August 2022

Feasibility Study

New York City-Nassau County Water Supply Interconnection

Contents

Executive Summary

Long Island, and Nassau County more specifically, is one of a very few locations in the U.S. where a high density of residential and commercial development overlies a sole source aquifer on which the residents rely for drinking water. The combination of decades of development and increased stress on the aquifer has produced unique challenges involving saltwater intrusion and providing drinking water that meets ever-tightening regulatory standards. The purpose of the *New York City-Nassau County Water Supply Interconnection Feasibility Study* (Feasibility Study) is to evaluate the feasibility of connecting New York City (NYC) public water supply to Nassau County.

Key Findings

Small Scale Scenarios are feasible: the primary small-scale scenario evaluated is the supply of 20 million gallons per day (MGD) from NYC based on the capacity of existing (inactive) interconnections between NYC and Nassau County along the Queens border. These existing connections would need to be rehabilitated.

Large Scale Scenarios would have significant challenges:

- Limited supply of NYC water, with projections out to 2040 indicating very little if any excess capacity by that time. Currently there are approximately 200 MGD of NYC supply in excess of the city's demand but that is expected to shrink over time. Nassau County has an average daily water demand of approximately 180 MGD.
- Financial and organizational challenges in creating new water sharing and distribution districts.

The Feasibility Study evaluated whether water quality differences in New York City's supply raise water sharing concerns; the study indicates that these differences would not prevent further consideration of supplying NYC water to Nassau County.

The chart below summarizes the major scenarios evaluated in the Feasibility Study. Based on a survey of the County water systems, a scenario between the Small Scale and Large Scale may address the needs in Nassau County for the foreseeable future.

The Feasibility Study Report provides details on the needs, issues and challenges associated with supplying NYC water to Nassau County.

Scenario Evaluation				
Scenario	**Capacity**	**Capital Cost**	**Time**	**Recommended Organizational Structure**
Small Scale – few water districts	20 MGD	$35 million – $53 million	2-5 years	Intermunicipal Agreements
Large Scale – dozens of water districts	180 MGD	$1.4 billion – $2.2 billion	10-15 years	New Authority or Special District

NOTE: Federal and State grants/loans may be available to offset part of the capital cost.

Summary Report

Introduction

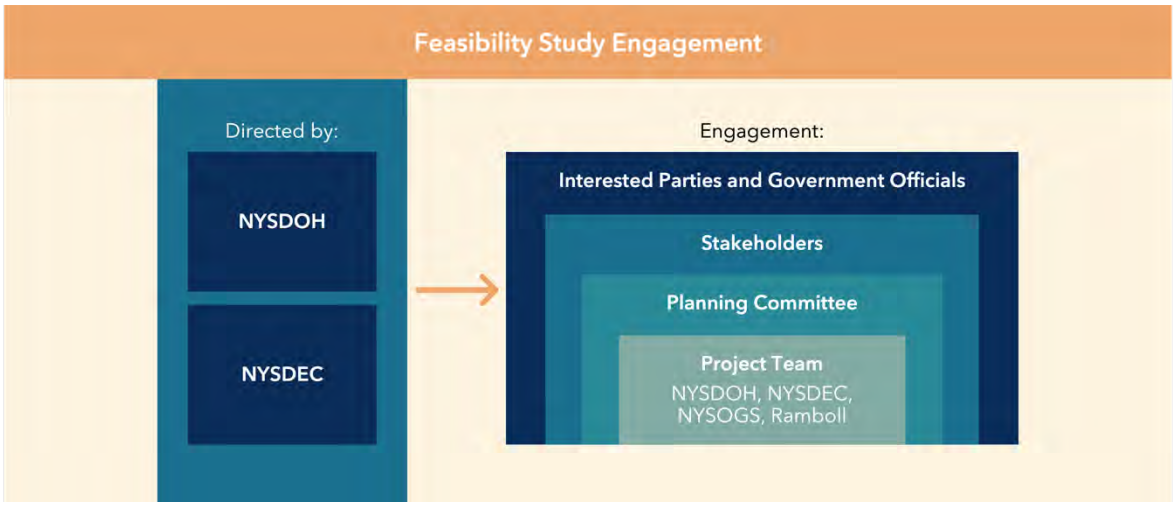
Long Island, and Nassau County more specifically, is one of a very few locations in the U.S. where a high density of residential and commercial development overlies a sole source aquifer on which the residents rely for drinking water. The combination of decades of development and increased stress on the aquifer has produced unique challenges in providing drinking water that meets ever-tightening regulatory standards. Numerous studies (see Appendix A) have documented the challenges related to Long Island's groundwater resources, and the many attempts to preserve and enhance this critical resource.

The purpose of the **New York City-Nassau County Water Supply Interconnection Feasibility Study** is to evaluate the feasibility of connecting New York City (NYC) public water supply to Nassau County. The Feasibility Study was authorized at a time when New York State Department of Health's (NYSDOH) Part 5 of the State Sanitary Code was being amended to establish maximum contaminant levels (MCLs) for 1,4 Dioxane and two PFAS compounds, commonly referred to as PFOA and PFOS, but the scope of the Feasibility Study also considers other water quality concerns

It is quite simply a study to help inform future decisions on the critical issues regarding water supply for Nassau County.

and water quantity impacts of saltwater intrusion. The Feasibility Study was directed by NYSDOH in collaboration with New York State Department of Environmental Conservation (NYSDEC). The Study is intended to provide useful information by more broadly exploring the use of NYC water in Nassau County. A similar study was conducted by the Long Island Commission for Aquifer Protection (LICAP) and described in their 2019 Groundwater Resources Management Plan.

It is important to also recognize what the Study is not. The Study does not obligate NYC, Nassau County, or the County's public water suppliers to pursue any interconnections and it is not a statement from NYSDOH or NYSDEC that any interconnections are needed. It is quite simply a study to help inform future decisions on the critical issues regarding water supply for Nassau County.



Please see Appendix B for information on the scope of the Feasibility Study, who participated and how it was completed. The remainder of this Summary Report is organized to address several key questions.

Where does Nassau County get its drinking water?

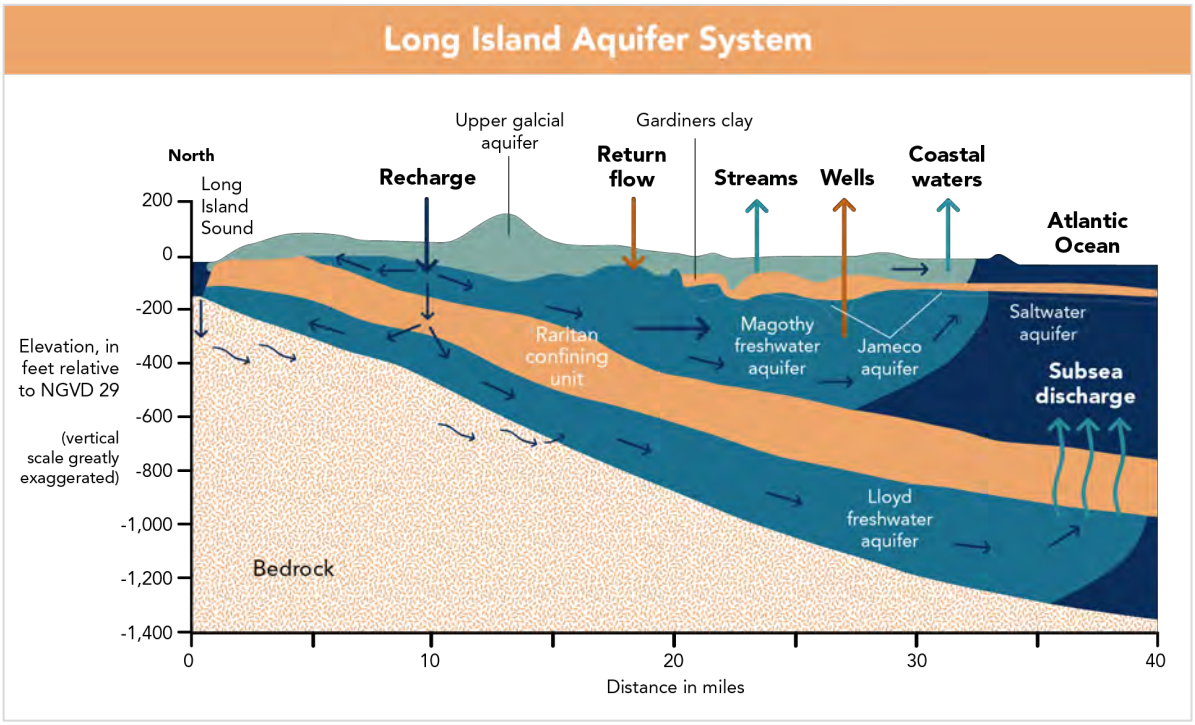
Nassau County's drinking water is sourced from aquifers (groundwater), via approximately 46 public water suppliers who have a total of approximately 500 wells (https://www.nassau-countyny.gov/2970/Public-Water-Supply) that are permitted for public water supply. The wells draw water from three major aquifers:

01 | Upper glacial aquifers

02 | Jameco-Magothy aquifer

03 | Lloyd aquifer

The figure below shows the aquifer system on Long Island (Ref. #27, Appendix A).



Source: adapted from USGS, Long Island Sole-source aquifer system, https://www.usgs.gov/media/images/long-island-sole-source-aquifer-system

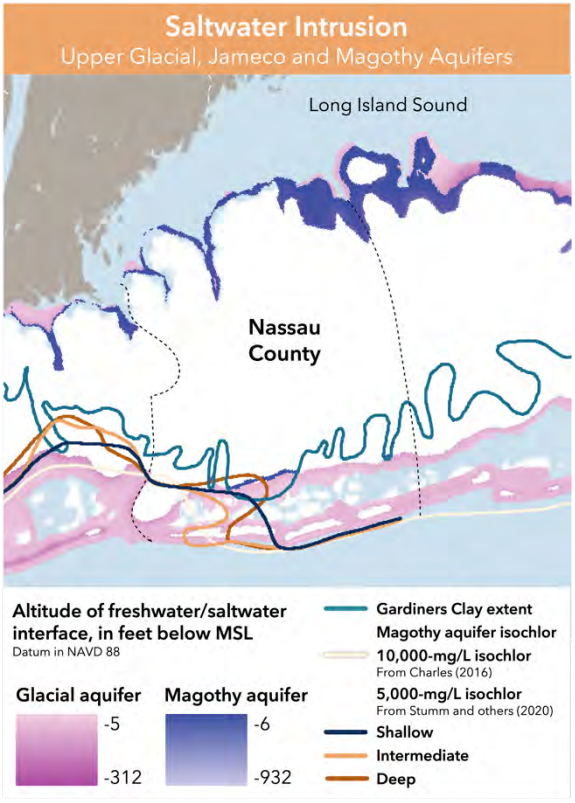
What are the current challenges facing Nassau County water suppliers?

Nassau County's water suppliers are facing several significant challenges:

- **Regulated Contaminants:** The aquifers used by Nassau County contain nitrates, volatile organic chemicals (VOCs) and chloride (saltwater intrusion) concentrations in excess of regulated maximum contaminant levels (MCLs). In recent years, the widespread discovery of 1,4 Dioxane and Per & Poly-fluoroalkyl Substances (PFAS), sometimes referred to as forever chemicals, requires new treatment systems to comply with New York State Department of Health's recently enacted MCLs for these emerging contaminants.

- **Saltwater Intrusion**: Saltwater intrusion continues to be a concern, particularly along the northern and southern coastal areas of Nassau County. Numerous wells have been taken off-line in these coastal areas to avoid excessive levels of chlorides in the drinking water. The figure to the right is from a 2020 USGS report (Ref. #27, Appendix A) and it shows the extent of chloride concentrations exceeding 5,000 mg/L.

The extent of chlorides exceeding the drinking water MCL of 250 mg/L is much greater, but wells with chlorides approaching the MCL have been taken off-line.



Source: adapted from USGS, Simulation of Groundwater Flow in the Regional Aquifer System on Long Island, New York, for Pumping and Recharge Conditions in 2005-15, https://pubs.usgs.gov/sir/2020/5091/sir20205091.pdf

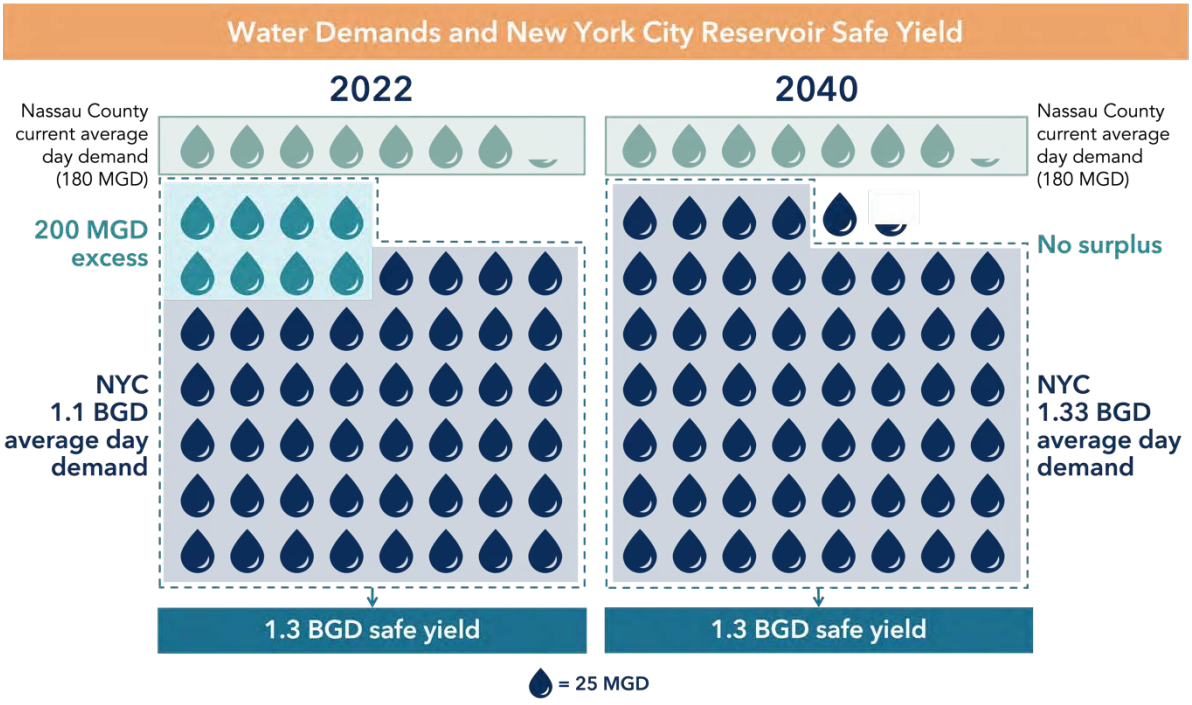
- **Safe Yield**: While water demand has been relatively steady in Nassau County, the potential loss of wells due to saltwater intrusion and chemical contamination raises concern over the ability to meet future needs. The Lloyd aquifer is the deepest of the three aquifer units, and the least contaminated; however, use of the Lloyd wells has generally been reserved for areas along the north and south shores, which are most susceptible to saltwater intrusion.

- **Other Emerging Contaminants**: As analytical detection limits improve laboratories are finding ever smaller, trace concentrations of known or suspected contaminants. Health officials are exploring the risks from trace amounts of these other emerging contaminants such as the PFAS compounds commonly referred to as GenX chemicals and PFBS. It is likely that Safe Drinking Water Act (SDWA) regulations will continue to become more stringent, requiring the water suppliers in Nassau County to remove more of these contaminants from their groundwater supplies.

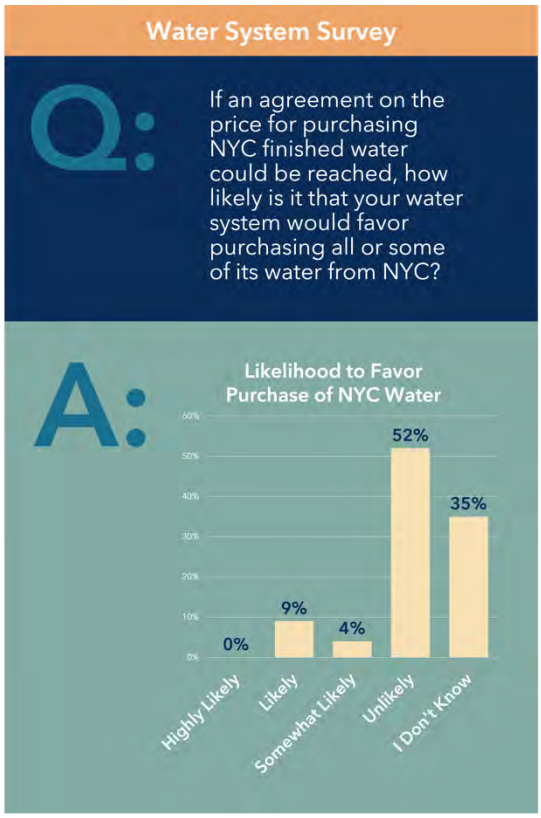
Does New York City have enough available water?

Thanks to successful conservation efforts over the past thirty years, New York City (NYC) reservoirs now have a safe yield that exceeds their water demands. The safe yield of NYC's reservoirs is 1.3 billion gallons per day (BGD). That means NYC's reservoirs can be relied upon, even in a repeat of the worst drought on record, to supply 1.3 BGD. The NYC water system's current average day demand is 1.1 BGD, leaving 0.2 BGD or 200 million gallons/day (MGD) of safe yield in excess of demand. NYC Department of Environmental Protection (NYCDEP) projects that in 2040, the water demands of the NYC water system could increase to 1.33 BGD, leaving no surplus for Nassau County.

Existing connections between NYC and Nassau County could, once rehabilitated, supply 20 MGD. By comparison, Nassau County has an average day water demand of approximately 180 MGD.



