Capital Project No. WP-169
Long Term Control Planning III

Combined Sewer Overflow Long Term Control Plan for Citywide/Open Waters

September 2020

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Department of Environmental Protection
Office of the Agency Chief Engineer

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TABLE OF CONTENTS

APPENDICES

LIST OF TABLES

LIST OF FIGURES

Section 1.0

Section 2.0

Harlem River

Hudson River

<u>East River/Long Island Sound</u>

New York Bay

Section 5.0

Section 6.0

1.0 INTRODUCTION

The New York City Department of Environmental Protection (DEP) prepared this Long Term Control Plan (LTCP) for Citywide/Open Waters pursuant to a New York State Department of Environmental Conservation (DEC) CSO Order on Consent (DEC Case No. CO2-20000107-8) (2005 CSO Order), modified by a 2012 CSO Order on Consent (DEC Case No CO2-20110512-25) (2012 CSO Order) and subsequent minor modifications (collectively referred to herein as the "CSO Order"). Pursuant to the CSO Order, DEP is required to submit 10 waterbody-specific LTCPs and one Citywide LTCP to DEC for review and approval. The Citywide/Open Waters LTCP is the final one of these LTCPs to be submitted.

1.1 Goal Statement

The following is the LTCP Introductory Goal Statement, which appears as Appendix C in the CSO Order. It is generic in nature, so that waterbody-specific LTCPs will take into account, as appropriate, the fact that certain waterbodies or waterbody segments may be affected by New York City's (NYC's) concentrated urban environment, human intervention, and current waterbody uses, among other factors. DEP will identify appropriate water quality outcomes based on site-specific evaluations in the drainage basin-specific LTCP, consistent with the requirements of the Federal CSO Control Policy and Clean Water Act (CWA).

> *"The New York City Department of Environmental Protection submits this Long Term Control Plan (LTCP) in furtherance of the water quality goals of the Federal Clean Water Act and the State Environmental Conservation Law. We recognize the importance of working with our local, State, and Federal partners to improve water quality within all citywide drainage basins and remain committed to this goal.*
>
> *After undertaking a robust public process, the enclosed LTCP contains water quality improvement projects, consisting of both grey and green infrastructure, which will build upon the implementation of the U.S. Environmental Protection Agency's (EPA) Nine Minimum Controls and the existing Waterbody/Watershed Facility Plan projects. As per EPA's CSO Control Policy, communities with combined sewer systems are expected to develop and implement LTCPs that provide for attainment of water quality standards and compliance with other Clean Water Act requirements. The goal of this LTCP is to identify appropriate CSO controls necessary to achieve waterbody-specific water quality standards, consistent with EPA's 1994 CSO Policy and subsequent guidance. Where existing water quality standards do not meet the Section 101(a)(2) goals of the Clean Water Act, or where the proposed alternative set forth in the LTCP will not achieve existing water quality standards or the Section 101(a)(2) goals, the LTCP will include a Use Attainability Analysis, examining whether applicable waterbody classifications, criteria, or standards should be adjusted by the State. The Use Attainability Analysis will assess the waterbody's highest attainable use, which the State will consider in adjusting water quality standards, classifications, or criteria and developing waterbody-specific criteria. Any alternative selected by a LTCP will be developed with public input to meet the goals listed above.*
>
> *On January 14, 2005, the NYC Department of Environmental Protection and the NYS Department of Environmental Conservation entered into a Memorandum of Understanding (MOU), which is a companion document to the 2005 CSO Order also executed by the parties and the City of New*

York. The MOU outlines a framework for coordinating CSO long-term planning with water quality standards reviews. We remain committed to this process outlined in the MOU, and understand that approval of this LTCP is contingent upon our State and Federal partners' satisfaction with the progress made in achieving water quality standards, reducing CSO impacts, and meeting our obligations under the CSO Orders on Consent."

This Goal Statement has guided the development of all of the LTCPs DEP has submitted to DEC including the Citywide/Open Waters LTCP.

1.2 Regulatory Requirements (Federal, State, Local)

The waters of NYC are subject to Federal and State regulations. The following sections provide an overview of the regulatory issues relevant to long term CSO planning.

1.2.a Federal Regulatory Requirements

The CWA established the regulatory framework to control surface water pollution, and gave the EPA the authority to implement pollution control programs. The CWA established the National Pollutant Discharge Elimination System (NPDES) permit program. The NPDES permit program regulates point sources discharging into waters of the United States. CSOs and MS4 are also subject to regulatory control under the NPDES permit program. In New York State (NYS), the NPDES permit program is administered by DEC, and is thus a State Pollutant Discharge Elimination System (SPDES) program. NYS has had an approved SPDES program since 1975. Sections 303(d) of the CWA and 40 CFR §130.7 (2001) require states to identify waterbodies that do not meet water quality standards (WQS) and are not supporting their designated uses. These waters are placed on the Section 303(d) List of Water Quality Limited Segments (also known as the list of impaired waterbodies or "303(d) List"). The 303(d) List identifies the sources potentially causing impairment, and establishes a schedule for developing a control plan to address the impairment. Placement on the list can lead to the development of a Total Maximum Daily Load (TMDL) for each waterbody and associated pollutant/stressor on the list. Pollution controls based on the TMDL serve as the means to attain and to maintain WQS for the impaired waterbody.

The Citywide/Open Waters LTCP covers the following waterbodies:

- Harlem River
- Hudson River (portion within NYC)
- East River/Long Island Sound
- Upper New York Bay
- Lower New York Bay
- Arthur Kill
- Kill Van Kull

The status of these waters in relation to the Final 2016 Section 303(d) list of impaired waters and waters listed under Category 4 "Other Impaired Waterbody Segments Not Listed Because Development of a TMDL is Not Necessary" is summarized in Table 1-1. The Hudson River and Upper and Lower New York Bay are not listed as impaired by CSOs in either the 2016 303(d) list or under the Category 4 list.

Table 1-1. 2016 DEC 303(d) Impaired Waters and Category 4 Waters with Listed Source of Impairment

Listing Category	Waterbody	Reach/Water Quality Classification	Listed Cause of Impairment[1]			
			Pathogens	DO/Oxygen Demand	Nitrogen	Floatables
303(d) Category 1[2]	Arthur Kill	South of Outerbridge Crossing Class I	NL[4]	Urban/Storm/ CSO	NL[4]	Urban/Storm/ CSO[5][6]
	Arthur Kill	North of Outerbridge Crossing Class SD	NL[4]	Urban/Storm/ CSO	NL[4]	Urban/Storm/ CSO[5][6]
	Kill Van Kull	Class SD	NL[4]	NL[4]	NL[4]	Urban/Storm/ CSO[5][6]
Category 4[3]	Harlem River	Class I	NL[4]	Municipal, Urban, CSOs	NL[4]	CSOs, Urban/ Storm[6] [7]
	East River/Long Island Sound	Western Long Island Sound Class SB	NL[4]	Municipal, Urban, CSOs	Municipal, Urban, CSOs	NL[4]
	East River/Long Island Sound	Eastchester Bay Class SB	Municipal, Urban, CSOs[8]	NL[4]	NL[4]	NL[4]
	East River/Long Island Sound	East River East of Whitestone Bridge Class SB	NL[4]	Municipal, Urban, CSOs	NL[4]	CSOs, Urban/ Storm[6] [7]
	East River/Long Island Sound	East River West of Whitestone Bridge to Battery Class I	NL[4]	Municipal, Urban, CSOs	NL[4]	CSOs, Urban/ Storm[6] [7]

Notes:
(1) Causes of Impairment not related to CSO (e.g. contaminated sediment) are not shown in this table.
(2) 303(d) List Category 1 = Individual Waterbody Segments with Impairment Requiring TMDL Development.
(3) Category 4 Waters = Other impaired waterbody segments not listed because development of a TMDL is not necessary.
(4) NL = Waterbody not listed as impaired for this parameter.
(5) Footnote on 2016 303(d) list indicates that “A New York City CSO Abatement Program and NYCDEP Catch Basin Hooding Program are in place. Similar efforts to address floatables from New Jersey are necessary to restore water uses.”
(6) The draft 2018 303(d) list delists this waterbody for floatables, with a note indicating “the original listing was in error, impacts to best uses unknown.” The draft 2018 303(d) list has not been finalized as of the date of this LTCP.
(7) Footnote on the 2016 Category 4a list indicates that “These waters are being addressed under the NYC CSO Consent Order, which includes floatables control measures to address this impairment.”
(8) The draft 2018 4a/b/c Waters list delists this waterbody for pathogens, with a note indicating “Removed, due to reassessment, more recent data.” The draft 2018 303(d) list has not been finalized as of the date of this LTCP.

