Climate Change and Impacts to Groundwater Resources and Supply

Steven Colabufo, C.P.G.
Water Resources Manager
Suffolk County Water Authority

Richard Bova
Deputy Director, Office of Strategic Initiatives
Suffolk County Water Authority

2017

Climate Change and Impacts to Groundwater Resources and Supply on Long Island, New York

Steven Colabufo, C.P.G., Water Resources Manager
and Richard Bova, Deputy Director, Strategic Initiatives
Suffolk County Water Authority

Abstract

Climate change will present numerous challenges to water suppliers in the next decades. In addition to infrastructure-related issues, aquifer conditions will change in response to future weather variables including sea level rise, increased temperature and precipitation, and increased occurrence of weather extremes. The anticipated aquifer conditions resulting from climate change include elevated water table, increased stream flow, and both vertical and lateral migration of the salt water interface. Impacts to both the quantity and quality of surface water features such as lakes, streams, and estuaries are predicted as well, and elevated water tables are also anticipated to affect wastewater disposal practices in coastal areas. The Suffolk County Groundwater model has been utilized to help analyze and quantify these anticipated conditions on the aquifer system in Suffolk County. Responses by water suppliers and regulatory bodies to these new conditions should include such actions as: development of a user-friendly, Island-wide groundwater flow model as is currently underway as part of the Long island groundwater Sustainability Project, regional water quality and quantity monitoring, longer distance transmission of water from central Long Island toward the coastal communities, changes to water withdrawal permit conditions to adapt to changing aquifer characteristics (both quality and quantity), and reduced reliance on on-site sewage disposal systems in coastal areas.

Introduction

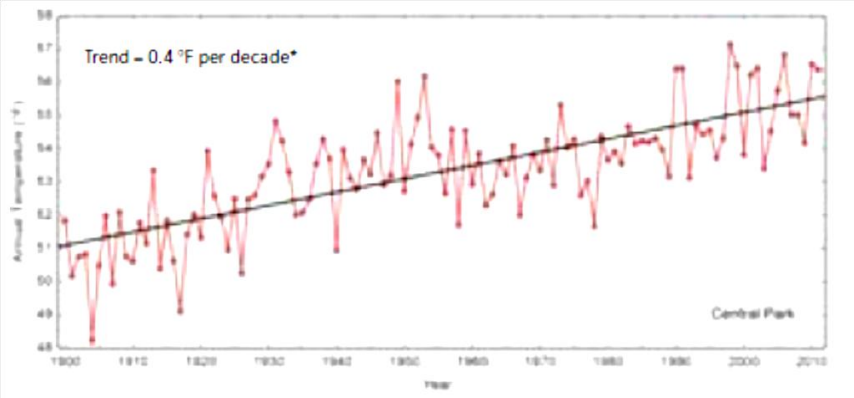
The purpose of this report is to summarize the potential challenges that climate change will present to Long Island's water suppliers through the prism of what may be best described as "New Normal" conditions. As climate change conditions increasingly deviate from current conditions, water suppliers will be required to reevaluate both Water Resource and Facilities Management responses, and also contend with potential Policy and Regulatory Changes. The United States Environmental Protection Agency (USEPA) defines climate change as any significant change in the measures of climate such as temperature, precipitation and other effects that last for an extended period of time (USEPA, http://www3.epa.gov/climatechange/basics/). It can be identified from changes in, "the average state or the variability of weather and can refer to the effects of 1) persistent human caused changes in the composition of the atmosphere and/or land use, or 2) natural processes, such as volcanic eruptions, and Earth's orbital variations" (IPCC, 2007a, p. 8).