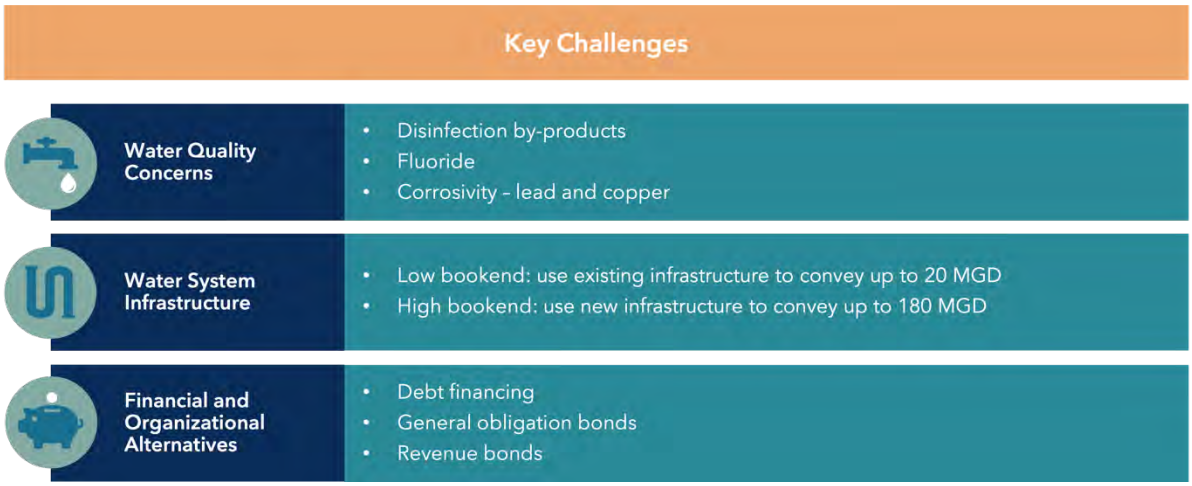
The current availability of 20 MGD from NYC is considered a significant potential benefit, provided the water can be conveyed from NYC to the locations where it is needed in Nassau County; however, it is also recognized that Nassau County may seek more than 20 MGD now or in the future as it addresses the many challenges facing its groundwater supplies. This Feasibility Study investigated alternatives to convey 20 MGD from NYC to Nassau County as well as alternatives to convey much larger quantities, up to the average day demand of Nassau County. Feedback from Nassau County water suppliers to a survey conducted during the Feasibility Study (see figure below) suggests that their current interest in purchasing NYC water is unlikely to reach the higher end of the range.



What are the challenges in supplying NYC water to Nassau County?

Water Quality Concerns

NYC's surface water supplies contain little or no detected amounts of the nitrates, VOCs, PFOA, PFOS or 1,4 Dioxane found in Nassau County's groundwater supply. While the water that could be supplied by NYC's connections in Queens meets all SDWA requirements, there nonetheless are some water quality related concerns that were identified by the survey of water systems that was conducted during the Feasibility Study (see Appendix B for discussion on the Water System Survey and Appendix C for the Water Quality Review).



- **Disinfection By-products**: Disinfection by-products (DBPs) are formed when natural organic matter common in streams and reservoirs combines with chlorine. (NYC and nearly all water systems add chlorine as a disinfectant.) Two groups of DBPs are regulated under the SDWA: trihalomethanes (THMs) and haloacetic acids (HAAs). Nassau County utilizes groundwater, which has lower levels of natural organics and therefore lower levels of DBPs are present in Nassau County's drinking water. Since NYC's water has higher THMs and HAAs than the Nassau County waters, introducing NYC water would increase the concentrations of THMs and HAAs in Nassau County's drinking water.

  The relative increase would depend in part on the blend of NYC and Nassau County finished waters. The relative increase would also depend on how long it takes the water to travel from NYC to the customers in Nassau County, because the DBPs, particularly THMs, generally increase as the water ages. While additional investigations are needed for a definitive prediction, the Feasibility Study concluded that while DBPs represent a potential water quality concern, they should not prevent further consideration of supplying New York City water to Nassau County.

- **Fluoride**: NYSDOH recommends but does not require the addition of fluoride to public water supplies for dental protection. NYC currently fluoridates their water, but none of the Nassau County water systems fluoridate. Given the high costs and complexities of fluoride removal, this Feasibility Study has not considered fluoride removal from NYC water.

- **Corrosivity – Lead and Copper**: Lead in drinking water is a serious health issue, especially for infants and young children. While NYC and Nassau County water systems meet the current Lead and Copper Rule regulation for the 90th percentile at-the-tap lead levels, the household samples in NYC have higher concentrations of lead than in Nassau County. Based on the water quality review (Appendix C) it appears that the higher lead levels in NYC are the result of the older housing stock, because the older houses in NYC are more likely to have lead service lines and/or brass plumbing fixtures with lead content. The review confirmed that the water in the water transmission and distribution mains is essentially lead free in both NYC and Nassau County and exhibits generally similar potential for lead corrosion. It is therefore probable that NYC water could be introduced into Nassau County without significantly increasing lead levels. While additional investigations are needed for a definitive prediction, the Feasibility Study concluded that while lead levels at the household tap represent a potential water quality concern, they should not prevent further consideration of supplying New York City water to Nassau County.

Water System Infrastructure

The Feasibility Study investigated challenges in conveying NYC water to Nassau County and developed concepts and cost estimates for needed investments for two "bookends". The **Low Bookend** would use mostly existing infrastructure to convey up to 20 MGD, while a **High Bookend** would require mostly new infrastructure to convey up to the average day demands of Nassau County (180 MGD). Based on the water system survey (Appendix B), it is possible/likely that something in between the Low and High Bookends may address the needs in Nassau County for the foreseeable future.

Low Bookend: NYC could provide finished water to several Nassau County water systems along the Queens border under separate buy-sell agreements. NYCDEP provided information on the hydraulic capacity of five existing interconnections in Queens near the Nassau County border (see Appendix D). The Low Bookend concept includes costs to rehabilitate these interconnections, which have not been used in 20 years or more, and also includes a new interconnection to serve the north shore areas.

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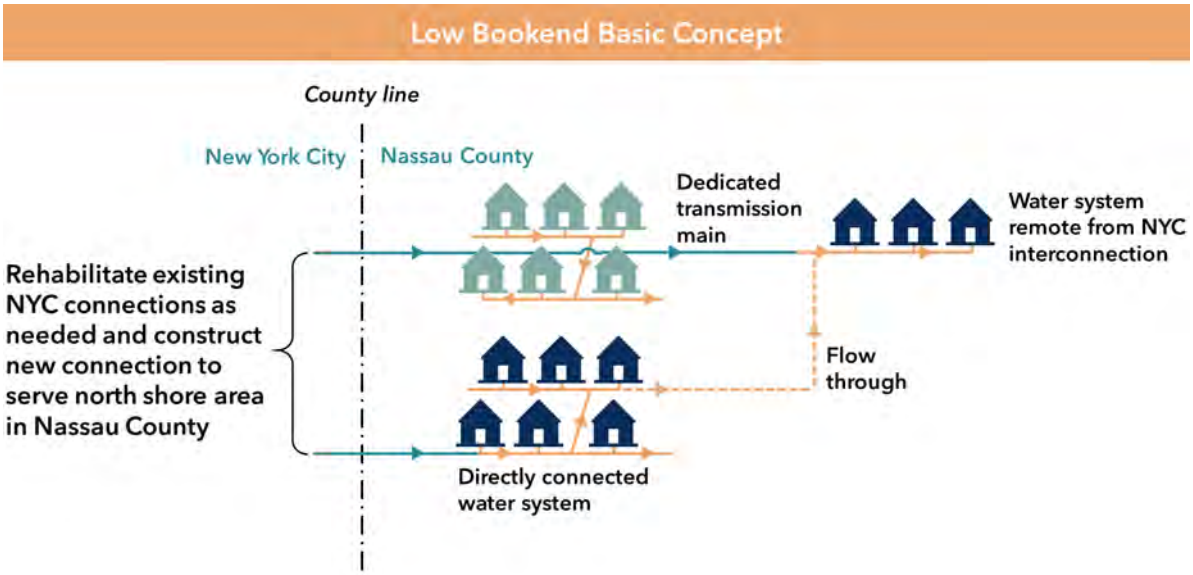


To serve water systems remote from the NYC interconnections, there are two concepts illustrated above:

01 | Flow through approach, where NYC water mixes with water in the first Nassau County water system and then flows through to adjoining water systems.

02 | Dedicated transmission mains from NYC that convey water directly to water systems remote from the NYC (Queens) border.

Ramboll suggests allowing approximately two years for implementing a Low Bookend project that uses existing interconnections and three to five years to implement a Low Bookend project that involves a new interconnection or a new dedicated transmission main. See Appendix D.

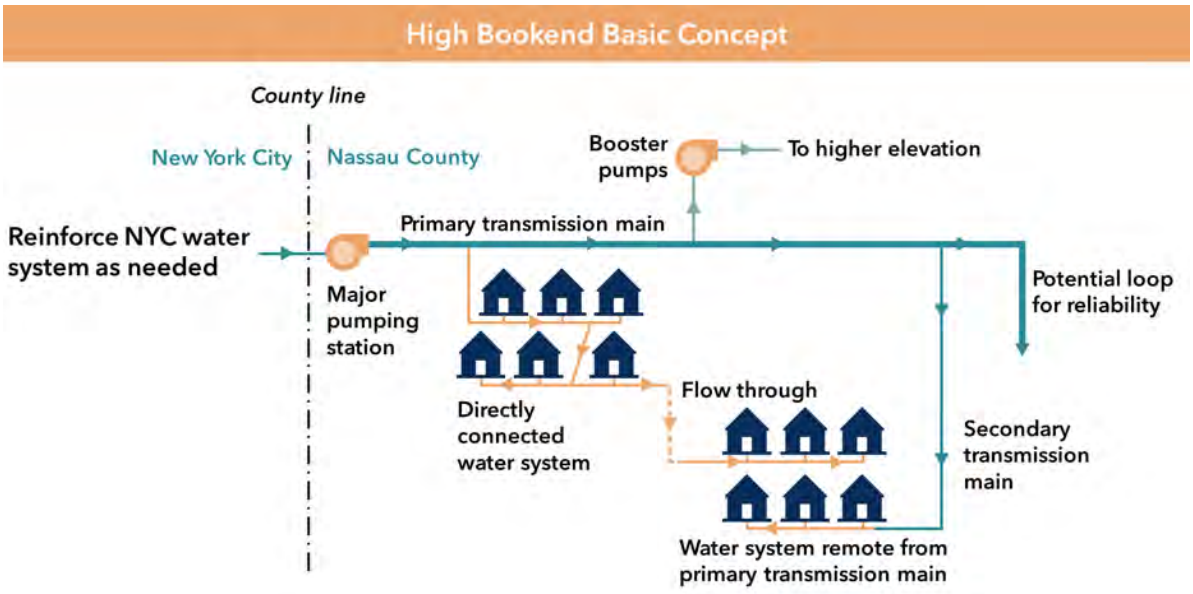
High Bookend: As noted above, this option was developed to enhance the body of information available to interested parties, in the event that Nassau County and NYC decide to explore the transfer of substantially larger amounts of NYC water. The backbone of the High Bookend includes one or more major pumping stations and primary transmission mains, along with complex hydraulic controls, booster pumping stations and secondary transmission mains. To serve water systems remote from the primary transmission main(s) there are two concepts illustrated on the following page and described further in Appendix D:

01 | Flow through approach, where NYC water mixes with water in Nassau County water systems which are connected to the primary transmission main, and then flows through to adjoining water systems.

02 | Dedicated secondary transmission mains that convey water from the primary transmission main(s) directly to water systems remote from the primary transmission main(s).

Based on the technical complexity, need for routing studies and property acquisition, financing and organizational needs, and likely five years or more for construction, the High Bookend should be viewed as a 10 to 15-year undertaking. However, the Low Bookend project(s) (see above) could serve as the initial phase. See Appendix D.

The backbone of the High Bookend includes one or more major pumping stations and primary transmission mains, along with complex hydraulic controls, booster pumping stations and secondary transmission mains.



Both the Low and High Bookend concepts present technical challenges, with these challenges magnified by the scale of infrastructure in the high bookend: pipeline routing, easement acquisition, construction impacts, hydraulic controls, etc. Not to be overlooked is the need to avoid water quality problems caused by stagnant water or extended water age. Minimum daily takings of water will likely be needed to avoid these problems. The High Bookend is also shown with a potential loop of the primary transmission main, to enhance reliability.

Financial and Organizational Alternatives

The Feasibility Study explored financial and organizational structures which may be needed to support the interconnection infrastructure, as detailed in Appendix E. Financing is a key consideration. The Low Bookend involves relatively modest investments which likely could be provided by the existing water systems. Financial support may be available through existing programs from New York State and the Federal Government to offset part of the cost. The High Bookend, with the potential need for over a billion dollars of new infrastructure, almost certainly will also require the ability to access some debt financing. Public water systems commonly use general obligation bonds or revenue bonds to fund water supply infrastructure. The type of organization determines whether the municipality is empowered to issue these bonds. The following table identifies some possible organizational alternatives, their ability to issue debt, and their viability for the Low and High Bookends. A phased approach could be applied, with several intermunicipal agreements as a first step to utilize water available along the NYC/Queens border (Low Bookend), followed by a new county-wide organization if needed to streamline operations and/or to finance more substantial investments.

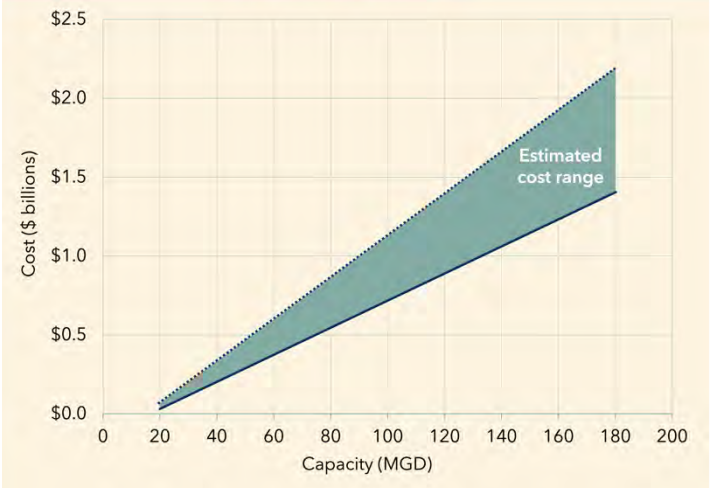
Summary Matrix for Organizational and Financial Review			
Organizational Alternative	**Ability to Issue Debt**	**Viable for Near Term "Low Bookend"**	**Viable for Longer Term "High Bookend"**
Public Utility Authority	Yes, via revenue bonds	Yes, but probably not needed	Yes
County Special District	Yes, via general obligation bonds	Yes, but probably not needed	Yes
Intermunicipal Agreements	No, each utility issues own debt	Yes	Not practical
Combination of Above Alternatives (Phased Approach)	Yes, via revenue bonds or general obligation bonds	Yes, with Intermunicipal Agreements	Yes, with new organization and debt financing

How much will it cost to interconnect NYC and Nassau County's water systems?

The rough order of magnitude (ROM) cost estimate for the "Low Bookend" scale improvements is $35 million to $53 million, including water quality and hydraulic studies, engineering, property acquisition, construction, and allowances for miscellaneous costs and contingencies.

For the High Bookend (large scale) program, the ROM cost estimate is $1.4 billion to $2.2 billion. Both the Low and High Bookend concepts can be implemented in phases. These cost estimates involve numerous assumptions, and financial support may be available through existing programs from New York State and the Federal Government to offset part of the cost. For more information on the costs estimates, financial support, timing and other aspects of potential implementation, please see Appendix D.

ROM Cost Estimate



The figure to the left illustrates the estimated cost versus capacity, using the above-described ROM costs for Low and High Bookends. While the cost for capacities greater than the Low Bookend and less than the High Bookend will be driven by the specific components and areas to be supplied, this figure can be used for a preliminary assessment of ROM costs.

Cost estimate includes construction, contingencies and allowances for property acquisition, engineering, leaal and miscellaneous costs.

This study shows that NYC water can be used to serve some of Nassau County's water demands, but what are the needs, issues and challenges?

01 | **Level of Interest**
Establishing the level of interest by Nassau County water suppliers in the NYC water supply, including details such as the quantity of water, location and frequency of water purchases.

02 | **Conservation Efforts**
Exploring the extent to which conservation efforts could reduce Nassau County's water demand.

03 | **Existing and New Connections**
Reactivation of NYC's existing connections and potential installation of a new connection to serve Nassau County north shore areas.

04 | **Willingness and Ability to Sell**
Establishing NYC's long-term willingness and ability to sell water to Nassau County.

05 | **Price**
Establishing the price for wholesale water and the terms and conditions of buy-sell agreements.

06 | **Corrosion Control**
Technical studies to confirm that blending the NYC's surface water supplies and Nassau County's groundwater supplies would maintain acceptable concentrations of lead and copper, in conformance with the 2021 Lead and Copper Rule Revisions.

07 | **Acceptance**
Exploring the acceptance of Nassau County communities to receiving fluoridated NYC water.

08 | **Disinfection By-product Concentrations**
Technical studies and development of an integrated NYC-Nassau County hydraulic and water quality model to predict disinfection by-product concentrations in Nassau County.

09 | **Water Flow**
Technical investigations and use of above hydraulic model for analyzing how water could move from NYC through Nassau County, to predict pressures and determine the need for booster pumping and pressure regulating.

To learn more about the Feasibility Study and its findings, you can access the following appendices (via links):

A. Prior Related Investigations and Sources of Information
B. Feasibility Study Scope, Communications and Engagement
C. Water Quality Review
D. Water System Infrastructure Concepts and Costs
E. Finance and Organizational Alternatives

Appendix A

Prior Related Investigations and Sources of Information

Introduction

This appendix lists prior related studies and sources of information that were reviewed during the Feasibility Study.

Prior Related Investigations

Over the years, there have been numerous investigations into the public water supplies serving the metropolitan New York area, including studies of the groundwater supplies that are used by the water suppliers in Nassau County. These reviews have been conducted by New York State Agencies, the County, and Independent Commissions. In December 2020, NYSDOH and NYSDEC provided hard copies of all the relevant, available investigations to Ramboll for review.

Ramboll digitized and catalogued these studies as summarized in the attached table. Nealy all these studies are old, having been prepared in the 1960s to the 1990s.

During this Feasibility Study, Ramboll identified other relevant studies which are more recent and have been prepared by entities other than New York State agencies. These studies are listed in the attached table as well. The table identifies the topics addressed in each study and includes a very brief overview of the contents, if relevant to the Feasibility Study.

Data Sources

The attached table also includes the primary sources of data that were provided to Ramboll, and source(s) that are publicly available.