1.2.b Federal CSO Policy

The 1994 EPA CSO Control Policy provides guidance to permittees and to NPDES permitting authorities on the development and implementation of an LTCP in accordance with the provisions of the CWA. The CSO policy was first established in 1994, and was codified as Section 402(q) of the CWA in 2000.

1.2.c New York State Policies and Regulations

New York State has established WQS for all navigable waters within its jurisdiction. The current WQS classifications for the waterbodies covered under the Citywide/Open Waters LTCP are shown in Table **1-2**. The corresponding total and fecal coliform criteria for the non-coastal tributary waters and the *Enterococcus* criteria for the coastal recreational waters for primary contact recreation are set forth in 6 NYCRR Part 703. Additional details on water quality classifications and criteria are presented in Section 2.

The States of New York, New Jersey and Connecticut are signatories to the Tri-State Compact, which designated the Interstate Environmental District and created the Interstate Environmental Commission (IEC). The Interstate Environmental District includes all saline waters of greater NYC, including Citywide/Open Waters. The IEC was recently incorporated into, and is now part of, the New England Interstate Water Pollution Control Commission (NEIWPCC), a similar multi-state compact of which NYS is a member. The IEC Classifications of the waterbodies covered under the Citywide/Open Waters LTCP are presented in Figure 1-1. Details of the IEC Classifications are presented in Section 2.

1.2.d Administrative Consent Order

In 2005 NYC and DEC entered into a CSO Consent Order (DEC Case No: CO2-20000107-8), as modified and collectively referred to as the "CSO Order," to address CSOs in NYC. Among other requirements, the CSO Order requires DEP to evaluate and to implement CSO abatement strategies on an enforceable timetable for 18 waterbodies and, ultimately, for citywide long-term CSO control. Consistent with the 1994 EPA CSO Control Policy, the CSO Order also requires that DEP meet construction milestones and incorporate green infrastructure (GI) into the LTCP process, as proposed under the *NYC Green Infrastructure Plan*. In a separate MOU, DEP and DEC established a framework for coordinating LTCP development with WQS reviews in accordance with the 1994 CSO Control Policy.

Table 1-2. Classification and Best Uses of Waterbodies Addressed in the Citywide/Open Waters LTCP

Waterbody	Description	Water Quality Classification	Best Uses
Harlem River	Non-coastal tributary	I	Best usages are secondary contact recreation and fishing. Suitable for fish, shellfish and wildlife propagation, and survival.
Hudson River north of Harlem River	Primary Contact Recreational, non-coastal tributary	SB	Best usages are primary and secondary contact recreation and fishing. Suitable for fish, shellfish and wildlife propagation, and survival.
Hudson River south of Harlem River	Non-coastal tributary	I	Best usages are secondary contact recreation and fishing. Suitable for fish, shellfish and wildlife propagation, and survival.
Long Island Sound East of Throgs Neck Bridge	Coastal Primary Contact Recreational	SB	Best usages are primary and secondary contact recreation and fishing. Suitable for fish, shellfish and wildlife propagation, and survival.
East River between Whitestone Bridge and Throgs Neck Bridge	Primary Contact Recreational, non-coastal tributary	SB	Best usages are primary and secondary contact recreation and fishing. Suitable for fish, shellfish and wildlife propagation, and survival.
East River from Whitestone Bridge to Battery	Non-coastal tributary	I	Best usages are secondary contact recreation and fishing. Suitable for fish, shellfish and wildlife propagation, and survival.
Upper and Lower New York Bay	Coastal Primary Contact Recreational	SB	Best usages are primary and secondary contact recreation and fishing. Suitable for fish, shellfish and wildlife propagation, and survival.
Kill Van Kull	Non-coastal tributary	SD	Best usage is fishing. Suitable for fish, shellfish and wildlife survival. Waters with natural or man-made conditions that cannot meet the requirements for fish propagation.
Arthur Kill, from Kill Van Kull to Outerbridge Crossing	Non-coastal tributary	SD	Best usage is fishing. Suitable for fish, shellfish and wildlife survival. Waters with natural or man-made conditions that cannot meet the requirements for fish propagation.
Arthur Kill, from Outerbridge Crossing to southern tip of Staten Island	Non-coastal tributary	I	Best usages are secondary contact recreation and fishing. Suitable for fish, shellfish and wildlife propagation and survival.