Climate Change Characteristics, Impacts, and Projections

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

Temperature Rise

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



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

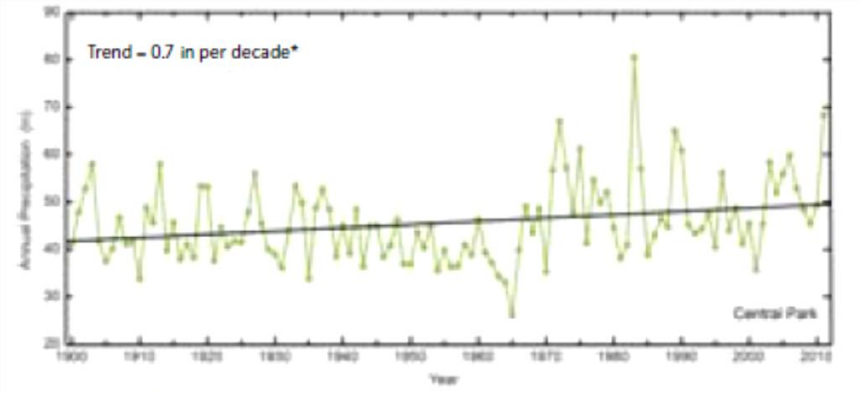
Figure 1. Observed Annual Temperature in New York City (NPCC Climate Risk Information 2013: Observations, Climate Change Projections, and Maps p. 12)

Extreme Temperature and Heat Waves
The NPCC CLIMATE RISK INFORMATION 2013 Report defines Extreme Temperature events using daily data from Central Park since 1900 using the following metrics:

• Individual days with maximum temperatures at or above 90°F
• Individual days with maximum temperatures at or above 100°F
• Heat waves, defined as three consecutive days with maximum temperatures at or above 90°F
• Individual days with minimum temperatures at or below 32°F
(NPCC CLIMATE RISK INFORMATION 2013: Observations, Climate Change Projections, and Maps p. 12).

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

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



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

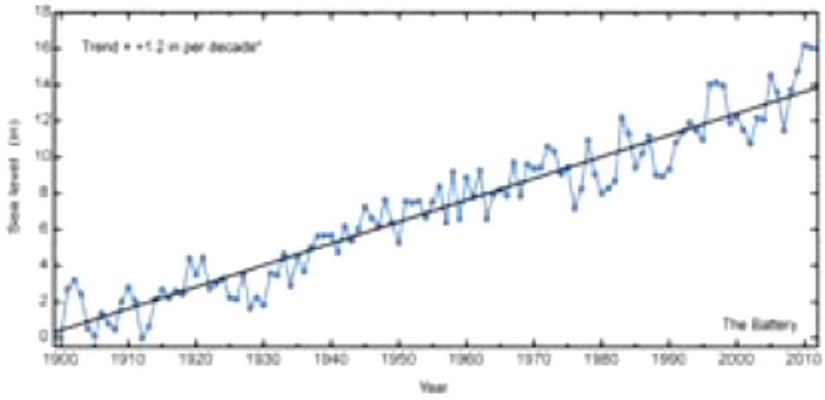
Figure 2. Observed Annual Precipitation in New York City (NPCC Climate Risk Information 2013: Observations, Climate Change Projections, and Maps, p. 12)

The effects of excessive flooding can negatively impact water quality and can damage water supply infrastructure such as distribution mains and well fields (www3.epa.gov/climatechange/impacts/water.html). These impacts will likely require changes in regional