Prior Related Investigations					Categories													
Document No.	Document Name and Link	Document Type	Issuing Agency/Entity	Cooperating Agencies/Entities	Release Date	Water Budget	Groundwater Quality	Groundwater Quantity	Groundwater Recharge	Groundwater Pollution	Surface Water Quality	Surface Water Quantity	Water Demand	Well Supply Reliability	Water Supply from NYC	Alternative Means of Water Supply	Governmental Programming	Additional Notes
1	An Atlas of Long Island's Water Resources	Report	New York Water Resources Commission	U.S. Geological Survey	Jul-68	✓	✓	✓	✓	✓	✓	✓	✓			✓		The Atlas was prepared by the U.S. Geological Survey in cooperation with the New York State Water Resources Commission. Now over 50 years old, this document provides a wide and still useful overview of the water sources available on Long Island along with recommendations for water conservation measures. It discusses the effects of groundwater withdrawal on the aquifer system, the yield of the aquifer system and alternative methods for developing and managing the aquifer system.
2	Diagnosing Water System Problems in New York	Report	New York State Senate Research Service Task Force on Critical Problems		Jun-85	✓				✓			✓		✓	✓		This report came out of legislation passed in 1983 to address NYS infrastructure. The report discusses the issues that water distribution systems were facing in NYS and focuses on distribution system failures and the lack of adequate data.
3	Long Island Water Resources Data No.1	Report	U.S. Geological Survey	Nassau County Department of Public Works New York State Water Resources Commission Long Island Water Corporation	Jul-62		✓	✓	✓	✓								This document contains six separate reports relating to groundwater, population, hydrology, storm water, and the water supply for Nassau County and Suffolk County. The Nassau County portion includes historical information on water supply systems in Nassau County and information on the aquifers.
4	Long Island Water Resources Data No.2	Report	U.S. Geological Survey	Nassau County Department of Public Works New York State Department of Conservation New York State Water Resources Commission Suffolk County Department of Environmental Control Suffolk County Department of Health Suffolk County Department of Public Works Suffolk County Legislature Suffolk County Water Authority Suffolk County Board of Supervisor	Jan-74	✓	✓	✓	✓	✓	✓	✓				✓		This document contains historical information on contaminants and groundwater supply issues. The document includes information on bacteria, Nitrogen/Nitrate, Corrosion, Nitrate Accumulation, and An Atlas of Long Island's Water Resources (reviewed separately).
5	Muddling Through	Report	New York State Senate Committee on Cities		Jul-88					✓		✓	✓	✓	✓			This document was a legislative review by the State Senate on the New York City water system following two historic water shortages in 1980 and 1985. It provides a review of the vulnerability of the New York City water system and methods to ensure proper management of the system.
6	Nassau County Dept. of Health - Ground Water and Public Water Supply Facts	Report	Nassau County Dept. of Health	Office of Groundwater Management Bureau of the Public Water Supply	Jun-91	✓	✓	✓		✓	✓		✓	✓	✓	✓		The "Water Supply Facts" document includes a variety of tables, maps, and graphics depicting Nassau County's public water supply and groundwater system. It includes information on the groundwater aquifer system, the public water systems source water and system pumpage, and raw water quality.
7	New York State Water Resources Management Strategy	Report	New York State Water Resources Planning Council	NYS DEC NYS Dept. of Health	Jan-89	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		This document is the comprehensive strategy for New York State's statewide water resources management strategy. It was conducted by a Planning Council created by the New York State Legislature. The document includes information on all water resource aspects.
8	Present and Potential Impact of Organic Chemical Contamination on the Jamaica Water Supply Co.	Report	Jamaica Water Supply Company	Prepared by: Leggette, Brashears & Graham, Inc., A. Guerrera Associates	May-83		✓			✓				✓				The Report provides information on organic chemical contamination in the aquifers supplying Queens and Nassau County. It includes a review of the Jamaica Water Supply Company and found multiple wells with organic constituents above the New York State limits. It sets the stage for the contamination issues facing the Queens and Nassau County water supply.

Prior Related Investigations					Categories													
Document No.	Document Name and Link	Document Type	Issuing Agency/Entity	Cooperating Agencies/Entities	Release Date	Water Budget	Groundwater Quality	Groundwater Quantity	Groundwater Recharge	Groundwater Pollution	Surface Water Quality	Surface Water Quantity	Water Demand	Well Supply Reliability	Water Supply from NYC	Alternative Means of Water Supply	Governmental Programming	Additional Notes
9	Progressive Report of the NYS Legislative Commission on Water Resource Needs of Long Island 1988	Report	NYS Legislative Commission on Water Resource Needs of Long Island		Mar-88			✓		✓				✓				The Progress Reports of the NYS Legislative Commission on Water Resource Needs of Long Island provide a detailed compilation of background information and then ongoing discussion of water resource challenges, especially groundwater, affecting Long Island. This 1988 report provides updates on issue areas in pumpage limitations, solid waste management, groundwater contamination, environmental review, and watershed planning programs The report also includes commission hearings on the impact of the federal Safe Drinking Water Act Amendment on local water suppliers and the status and effectiveness of the State Pollutant Discharges Elimination System (SPDES).
10	Progressive Report of the NYS Legislative Commission on Water Resource Needs of Long Island 1991	Report	NYS Legislative Commission on Water Resource Needs of Long Island		Mar-91		✓	✓		✓	✓						✓	The Progress Reports of the NYS Legislative Commission on Water Resource Needs of Long Island provide a detailed compilation of background information and ongoing discussion of water resource challenges, especially groundwater, affecting Long Island. This 1991 report provides updates on issue areas in groundwater quality, drinking water supply, watershed management, surface water protection, wetlands protection, public education and legislative programs.
11	Report on Immediate Public Water Supply Needs of the City of NY and County of Westchester	Report	State of New York Dept. of Health	Prepared by: Metcalf & Eddy, Hazen and Sawyer, Malcolm Pirnie Engineers	Aug-66	✓		✓				✓	✓	✓	✓	✓		This report was the first in a comprehensive intermunicipal public water supply study for the City of New York and Westchester County initiated in May of 1966. The report includes an outline of a management plan to serve immediate needs and a discussion of measures to be taken to serve said needs. The study assesses water demand for the NYC and Westchester County population, metering, leak detection and use restrictions to improve current supply, and a number of local projects to increase supply in the longer term.
12	Southeast Water Supply Commission-Alternative Futures a Re-evaluation	Report	Temporary State Commission on the Water Supply Needs of Southeastern New York		Nov-74								✓		✓	✓		Supplemental report to Southeast Water Supply Commission Conferences for the Commission's legislative program. The report re-evaluates alternative institutional water supply arrangements for the region- and the regional water facilities corporation. It also updates the status of other pieces of Commission legislation relative to universal metering, stream release requirements and private water and sewage works corporations.
13	Southeast Water Supply Commission-Compendium Of Water Supply Studies	Report	Temporary State Commission on the Water Supply Needs of Southeastern New York		Aug-72	✓		✓				✓	✓	✓	✓	✓	✓	This publication is a compendium of the major water supply studies done in southeastern New York (compiled for each County and the region as a whole) and is responsive to the legislative mandate.
14	Southeast Water Supply Commission-Emerging Water Supply Technology	Report	Temporary State Commission on the Water Supply Needs of Southeastern New York		Mar-73	✓	✓		✓							✓	✓	This report investigates emerging 1973 technologies to address supply concerns for the future water needs of southeastern New York. Discussion includes a review of current literature, feasibility of new desalination methods, induced rainfall, reclamation and reuse, and recharge. The report also notes the comments and suggestions of numerous agencies who reviewed it, including but not limited to USGS, EPA, DEC, DOH, and USACE.

Prior Related Investigations					Categories													
Document No.	Document Name and Link	Document Type	Issuing Agency/Entity	Cooperating Agencies/Entities	Release Date	Water Budget	Groundwater Quality	Groundwater Quantity	Groundwater Recharge	Groundwater Pollution	Surface Water Quality	Surface Water Quantity	Water Demand	Well Supply Reliability	Water Supply from NYC	Alternative Means of Water Supply	Governmental Programming	Additional Notes
15	Southeast Water Supply Commission-Institutional Arrangements and Alternative Futures	Water Supply Database	Temporary State Commission on the Water Supply Needs of Southeastern New York	NYS Dept. of Health Division of Sanitary Engineering Bureau of Public Water Supply	Dec-73							✓			✓	✓		This report in the series by the Southeast Water Supply Commission, reviews and analyzes present institutional arrangements at all levels of government relative to the provision of community water supply services. Community water supply services are provided throughout the Region by local governments, cities, towns and villages and by investor-owned companies. The report reviews the role of government and private institutions in planning and regulatory activity in light of water supply, sourcing, and conservation needs. The commission recommends the introduction of new regional institution to develop and operate facilities for water supply.
16	Southeast Water Supply Commission-Legal, Operational, and Financial Data Onn Water Supply Systems	Report	Temporary State Commission on the Water Supply Needs of Southeastern New York		Dec-73										✓	✓		This report sets forth, in tabular form, water supply data collected over the life of the Commission, on each of the 600+ local public water suppliers in Southeastern New York.
17	Southeast Water Supply Commission-Proceedings Local Government Conferences	Meeting Transcription	Temporary State Commission on the Water Supply Needs of Southeastern New York	NYS Dept. of Health Division of Sanitary Engineering Bureau of Public Water Supply	Dec-72												✓	This publication is an edited transcript of meetings between the Southeast Water Supply Commission and local officials concerned with water supply matters. Meetings were conducted by county to discuss water supply facilities and services, to identify needs and propose programs.
18	Southeast Water Supply Commission-Proceedings of Public Hearings	Meeting Transcription	Temporary State Commission on the Water Supply Needs of Southeastern New York		Dec-73								✓			✓	✓	This publication is a record of the public hearings held by the Southeast Water Supply Commission in July of 1973 across the State of New York. Agenda items include source development, new technologies, water resources utilization, and management and regulation to meet projected population and water demand.
19	Southeast Water Supply Commission-Second Year Report	Report	Temporary State Commission on the Water Supply Needs of Southeastern New York	Delaware River Master Connecticut Water Resources Planning Board US EPA concerning reuse and recharge NJ DEP US Corps of Engineers concerning the NEWS Study Delaware River Basin Commission	Mar-73	✓		✓				✓	✓				✓	✓	This Second Year Report of the Southeast Water Supply Commission describes program activity and progress made by the commission between February 1972 and February 1973. It evaluates water supply needs, available water resources and facilities, and develops specific alternatives to meet needs with an overview of all efforts undertaken by the Commission in the previous two years..
20	Southeast Water Supply Commission-State Agency Conferences	Conference Transcription	Temporary State Commission on the Water Supply Needs of Southeastern New York		Nov-72			✓					✓		✓	✓	✓	This is a transcript of the State Agency Conferences by the Southeast Water Supply Commission. The majority of the discussion surrounds increasing water demand and alternative water supplies such as from NYC or desalination.
21	Water For Tomorrow - Recommendations of the Commission	Report	Temporary State Commission on the Water Supply Needs of Southeastern New York		Dec-73	✓			✓		✓		✓		✓	✓		Water For Tomorrow reports the final recommendations of the Southeast Water Supply Commission based on their studies, conferences and hearings. The Commission recommends that a regional Southeast Water Facilities Corporation be established in addition to mechanisms to increase water supply and reduce consumption. The reports compiles the shorter studies mentioned above with formal recommendations for action.
22	State of the Aquifer 2019 Update	Report	Long Island Commission for Aquifer Protection		Dec-19		✓	✓	✓	✓	✓	✓	✓	✓				LICAP's 2019 State of the Aquifer report is an annual update to the 2016 Aquifer report that focuses on the threat of synthetic organic chemical contaminants, namely 1,4-dioxane and 1,1,1-trichloroethane, to Long Island water quality.
23	Groundwater Resources Management Plan	Report	Long Island Commission for Aquifer Protection		Dec-19		✓	✓	✓	✓				✓	✓	✓		The LICAP Groundwater Resources Management Plan provides a blueprint for management of Long Island's sole source aquifer for drinking water. This report assesses the prevalence of private wells, options for public water, wastewater management, contaminant regulation, and potential supply of NYC water.

Prior Related Investigations					Categories													
Document No.	Document Name and Link	Document Type	Issuing Agency/Entity	Cooperating Agencies/Entities	Release Date	Water Budget	Groundwater Quality	Groundwater Quantity	Groundwater Recharge	Groundwater Pollution	Surface Water Quality	Surface Water Quantity	Water Demand	Well Supply Reliability	Water Supply from NYC	Alternative Means of Water Supply	Governmental Programming	Additional Notes
24	State of the Aquifer 2020 Update	Report	Long Island Commission for Aquifer Protection		Dec-20		✓	✓		✓			✓			✓		The 2020 State of the Aquifer Update discusses "Mapping a Sustainable Future for Long Island's Aquifers", a USGS & NYSDEC study for future management of LI groundwater resources and groundwater flow model. Study includes: 1. Mapping of the current extent of onshore saltwater intrusion in western Long Island: https://pubs.usgs.gov/of/2020/1093/ofr20201093.pdf 2. Characterization of the hydrogeologic characteristics of the Upper Glacial and Magothy aquifers: https://pubs.er.usgs.gov/publication/sir20205023 3. Analyses of aquifer properties of western Long Island: https://pubs.er.usgs.gov/publication/ofr20201108 4. Development of groundwater-flow model: https://pubs.er.usgs.gov/publication/sir20205091
25	Suffolk County 2020 Drinking Water Quality Report	Report	Suffolk County Water Authority		Jan-20	✓	✓	✓		✓			✓	✓				The 2020 Drinking Water Quality Report contains detailed information about the water quality of public water supply wells in the County. The report also tabulates new wells placed in and old wells taken out of service in 2019.
26	Western Nassau County 2019 Annual Water Quality Report	Report	Water Authority of Western Nassau County		Jan-20	✓	✓			✓			✓	✓		✓		The WAWN Annual Water Quality Report educates customers on drinking water source, treatment, and safety and provides data on local drinking water quality.
27	Simulation of Groundwater Flow in the Regional Aquifer System on Long Island, New York, for Pumping and Recharge Conditions in 2005–15	Report	U.S. Geological Survey	National Water Quality Program New York State Department of Environmental Conservation US Department of the Interior	Dec-20	✓		✓	✓			✓	✓					This USGS report documents the development and calibration of a numerical model of the Long Island aquifer system and the use of that model to simulate hydrologic conditions for the years 2005–2015.
28	Aquifer Transmissivity in Nassau, Queens, and Kings Counties, New York, Estimated From Specific-Capacity Tests at Production Wells	Report	U.S. Geological Survey	New York State Department of Environmental Conservation US Department of the Interior	Oct-20			✓	✓				✓	✓				This USGS report estimates the transmissivities of four aquifers from specific-capacity tests at 447 production wells in Nassau, Queens, and Kings Counties in order to evaluate the sustainability of Long Island's sole-source aquifer system.
29	Use of Time Domain Electromagnetic Soundings and Borehole Electromagnetic Induction Logs To Delineate the Freshwater/Saltwater Interface on Southwestern Long Island, New York, 2015–17	Report	U.S. Geological Survey	New York State Department of Environmental Conservation US Department of the Interior	Sep-20		✓	✓		✓			✓					This study documents extensive saltwater intrusion of the Lloyd, Upper Glacial, Jameco, and Magothy aquifers. Several public-supply wells in the southern parts of Nassau, Queens, and Kings Counties have been adversely affected by saltwater intrusion causing supply wells to be shutdown and abandoned. Due to the ongoing groundwater pumping in southern Nassau County, the freshwater/saltwater interface requires delineation and monitoring for any inland movement.

Prior Related Investigations					Categories														
Document No.	Document Name and Link	Document Type	Issuing Agency/Entity	Cooperating Agencies/Entities	Release Date	Water Budget	Groundwater Quality	Groundwater Quantity	Groundwater Recharge	Groundwater Pollution	Surface Water Quality	Surface Water Quantity	Water Demand	Well Supply Reliability	Water Supply from NYC	Alternative Means of Water Supply	Governmental Programming	Additional Notes
30	Water-Table and Potentiometric-Surface Altitudes in the Upper Glacial, Magothy, and Lloyd Aquifers of Long Island, New York, April-May 2016	Report	U.S. Geological Survey	New York State Department of Environmental Conservation US Department of the Interior Manhasset-Lakeville Water District Nassau County Department of Public Works New York State Department of Environmental Conservation Port Washington Water District Sands Point Water Department Suffolk County Department of Health Services Suffolk County Water Authority Town of North Hempstead Town of Shelter Island Water Authority of Great Neck North	Jun-21			✓	✓				✓	✓					These data and the maps constructed from them are commonly used in studies of the hydrology of Long Island and are used by water managers and suppliers for aquifer management and planning purposes.
31	Master Water Plan	Report	Nassau County	Holzmacher, McLendon, and Murrell, P.C/H2M Corp.	Sep-80	✓	✓	✓		✓	✓	✓	✓		✓	✓		The purpose of the Nassau County Master Water Plan Study and Report is to reassess the potable water resources and consumptive demands within the County and to develop a recommended plan for implementation. The plan considers local and County—wide needs and includes both structural and non—structural recommendations to achieve adequate water resources to the year 2020. The scope included updating climatological, population, and water use data and projecting the water needs to the year 2020. An update of the water budget and estimate of permissive yield showed a deficiency, but lower than previous estimates. A plan of implementation which includes resource conservation, staged transfer of water from surplus to deficient areas in the county and continued study and research for the future are all part of the Water Plan.
32	Lynbrook 2020 Annual Water Quality Report	Report	New York American Water		Apr-21		✓			✓			✓					This Annual Water Quality Report is a public facing document for the New York American Water Lynbrook Operations District. It includes an overview of treatment processes, planned capital improvements for 2021, and water quality testing data. Detected Contaminants data was extracted and analyzed in the Feasibility Study.
33	Western Authority of Western Nassau County 2020 Annual Water Quality Report	Report	Western Authority of Western Nassau County		Apr-21		✓			✓			✓					This Annual Water Quality Report is a public facing document for the Water Authority of Western Nassau County. It includes an overview of treatment processes, planned capital improvements for 2021, and water quality testing data. Detected Contaminants data were utilized by Ramboll in the Feasibility Study.
34	Manhasset-Lakeville Water District 2019 Annual Water Quality Report	Report	Manhasset-Lakeville Water District		Apr-21		✓			✓			✓					This Annual Water Quality Report is a public facing document for the Manhasset-Lakeville Water District. It includes an overview of treatment processes, completed capital improvements in 2019, water quality testing data, and an announcement of two new dioxane treatment plant installations underway. Detected Contaminants data were utilized by Ramboll in the Feasibility Study.