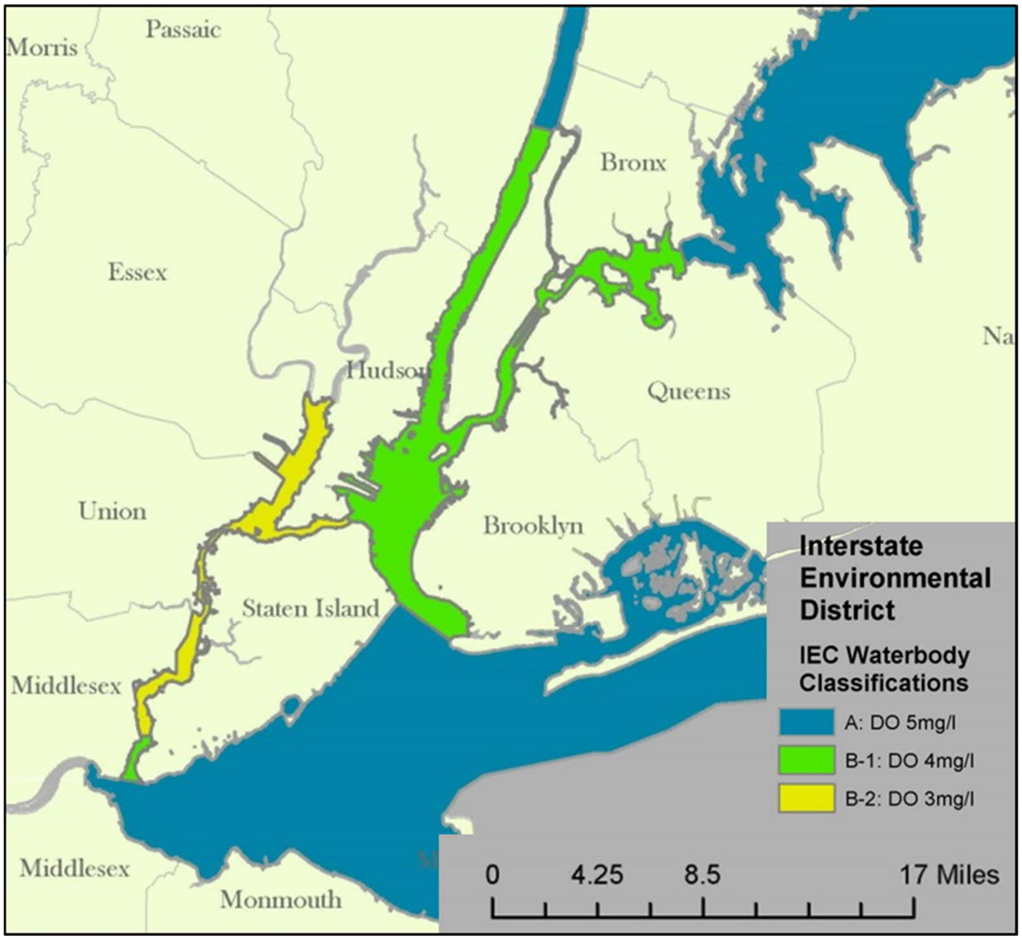


Figure 1-1. Interstate Environmental Commission Water Quality Classifications

1.3 LTCP Planning Approach

LTCP planning includes several phases. The first is the characterization phase – an assessment of current waterbody and watershed characteristics, system operation and management practices, green and grey infrastructure projects, and system performance. DEP gathers the majority of this information from field observations, historical records, analyses of studies and reports, and collection of new data. The next phase identifies and analyzes alternatives to reduce the amount and frequency of wet-weather discharges and to improve water quality. Alternatives may include a combination of green and grey infrastructure elements that are carefully evaluated using both the collection system and receiving water models. After analyzing alternatives, DEP develops a recommended plan, along with an implementation schedule and strategy. If the proposed alternative does not achieve existing WQS or the Section 101(a)(2) goals of CWA, an LTCP also includes a Use Attainability Analysis (UAA) or variance, as appropriate, examining whether applicable waterbody classifications, criteria, or standards should be adjusted by DEC.

1.3.a Integrate Current CSO Controls from Waterbody/Watershed Facility Plans (Facility Plans)

This LTCP integrates and builds upon DEP's prior efforts by capturing the findings and recommendations from the previous facility planning documents for this watershed, including the waterbody/watershed facility plans (WWFP).

In June 2007, DEP submitted the East River and Open Waters Waterbody/Watershed Facility Plan Report to DEC. The report recommended a series of projects focusing on maximizing the utilization of the existing collection system infrastructure and treatment of combined sewage at the City-owned Wastewater Resource Recovery Facilities (WRRFs). Although this WWFP was not approved by DEC, a number of grey infrastructure projects were implemented that resulted in reductions in combined sewer overflows to the Citywide/Open Waters waterbodies. These projects included the following (see Section 4 for further descriptions of these projects):

- Wards Island WRRF Headworks
- Bowery Bay WRRF Headworks
- Hunts Point WRRF Headworks
- Tallman Island WRRF Headworks
- North River WRRF Headworks
- Port Richmond WRRF Throttling Facility
- Tallman Island Conveyance
- Outer Harbor CSO Regulator Improvements
- Inner Harbor In-Line Storage

1.3.b Coordination with DEC

As part of the LTCP process, DEP works closely with DEC to share ideas, track progress, and work toward developing strategies and solutions to address wet-weather challenges for the Citywide/Open Waters LTCP.

DEP shared the Citywide/Open Waters alternatives and held discussions with DEC on the formulation of various control measures, and coordinated public meetings and other stakeholder presentations with DEC. DEP also submitted a monthly report on the Citywide/Open Waters LTCP and posted it on the DEP website. On a quarterly basis, DEC, DEP, and outside technical consultants also convened for larger progress meetings that typically include technical staff and representatives from DEP and DEC's Legal Departments and Department Chiefs who oversee the execution of the CSO program. Additionally, DEP held topic-specific technical meetings with DEC to discuss various aspects of the development of the LTCP.

1.3.c Watershed Planning

DEP prepared its CSO WWFPs before the emergence of GI as an established method for reducing stormwater runoff. Consequently, the WWFPs did not include a full analysis of GI alternatives for controlling CSOs. In comments on DEP's CSO WWFPs, community and environmental groups voiced widespread support for GI, urging DEP to rely more heavily upon that sustainable strategy. In September 2010, DEP published the *NYC Green Infrastructure Plan* (GI Plan). Consistent with the GI Plan, the CSO Order requires DEP to analyze the use of GI in LTCP development. This sustainable approach includes the management of stormwater at its source through the creation of vegetated areas, bluebelts and greenstreets, green parking lots, green roofs, and other technologies. Details of the DEP Green Infrastructure Program are presented in Section 5.

1.3.d Public Participation Efforts

DEP made a concerted effort during the Citywide/Open Waters LTCP planning process to involve relevant and interested stakeholders, and to keep interested parties informed about the project. Specific objectives of this initiative include the following:

- Develop and implement an approach that would reach interested stakeholders;
- Integrate the public outreach efforts with other aspects of the planning process; and
- Take advantage of other ongoing public efforts being conducted by DEP and other NYC agencies as part of related programs.

The public participation efforts for the Citywide/Open Waters LTCP are summarized in Section 7.

2.0 WATERSHED/WATERBODY CHARACTERISTICS

This section summarizes the major characteristics of the Harlem River, Hudson River, East River/Long Island Sound, Upper and Lower New York Bay, Arthur Kill, and Kill Van Kull watersheds and waterbodies. This section is organized into the following subsections:

- 2.1 – Harlem River HAR
- 2.2 – Hudson River HUD
- 2.3 – East River/Long Island Sound ER/LIS
- 2.4 – Upper/Lower New York Bay NYB
- 2.5 – Arthur Kill and Kill Van Kull AK/KVK

Given the volume of material and length of this section, icons are included in the page headers to key the reader to the specific waterbody being addressed on the page. The icons for each waterbody are shown above. Material that is common to more than one waterbody, such as the description of water quality standards, or the descriptions of Water Resources Recovery Facilities (WRRFs) that have CSO outfalls that discharge to more than one waterbody, is presented once in the sections below. Where the topic is encountered in the subsections for subsequent waterbodies, the reader is referred back to the earlier section where the relevant information is presented.

2.1 Harlem River HAR

This section summarizes the major characteristics of the Harlem River watershed and waterbody, building upon earlier documents that characterized the area. Section 2.1.a addresses watershed characteristics and Section 2.1.b addresses waterbody characteristics.

2.1.a Watershed Characteristics

The Harlem River watershed is highly urbanized and is primarily composed of residential areas with some commercial, industrial, institutional, and open space/outdoor recreation areas within the Boroughs of Bronx and Manhattan, NY. The most notable outdoor recreation areas within this watershed include the federally owned Gateway National Recreation Area and City-owned parks such as Randall's Island Park, Wards Island Park, Inwood Hill Park, and the Harlem River Park and Greenway.

This subsection presents a summary of the watershed characteristics as they relate to the land use, zoning, permitted discharges and their characteristics, sewer system configuration, performance, and impacts to the adjacent waterbodies, as well as the modeled representation of the collection system used to analyze system performance and CSO control alternatives.

2.1.a.1 Description of Watershed/Sewershed

The Harlem River is an eight-mile long, navigable tidal channel which separates Manhattan from the Bronx, and connects the Hudson River to the East River (Figure 2.1-1).

Typically, the watershed of a body of water is delineated by the topography of the surrounding area. Overland flows from rainfall or snow melt flows from topographic high points down to the receiving waterbody. However, the sewer system that has been constructed in the Harlem River watershed has altered the natural flow path within the watershed by intercepting and diverting flow that would normally drain to the River. The land area that is actually tributary to Harlem River is the area served by combined and separate storm sewer systems that collect and convey sanitary wastewater and stormwater. This flow is eventually discharged to Harlem River as combined sewer overflow, stormwater, and treated wastewater. This area is referred to as the sewershed, and for the Harlem River, the sewershed is approximately 9,674 acres, all in New York City. Since the sewershed defines the limits of the combined sewer tributary area, this LTCP focuses on the sewershed of the Harlem River. The Harlem River sewershed is shown in Figure 2.1-1.

The Harlem River has been modified over the last 150 years by dredging and filling activities that have altered islands and shorelines, bulkheading to stabilize and protect shorelines, dredging of channels and borrow areas that have altered bottom contours and flow patterns, and the filling of natural tributaries. These activities have eradicated natural habitats, negatively affected water quality, and modified the rich ecosystem that characterized the Harlem River up until the mid-nineteenth century.