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

Sea Level Rise

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



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

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

Extreme Storm Events

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

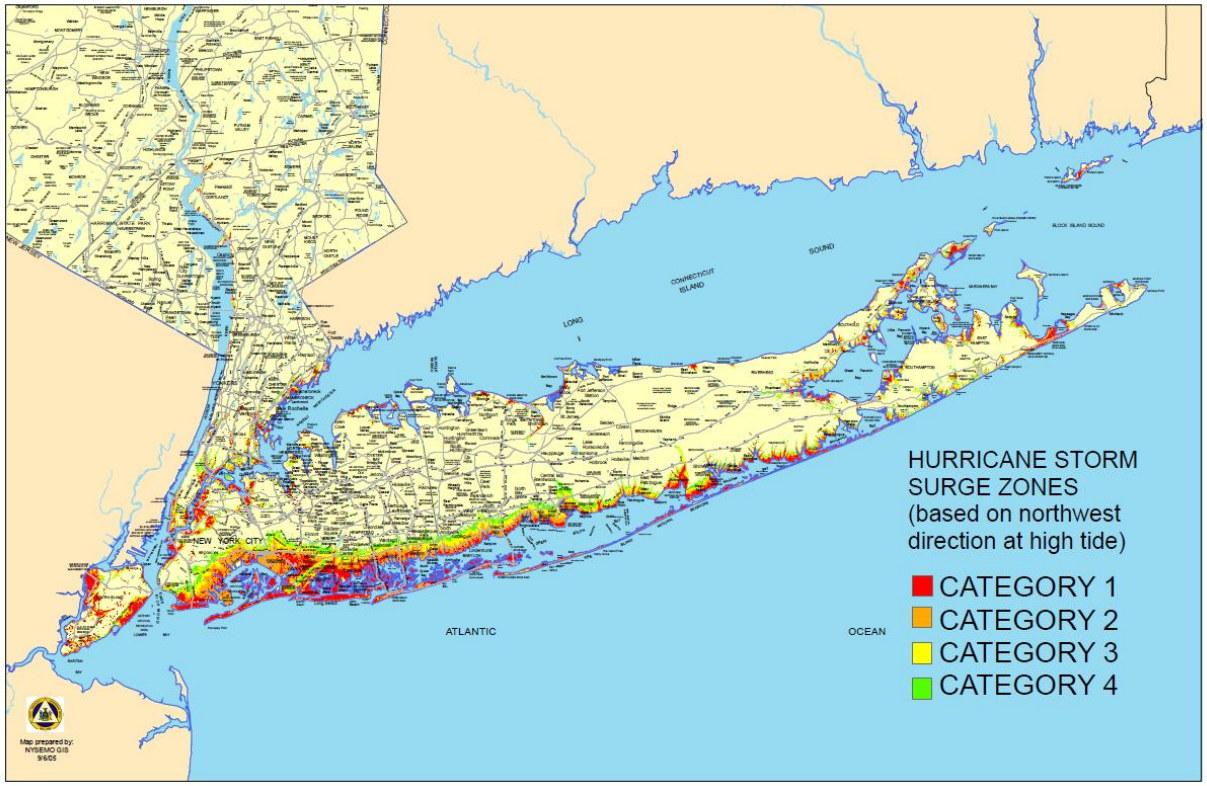


Figure 4. Sea, Lake, and Overland Surges from Hurricanes (SLOSH) – NYSEMO GIS

The New Normal

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

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

In addition to the above issues which will result in changes to Long island's water resources as a whole, the increased frequency of extreme weather events such as heavy downpours, hurricanes or nor'easters could impact operations and infrastructure in low-lying or coastal areas of Long Island. Due to threats of intensity, duration and frequency of these events, and the associated impacts such as inundation, wind damage, storm surge damage may cause, water suppliers to abandon or relocate assets. In addition, if inundations become permanent, the relocation of populations out of at-risk areas will be necessary. Populations moving in-land will require water suppliers to create additional infrastructure (out of At-Risk areas) to supply newly settled regions.

When the draft 2010 Suffolk County Comprehensive Water Resources Management Plan was developed, global climate models at that time projected the following increases in sea level elevation in the New York City area:

Decade	Increase
2020s	2 to 5 inches
2050s	7 to 12 inches
2080s	12 to 23 inches

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

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

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

Suffolk County Groundwater Model Projections

The effects of sea level rise on groundwater resources have been studied extensively as part of the Suffolk County Comprehensive Groundwater Resources Management Plan ("Comp Plan"). A portion of this plan was devoted to utilizing the Suffolk County Groundwater model to investigate the effects of various sea level rise scenarios on the groundwater resources of the Main Body of Suffolk as well as the North and South Forks. As a conservative approach, the mean sea-level rise projection under the "business as usual" case as presented in Zhang et al. (2014) was utilized, projecting an increase in sea level of 34 inches. For consistency purposes, a baseline value of 0.5 feet was used as the beginning mean sea level in all model simulations. These simulation results were used to assess the potential impact to on-site sewage disposal systems, as discussed in Section 8. Model simulations were run through 2099 assuming an increase in sea level of 34 inches.