Prior Related Investigations					Categories														
Document No.	Document Name and Link	Document Type	Issuing Agency/Entity	Cooperating Agencies/Entities	Release Date	Water Budget	Groundwater Quality	Groundwater Quantity	Groundwater Recharge	Groundwater Pollution	Surface Water Quality	Surface Water Quantity	Water Demand	Well Supply Reliability	Water Supply from NYC	Alternative Means of Water Supply	Governmental Programming	Additional Notes
35	Water Authority of Great Neck North 2020 Annual Water Quality Report	Report	Water Authority of Great Neck North		Apr-21		✓		✓			✓						This Annual Water Quality Report is a public facing document for the Water Authority of Great Neck North. It includes an overview of treatment processes, completed capital improvements in 2019, water quality testing data, and an announcement of two new dioxane treatment plant installations underway. Detected Contaminants data were utilized by Ramboll in the Feasibility Study.
36	Town of Hempstead 2020 Annual Water Quality Report	Report	Town of Hempstead Water Department		Apr-21		✓		✓			✓						This Drinking Water Quality Report is a consumer confidence report for the Village of Hempstead. It includes an overview of treatment processes, planned capital improvements for 2020, and water quality testing data. Detected Contaminants data were utilized by Ramboll in the Feasibility Study.
37	Jericho Water District 2020 Annual Water Quality Report	Report	Jericho Water District		Apr-21		✓		✓			✓						This Annual Water Quality Report is a public facing document by the Jericho Water District. It includes an overview of treatment processes, planned capital improvements for 2021, and water quality testing data. Detected Contaminants data were utilized by Ramboll in the Feasibility Study.
38	Village of Farmingdale 2019 Annual Water Quality Report	Report	Village of Farmingdale		Apr-21		✓		✓			✓						This Annual Water Quality Report is a public facing document by the Village of Farmingdale Water Department. It includes an overview of treatment processes, planned capital improvements for 2021, and water quality testing data. Detected Contaminants data were utilized by Ramboll in the Feasibility Study.
39	New York City Drinking Water Supply and Quality Report 2019	Report	New York City Department of Environmental Protection		Apr-20	✓				✓	✓				✓		✓	The annual New York City Drinking Water Supply and Quality Report describes the sources and quality of NYC water supply. It is prepared in accordance with the New York State Sanitary Code and the National Primary Drinking Water Regulations. Detected Contaminants data were utilized by Ramboll in the Feasibility Study.
40	New York City Drinking Water Supply and Quality Report 2020	Report	New York City Department of Environmental Protection		Apr-21	✓				✓	✓				✓		✓	The annual New York City Drinking Water Supply and Quality Report describes the sources and quality of NYC water supply. It is prepared in accordance with the New York State Sanitary Code and the National Primary Drinking Water Regulations. Detected Contaminants data were utilized by Ramboll in the Feasibility Study.
41	Queens Disinfection Byproduct Data from January 2019 – March 2021	Water Quality Database	New York State Department of Health	New York City Department of Environmental Protection	Mar-21		✓		✓									Disinfection Byproduct data for sampling sites in Queens from January 2019 – March 2021. Sites are sampled by NYCDEP quarterly for HAA5, TTHM, and VOCs.
42	Nassau Co. Water Districts Annual Withdrawal Reports	Water Quality Database	New York State Department of Environmental Conservation	All public water systems in Nassau County	2021			✓										Database providing the self report well withdrawal rates for all water districts within Nassau County. Compiled by DEC.
43	Nassau County Raw Water Well Sampling Data	Water Quality Database	Nassau County Dept. of Health	All public water systems in Nassau County	2021		✓		✓									Included raw water sampling data for permitted wells in Nassau County. Well information provided was from 2016 to 2021 and included information for over 300 wells and 270 different analytes.
44	Digital Elevation Models for Nassau County	Elevation Data	Cornell University Geospatial Information Repository	Cornell University	1995													Digital Elevation Models (DEM) provide publicly accessible ground surface elevation data for Nassau County utilizing Lidar data.

Appendix B

Feasibility Study Scope, Communications and Engagement

Introduction

This appendix describes the scope of the Feasibility Study, the approaches used for communication and the engagement of stakeholders and interested parties.

Scope of Feasibility Study

The Feasibility Study scope of services included the following tasks:

Task 1: Document Review/Research
The collection and review of available reports, mapping and data that are relevant to the project, including but not limited to the following types of information:

a | Reports New York State Agencies, the County, and Independent Commissions dating back to the 1960's, and more recently by USGS and the Long Island Commission for Aquifer Protection (LICAP) that addressed the water resources issues in Nassau County and southeastern New York.

b | Mapping, including GIS mapping and where available, water system mapping

c | Water quantity and water quality data

Task 2: Stakeholder Outreach and Meetings
Communications and meetings with key stakeholders (*e.g.*, NYC, NYSDEC, NYSDOH, Nassau County, USGS, public water systems in Nassau County, and elected officials). The scope of this task included:

- A communications plan
- A Project Team/Advisory Group
- A survey of public water systems to collect information and solicit opinions on the use of NYC water in Nassau County
- Stakeholder workshops

Task 3: Engineering
Engineering evaluations to develop the type and scale of water system infrastructure needed to convey finished water from NYC to the water utilities in Nassau County.

Task 4: Financial
Review of financing alternatives including options for debt financing, potential grants/debt forgiveness and low interest loans.

Task 5: Organizational Alternatives
Identified alternative organizational approaches for ownership and management of the proposed infrastructure assets needed to convey finished water from NYC to Nassau County. Ownership alternatives were linked with ability to access debt financing.

Task 6: Report
Preparation of a high-level summary report with appendices for supporting information.

Schedule

The project schedule required Ramboll to complete the draft report in approximately 12 months. The project was kicked off in January 2021, and a complete draft report was delivered in January 2022.

Project Communication

The Feasibility Study was conducted using effective methods to:

- Collect relevant information as needed for conducting the feasibility study
- Engage stakeholders and other interested parties to gather input in developing alternative solutions
- Convey information regarding the status and findings of the feasibility study to stakeholders, interested parties, government officials and the public

The approach for external communications involved the following:

- Identifying and engaging stakeholders, interested parties and government officials
- Preparing information requests to secure information from stakeholders and other parties
- Conducting a survey of Nassau County public water systems
- Conducting technical work sessions (2)
- Preparing a Feasibility Study Report

At the time that this study was completed, New York State had implemented controls on gatherings and workplaces due to the COVID-19 pandemic. As a result, all meetings and work sessions were conducted virtually using "online" meeting technologies such as Microsoft Teams. The communications progressed as the project developed, to include the following groups as depicted, and as described below.

Technical Stakeholder Meetings

The Feasibility Study involved meetings and exchanges of information with several technical stakeholders, including (but not limited to) New York City Department of Environmental Protection (NYCDEP), Nassau County Department of Health (NCDOH) and the United States Geological Service.

Surveys and Workshops

a | **Water Systems Survey** – An online survey of the Nassau County public water systems was conducted in June-July 2021 and the results were discussed in the first stakeholder workshop in July 2021. The survey was used to collect technical information about water use and water system infrastructure and provided an opportunity for the water systems to provide input on their interest in water from NYC, as well as any related concerns. Approximately 60% of the Nassau County water systems participated in the survey.

b | **Technical Workshop No. 1, July 14, 2021,** focused on engagement with the public water systems in Nassau County. Ramboll facilitated the workshop, which provided project background, results of the water system survey, findings to date including input from NYCDEP, NCDOH and USGS, water quality investigations and provided opportunities for questions and comments from the participants. The water systems were invited to participate in one-on-one meetings with Ramboll for more detailed discussions, and several water systems participated in additional discussions.

c | **Technical Workshop No. 2, November 3, 2021,** provided an engagement opportunity for stakeholders and interested parties. Ramboll facilitated the workshop, which provided project background, findings to date including the status of engineering studies, financial and organizational reviews. The workshop provided opportunities for questions and comments from the participants.

Feasibility Study Report

The Report consists of an executive summary and several appendices which contain supporting details and references.

Appendix C

Water Quality Review

Introduction

The New York State Department of Health, in cooperation with the New York State Department of Environmental Conservation, has engaged Ramboll to evaluate the feasibility of utilizing New York City's public water to supply Nassau County, New York ("Feasibility Study"). These services are being provided using an environmental engineering contract between Ramboll and the New York State Office of General Services.

As one of several aspects of the Feasibility Study, Ramboll performed a high-level review of perceived benefits and potential concerns related to the drinking water quality that would be supplied by New York City to Nassau County. Other aspects of the Feasibility Study involve financial and organizational approaches, the quantity of water needed in Nassau County and the quantity available from New York City, and engineering concepts for supplying the water and costs. The primary objective of this Appendix is to identify potential water quality concerns and issues that could by themselves discourage further consideration of supplying New York City water to Nassau County.

Abbreviations

The following abbreviations are used in this appendix:

Abbreviations	
Avg	Average
DBP	Disinfection by-product
Fl	Fluoride
HAA5	Haloacetic acids (group of 5 regulated compounds)
LCR	Lead and Copper Rule
LCRI	Lead and Copper Rule improvements
LCRR	Lead and Copper Rule revisions
LRAA	Locational running annual average
LSL	Lead service line
MCL	Maximum contaminant level
mg/L	Milligrams per liter
ND	Not detected
NOM	Natural organic matter
NYC	New York City
NYCDEP	New York City Department of Environmental protection
NYSDEC	New York State Department of Environmental Conservation
NYSDOH	New York State Department of Health
NYSOGS	New York State Office of General Services
PFOA	Perfluorooctanoic acid
PFOS	Perfluorooctanesulfonic acid
TOC	Total organic carbon
TTHM	Total trihalomethanes
VOC	Volatile organic chemical
SDWA	Safe Drinking Water Act
SU	Standard unit
ug/L	Micrograms per liter
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey

Background

Nassau County's drinking water is sourced from aquifers (groundwater), via approximately 46 public water suppliers who have a total of approximately 500 wells (https://www.nassau-countyny.gov/2970/Public-Water-Supply) that are permitted for public water supply. The wells draw water from three major aquifers: the upper glacial aquifers, the Jameco-Magothy, and the Lloyd (Ref. #27, Appendix A). Figure C1 below shows the aquifer system on Long Island.

There are wells within Nassau County that are contaminated with nitrates, VOCs, PFOA, PFOS and/or 1,4 Dioxane at concentrations above the maximum contaminant levels (MCLs) established by the USEPA or NYSDOH. As a result, some water systems in Nassau County are required to install and operate treatment systems to reduce the concentrations of these contaminants to below their MCLs.

New York City's water supply system consists of two primary surface water supplies known as the Catskill/Delaware and Croton supplies. The City also has a permitted groundwater system in Southeast Queens, although water from that system has not been delivered to customers since 2007. In 2020, approximately 96% of the water supplied by NYC to its customers was from the Catskill/Delaware system, and 4% was from Croton; all the water used in Queens was from the Catskill/Delaware system. As such, the water quality data in this Appendix represents water from the Catskill/Delaware system, since that water would be the water primarily supplied from NYC via Queens to Nassau County. The synthetic chemical contaminants noted above that have been detected in Nassau County's groundwater supplies (VOCs, PFOA, PFOS, 1,4 Dioxane) are below detection levels in NYC's Catskill/Delaware surface water supplies, and nitrates are well below the MCL in samples collected from NYC's surface water supplies.

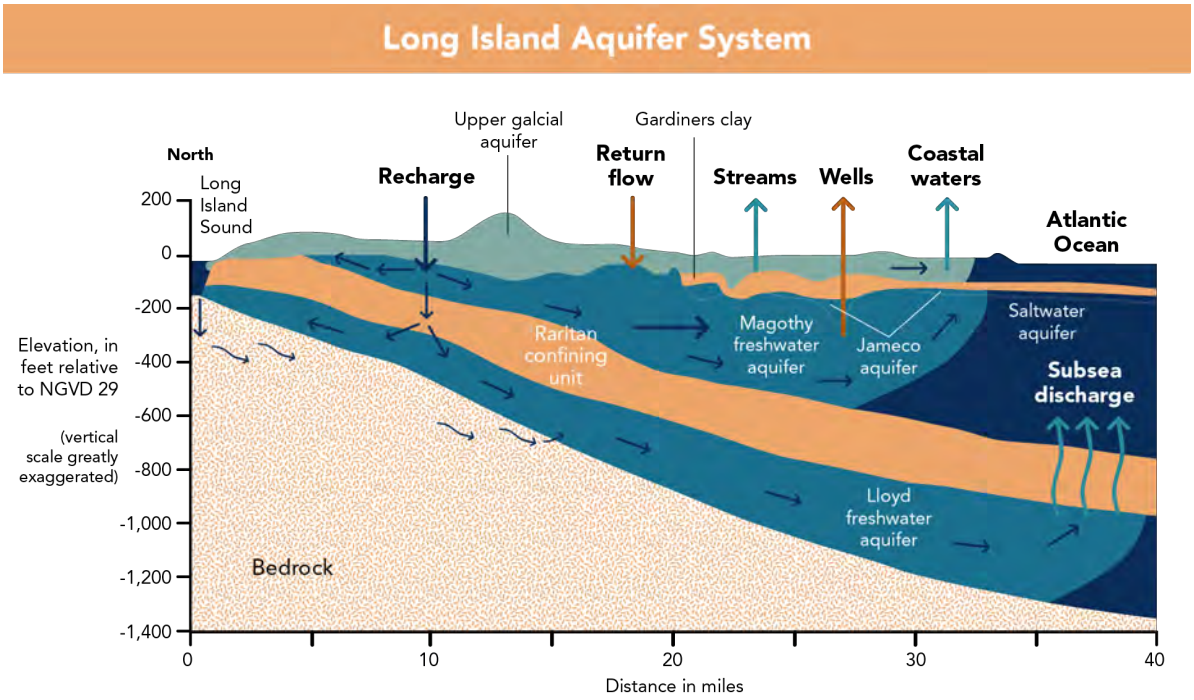


Figure C1. Long Island Aquifer System

Source: adapted from USGS Long Island Sole-source aquifer system - https://www.usgs.gov/media/images/long-island-sole-source-aquifer-system

To provide comparison between the systems, Ramboll reviewed recent Annual Water Quality Reports posted on the website of New York City and from a representative group of seven Nassau County water systems. Four of the seven water systems are located along the Queens-Nassau County border. These Four Nassau County water systems (Water System A, B, C, and D) represent a potential Phase 1 for supplying NYC water to Nassau County due to existing interconnections with NYC's distribution system.

The remaining three Nassau County water systems are in central and eastern Nassau County (Water System E, F, and G). These water systems were included to assess finished water quality variations between the western, central and eastern part of the County.

In accordance with the federal Safe Drinking Water Act and NYSDOH Sanitary Code requirements, public water systems analyze for over 90 water quality constituents and contaminants. A limited number of water quality constituents and contaminants are presented in the Table C1, those being parameters particularly relevant to compare NYC's water quality with the water quality in the seven representative Nassau County systems. Note that the parameters on the right-hand side of the table are related to corrosion control.

		Water Quality Parameter											
Water System		TOC	TTHMs	HAA-5	FI	Chlorine residual	Lead[1]	Copper	Alkalinity	Total Hardness	pH	Chloride	Corrosion Control Treatment
	Units	mg/L	ug/L	ug/L	mg/L	mg/L	ug/L	mg/L	mg/L	mg/L	SU	mg/L	
	MCL	TT	80, LRAA	60, LRAA	4	4	AL=15	AL=1.3	NA	NA	NA	250	
Water System A		ND-0.4	7.40	ND	ND	avg. 0.88	3.2	0.21	53-77	7 to 52	7.2-8.5, avg 7.68	10 to 35	Sodium hydroxide, lime, sodium silicate
Water System B			ND-9	ND	ND	0.27 to 1.47	1.3	0.11	ND-90	8-120	5.3-8.4	3 to 87	Sodium hydroxide, zinc orthophosphate
Water System C			ND-1	ND	ND		5.3	0.12	11 to 90	10-183	7.5-8.1	3-107	Sodium hydroxide
Water System D		0.94-3.26	0-7.6	ND	ND-0.11		3.8	0.18	48-84	73-170	6.4-8.0	6.2 to 108	Sodium hydroxide, polyphosphate
Water System E			ND to 6.7	ND	ND	0.09 to 1.25	1.3	0.08	4 to 63	15 to 59	7 to 8.8	8 to 60	Lime, polyphosphate
Water System F			ND to 9	ND	ND		ND	0.19	26-69	7 to 25	7.1-8.05	5.2-11.5	Sodium hydroxide
Water System G			ND	ND	ND		1.7	0.66	ND-42	4 to 24		4 to 32	Sodium hydroxide
New York City Water Supply 2019		1.3 to 2.6, avg. 1.6	11 to 79, LRAA 50	19-60, LRAA 51	0.7	avg. 0.6	10	0.19	13-70, avg. 22	16 to 102, avg. 25	avg. 7.4	10 to 91, avg. 19	Sodium hydroxide, orthophosphate
New York City Water Supply 2020		0.7-3.0, avg. 1.6	7-75, LRAA 51	4-72, LRAA 51	0.7	avg. 0.6	11	0.2	14-76, avg. 20	16-106, avg. 24	avg. 7.4	11 to 75, avg. 17	Sodium hydroxide, orthophosphate

Corrosion control related

Source: All water quality data and corrosion control treatment information are from the water systems' Annual Water Quality Reports.
1 - Data presented here as "Lead" represents samples taken from household tap. While not required by SDWA, NYCDEP also monitors lead concentrations in the distribution system, where the "90th percentile" was non-detect in 2019 and 2020. In 2020, out of 300 samples, lead was only detected in one distribution system sample (site 11750) at 2 ug/L. In 2019, out of 600 samples, lead was only detected in one sample (site 17250) at 28 ug/L.

Table C1. Water Quality Data Summary Table

Water Quality Observations

The following sections provide high-level observations with a focus on comparing New York City's water quality to the water quality in the various Nassau County water systems.

Nassau County Water Quality

Finished water quality in the seven representative Nassau County water systems can be summarized as follows:

Consistency – the finished water quality in the four water systems along the Queens/Nassau County border is similar to that in the three water systems selected to represent the central and eastern parts of Nassau County. This is not surprising given that all the wells draw water from the same group of aquifers and should generally be expected to have similar water quality. The similarity in finished water quality would generally simplify any future evaluations in blending with NYC water.

Alkalinity and hardness are both at low to moderate levels in the finished water in Nassau County.

Lead and copper levels at the household tap are well within the regulatory Action Levels for the Lead and Copper Rule.

In comparison with the SDWA Action Levels:

- For lead, which has an Action Level of 15 ug/L at the "90th percentile", the Nassau County Water systems reported 90th percentiles of 1.3 to 5.3 ug/L.
- For copper, which has an Action Level of 1.3 mg/L at the "90th percentile", the Nassau County Water systems reported 90th percentiles of 0.08 to 0.66 mg/L.

The water systems use a variety of techniques for controlling corrosion of lead and copper. Chlorides can also be used as an indicator of potential corrosion. All seven of the representative Nassau County water systems add chemicals to increase pH and alkalinity as part of their strategy to control corrosion of lead and copper.

- Six of the seven water systems feed sodium hydroxide (a/k/a caustic soda), which increases pH and alkalinity.
- Two water systems feed lime which increases pH, alkalinity and hardness.
- One water system feeds sodium silicate which increases pH and is intended to enhance corrosion control.
- Three of the seven Nassau County water systems also add a phosphate-based product for corrosion control and/or as a sequestering agent to reduce the discoloration of the finished water.

Disinfection by-product levels (DBPs) are formed when natural organic matter (NOM) common in most surface waters and some groundwaters react with free chlorine. While the Annual Water Quality Reports for the water systems have limited data on the natural organic levels in Nassau County's groundwater, comparative data from representative wells suggest the water has relatively low levels of natural organic matter. The low levels of DBPs reported in the Nassau County water systems seem to confirm this assertion. DBPs include Total Trihalomethanes (TTHMs) and a group of five Haloacetic Acids (HAA5s). TTHM and HAA5 concentrations are regulated by the maximum Locational Running Annual Average (LRAA) of the water system's sampling sites.

- For **TTHMs**, the LRAAs in 2019-2020 ranged from non-detect (ND) to 10 ug/L, well under the LRAA maximum contaminant limit (MCL) of 80 ug/L.
- For **HAA5s**, the LRAAs in 2019-2020 were reported as non-detect in all seven water systems; the MCL is 60 ug/L.