The urbanization of NYC and the Harlem River sewershed has led to the creation of large combined sewer systems (CSS), as well as areas of separate and direct drainage, primarily in areas adjacent to the Harlem River. Parts of the collection systems of two WRRFs are located within the Harlem River sewershed: Wards Island (275 MGD design dry-weather flow [DDWF]), and North River (170 MGD DDWF). These WRRFs are permitted pursuant to DEC-issued SPDES permits. During dry-weather, the combined and sanitary sewer systems convey sewage to the WRRFs for treatment. During wet-weather, combined storm and sanitary flow is conveyed by the sewer system to the WRRFs. If the sewer system or WRRF is at full capacity, a diluted mixture of combined storm and sanitary flow may discharge through one or more of the 65 SPDES-permitted CSO outfalls to the Harlem River. No MS4 outfalls are located along the Harlem River. The locations of the WRRFs are shown in Figure 2.1-1. Figure 2.1-2 shows the locations of the CSO outfalls along the Harlem River, along with the delineations of the combined sewer area, separate stormwater area, and direct drainage area.

Several large transportation corridors cross the Harlem River sewershed. The major east/west transportation corridor is the Cross Bronx Expressway (Interstate I-95). The major north/south transportation corridors include Harlem River Drive, the Major Deegan Expressway (Interstate I -87), and Broadway (Route 9). The Spuyten Duyvil Station of the Metro-North Railroad and the A, B, C, D, 1, 2, 3, 4, 5, and 6 subway lines also traverse the sewershed. These transportation corridors limit access to some portions of the waterbody and are taken into consideration when developing CSO control solutions. These features are shown in Figure 2.1-3.