Main Body of Suffolk

Assuming a 34-inch rise in sea level, the change in water level varies from 2.8 feet to less than 0.25 feet, with most of the model area showing an increase of 1 foot or less. Similar to the original sea level rise scenarios (Task 4.4), the predicted change in water level is much lower along the south shore, compared to the north shore, because increases in stream baseflow limit the water level rise in the vicinity of the non-tidal portion of the south shore streams (simulated to increase by approximately 48 percent in response to a 34-inch rise in sea level).

North Fork

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

South Fork

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

Conclusions

Flow models used in the Comp Plan confirm that Suffolk County's aquifer system can continue to meet current and projected rates of water supply pumping on a County-wide basis. Nevertheless, as water supply pumping increases in the future and becomes a larger percentage of the overall water budget on Long Island, fresh groundwater supplies and surface water bodies will most likely become more limited in

many areas, particularly the North and South Forks. The water balances also identify the net loss of baseflow to area streams and to coastal areas in those parts of the County where water supply pumping is not returned to the aquifer, i.e. Sewer District areas with tidal water discharge (Southwest Sewer District and others).

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

Impacts on Wastewater Treatment Practices in Suffolk County

Pre-1972 Suffolk County standards identified a minimum distance of one foot from the bottom of a cesspool to groundwater (providing nine feet from ground surface to the water table). Current standards identify a minimum distance of three feet (providing eleven feet from ground surface to the water table). There are many areas along the coast that are currently developed where the existing depth to groundwater is less than 10 feet below grade. These areas also generally correspond with areas that are projected to be further impacted by rising sea level. It is possible that many of the systems within these areas are currently just above the seasonal high water table and may become flooded as sea-level rises in the future. This would not only reduce treatment capability of existing on-site treatment systems, but could completely eliminate the functionality of the system(s). At greatest risk to elevated sea level are the communities along the south shore barrier island. Not only does the water table rise significantly, but much of the land area becomes flooded, similar to a wetland as the groundwater system adjusts to the rising sea level

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

Conclusions and Recommendations

The Northeast is experiencing warming temperatures and a large increase in the amount of rainfall measured during heavy precipitation events. Sea level rise and more frequent heavy rains are expected to increase flooding and storm surge, threatening infrastructure.

As described in this report, climate change will create, “New Normal” conditions for which water suppliers will have to adapt with regard to both source and operational management. Water suppliers will be required to reevaluate Water Resource Management, Facilities Management Responses, and Potential Policy and Regulatory Changes. The following is a summary of potential water supplier actions necessary to respond to climate change impacts:

- Mandatory conservation – reduce summertime peak pumping, “stretch out” the peak
- Regional pumping centers in “safe” areas and longer distance transmission vs. localized pumping per current practice
- Connections to NYC water supply for Nassau barrier island communities, and North Shore peninsula communities with salt water intrusion issues
- Possible imposition of Pumpage caps on Water Suppliers – additional supply from NYC, and longer distance transmission from one district to another can alter the caps
- Possible Regulatory responses: mandatory monitoring by water suppliers of regional water quality, water table elevation, and potentiometric head, with “triggered” actions); restrictions on pumping rates, or hours of use in certain areas; outright ban on new wells in certain areas
- The use of aquifer storage and recovery in marginal areas

- Need for regional working computer model with active participation among water suppliers, regulators, consultants to assess potential problems and evaluate solutions. Such a model is currently under development as part of the Long island Groundwater Sustainability Project.

References

"Climate Risk Information 2013 – Observations, Climate Change Projections, and Maps", New York City Panel on Climate Change, June 2013.

"Climate Risk Report for Nassau and Suffolk County", TR-014-01, Zhang, Bokuniewicz, Lin, Jang Liu, August 2014

Suffolk County Comprehensive Water Resources Management Plan, 2015 (http://www.suffolkcountyny.gov/Departments/HealthServices/EnvironmentalQuality/WaterResources/ComprehensiveWaterResourcesManagementPlan.aspx)

USEPA Climate Change website: http://www3.epa.gov/climatechange/