Fluoride, which can be present naturally, is below detection limits or present at very low levels. Note that fluoridation of potable water is locally determined, and currently none of the seven Nassau County water systems fluoridate their water.

All seven representative Nassau County water systems reported one or more of the following regulated contaminants in their groundwater supplies. Their Annual Water Quality Reports describe current or planned treatment:

- **Nitrates**, which some water systems remove or are planning to remove using ion exchange while others address by blending with low nitrate waters.
- **VOC's**, which some water systems remove by air stripping or by treating with granular activated carbon (GAC).
- **PFOA and PFOS**, which some water systems remove or are planning to remove using GAC contactors.
- **1,4 Dioxane**, which some water systems remove or are planning to remove using advanced oxidation processes (AOP) such as ultraviolet (UV) light with peroxide or ozone.

Saltwater intrusion continues to be a concern, particularly along the northern and southern coastal areas of Nassau County. Numerous wells have been taken off-line in these coastal areas to avoid excessive levels of chlorides in the drinking water. Figure C2 is from a 2020 USGS report (Ref. #27, Appendix A) and it shows the extent of chloride concentrations exceeding 5,000 mg/L. The extent of chlorides exceeding the drinking water MCL of 250 mg/L is much greater, but wells with chlorides approaching the MCL have been taken off-line.

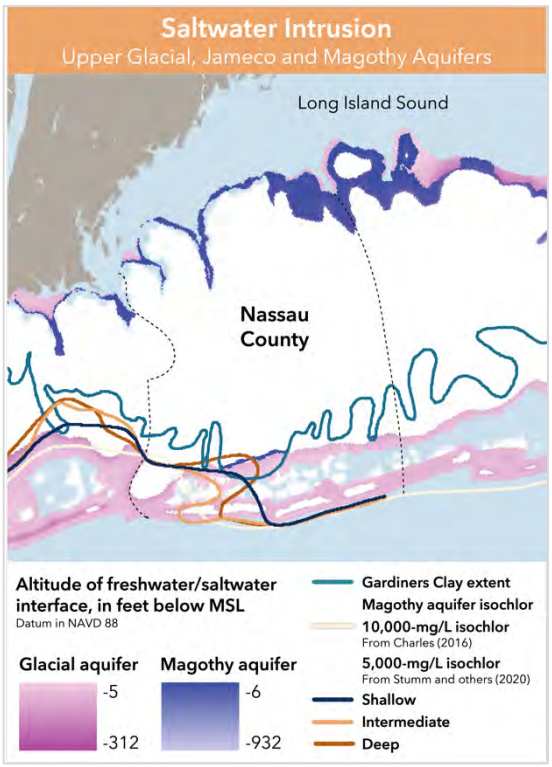


Figure C2. Saltwater Intrusion

Source: adapted from USGS, Simulation of Groundwater Flow in the Regional Aquifer System on Long Island, New York, for Pumping and Recharge Conditions in 2005-15, https://pubs.usgs.gov/sir/2020/5091/sir20205091.pdf

New York City Water Quality

By comparison, the **alkalinity, hardness, pH and chloride** concentrations in New York City's finished water are relatively similar to those in finished waters of the seven Nassau County water systems. The primary differences between New York City water quality and water quality in the seven Nassau County water systems are:

Disinfection By-products

As noted earlier, groundwater sources similar to Nassau County's typically contain lower levels of natural organics compared to most surface water sources, and hence lower levels of DBPs. DBPs in NYC water are generally within the MCLs as further detailed below but are significantly higher than in the seven Nassau County water systems. NYC's DBP results for 2021 became available as this water quality review was being finalized and are included here; 2021 data was not yet available for the Nassau County water systems.

- In 2019 and 2020, NYC's **TTHMs** ranged from 7-79 ug/L with reported highest LRAAs of 50 ug/L and 51 ug/L in 2019 and 2020, respectively, which are under the LRAA

maximum contaminant level (MCL) of 80 ug/L. In 2021, NYC's **TTHMs** ranged from 6-75 ug/L with reported highest LRAA of 54 ug/L, which is under the LRAA maximum contaminant level (MCL) of 80 ug/L. In comparison, the Nassau County systems reported LRAAs of non-detect to 10 ug/L.

- NYC's **HAA5s** ranged from 4-72 ug/L with a reported highest LRAA of 51 ug/L in both 2019 and 2020; the LRAA MCL is 60 ug/L. In 2021, HAA5s ranged from 6-93 ug/L with a reported highest LRAA of 65 ug/L, exceeding the MCL. The MCL exceedances were in Staten Island and Brooklyn. NYCDEP issued a public notification and reported their remedial action plans to reduce HAA5s to below the MCL. In comparison, HAA5s were not detected in the Nassau County water systems.

Fluoride
NYC adds approximately 0.7 mg/L fluoride to its finished water for dental protection. As previously noted, the Nassau County water systems do not add fluoride, and natural fluoride levels are typically near or below detection limits.

Lead and Copper
Lead and copper levels at the household tap are within the regulatory Action Level for the Lead and Copper Rule (LCR). (LCR Revisions are discussed later in this review.)

In comparison with the SDWA Action Levels:

- For copper, which has an Action Level of 1.3 mg/L at the "90th percentile", NYCDEP reported 90th percentiles of 0.19 and 0.2 mg/L for 2019 and 2020 respectively, which is similar to copper concentrations reported by the Nassau County water systems.

- For lead, which has an Action Level of 15 ug/L at the "90th percentile", NYCDEP reported 90th percentiles of 10 and 11 ug/L for 2019 and 2020 respectively.
    - In comparison, the Nassau County water systems reported significantly lower 90th percentiles of 1.3 ug/L to 5.3 ug/L.

This difference merits a closer look:

- pH and alkalinity, which are two of several factors affecting corrosivity, are similar in NYC and Nassau County.

- Above data presented as "Lead" represent samples taken from household taps. While not required by SDWA, NYCDEP also monitors lead concentrations in their distribution system, where the "90th percentile" was non-detect in 2019 and 2020. In 2020, out of 300 samples, lead was only detected in one distribution system sample, at 2 ug/L. In 2019, out of 600 samples, lead was only detected in one sample at 28 ug/L.

- NYC raises the pH (using sodium hydroxide) similar to Nassau County water systems.

- NYC also adds orthophosphates for corrosion control; several of the Nassau County water systems also take this additional step.

- NYCDEP's sample pool for lead sampling is composed primarily by residences with lead service lines (LSLs):
    - In 2019, sample pool (n=511) was 57% LSLs.
    - In 2020, sample pool (n=476) was 59% LSLs.

- Since lead levels are essentially non-detect in the distribution system and considering that finished water quality and corrosion control techniques appear similar, it may be that the higher lead level in NYC results primarily from a greater presence of lead service lines in the sample pool and higher lead content in household plumbing fixtures in NYC's older housing stock.

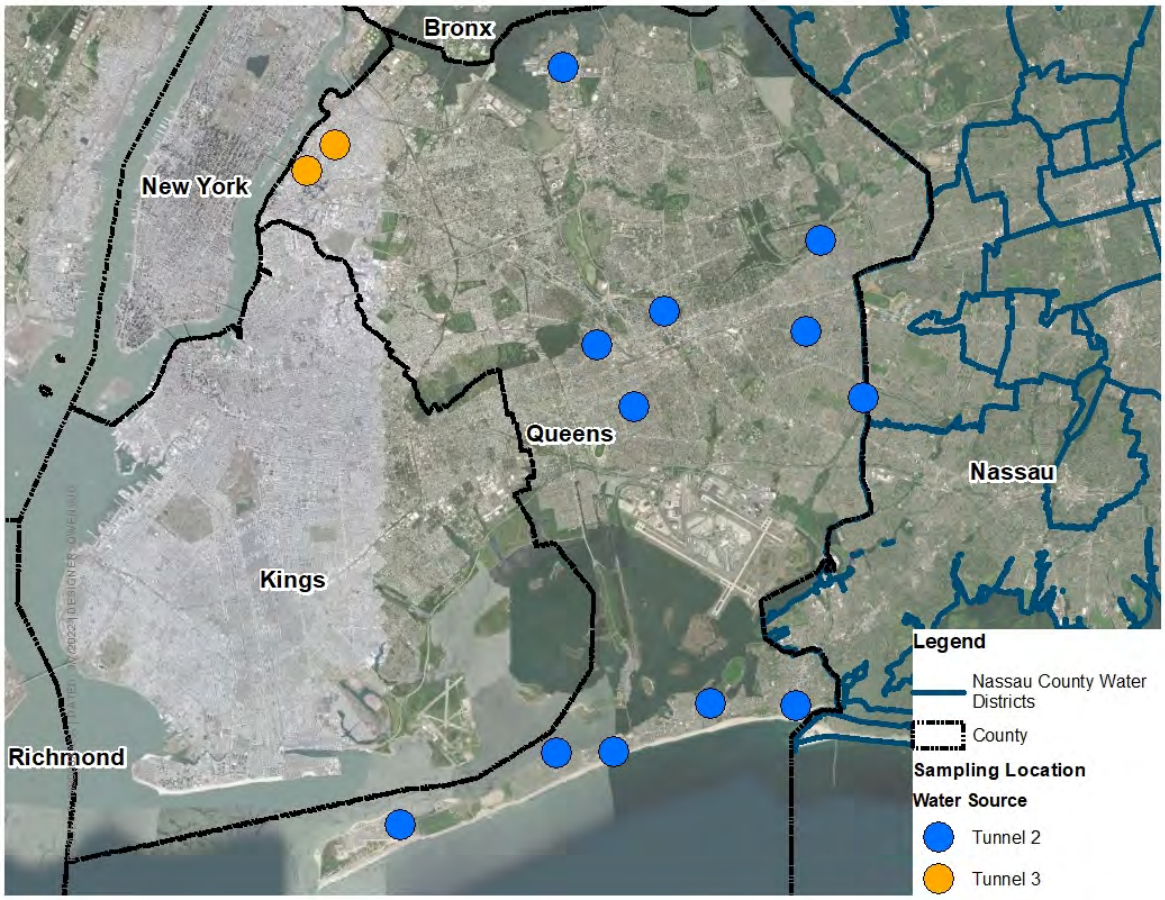


Figure C3. Sampling location water source

On December 16, 2021, in a Federal Register notice, USEPA announced that the Lead and Copper Rule Revisions (LCRR) will go into effect and that it plans to finalize Lead and Copper Rule Improvements (LCRI) by December 16, 2024, to strengthen key elements of the rule. As currently written, the LCRR adds a "trigger level" of 10 ug/L to the existing Action Level and includes other changes that may cause NYC to adjust its approach to compliance with the LCRR.

Review of NYC DBP Sampling Data

Given that introduction of NYC water into Nassau County could result in higher water age and hence higher DBP levels, a better understanding of current DBP levels in the NYC system is warranted. Therefore, in addition to the review of Annual Water Quality Reports, Ramboll reviewed the last three years of DBP sampling data (2019-2021) furnished by the NYSDOH, for the sampling sites in Queens, given that Queens would be the take point for any supply into Nassau County. The data was entered into a GIS platform, so the results can be viewed from a locational perspective. The figures below show the TTHM and HAA5 data respectively for 2019-2021.

Figure C3 shows the sampling locations by their source: T2 (Tunnel 2), T3 (Tunnel 3) and T2/GW, which indicates the source could be either Tunnel 2 or the groundwater supply which is now inactive. All the finished water distributed in Queens is from the Catskill/Delaware supply, and nearly all enters Queens via Tunnel 2.

This Feasibility Study offers the following observations from its review of the DBP sampling data in Queens:

TTHMs (Figure C4)

- The 2019 - 2021 TTHM concentrations at the sampling sites in Queens are generally consistent, with LRAA concentrations in these three years reported at 31-43 ug/L at sampling sites along the Queens-Nassau County border.
- The TTHM concentrations along the Queens-Nassau County border are lower than those on the Rockaway Peninsula, which reports concentrations of 46-53 ug/L.
    - The TTHM concentrations at the end of The Rockaways are similar to NYC's maximum LRAAs of 50 ug/L and 51 ug/L in 2019 and 2020 respectively, as reported in NYC's Annual Water Quality Reports.
    - The sample site at the end of the Rockaways which appears to be near the terminus of a long pipeline on the Rockaway Peninsula is suspected as having higher water age than sample sites along the Queens-Nassau County border. This apparent correlation of water age and TTHM concentration would be consistent with typical TTHM formation kinetics.

See the next section for further discussion on the implications of the TTHM data review.

HAAs (Figure C5)

- The 2019 and 2020 HAA5 data at the sampling sites in Queens are generally consistent, with LRAA concentrations in both years reported at approximately 25-45 ug/L at sampling sites near the Queens-Nassau County border. In 2021, several of those sites experienced higher HAA5s, up to a maximum of 58 ug/L LRAA.
- The HAA5 concentrations along the Queens-Nassau County border are generally similar to or higher than those in Rockaway Park, which reports concentrations of 30-33 ug/L in 2019-2021.

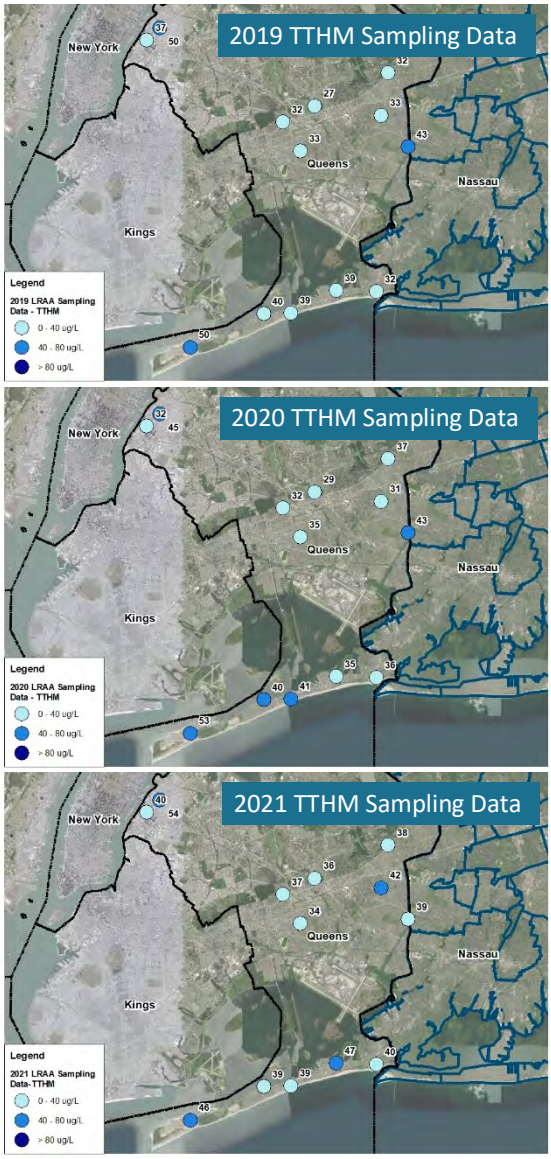


Figure C4. 2019, 2020 and 2021 TTHM Sampling Data in Queens

    - A sample site, which appears to be near the terminus of a long pipeline on the Rockaway Peninsula, is suspected as having higher water age than sample sites along the Queens-Nassau County border. Similar to TTHMs, when chlorine and natural organic matter are present, HAAs will continue to form as the water ages. But if there are lower chlorine residuals, biofilms and biological activity

may degrade HAAs faster than they form, resulting in a net decline in HAA concentration with age. As a result, depending on chlorine residual and biological activity in the distribution system, HAA5 levels could stay constant or increase with time. NYCDEP should be engaged to better understand water age and DBP formation kinetics for HAAs and TTHMs prior to making a prediction as to DBP concentrations in Nassau County. Detailed investigations would also be required to support definitive predictions of the influence of water age on DBP formation.

See the next section for further discussion on the implications of the HAA5 data review.

Review of water quality benefits and potential concerns related to the quality of drinking water supplied by New York City to Nassau County

A summary of the key findings follows below.

Water Quality Benefits

The primary water quality benefit of NYC Water is the relative absence of nitrates, VOCs, PFOA, PFOS and 1,4 Dioxane in NYC water.

In Nassau County, these regulated contaminants are widespread and require wellhead treatment throughout the County.

- NYC water could help protect Nassau County against the risk that currently unknown or undetected contaminants will be discovered in Nassau County's groundwater supplies.

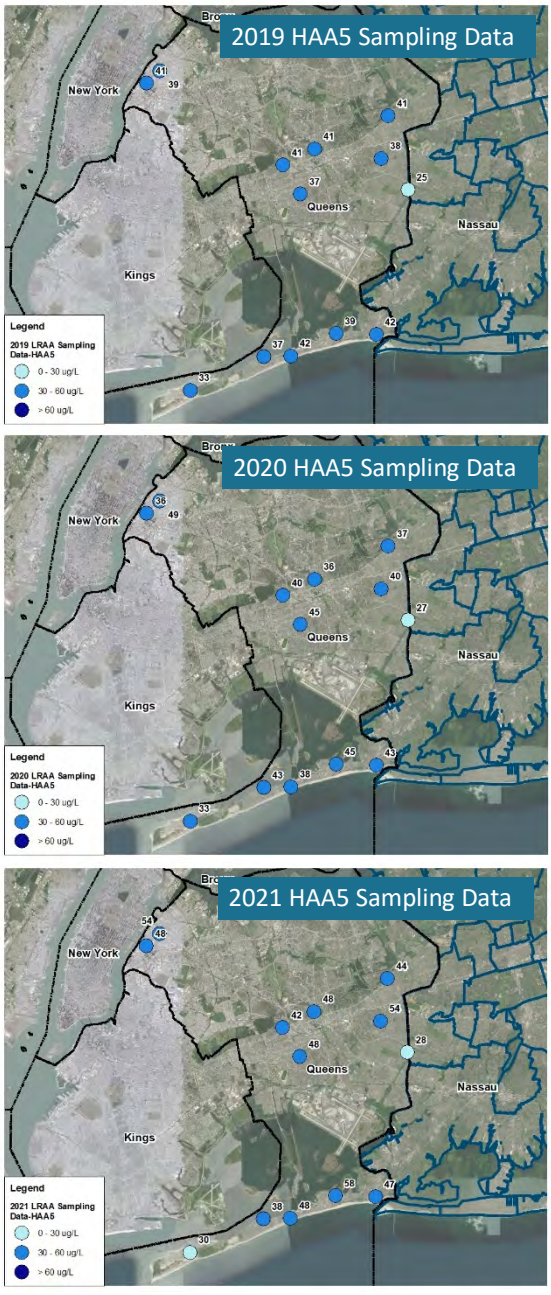


Figure C5. 2019, 2020 and 2021 HAA Sampling Data in Queens

- The list of contaminants for which the water systems must test is growing.
- As laboratory detection limits improve, lower concentrations of contaminants will be discoverable.

- NYC water could help reduce the risk that changes in the drinking water regulations, either at the state or federal level, would require Nassau County to make investments into groundwater treatment beyond that which is currently installed or planned.
    - The Nassau County water systems could be required to construct more treatment systems using more advanced and costly technologies, to meet more stringent regulations.