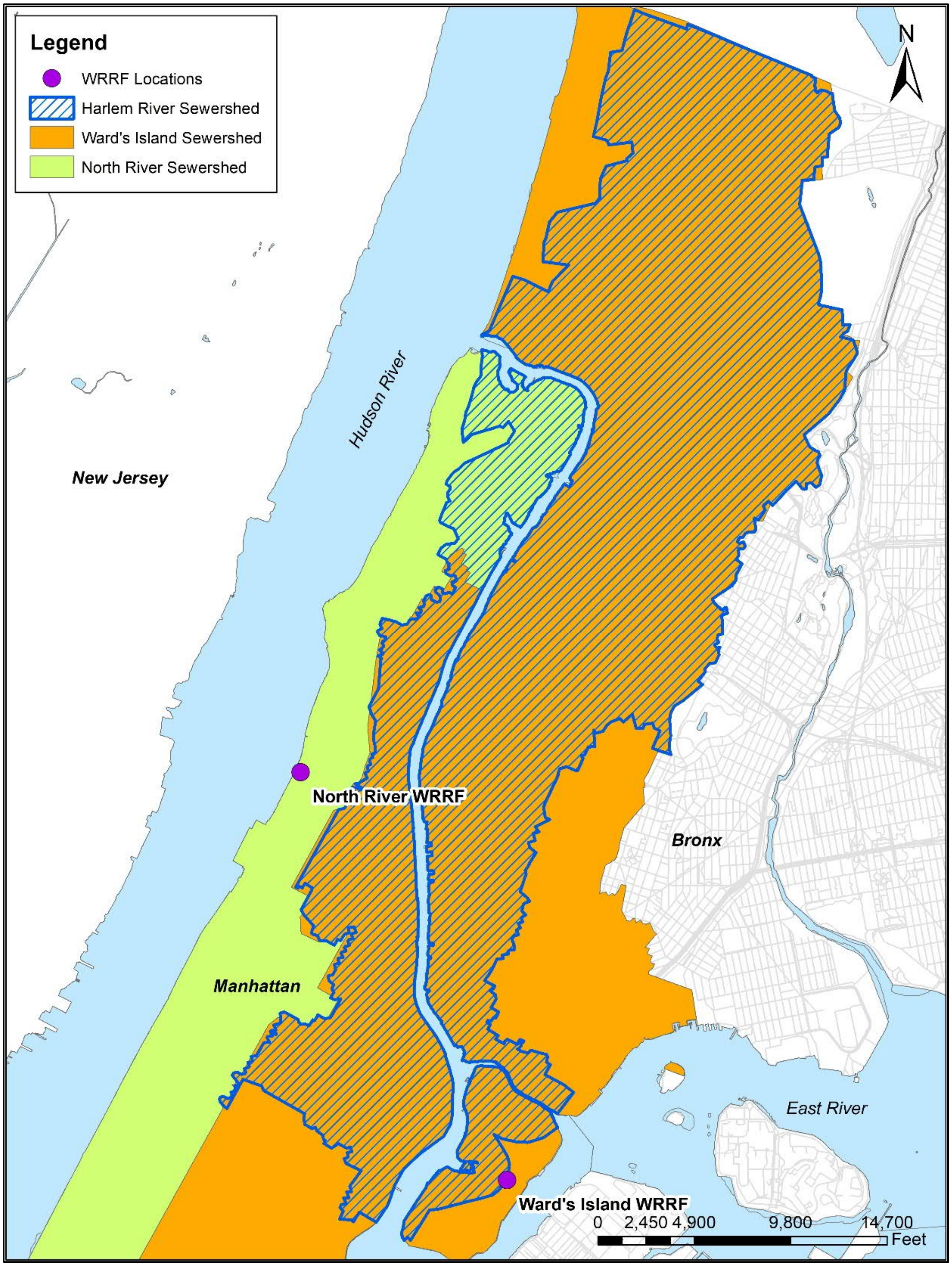


Figure 2.1-1. Harlem River Watershed

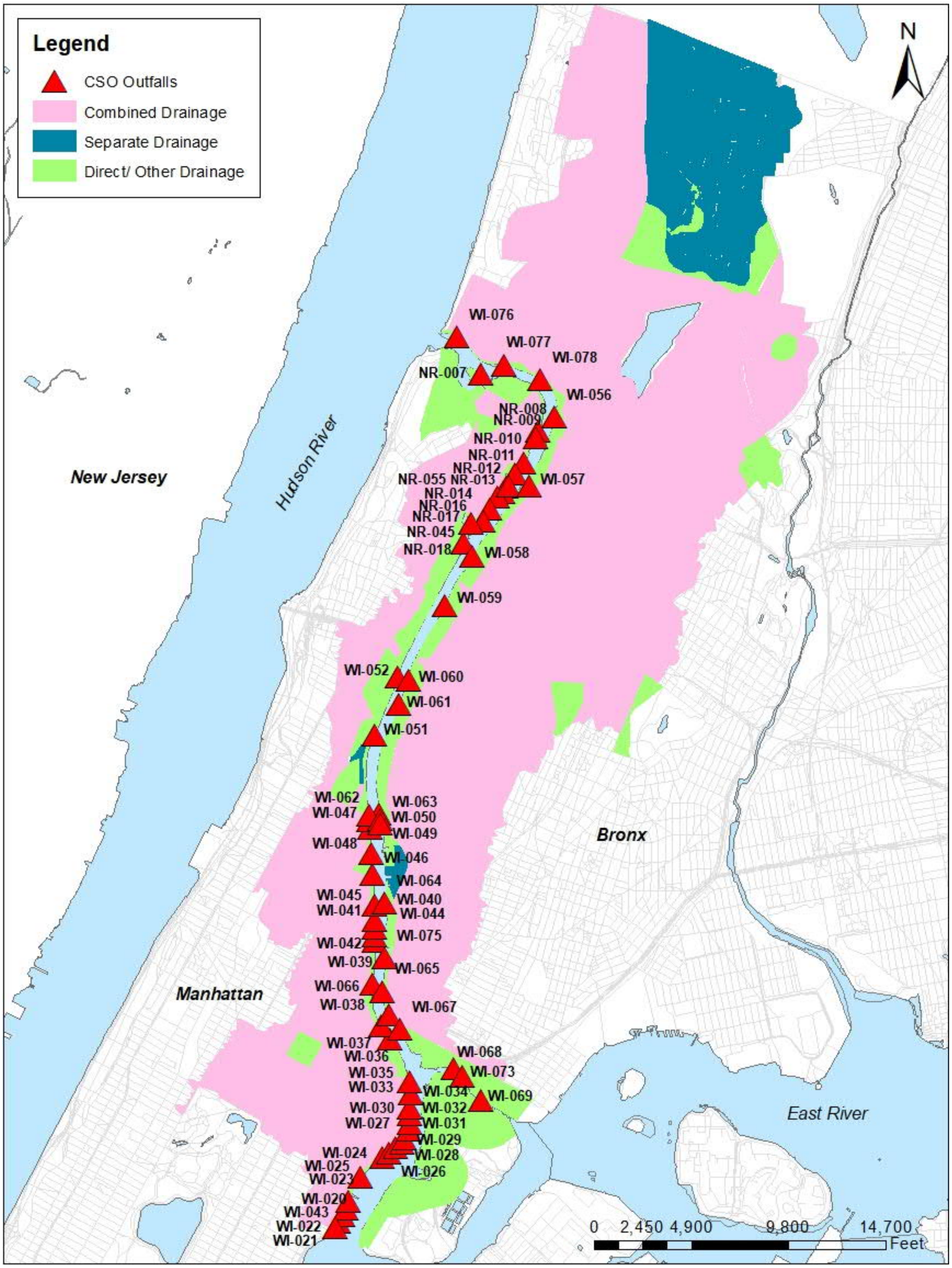


Figure 2.1-2. Components of the Harlem River Sewershed

Figure 2.1-3. Major Transportation Features

Existing and Future Land Use and Zoning

The current land use in the Harlem River sewershed has a substantial effect on water quality, as well as the volume, frequency, and timing of combined sewer overflows. The presence of hard structures, roads, parking lots, and other impervious surfaces alongside parkland, undeveloped open space, and other vegetated pervious surfaces creates a complex runoff dynamic. The current land use is largely attributable to historical urbanization and development within the sewershed. Future use and development is controlled by zoning, land use proposals, and evolving land use policies.

Table 2.1-1 summarizes the land use characteristics of the overall Harlem River sewershed area, as well as the riparian area within a quarter-mile radius of the River. The locations of the existing land uses within the overall Harlem River sewershed are shown in Figure 2.1-4.

Table 2.1-1. Existing Land Use within the Harlem River Sewershed

Land Use Category	Percent of Area	
	Within Sewershed	Within 1/4-mile of Shoreline
Residential	33.3	22.1
Mixed Residential and Commercial	5.0	4.5
Commercial and Office	4.2	3.2
Industrial and Manufacturing	2.3	4.4
Transportation and Utility	6.1	15.3
Public Facilities and Institutions	12.5	8.9
Open Space and Outdoor Recreation	30.8	32.7
Parking Facilities	2.7	3.9
Vacant Land	2.5	3.5
Unknown	0.6	1.5

As indicated in Table 2.1-1, approximately 33 percent of the total Harlem River sewershed area consists of residential uses with primarily multi-family housing. Open space and recreation makes up 31 percent of the uses within the sewershed, largely due to the numerous City parks which cover a significant fraction of area. The sewershed also includes one State park (Roberto Clemente State Park) and one private park (the Cambell Sports Center/Muscota Marsh). The Inwood Hill Park (NYC Department of Parks and Recreation [DPR]) is the largest park in the Harlem River sewershed, consisting of approximately 194 acres. Approximately 13 percent of the uses in the watershed consists of public facilities and institutions while the remaining 23 percent is mixed-use, transportation, utility, industrial, manufacturing, office and commercial, and vacant or other uses.

Within the riparian areas immediately surrounding the Harlem River (including all blocks which are wholly or partially within a quarter-mile of the River), the uses are dominated by open space and recreation (33 percent), residential (22 percent), and transportation (15 percent). Major transportation uses include the NYC Subway 207th Street Train Yards in Inwood, and the Metro-North Railroad that runs along the entire western shoreline of the River. The Metro-North Railroad has several train stations and rail yards along the Harlem River, including the Harlem River Yards and the Highbridge Yards. The remaining 30 percent of the riparian area is a mix of various uses including public facilities and institutions, commercial, and industrial and manufacturing, and other uses.

