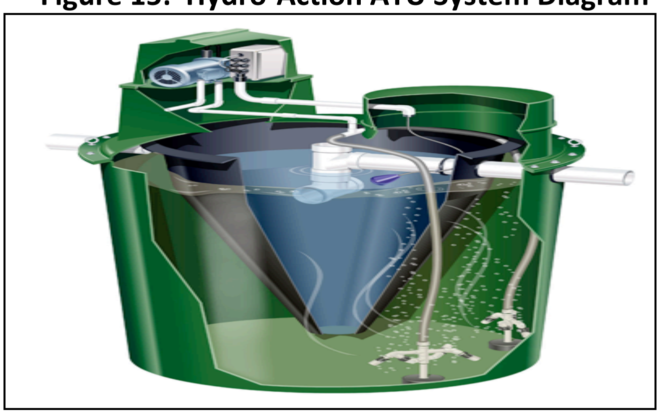


Source: Dad's Septic Service, Atlanta Georgia

Hydro-Action Industries

The Hydro-Action AP-500 ATU (aerobic treatment unit) system provides additional treatment for on-site and residential wastewater treatment. It performs additional treatment to wastewater generated by a typical septic tank that performs some level of organic pretreatment and settling of solids. The effluent from the septic tank flows into the Hydro-Action unit. Inside the tank, air is forced into the effluent through diffusers at the bottom of the container. This oxygenates the wastewater and promotes aerobic bacteria growth and decomposition of the wastewater. Solids in the tank are collected and given additional treatment time in the system. Contact time for wastewater in the tank is 70 hours. The treated effluent is then sent to a leaching field.[58]

Figure 15: Hydro-Action ATU System Diagram



Source: Hydro-Action Brochure

7. **Zero-Discharge/Waterless Toilets**

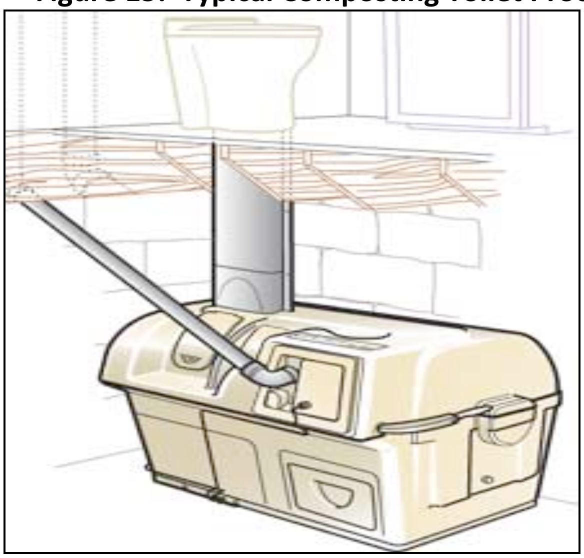
There are many manufacturers and types of waterless, zero-discharge and composting wastewater systems. They come in many sizes and designs to fit simple to complex applications. Most frequently considered for vacation and remote area applications such as wilderness, vacation homes and cabins, and off-the-grid settings, waterless and composting

[58] Hydro-Action Brochure, online. http://www.hydro-action.com/page/72/HYDRO-ACTION.

systems are now gaining a wider audience base in the U.S. Such systems have already received acceptance in Europe and the logic of such systems is now gaining converts in the U.S. Massachusetts has already established regulatory policies for their use in the state.[59] Composting and zero discharge systems can be used in conjunction with existing conventional systems. The obvious benefit is that these highly improved systems do not require the major infrastructure investments that traditional systems need and there is little to cause environmental impairment or water quality impacts from the systems.

Most systems have similar approaches to wastewater treatment. They separate liquid waste from solids. The solids undergo a natural degradation process using bacteria to create a composted material that is periodically removed. The composting can take place in the toilet unit or in a separate chamber that can be placed in the basement or other convenient location. Some systems discharge the remaining liquid to a disposal system such as leaching field, or it can be evaporated so there is no liquid discharge.

Figure 15: Typical Composting Toilet Process



Source: Let's Go Green

The cost of the systems can run from one thousand to several thousand dollars with very low operational costs. Some of the better-known manufacturers include:

- Biolet – 4 models
- Clivus Multrum – custom designed
- Ecolet
- Eco Tech

[59] Regulatory Provisions for Composting Toilets and Greywater Systems, Mass. Department of Energy and Environmental Affairs, Massachusetts General Law (Chapter 176, Acts of 2002, Sec. 3); also, 310 CMR 15.262 for Greywater; and 310 CMR 15.289 for Humus/Composting Toilets. http://www.mass.gov/eea/agencies/massdep/water/wastewater/ regulatory-provisions-for-compost-toilets-and-greywater.html

- Envirolet – 4 models
- Nature's Head
- Phoenix
- Sun Mar / Centrex

Models that fit into a modern bathroom setting are widely available.

The Suffolk County Department of Health Services has signaled its willingness to permit waterless/compost and similar systems, assuming that at least one conventional toilet system with a septic system is present to accept greywater from other water-using fixtures and appliances. The county has not formalized a review process to speed the installation of these alternative systems as Massachusetts has.

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