Potential Water Quality Concerns

While NYC's relatively pristine source water presents advantages, there nonetheless are some concerns which are discussed further here:

Disinfection By-products
Since NYC's water has higher TTHMs and HAA5s than the Nassau County waters, introducing NYC water into the County would increase the concentrations of TTHMs and HAAs in Nassau County. The relative increase would depend in part on the blend of NYC and Nassau County finished waters.

- **TTHMs** are well documented to increase with water age. However, based on the high-level review conducted for this Appendix, TTHMs at the Queens-Nassau border appear to be well within the MCL. As NYC water ages, TTHMs could increase, however it is likely that blending and other mitigating measures could allow for effective management of TTHMs in Nassau County.
    - ***While additional investigations are needed for a definitive prediction, the data available for this Water Quality Review do not indicate that TTHMs represent a potential water quality concern that should by itself prevent further consideration of supplying New York City water to Nassau County.***
    - Bench testing and development of an integrated NYC-Nassau County hydraulic and water quality model would provide a more refined prediction for TTHM concentrations across Nassau County.
- As noted earlier in Appendix C, HAA5 concentrations in Queens approached the LRAA MCL, especially in 2021. NYCDEP reported their remedial action plans to reduce HAA5s.
- As also noted earlier in Appendix C, HAA5s can continue to form as the water ages. But there are also many instances where relatively low chlorine residuals in the presence of biofilms/biological activity may degrade HAAs faster than they form, resulting in a net decline in HAA concentration with age. That may be the reason the water at the sample site at the end of the Rockaways and at the Nassau County border contains HAA5 concentrations that are lower than at most of the other sample sites in Queens. If so, that would suggest that HAAs in Nassau County may not be significantly higher than the currently highest levels in Queens.
    - ***While additional investigations are needed for a definitive prediction, the limited data available for this Water Quality Review do not indicate that HAA5s represent a potential water quality concern that should by itself prevent further consideration of supplying New York City water to Nassau County.***
    - Bench testing and development of an integrated NYC-Nassau County hydraulic and water quality model would provide a more refined prediction for HAA5 concentrations across Nassau County.

Fluoride
NYSDOH recommends but does not require the addition of fluoride to public water supplies for dental protection. NYC currently fluoridates their water, but none of the Nassau County water systems fluoridate. Given the high costs and complexities of fluoride removal, this Feasibility Study has not considered fluoride removal from NYC water.

Corrosivity – Lead and Copper
Since lead levels are essentially non-detect in NYC's distribution system and considering that finished water quality and corrosion control techniques applied by NYC and Nassau County water systems appear similar, the data suggest the higher "at the tap" lead level in the NYC "LCR sample pool" results primarily from a greater presence of lead service lines and higher lead content in household plumbing fixtures in NYC's older housing stock. If so, it would indicate that supplying NYC water to Nassau County is unlikely to cause a significant increase in lead or copper concentration.

- While additional investigations are needed for a definitive prediction, the limited data available for this Water Quality Review do not indicate that lead levels at the household tap represent a potential water quality concern that should by itself prevent further consideration of supplying New York City water to Nassau County.
- Prior to introducing NYC water into Nassau County on a regular basis, NYSDOH and/or NCDOH may require studies to confirm that blending the NYC water and Nassau County supplies would maintain acceptable concentrations of lead and copper, in conformance with the 2021 Lead and Copper Rule Revisions.

In summary, none of the above potential water quality concerns should by themselves prevent further consideration of supplying New York City water to Nassau County.

Looking Ahead

01 | Technical studies to confirm that blending the NYC water and Nassau County supplies would maintain acceptable concentrations of lead and copper, in conformance with the 2021 Lead and Copper Rule Revisions.

02 | Explore the acceptance of Nassau County communities to receiving fluoridated NYC water.

03 | Technical studies and development of an integrated NYC-Nassau County hydraulic and water quality model to predict disinfection by-product concentrations in Nassau County.

In summary, none of the above potential water quality concerns should by themselves prevent further consideration of supplying New York City water to Nassau County.

Appendix D

Water System Infrastructure Concepts and Costs

Introduction

This appendix describes the Feasibility Study's review of potential infrastructure concepts and their potential cost.

Background

Currently, Nassau County's drinking water is sourced from groundwater aquifers, via approximately 46 public water suppliers who have a total of approximately 500 wells that are permitted for public water supply. The wells draw water from three major aquifers: the upper glacial, Jameco-Magothy and the Lloyd aquifers. Figure D1 shows the 46 water systems and their average daily use as reported in 2019 and confirmed with responses to the water survey that was conducted as part of this Feasibility Study. In 2019, Nassau County's total average daily water usage was approximately 173 million gallons per day (MGD); over the past decade, average daily water usage was typically around 180 MGD. During the summer months, water usage increases to support lawn/landscape irrigation and other seasonal purposes. In 2019, summertime usage (May-September) averaged approximately 233 MGD, and in recent years, the annual maximum day demand has been in the order of 300 MGD. Peak hour usage can be much higher during the time of day (early morning) when most irrigation occurs.

In order to begin to assess potential solutions for the Feasibility Study, Ramboll facilitated conversations with New York City Department of Environmental Protection (NYCDEP) to explore the amount of water that could potentially be made available to the County. Thanks to successful conservation efforts over the past thirty years, New York City's (NYC) raw water supply reservoirs now have a safe yield that exceeds their water demands. The safe yield of NYC's reservoirs is 1.3 billion gallons per day

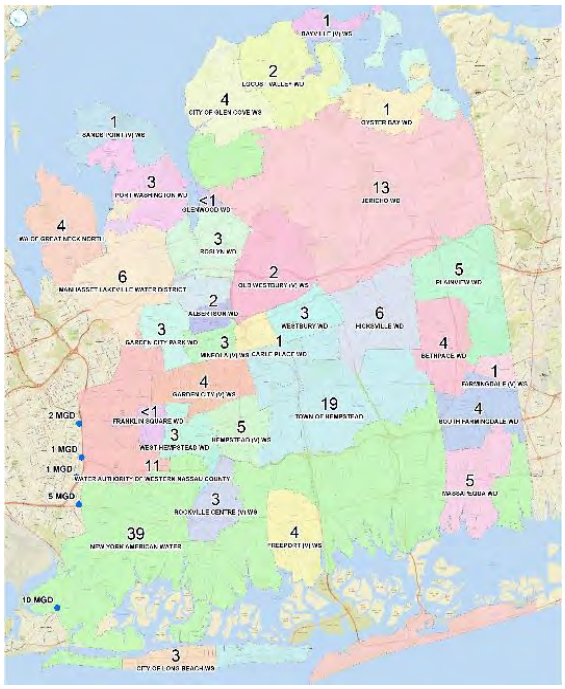


Figure D1. Nassau County Water System Average Daily Usage in MGD

(BGD). That means NYC's reservoirs can be relied upon, even in a recurrence of the worst drought on record, to supply 1.3 BGD. The current average day demand on the NYC water supply system is 1.1 BGD, leaving 0.2 BGD or 200 million gallons/ day (MGD) of safe yield in excess of demand. NYCDEP projects that in 2040, the water demands of the NYC water system will increase to 1.33 BGD, leaving no surplus for Nassau County in times of drought. Based on discussions with NYCDEP, NYC has suggested using 20 MGD to further the objectives of this Feasibility Study, recognizing that existing connections between NYC and Nassau County could, once rehabilitated, supply 20 MGD. Currently, NYC has five existing interconnections with Nassau County and has the capacity to provide a certain amount of flow at each along the borders of the Water Authority of Western Nassau and New York American Water. This information is shown in Figure D2 on the following page.

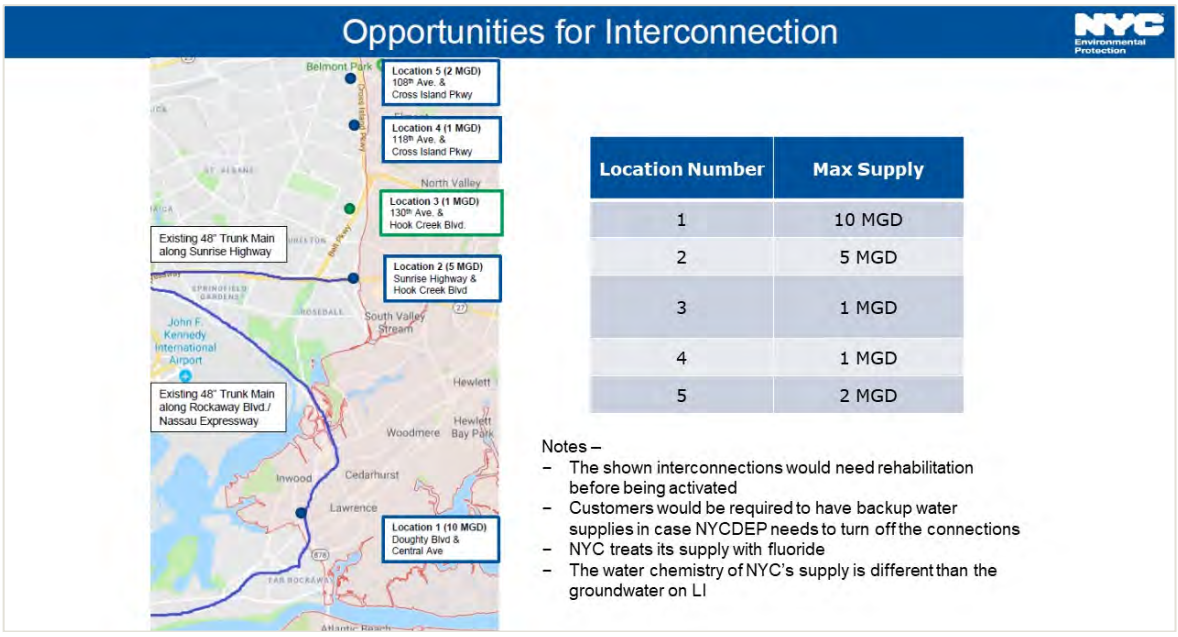


Figure D2. Interconnection Information Based on NYC DEP Provided Data

The current availability of 20 MGD from NYC is considered a significant potential benefit, provided the water can be conveyed from NYC to the locations where it is needed in Nassau County; however, it is also recognized that Nassau County may seek more than 20 MGD now or in the future as it addresses the many challenges facing its groundwater supplies.

Following conversations with NYCDEP, NYSDOH and NYSDEC, Ramboll reviewed potential concepts for the infrastructure to supply water from NYC to Nassau County. These options are infrastructure for limited supply (aka Low Bookend) and infrastructure for larger scale supply (aka High Bookend).

Infrastructure for Limited Supply

Limited Supply (Low Bookend)

Infrastructure for the limited supply option would utilize existing interconnections, along with the potential construction of one or more new interconnections with New York City to serve the northern portion of Nassau County. These connections could convey up to 20 MGD, consistent with the above discussions with NYCDEP. This concept is similar to what was

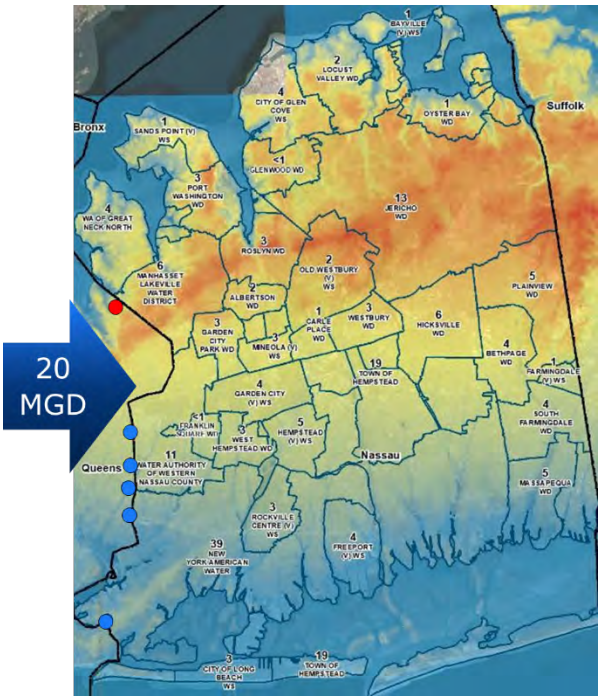


Figure D3. NYC Interconnection Map

described in a report by the Long Island Commission for Aquifer Protection (LICAP) in their Groundwater Resources Management Plan dated December 11, 2019. Figure D3 on the previous page shows the locations of existing NYC interconnection in blue and a potential location for a northern interconnection in red.

The basic concept for the Limited Supply option is illustrated by the schematic Figure D4 below. This option would require investments in Queens and Nassau County to rehabilitate the existing connections, along with the construction of one or more new connections that could supply NYC water to water suppliers serving the nearby north shore areas of Nassau County.

The below schematic figure displays four key aspects of the Low Bookend approach:

- *Rehabilitate existing NYC interconnections as needed* – Per discussions with NYCDEP, the existing interconnections along the Queens/Nassau County borders have not been utilized in approximately 20 years or more and it is likely that each existing interconnection will need to be rehabilitated, as noted on the schematic.

- *Construct new NYC connection(s)* – The existing interconnections are in the southern part of the Queens-Nassau County border. Due to saltwater intrusion on the north shore, as discussed in Appendix C: Water Quality Review, water suppliers may be interested in one or more new connections to supplement the supply to areas along the north shore.

- *Flow-through approach* – If the full 20 MGD was not needed by the communities with direct connections to NYC, it would be beneficial to flow through those "connected water systems" to supply adjoining water systems, and potentially utilize all the available NYC water.

- *Dedicated transmission mains* – As an alternative to the above flow-through approach, dedicated transmission mains could be constructed to reach the water systems that do not share a border with NYC. These dedicated transmission mains could be routed through the water systems that share a border with NYC, without connecting to those water systems, as shown by the schematic. The dedicated transmission main approach could apply to the existing NYC connections, extending NYC water to the south shore via a dedicated transmission main, or new (northern) NYC connection(s).

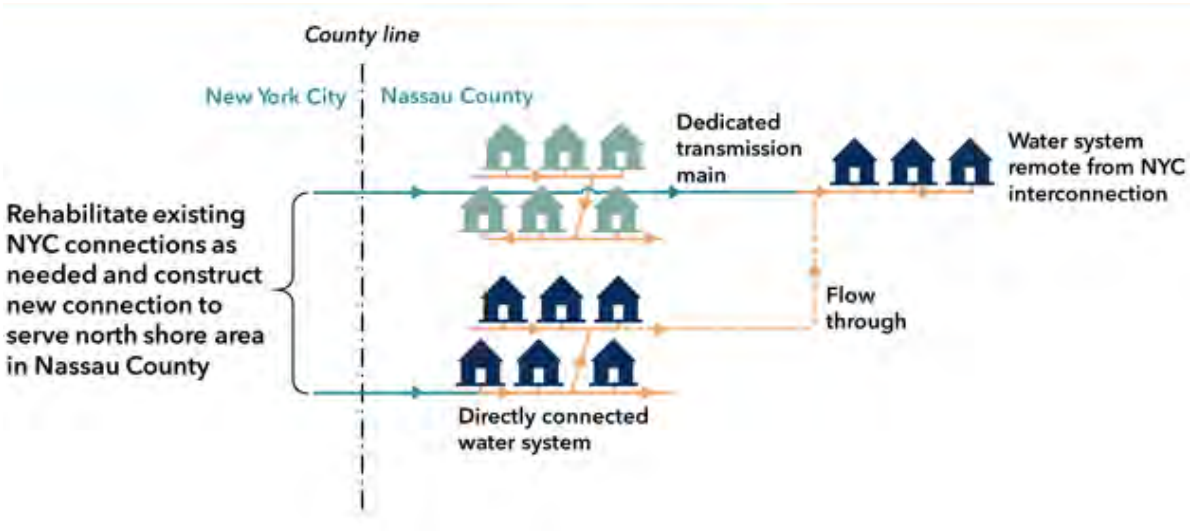


Figure D4. Low Bookend Basic Concept

Benefits and Challenges

The limited supply option has potential benefits to Nassau County and New York City:

- This option would supplement the supply for the water systems along the border with NYC, as a minimum, and possibly supplement supplies to adjoining water systems as well.
    - Some of the water systems close to NYC have expressed interest due to saltwater intrusion or chemical contamination of their existing well supplies.
- This option could likely be implemented in a relatively short time frame utilizing purchase agreements (i.e., intermunicipal agreements) without creating a new organization such as a water authority, to contract with NYC on behalf of multiple water suppliers.
- This option can be implemented in a phased approach. The phased approach would allow for the water systems with the most need to act quickly to establish water purchase agreements and collaborate with NYC to rehabilitate existing connections or construct new connections.
- NYC would upgrade or replace existing infrastructure and derive additional revenue.

Although the limited supply option might reasonably be implemented in a relatively short time frame, there are challenges:

- Water purchase agreement terms and the price of wholesale water would need to be negotiated. The term “wholesale water” means bulk water which is resold at a retail level by the County water suppliers.
- Further studies would be required to evaluate blended water quality as discussed in Appendix C: Water Quality Review.
- NYC requires their wholesale customers to maintain a backup supply.
- The design and operation of the limited supply concept will require a means to control water age, such as minimum daily takes by the water systems to keep water fresh.
- While the flow-through approach reduces the time and cost to convey NYC water to water systems not directly connected to the NYC system, it would require purchase agreements between the adjoining Nassau County water systems, as well as purchase agreements with NYC.

Infrastructure for Large Scale Supply

Large Scale Supply (High Bookend)

Implementation of the large-scale (High Bookend) supply option would require significant investments in new infrastructure, including large diameter pipelines, multiple pumping stations, complex hydraulic controls and possibly storage, in addition to improvements which would be part of the Low Bookend. For the purposes of this Feasibility Study, the High Bookend concept was developed to enhance the body of information available to interested parties, in the event that Nassau County and NYC decide to explore the transfer of substantially larger amounts of NYC water. The large-scale supply option is sized for the average day demands in Nassau County i.e., approximately 180 MGD.