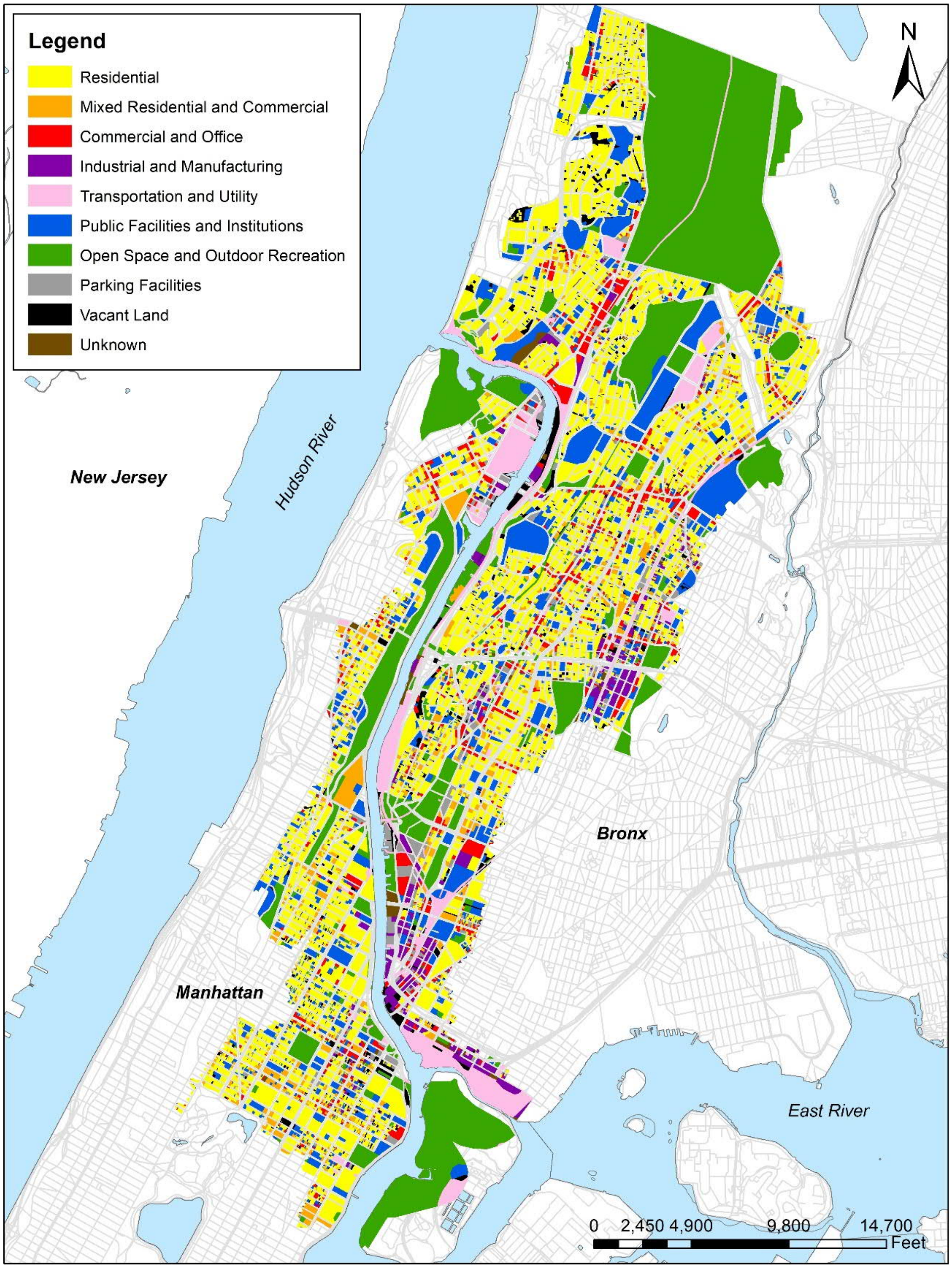


Figure 2.1-4. Land Use in the Harlem River Sewershed

The Zoning Resolution of NYC regulates the size of buildings and other properties, the density of populations, and the locations that trades, industries, and other activities are allowed within NYC limits. The Resolution divides the zoning categories into districts with use, bulk, and other controls. Residential districts are defined by the allowable density of housing, lot widths, and setbacks. A higher number generally indicates higher allowable density (e.g., single-family detached districts are designated R1 and R2, while R8 and R10 allow higher density apartment buildings). Commercial districts are defined by usage type such that local retail districts (C1) are distinguished from more regional commercial activities (C8). Manufacturing districts are defined based on their impact on sensitive neighboring districts to ensure that heavy manufacturing (M3) is buffered from residential areas by lighter manufacturing districts (M1 and M2) that have higher performance levels and fewer objectionable influences.

Figure 2.1-5 presents a map of the established zoning within the riparian areas surrounding the Harlem River. Approximately 43 percent of the riparian area surrounding the Harlem River is zoned as residential with the majority (95 percent) being R5, R6, or R7 zones. Park property covers about 31 percent of the zoning within the riparian area and nearly 19 percent cover manufacturing zones.

Similar to the riparian area, the overall Harlem River watershed is dominated by residential (57 percent) and park property (30 percent) zoning. Within the residential classification, 73 percent of the area is medium density housing consisting of R5, R6, and R7 districts. Low density residential districts including R1, R2, R3, and R4 districts account for approximately 13 percent of the residential zoning and high-density residential districts, and R8 or higher make up approximately 14 percent of residential zoning within the sewershed. Nearly 19 percent of the sewershed is covered by manufacturing zones while the remaining 8 percent is commercial and mixed zoning.

New York City Department of City Planning (DCP) has designated the entire Harlem River sewershed as within the Coastal Zone Boundary under the Waterfront Revitalization Program (WRP). In addition, the southern reach of the sewershed at the Bronx Kill is designated as within the South Bronx Significant Maritime and Industrial Areas (SMIA). As defined by DCP, a SMIA is especially valuable as an industrial area and working waterfront. A priority policy of the WRP is to promote water-dependent and industrial uses within these SMIAs. The WRP has also identified several recognized ecological complexes (RECs) within the Harlem River watershed, including Spuyten Duyvil, Inwood Park, Boathouse Marsh, Sherman Creek, Highbridge Park, and Little Hell Gate Wetlands. RECs are clusters of valuable natural features which are more fragmented than those in a significant natural waterfront area (SNWA) and are often scattered within developed areas. A WRP priority policy is to identify, remediate, and restore ecological functions within these areas.

In addition to the standard zoning classifications, 10 “Special Use Districts” are located within the Harlem River sewershed. Special use districts are defined within the Zoning Resolution as areas designated “to achieve the specific planning and urban design objectives in areas with unique characteristics”. The following Special Use Districts are located within the Harlem River sewershed:

- The *Harlem River Waterfront District* is located along the east bank of the Harlem River and is generally bounded by 149th Street to the north, Exterior Street to the east, and Lincoln Avenue to the south, as shown in Figure 2.1-6. As indicated in Figure 2.1-6, an expansion is proposed to this district. This Special Use District supports the revitalization of this area into a vibrant, mixed-use, mixed-income neighborhood while retaining viable light industry and promoting orderly waterfront development in accordance with the Waterfront Access Plan.