While the Low Bookend is similar to what was described in LICAP’s 2019 Report, it is believed that this High Bookend concept represents new information. Ramboll’s intent is to use this option to explore the technical and cost implications of a large-scale supply, recognizing that NYCDEP has indicated that they do not expect to have enough “surplus” capacity to support a large-scale option. While the following discussion focuses on new infrastructure in Nassau County, NYC would also need to make improvements to reinforce the hydraulic capacity as needed to convey large

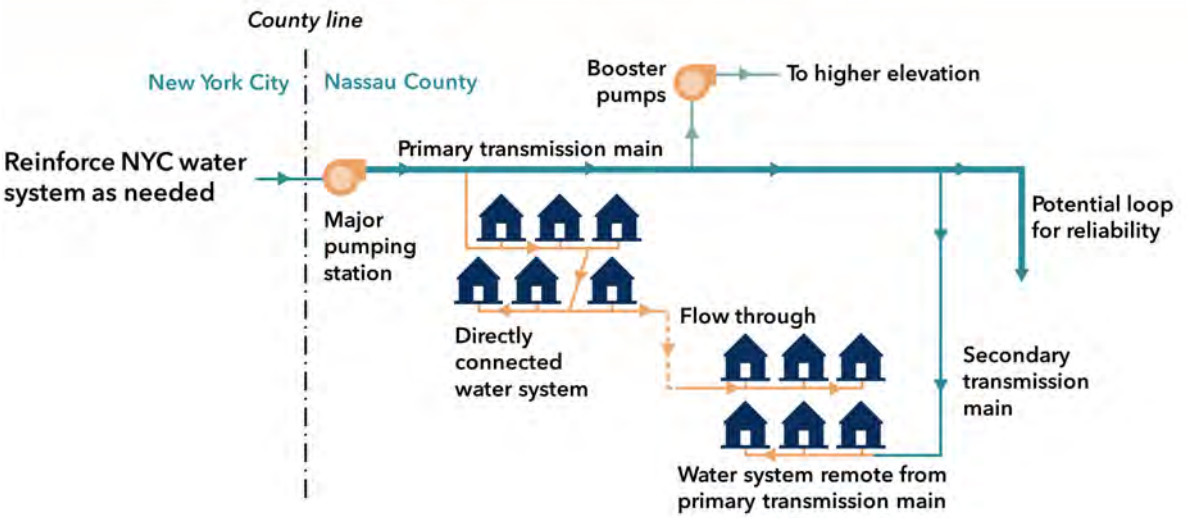


Figure D5. High Bookend Basic Concept

quantities of water to Nassau County. The hydraulic analysis of the NYC water system is beyond the scope of the Feasibility Study, however Ramboll's cost estimate includes a "placeholder" budget for improvements in NYC. The basic concept for the infrastructure for the high bookend is illustrated by Figure D5. The primary aspects of the high bookend are:

- *Reinforcement to the NYC Water System as needed*: Upgrades to the NYC water system will be required to provide 180 MGD to Nassau County, such as new water transmission mains to increase capacity to the Nassau County border. Determining the exact nature of these improvements would require detailed hydraulic modeling and alternatives development by NYCDEP. These reinforcements would be additional to the improvements to NYC's existing interconnections that are included in the Low Bookend. Note that the cost estimates do not include increasing the safe yield of NYC's water supplies.

- *Major Pumping Stations* – New pumping stations would be required to convey water from NYC to Nassau County. For the purposes of the cost estimate, it was assumed that two pumping stations would be provided, to enhance reliability and facilitate phased implementation. The pumping stations would include means for hydraulic surge suppression, in consideration of the long transmission mains and the potential for hydraulic transients (aka water hammer).

- *Primary Transmission Main* – A primary transmission main would be required to transmit water through Nassau County. While the Feasibility Study did not include a pipeline routing study, it is noted that aligning the primary transmission main along or near the boundaries between the water systems where feasible would minimize the length of piping to connect with each water system. For purposes of costs estimating, Ramboll made some basic assumptions:

    - There would be two "legs" of the primary transmission main, both starting at 60" diameter and decreasing in size and capacity from west to east, as flow is delivered to the connected water systems.

    - The two legs would be interconnected to form a loop to enhance reliability. Using two legs also facilitates phasing. Please see the subsection *Potential Cost of Water System Infrastructure* for additional assumptions.

- *Secondary Transmission Mains* – Similar to the low bookend concept, the high bookend concept would require (dedicated) secondary transmission mains to water systems remote from the primary transmission main. These secondary transmission mains would be required where existing water systems do not utilize the flow-through option. The secondary transmission mains would likely be sized at approximately 8" – 16" diameter, based on the desired flow rate.

- *Booster Pumping Stations* – There is the potential need for the use of booster pumping stations to overcome elevation changes in Nassau County as well as pipeline friction losses. As shown in Figure D6, there are higher elevations in the north-central part of the County, with elevations reaching approximately 350 feet above sea level. On Figure D6, red indicates the highest elevations, and blue indicates areas with ground elevations near sea level along the north and south shores. Depending on the location and hydraulics of the primary transmission main, booster pumping could be required to serve customers in the higher elevations and to cross over the higher elevations.

- *Loop for reliability* – As noted above, there is the potential to design the primary transmission main in a loop for reliability. The loop approach aligns with use of two major pumping stations and provides reliability if a failure occurs along the primary transmission main or at a major pumping station.

Benefits and Challenges

The high bookend concept has potential benefits to Nassau County and New York City:

- This option could supplement the supply for all water systems throughout Nassau County as they face water issues related to saltwater intrusion, chemical contamination, and capacity concerns. Water quality concerns within Nassau County are discussed in Appendix C: Water Quality Review.
    - As described here, the high bookend concept would provide capacity equal to Nassau County's total average daily use.

- This option could be implemented in a phased approach, as may be preferred based on need or funding constraints.

- NYC would have to upgrade or replace existing infrastructure but in return would derive additional revenue.

There are significant challenges involved with the high bookend:

- NYCDEP has indicated that they do not expect to have enough surplus capacity to support a large-scale option.

- This option would likely require formation of a new organization such as a water authority or county special district, that is empowered to finance with debt. The organizational and funding requirements for the high bookend concept are further discussed in Appendix E: Finance and Organizational Alternatives.

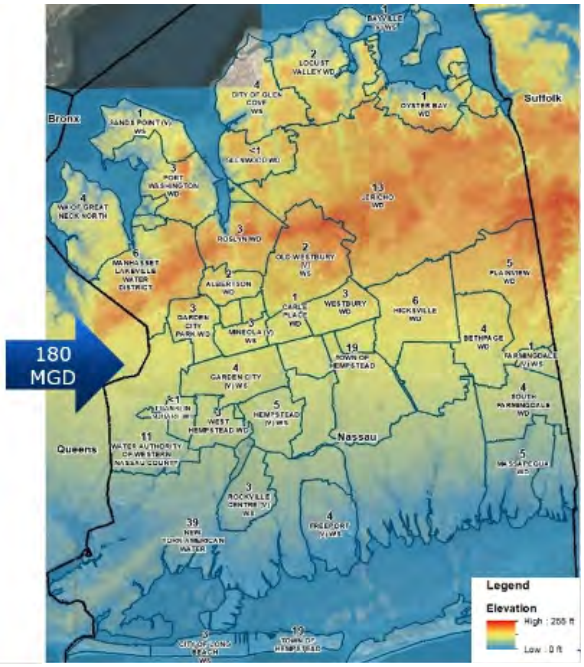


Figure D6. Nassau County Elevation Map

- NYC requires their wholesale customers to maintain a backup supply. This would apply to the Low Bookend as well as the High Bookend, but the much higher investment associated with the High Bookend magnifies the impact of this requirement.
- Routing studies, property acquisition and easements will be required on a very large scale for the pipelines, pumping stations, water storage and interconnections. This will require extensive time and highly coordinated efforts for the "county scale" infrastructure.
- The High Bookend also has the challenges identified above under the Low Bookend:
    - Water purchase agreement terms and the price of wholesale water would need to be negotiated.
    - Further studies would be required to evaluate blended water quality as discussed in Appendix C: Water Quality Review.
    - The design and operation of the large-scale supply concept will require a means to control water age, such as minimum daily takes by the water systems to keep water fresh.
    - Also, while the flow-through approach reduces the time and cost to convey NYC water throughout the County, it requires purchase agreements between the adjoining Nassau County water systems, as well as a purchase agreement with NYC.

Potential Cost of Water System Infrastructure

Cost estimates for the water infrastructure were developed at the "rough order of magnitude" (ROM) level, to provide a first order approximation of value. ROM costs such as provided here are based on general experience with similar facilities rather than estimates that would use detailed take-offs of quantities and known or anticipated construction methods. ROM estimates are generally thought to provide accuracy of +/- 50% and are used by stakeholders to screen alternatives and/or to decide whether to continue with a particular project. In the case of the estimates provided here, Ramboll used parametric estimating, i.e., developed conceptual estimates for size and length of pipelines, pumping station capacities, etc., and assigned unit costs based on experience. These ROM costs include allowances for property acquisition, construction contingencies, engineering, legal and miscellaneous costs including water quality and hydraulic studies, and therefore are intended to represent the total project cost.

In the cases of both the low bookend and high bookend, there are significant unknowns that would result in a wide range of costs. Those unknowns are described below, with the resulting range of costs.

Low Bookend Cost

As the low bookend can be implemented in a phased approach, the cost estimate considers a few line items for different connections to the NYC system. The cost estimate includes an allowance for upgrades to New York City infrastructure, as well as construction of new infrastructure in Nassau County. Table D1 and Table D2 on the following page show the cost estimate which ranges from $35 million(M) to $53M. The low end of the range assumes flow-through, and the higher end of the range includes an allowance for dedicated transmission mains.

Table D1. Low Bookend Cost Estimate – Low Range

Item	Description	Quantity	Unit	Unit Cost	Cost
1	Northern Area Connection	1	Lump sum	$1,000,000	$1,000,000
2	Northern Area Dedicated Transmission Main	4,000	Linear feet	$640	$2,560,000
3	Crossing to South Shore	9,500	Linear feet	$640	$6,080,000
4	Extend South Shore Crossing to Long Beach	9,000	Linear feet	$640	$5,760,000
5	Assume Upgrades to NYC Infrastructure	5	Each	$750,000	$3,750,000
				Subtotal:	**$19,150,000**
				10% for Land and Rights of Way	$1,915,000
				30% for Contingency:	$5,745,000
				Subtotal*:*	**$26,810,000**
				25% for Engineering, Legal and Misc.:	$6,702,500
				Water Quality and Hydraulic Studies:	$1,500,000
				Total (rounded):	**$35,000,000**

Table D2. Low Bookend Cost Estimate – High Range

Item	Description	Quantity	Unit	Unit Cost	Cost
1	Northern Area Connection	1	Lump sum	$1,000,000	$1,000,000
2	Northern Area Dedicated Transmission Main	4,000	Linear feet	$640	$2,560,000
3	Crossing to South Shore	9,500	Linear feet	$640	$6,080,000
4	Extend South Shore Crossing to Long Beach	9,000	Linear feet	$640	$5,760,000
5	Assume Upgrades to NYC Infrastructure	5	Each	$1,000,000	$5,000,000
6	Additional 12" Dedicated Transmission Mains	21,120	Linear feet	$480	$10,137,600
				Subtotal:	**$29,287,600**
				10% for Land and Rights of Way	$2,928,760
				30% for Contingency:	$8,786,280
				Subtotal*:*	**$41,002,640**
				25% for Engineering, Legal and Misc.:	$10,250,660
				Water Quality and Hydraulic Studies:	$1,500,000
				Total (rounded):	**$53,000,000**

The line items for the low bookend cost estimate took into consideration the following:

- Installation of a new interconnection at the northern portion of the Queens and Nassau County border.
- Utilization of an existing interconnection with NYC to construct a dedicated transmission main to the South Shore and then to extend it to Long Beach.
- Cost estimates for all piping were based on the assumption of $40/in-ft of pipe diameter and length.

For the high range cost estimate for the low bookend, an additional 4 miles of dedicated transmission mains was included.

High Bookend Cost

This high bookend cost estimate includes the Low Bookend baseline improvements, which would likely be the initial phase, and then adds the pipelines, pumping stations and other major cost items. The cost estimate includes an allowance for upgrades to New York City water transmission infrastructure, as well as construction of new infrastructure in Nassau County. Note that the cost estimates do not include increasing the safe yield of NYC's water supplies. Table D3 and Table D4 on the following page show the cost estimate which ranges from $1.4 billion (B) to $2.2 B. The higher end of the range assumes more extensive use of tunneling and more secondary transmission mains.

The high bookend cost estimate utilized the following assumptions and considerations:

- This high bookend cost estimate includes the low bookend improvements, which would likely provide the initial 20 MGD capacity. The major pumping stations would have a combined capacity of 160 MGD, to bring total capacity to 180 MGD.
- The major pumping stations would include pressure surge control systems
- There would be two legs of primary transmission mains each starting at 60" diameter and decreasing to 48" as they progress from west to east. The pipe sizes would result in a maximum fluid velocity of approximately 6.4 feet/second.
- 30% of length of the 60" transmission mains would be constructed by tunnelling to reduce the impacts on residents, traffic, and other utilities, while the remainder would be open dig.
- The estimate allows for three types of connections to the primary transmission mains:
    - Direct connections into a water system (twenty assumed)
    - Secondary transmission mains to a non-contiguous water system (15 miles of 16" diameter mains assumed)
    - Connections via a booster pump station (18 MGD or 10% of the high bookend capacity assumed).
- In addition to surge pressure protection at the pump station, 8 MG of water storage for hydraulic balancing was included.
- A 36" diameter suction header is included to connect multiple feeds from NYC to the major pumping stations.
- Hydraulic improvements to the NYC system are included. The basis is 50% of the cost of the 60" and 48" transmission mains (cost items 3, 4 and 5).
- Cost for open dig pipe installation is estimated at $40/in-ft of pipe diameter and length.
- Costs for 60" pipeline installation by tunneling is estimated at $10,000/linear foot.

The ROM cost for the high bookend is shown in Table D3 on the following page.

Table D3. High Bookend Cost Estimate – Low Range

Item	Description	Quantity	Unit	Unit Cost	Cost
1	Low Bookend Investments	1	Lump sum	$19,150,000	$19,150,000
2	Pump Station on Nassau County Border	160,000,000	Gallons per day	$.50	$80,000,000
3	60" Primary Transmission Main - Tunnel	20,600	Linear feet	$10,000	$206,000,000
4	60" Primary Transmission Main – Trench Dug	4,800	Linear feet	$2,400	$12,000,000
5	48" Primary Transmission Loop	84,500	Linear feet	$1,920	$162,240,000
6	16" Secondary Transmission Mains	79,000	Linear feet	$640	$50,560,000
7	Direct Connection to NC Water Systems	20	Each	$500,000	$10,000,000
8	Water Storage for Hydraulic Balancing	8,000,000	Gallons	$5	$40,000,000
9	Booster Pumping Stations	18,000,000	Gallons per day	$1	$18,000,000
10	36" Suction Header from PS 1 to PS 2	31,150	Linear feet	$1,440	$44,856,000
				Subtotal:	**$642,806,000**
				NYC Infrastructure Improvements	$190,120,000
				10% for Land and Rights of Way	$64,280,600
				30% for Contingency:	$212,125,980
				Subtotal:	**$1,109,332,580**
				**25% for Engineering, Legal and Misc.:*	$277,333,145
				Total (rounded):	**$1,400,000,000**

**Engineering costs include water quality and hydraulic studies.*

Table D4. High Bookend Cost Estimate – High Range

Item	Description	Quantity	Unit	Unit Cost	Cost
1	Low Bookend Investments	1	Lump sum	$19,150,000	$19,150,000
2	Pump Station on Nassau County Border	160,000,000	Gallons per day	$.50	$80,000,000
3	60" Primary Transmission Main - Tunnel	68,640	Linear feet	$10,000	$686,400,000
4	48" Primary Transmission Loop	84,480	Linear feet	$1,920	$162,240,000
5	16" Secondary Transmission Mains	158,000	Linear feet	$640	$50,560,000
6	Direct Connection to NC Water Systems	20	Each	$500,000	$10,000,000
7	Water Storage for Hydraulic Balancing	8,000,000	Gallons	$5	$40,000,000
8	Booster Pumping Stations	18,000,000	Gallons per day	$1	$18,000,000
9	36" Suction Header from PS 1 to PS 2	31,152	Linear feet	$1,440	$44,856,000
				Subtotal:	**$1,111,206,000**
				NYC Infrastructure Improvements	$190,120,000
				10% for Land and Rights of Way	$111,120,600
				30% for Contingency:	$366,697,980
				Subtotal:	**$1,779,144,580**
				**25% for Engineering, Legal and Misc.:*	$444,786,145
				Total (rounded):	**$2,200,000,000**

**Engineering costs include water quality and hydraulic studies.*

The high end of the range for High Bookend includes these additional costs:

- Installing all the 60" primary transmission mains using tunneling
- Twice as many miles of secondary transmission mains (30 miles of 16" diameter mains assumed)

Figure D7 illustrates the estimated cost versus capacity, using the above-described ROM costs for Low and High Bookends. While the cost for capacities greater than the Low Bookend and less than the High Bookend will be driven by the specific components and areas to be supplied, Figure D7 can be used for a preliminary assessment of Rough Order of Magnitude costs.

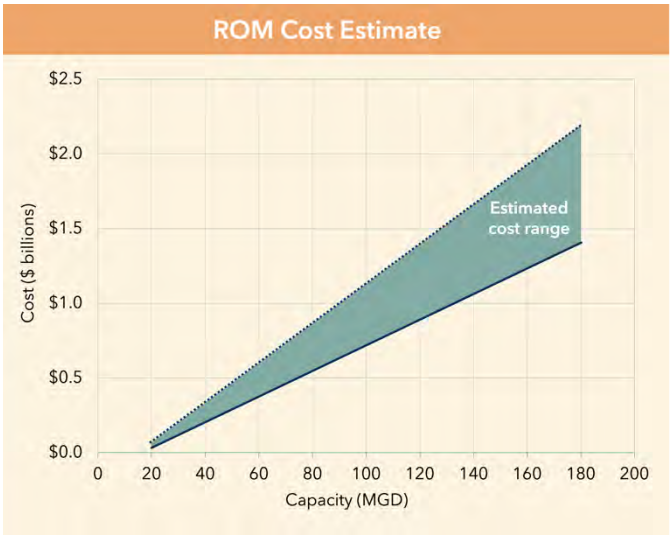


Figure D7. ROM Estimated Cost Range – cost estimate includes construction, contingencies and allowances for property acquisition, engineering, legal and miscellaneous costs.

Looking Ahead

This Appendix provides conceptual approaches and rough order of magnitude cost estimates for the Low Bookend and High Bookend scale of improvements to convey a wide range of potable water supply from NYC to Nassau County. To further the potential for interconnecting the NYC and Nassau County water supplies, interested parties should explore the implementation process, potential for financial support, and likely time to implement, as described briefly below.

Implementation Process
A critical step for implementation is establishing NYC's long-term willingness to sell water to Nassau County. Another critical and early step in the implementation process is to establish which parties in Nassau County want to purchase NYC water. It would be helpful if the interested Nassau County water suppliers, Nassau County Department of Health, NYCDEP and other key stakeholders collaborate to identify their shared interests (how much water, where, when) and their respective concerns. These initial collaborations would define the need for studies into blended water quality, hydraulic capacity, etc., so that follow-on studies can be scoped, and specific interconnection projects developed. The result of these collaborations would also inform whether there is a need for a new organization vs. a decision to utilize intermunicipal agreements (see also Appendix E, Financial and Organizational Alternatives).

Financial Support
Water supply projects required for either the Low Bookend or High Bookend concepts could be eligible for grants and/or low interest financing available through federal or state government programs. See Appendix E for additional information on these programs.