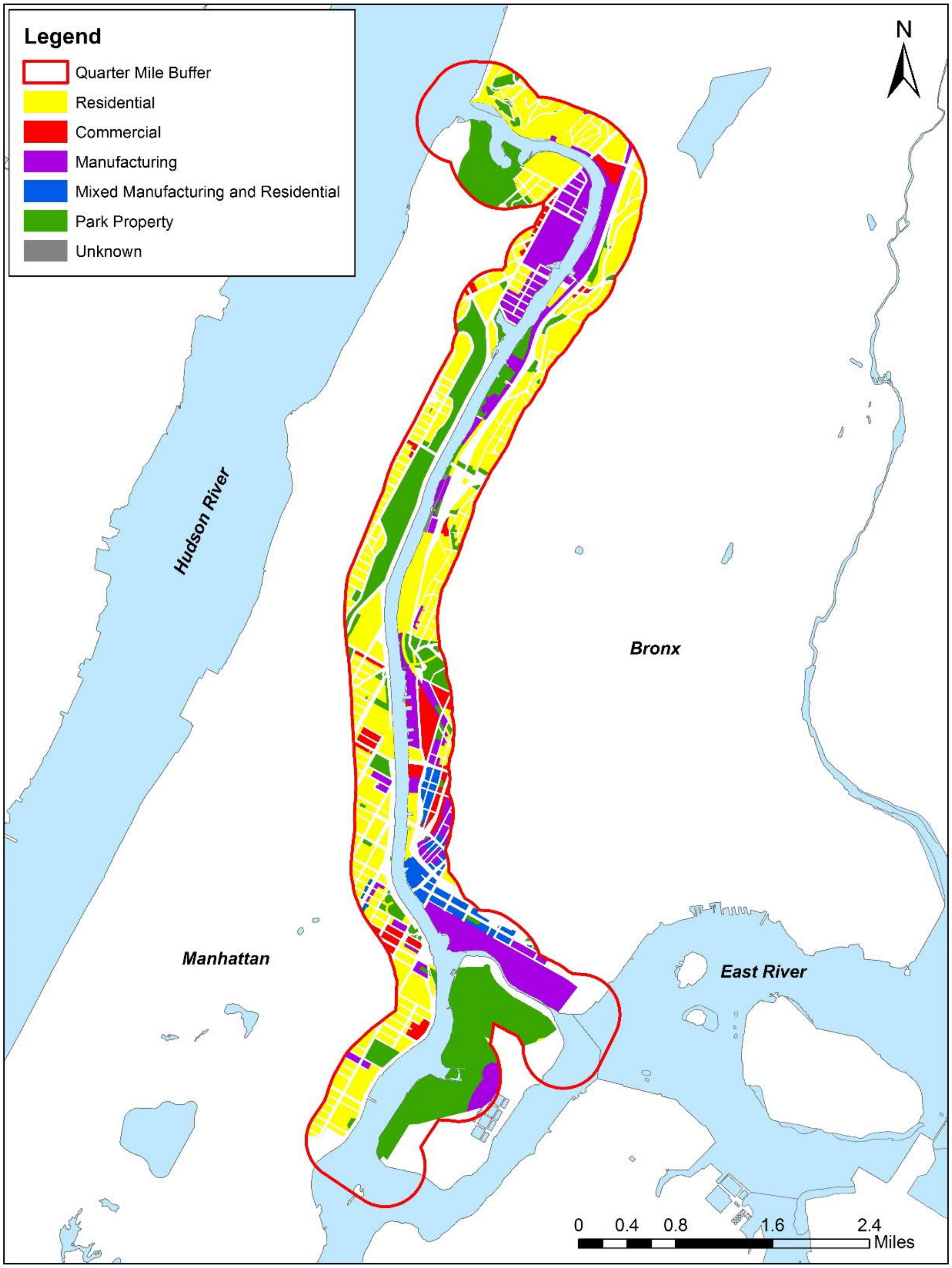


Figure 2.1-5. Zoning within 1/4 Mile of Shoreline

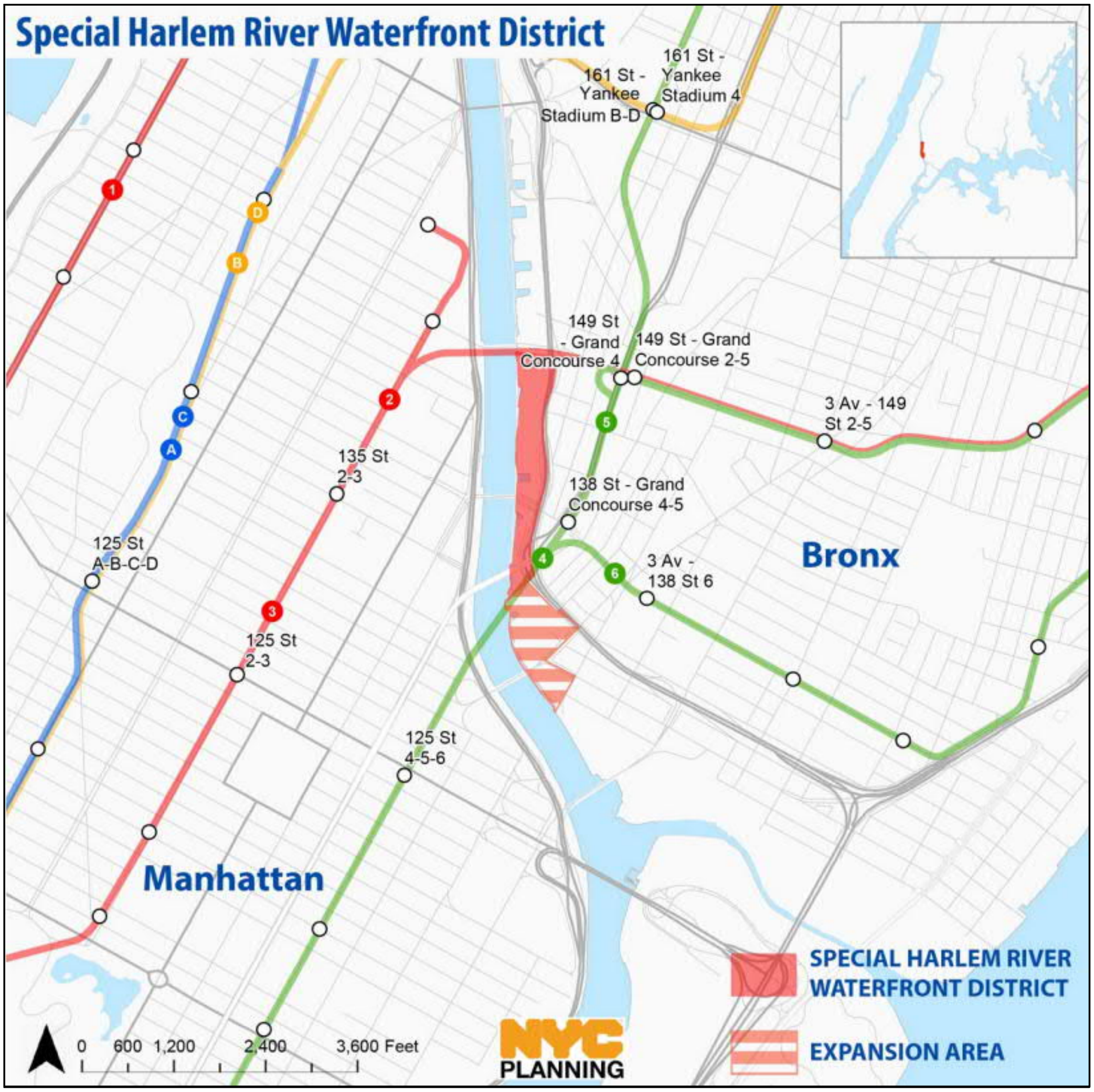


Figure 2.1-6. Special Harlem River Waterfront District

- The *Grand Concourse Preservation District* was created to protect the distinctive art deco composition and scale of the apartment buildings that line the boulevard extending from East 151st Street to Mosholu Parkway. The district includes a Residential Preservation Area and three commercial areas where retail uses do not conflict with the traditional residential character.

- The *125th Street District* is part of a City initiative to support and enhance Harlem's "Main Street" as a major arts/entertainment destination and regional business district. The intent is to generate new mixed-use development while protecting the scale of the 125th Street corridor's commercial and historic rowhouse areas by establishing street walls and height limits. Regulations restrict the amount of ground-floor street frontage that may be occupied by banks, office and residential lobbies, and other non-active uses. Additionally, the district requires the inclusion of arts and entertainment uses for developments over a certain size. The district also establishes an innovative art bonus to provide an incentive for the creation of nonprofit visual or performing arts spaces.

- *Mixed Use Districts 1, 13, and 14* (Port Morris, Lower Concourse, and Third Avenue/Tremont Avenue) were established to encourage investment in, and enhance the vitality of, existing neighborhoods with mixed residential and industrial uses in close proximity and to create expanded opportunities for mixed-use communities.

- *Natural Area District 2* (Riverdale, Sputen Duyvil, and Fieldston) guides new development and site alterations in areas that have unique natural characteristics, including forests, rock outcrops, steep slopes, creeks, and a variety of botanic and aquatic environments. These natural features are protected by limiting modifications in topography and by encouraging clustered development.

- The *Planned Community Preservation District* protects the unique character of communities that have been planned and developed as a unit. Those communities characteristically have large landscaped open spaces and a superior relationship of buildings, open spaces, commercial uses, and pedestrian and vehicular circulation. No demolition, new development, enlargement or alteration of landscaping or topography is permitted within this district except by special permit.

- The *Park Improvement District* was created to preserve the residential character and architectural quality of Fifth and Park Avenues from East 59th Street to East 111th Street. It limits the height of new buildings to 210 feet or 19 stories and mandates street wall continuity.

Plans for significant development and redevelopment within the Harlem River sewershed include the following:

- The *Jerome Avenue Neighborhood Plan* calls for rezoning an approximately 92-block area which spans 151 acres along Jerome Avenue and is bounded by East 165th Street to the south and 184th Street to the north. The Plan will create opportunities for new affordable housing and community facilities including a new park, establish Mandatory Inclusionary Housing, diversify area retail, support small businesses, and promote a safe and walkable pedestrian area. This Plan would also involve the creation of a new Special Use District called the "Special Jerome Avenue District" to regulate irregular lots, control ground-floor uses, curb cuts, and transparency, and to regulate transient hotels.

- The *East Harlem Neighborhood Study* is a comprehensive, community-focused effort that will identify opportunities for the creation of new mixed-income housing and the preservation of existing affordable units, and will identify complementary initiatives to address key community wellness, infrastructure, economic development, and workforce issues.

- The *Inwood NYC Planning Initiative* is a comprehensive plan that involves rezoning and land use actions to ensure that Inwood remains an affordable, attractive neighborhood for working and immigrant families. The Plan will also serve to restore parks and create waterfront accessibility and provide new STEM opportunities and support small businesses.

- The *East 126th Street Bus Depot Memorial and Mixed Use Project* focuses on the former MTA bus depot in East Harlem, which was once the site of an African burial ground dating back to the seventeenth century. This redevelopment project will create a living memorial and cultural center that acknowledges the historical significance of the site and will include a mixed-use component with housing, commercial uses, and public open spaces to meet the needs of the East Harlem community.

- The *Harlem River Yards Redevelopment* is a plan to redevelop the 12.8-acre train yard with mixed-use development and NYC's first soccer stadium. The $700M project would include 550 affordable apartments, a 25,000 square-foot medical facility, 150,000 square-feet of retail, and an 85,000-square-foot waterfront park.