Time to Implement
While the time for implementation will be driven by project specifics such as cost, availability of grant funding and many other issues, the following overview is provided as a basis for initial considerations:

Low Bookend related projects could be implemented relatively quickly, especially those that can be accomplished using NYCDEP's existing interconnections as shown on Figure D4. Rehabilitation of existing interconnection(s) could reasonably be completed in a year or less. The

time to negotiate and execute an intermunicipal agreement would be driven by NYCDEP and the wholesale customer, and this effort also could reasonably be accomplished in a year or less. The "critical path" may be the time required for water quality and hydraulic studies and permitting/ Health Department approvals. Ramboll suggests allowing approximately 2 years for implementing a Low Bookend project that uses existing interconnections and 3-5 years to implement a Low Bookend project that involves a new interconnection or a new dedicated transmission main.

Implementing major elements of the ***High Bookend*** concept must first overcome the challenge of available supply. NYCDEP has advised that projected 2040 water demands could utilize all of NYC's current safe yield. However, if substantial quantities of water could be made available for Nassau County, Ramboll projects that implementation would then require a decade or longer. Similar to the Low Bookend, the first step would be for the water suppliers and stakeholders in Nassau County and NYCDEP to collaborate on feasibility and preliminary engineering studies in order to establish the scope and cost of the large-scale program. The establishment of a county-level organization (see also Appendix E, Financial and Organizational Alternatives) could be initiated concurrently but may be deferred until the large-scale program and the participants are better defined. Finally, given the potential large scale and cost, the High Bookend may be constructed in phases. Based on the technical complexity, need for routing studies and property acquisition, financing and organizational needs, and likely 5 years or more for construction, the High Bookend should be viewed as a 10 to 15-year undertaking. However, the Low Bookend project(s) (see above) could serve as the initial phase (2-5 years), with the potential that NYCDEP and the participating entities in Nassau County could possibly expand the capacity of the Low Bookend beyond 20 MGD, before undertaking the construction of High Bookend scale infrastructure.

Appendix E

Finance and Organizational Alternatives

Introduction

This appendix describes the Feasibility Study's review of organizational and financial approaches that could support the potential interconnection.

Background

Conveyance of New York City (NYC) water to Nassau County requires an investment in capital assets, payments for the purchase of finished (treated) water, and continuing expenses to operate and maintain any new capital assets. The capital assets would involve pipelines, valves and meter vaults, and could include pumping stations, pressure regulating systems and water storage tanks. The conceptual design and costs for the capital investments are described in Appendix D. The Feasibility Study is assessing the small scale scenario (20 MGD) and large scale scenario (180 MGD, the average day demand for Nassau County) and refers to these scenarios as "Bookends". As Nassau County's needs are determined, one or more intermediate demand scenarios could also be considered in future studies. This Appendix introduces the basic alternatives for funding the investments, both high and low bookends, and explores the organizational structures which in many cases are related to the financial approach.

Please note that this review of potential financial and organizational approaches represents a collaborative effort with the key stakeholders, in which Ramboll provided technical support. Stakeholders should retain their own financial and legal advisors to further assess and advance their preferred financing and organizational approaches, as the initiative to supply NYC water to Nassau County progresses.

Funding Sources

Funding for public water supply infrastructure could involve one or more of the following:

Debt Financing
Municipal entities commonly use debt offerings (e.g., selling municipal bonds to finance capital investments) with repayment over terms that typically range from approximately 20 years to 30 years or more.

- A **general obligation bond** is a municipal bond backed solely by the credit and taxing power of the issuing jurisdiction rather than revenue from a particular project or from water sales and fees. General obligation bonds are issued with the belief that the municipality will be able to repay its debt obligation through taxation or operating revenues. No assets are used as collateral.

- A **revenue bond** is a category of municipal bond supported by revenue from a specific project or from general water system revenues. Revenue bonds, unlike general obligation bonds, are not funded by taxpayers.

As described below, the type of organization determines whether the municipal entity is empowered to issue general obligation or revenue bonds. If the project is undertaken by a private entity, it could issue commercial debt, or in the case of a public company, it could use its assets from shareholder investments to finance its share of a project.

Government Financing Programs
Water supply projects required for either the Low Bookend or High Bookend concepts could be eligible for grants and/or low interest financing available through federal or state government programs. There are three federal programs highlighted below, two of which involve administration by the United States Environmental Protection Agency (USEPA). There are also two NYS programs highlighted below that are administered by NYSDOH and New York State Environmental Facilities Corporation (NYSEFC).

- Infrastructure Investment and Jobs Act (IIJA) – The IIJA was signed into law on November 15, 2021. Federal funds from IIJA will be available for approximately the next five

years starting in 2022. A portion of the available funds are being allocated to NYS, which in turn will award grants and low interest loans on a project-by-project basis using criteria to be established by USEPA. The allocation of funding to specific water projects in NYS will be administered by NYSDOH and NYSEFC and is expected to follow the process currently utilized for the Drinking Water State Revolving Fund (SRF).

- American Rescue Plan Act of 2021 (ARPA) – ARPA authorized federal funds that can, among other purposes, be used for water system infrastructure and resiliency. ARPA funds were allocated to each state, including NYS, and to municipal governments (counties, cities, etc.). The recipient governmental agencies can dedicate a portion of their funds for projects of the sort required for the Low or High Bookend, provided the funds are committed by December 31, 2024.

- Water Infrastructure Finance and Innovation Act (WIFIA) – WIFIA is administered by USEPA. WIFIA provides attractive financing terms and below-market interest rates for water projects, both large and small. WIFIA funds can be used as a companion to SRF funds, where needed to finance water projects.

- Water Infrastructure Improvement Act (WIIA) – The New York State Clean Water Infrastructure Improvement Act (CWIA) of 2017 invests $4.5 billion in clean and drinking water infrastructure projects. The WIIA Drinking Water funds, which are administered by NYSEFC, provide competitive grants to help municipalities fund water quality infrastructure projects.

- Intermunicipal Grants (IMG) – Intermunicipal Grants (IMG) are also authorized under the New York State Clean Water Infrastructure Improvement Act (CWIA) of 2017. IMG funds are available for drinking water and wastewater/sewer (clean water) projects that serve multiple municipalities, such as a shared water quality project or the interconnection of multiple water systems. Cooperating municipalities with an eligible project may be awarded an IMG grant of up to $30 million or 40% of net eligible costs, whichever is less, provided funds are appropriated in future years.

Water Utility Revenues
Water utilities generate revenues from water sales and fees, such as connection fees and administrative/billing fees. Some utilities also assess fees for infrastructure renewal and water supply availability. Water utility revenues are used to pay for debt service and general operating expenses (labor, power, chemicals, repairs and maintenance). Where water utilities are purchasing water from a neighboring water system, their operating expenses would also include purchased water, and possibly availability fees if required by their purchase agreement. Water utility revenues can also be used to "pay as you go" (so called Pay Go), meaning that surplus revenues may be allowed to accumulate until the Utility can pay cash for capital improvements.

Ad Valorem Property Tax
An ad valorem property tax is a tax that is assessed based on a property's assessment value. States, counties and other incorporated municipalities and special districts generally are empowered to collect ad valorem property taxes. Ad valorem taxes are commonly used to finance capital investments in special districts.

As noted above, the funding sources are commonly linked to the organizational structure of the public water system, as further explained below.

Organizational Review

The purpose of this Organizational Review is to identify alternative organizational approaches for ownership and management of the proposed infrastructure assets needed to convey finished (treated) water from NYC to Nassau County. For each alternative organizational approach, this review describes the general requirements

associated with forming a new organization. Where appropriate, subsequent reviews could further describe the need for legislation and/or legislative approvals, public referendum, and approvals by existing governmental entities. The context for this review is that an organizational alternative could be selected to fund and manage the supply of water from New York City, but existing water utilities in Nassau County could stay in place as public water systems and retail providers.

Organizational Alternatives

Potential organizational alternatives could include, but not be limited to:

Public Utility Authority
The authorizing legislation for a Public Utility Authority is *Consolidated Laws of New York; Article 5 - Public Utility Authorities.* Public Utility Authorities have been established in New York State for Transportation, Power and Water, as well as for Finances. Each Authority formation requires an act by the New York State Legislature, in addition to approvals by local jurisdiction(s) where required. The powers and governance of the Authority are described in the Act by which it is formed. Under Article 5, a Public Utility Authority can be established as what is commonly referred to as either a "state authority" or a "local authority", which are distinguished by their governance:

a | So called "state authorities" have one or more members of their governing body (i.e., board of directors) appointed by elected officials of the State. While this is not common for operational water utilities, state appointed members are part of the governance for the New York City Municipal Water Finance Authority under Title 2-A, and the Niagara Falls Public Water Board, under Title10-B, Section 1230-E.

b | "Local authorities" have all members of their governing body (i.e., board of directors) appointed by local jurisdictions; none of their members would be appointed by elected officials of the State. Examples of county-governed water authorities include Monroe County Water Authority (Title 5) and Onondaga County Water Authority (Title 7). Water authorities established on Long Island include:

i. Suffolk County Water Authority (Title 4) – Suffolk County Water Authority existed prior to this authorizing legislation, which effectively continued this Authority's ability to exist. Its board members are appointed by Suffolk County.

ii. Water Authority of Great Neck North (Title 8B) – Governed by members appointed by the Villages of Great Neck, Great Neck Estates, Great Neck Plaza, Kensington, Kings Point, Saddle Rock, Thomaston, and the Town of Hempstead (all in Nassau County).

iii. Water Authority of Western Nassau (Title 8C) – Governed by members appointed by the Towns of Hempstead and North Hempstead, and the Villages of Bellrose, Floral Park, Garden City, New Hyde Park, South Floral Park, and Stewart Manor.

iv. South Nassau Water Authority (Title 5A) and North Shore Water Authority (Title 5A*2) - NYS assembly and senate passed bills on June 11, 2021, which were signed into law and become effective on February 1, 2022, creating South Nassau Water Authority (Title 5A) and North Shore Water Authority (Title 5A*2). These new authorities could be involved in a potential municipalization of New York American Water Service Corporation's assets in Nassau County. The South Nassau Water Authority would be governed by members appointed by the town of Hempstead and the Nassau County legislature who reside in the area currently served by New York American Water Service Corporation. The North Shore Water Authority would

be governed by members appointed by the villages of Old Brookville, Sea Cliff, Roslyn Harbor, the City of Glen Cove, and Town of Oyster Bay.

c | Powers of Public Utility Authorities – The powers of each Public Utility Authority are defined in their authorizing legislation. Of particular significance to the Feasibility Study:

i. Water authorities are commonly exempt from local property taxes, fees and income taxes, but may make payments in lieu of taxes.

ii. Water authorities are commonly empowered to issue revenue bonds, and their debts are not the responsibility of the State, County or other municipal entities they supply.

iii. Water authorities are commonly empowered to charge fees for their services (e.g., billings based on water usage, connection fees, etc.) but not to levy ad valorem property taxes.

Consideration for forming a new authority should further explore these aspects:

- A new authority may not be needed to serve only those water systems along Nassau County's western border, the so-called Low Bookend. A new authority brings more value to a High Bookend, where a larger number of water systems receive NYC water.
- Since there are already several water authorities in Nassau County, the relationship between them and a new authority needs to be established, including the relative position of debt obligations that are secured by operating revenues. Privately owned water utilities cannot be members of a Public Utility Authority. New York American Water and its privately-owned successors could have a contractual relationship with a new water authority but would not be a member of a new authority.

County Special District

Counties can form special districts for numerous purposes including public water supply, sewer service and solid waste disposal services, as well as school districts, fire districts, and districts created by a Special Act of the State Legislature. The term "special district" in *The Legal Framework for Providing Local Government Services* is based on the definition of special district as provided in subdivision 16 of section 102 of the Real Property Tax Law (RPTL) to mean "a town or county improvement district, district corporation or other district established for the purpose of carrying on, performing or financing one or more improvements or services intended to benefit the health, welfare, safety or convenience of inhabitants of such district, and in which real property is subject to special ad valorem levies or special assessments for the purposes for which said district was established" (Source: Legislative Commission on State-Local Relations, 06/2009). The special district can cover the entire county or a defined part of it. Issuance of debt requires approval by the NYS Office of State Controller (OSC) under so called "Article 85." County Districts can be established with the power to make ad valorem-based assessments as a means for generating revenue which can be used to make debt service payments or for other expenses. Although the special districts in Nassau County appear to be town districts, there are several County Sanitary Districts in Suffolk County. Onondaga County created a County Special District called the Onondaga County Water District (OCWD), and its administrative body, the Metropolitan Water Board when it constructed its Lake Ontario Water Supply in the 1960s. OCWD has power to collect property taxes based on ad valorem assessments. See also Combination of Above Organizations, below, for additional information on OCWD.

Consideration for forming a county special district should further explore these aspects:

- A county special district may not be needed to serve only those water systems along the western border, the so-called "low bookend". A county special district brings more value to a High Bookend, where a larger number of water systems receive NYC water,

- The impacts, if any, of including the area served by New York American Water's Long Island system in a county special district.

Intermunicipal Agreements
New York State General Municipal Law governs municipal contracting in general and Article 5C covers Contract for Water Supply (Section 118A). Article 5C allows a municipal entity to sell excess water for a term not to exceed 40 years and may require conservation to maintain the quantity of water within the excess capacity of seller. Two party intermunicipal agreements are commonly used in New York State and throughout the country for sale and purchase of drinking water. Multiple party intermunicipal agreements are also used in New York State, an example being the Agreement of Municipal Cooperation (AMC) between the Towns of Dryden, Ithaca and Lansing and the Villages of Cayuga Heights and Lansing, which established the Southern Cayuga Lake Intermunicipal Water Commission (see below).

Consideration for using intermunicipal agreements should further explore these aspects:

- If NYCDEP and the water systems that NYCDEP can serve directly are agreeable to using water purchase agreements, this could present a relatively simple ways to implement a Low Bookend approach. However, intermunicipal agreements are less than ideal as a means for financing large capital investments needed for the High Bookend option, because they do not provide a direct means for issuing debt.

Intermunicipal Water Commission
An Intermunicipal Water Commission may be established via an Intermunicipal Agreement (see above), such as the Southern Cayuga Lake Intermunicipal Water Commission, commonly known as "the Bolton Point Water System".

In the case of Bolton Point, the Commission is populated by representatives from the five municipalities that joined together to build and

operate the water system. The Commission assesses to each of the parties their share of debt and operating expenses. Consideration for using an Intermunicipal Water Commission should further explore these aspects:

- An Intermunicipal Water Commission is probably only needed if the intermunicipal agreement sets up an operational entity. It would not likely be needed to support more typical two-party water sales agreements for a Low Bookend option.

Private Water Company
A private water company could build and finance assets required to convey NYC water to Nassau County. Privately-owned water companies are regulated by the New York Public Service Commission (PSC). The PSC is the public utilities commission of the New York State government that oversees water industries (and other industries), as part of the Department of Public Service (DPS). DPS's regulations are compiled in Title 16 of New York Codes, Rules and Regulations. An example of a private water company is New York American Water which serves part of Nassau County. New York American Water is part of the American Water Works Company, Inc., a public corporation traded on the New York Stock Exchange. The PSC oversees approval of rates and charges for public water service and establishes the franchise area.

New York American Water has announced its sale to Liberty Utilities of Canada; as of the date this section was written, the sale had not been executed, and New York State was investigating an alternate approach in which a public entity would assume ownership. NYS assembly and senate passed bills on June 11, 2021, which were signed into law and become effective on February 1, 2022, creating South Nassau Water Authority (Article 5, Public Utilities Authorities, Title 5A) and North Shore Water Authority (Title 5A*2). These new authorities could be involved in a potential municipalization of New York American Water

Service Corporation's assets in Nassau County. The new authorities are empowered to issue general obligation or revenue bonds. Any consideration for using a private water company to finance the needed investments should further explore the interest of the stakeholders in using a private entity for this purpose.

Combination of Above Organizations
The final option considered in this review of organizational structures is a combination of the above organizations. A combination of organizations may present an advantage over any singular organization via flexibility in financing. Some examples include:

a | **Onondaga County** - Onondaga County established a special district, Onondaga County Water District (OCWD) when it constructed its Lake Ontario Water Supply in the 1960s. OCWD has power to collect property taxes based on ad valorem assessments. The County also established Onondaga County Water Authority (OCWA) under Title 7 of the NYS Public Utilities Authority. OCWA is empowered to issue revenue bonds. In 2017, Onondaga County and OCWA entered into a Public Water Supply Cooperation Agreement that sets forth the details by which the County, owner of district assets, cooperates with OCWA, a public water system, for the benefit of all users. The combination of OCWD and OCWA provides the ability to use both tax revenues and water sales and fees to secure debt. It is understood that future debt would be secured via OCWA's revenue bonds, thereby limiting the debt obligations secured by real property in Onondaga County.

b | **New York City** – New York City uses NYCDEP to operate its water system and the New York City Municipal Water Finance Authority (established under Title 2A of the Public Utilities Authority), which is empowered to issue revenue bonds, to handle project financing. As noted above, the Finance Authority has members of their governing body appointed by both the City and by New York State. It is understood that recent and future debt has been and would be secured via revenue bonds issued by the Finance Authority, thereby limiting the debt obligations secured by real property in New York City.

This Feasibility Study also has identified that a phased approach could be provided using intermunicipal agreements as a first step, followed by formation of Public Utility Authority or a County Special District.

The Low Bookend approach that primarily uses existing infrastructure would require a relatively modest level of capital investment and could reasonably be implemented by intermunicipal agreements between NYC and each of the participating water systems. This could serve as an initial phase of the water system interconnection program.

The High Bookend approach involves a substantial capital investment in new water infrastructure. If/when a High Bookend approach is needed, a Public Utility Authority or a County Special District could be created to provide debt financing and a larger scale operational structure.

Summary

This Appendix describes organizational alternatives and their financial capabilities, in connection with the Feasibility Study addressing the supply of NYC water to Nassau County. The selection of the organizational approach will be driven by purpose, and purpose involves the magnitude of water conveyed and how it is used. If the magnitude and use of water will change over time, the organization may also need to change. The following matrix presents a summary of this review.

The matrix on the following page can be supported with this example: If NYC supplies approximately 20 MGD to the water systems along the Queens border, relatively standard water sales agreements may be adequate. This could be the first phase. If/when NYC agrees to

supply a greater volume of water to merit the construction of large-scale transmission assets in Nassau County, a different approach may be needed, such as an authority or special district. This could be a second phase.

Summary Matrix for Organizational and Financial Review

Organizational Alternative	Ability to Issue Debt	Viable for Near Term "Low Bookend"	Viable for Longer Term "High Bookend"
Public Utility Authority	Yes, via revenue bonds	Yes, but probably not needed	Yes
County Special District	Yes, via general obligation bonds	Yes, but probably not needed	Yes
Intermunicipal Agreements	No, each utility issues own debt	Yes	Not practical
Combination of Above Alternatives (Phased Approach)	Yes, via revenue bonds or general obligation bonds	Yes, with Intermunicipal Agreements	Yes, with new organization and debt financing