- The *Kingsbridge Armory* has been vacant since 1996 and occupies a full City block. It is currently being redeveloped into the Kingsbridge National Ice Center, a 750,000 square-foot ice sports facility, which will feature nine year-round indoor ice rinks and a 5,000-seat feature rink for major ice hockey and skating events.

- The *South Bronx Initiative Plan* aims to build upon the South Bronx's existing assets and potential to enhance and sustain revitalized neighborhoods that include affordable housing, vibrant commercial districts, improved streetscapes, public spaces, and parks, a publicly accessible waterfront, an efficient transportation network, and a diverse economy. The Plan is focused on three areas with opportunities for growth, including the Bronx Civic Center, Melrose Commons/ Third Avenue, and the Lower Grand Concourse:

    - The Bronx Civic Center focus area was rezoned to encourage high-density commercial and residential housing, and transportation improvements were targeted to improve mobility. This initiative also aims to improve streetscapes and public spaces and develop City-owned sites along River Avenue into a mixed-use space.

    - The goal for the Melrose Commons/Third Avenue focus area is to create an attractive, mixed-income, urban village with balanced neighborhood, retail, new parks, open spaces, and a college campus. This initiative will aim to develop City-owned vacant lots into affordable housing and ground-floor retail, strengthen retail corridors, reconfigure key intersections, and create or enhance parks and open spaces.

    - The Lower Grand Concourse focus area would retain industry and jobs for local residents while supporting new residential development, retail, grocery stores, and public waterfront access and open space.

- The DCP's *Waterfront Revitalization Program* establishes policies for development and use of the waterfront. The goal of the program is to maximize benefits from economic development, environmental conservation, and public use of the waterfront, while minimizing any potential conflicts among these objectives.

- The DCP's *Vision 2020 Comprehensive Waterfront Plan* builds on NYC's success in opening up to the public miles of shoreline that had been inaccessible for decades, and supporting expansion of the maritime industry (DEP, 2010c). Vision 2020 set the stage for expanded use of waterfront parks, use of waterways for transportation, housing and economic development, and recreation and natural habitats. The 10-year Plan lays out a vision for the future with new citywide policies and site-specific recommendations. The Harlem River spans Reaches 5, 6, and 7 within the Vision 2020 Plan and consists of 10 site-specific waterfront revitalization strategies (see Figure 2.1-7 through Figure 2.1-9).

Impervious Cover Analysis

Impervious surfaces within a watershed are characterized by a hard surface that prevents rainfall infiltration, such as concrete, asphalt, rock, or rooftop. Some of the rainfall that lands on an impervious surface will remain on the surface via ponding, and will evaporate. The remaining rainfall volume becomes overland runoff that may flow directly into the CSS or into a separate stormwater system, may flow to a pervious area and soak into the ground, or may flow directly to a waterbody. The percentage of impervious surface that is directly connected to the CSS is an important parameter in the characterization of a watershed and in the development of hydraulic models used to simulate CSS performance.

A representation of the impervious cover was made in the 2007 versions of the models for the 13 NYC WRRFs that serve combined watersheds to support the WWFPs that were submitted to DEC in the period 2009-2011. Efforts to update the models and the impervious surface representation concluded in 2012.

As DEP began to focus on the use of GI to manage stormwater runoff by either slowing it down prior to entering the combined sewer network, or preventing it from entering the network entirely, it became clear that a more detailed evaluation of the impervious cover would be beneficial. In addition, DEP determined that the distinction between impervious surfaces that introduce storm runoff directly to the sewer system (Directly Connected Impervious Areas [DCIA]) and impervious surfaces that may not contribute runoff directly to the sewers was important. For example, a rooftop with drains directly connected to the combined sewers (as required by the NYC Plumbing Code) would be an impervious surface that is directly connected. However, a sidewalk or impervious surface adjacent to parkland might not contribute runoff to the CSS and, as such, would not be considered directly connected.

In 2009 and 2010, DEP invested in the development of high quality satellite measurements of impervious surfaces to support analyses that improved the differentiation between pervious and impervious surfaces, and further differentiated the types of impervious surfaces. Flow meter data were then used to estimate the DCIA. The data and the approach used are described in detail in the InfoWorks CS^{TM} (IW) Citywide Model Recalibration Report (DEP, 2012a). These efforts resulted in an updated model representation of the areas that contribute runoff to the CSS. This improved set of data aided in model recalibration, and allowed for better deployment of GI projects to reduce runoff from impervious surfaces that contribute flow to the CSS.

Neighborhood Strategies

Hudson Riverfront

- Improve access to the waterfront through enhanced streetscape, more lighting, better signage, and more wayfinding.
- Examine opportunities for enhanced overlooks of the waterfront.

W.125th St. to W.145th St. 1

- Find appropriate use for the dormant marine transfer station at W. 135th St., including public access.
- Explore mapping as parkland West Harlem Piers Park and the North River Sewage Treatment Plant access road areas.

165th St. to Dyckman 2

- Provide improved pedestrian and bicycle access to the waterfront, including improvements to Manhattan Waterfront Greenway.
- Examine use of sand beach as a kayak launch at 170th St. and use of 178th St. as a site for storage container based on criteria described in the Citywide Strategy.
- Work with DDC to ensure that the planned re-construction of the pedestrian bridge at W. 181st St. maximizes connections to the waterfront.
- Construct pedestrian bridge and multi-use path at Fort Washington Park.

Dyckman St. Marina 2.a

- Complete improvements to marina, including repair and replacement of floating docks (consistent with the criteria described in the Citywide Strategy), construction of restaurant, snack bar and restrooms, and stormwater treatment wetland.

Inwood Hill Park 3

- Restore the inlet as natural wetland and habitat.

Harlem River

- Explore opportunities to reduce wave action to promote recreational boating and limit shoreline erosion.

Baker Field 4

- Support Boathouse Marsh project which will provide additional public waterfront access, passive recreation spaces, new fresh and salt water wetlands, and expanded water-related educational opportunities, consistent with the criteria described in the Citywide Strategy.

W. 215th St. & W. 216th St. 5

- Provide street-end waterfront parks and explore possible remediation of natural environment.

Sherman Creek 6

- Study for redevelopment possibilities, including publicly oriented water-dependent uses.
- Enhance natural habitat and wetlands.
- Complete the Sherman Creek Waterfront Esplanade Master Plan to reclaim the Harlem River waterfront from Sherman Creek Inlet to W. 208th St.
- Provide waterfront access via 9th Ave. at wedge-shaped property at 208th St. and ensure tidal mudflat preservation.
- Examine 207th St. as a site for kayak storage container based on criteria described in the in the Citywide Strategy.

Harlem River Speedway 7

- Improve maintenance, signage and wayfinding throughout the Harlem River Speedway (especially at southern entrance).

High Bridge, E.173rd St. 7.a

- Restore the High Bridge over the Harlem River, and restore access paths within Highbridge Park to improve connectivity between Northern Manhattan and the Bronx.

E. 125th St. to E. 145th St. 8

- Complete greenway connection to Harlem River Park at E. 135th St.
- Improve upland connections between the existing park and the future waterfront esplanade.
- Consider future uses for DOT staging area.
- Examine opportunities for water access, kayak launch, storage, and a community paddling program based on criteria described in the in the Citywide Strategy.

REACH 5-*NORTHERN MANHATTAN*

Figure 2.1-7. NYCDCP Vision 2020 Comprehensive Waterfront Plan – Reach 5

Neighborhood Strategies

Reachwide

- Implement creation of Putnam Greenway along existing rail right-of-way and identify opportunities to create continuous connections from Westchester County to Port Morris.

Hudson River Waterfront (1)

- Support the study and the implementation of Hudson River Greenway Link providing bicycle and pedestrian connectivity from Manhattan to Yonkers with access to the waterfront.
- Work with NY Central Railroad to provide safe access to Hudson River shoreline.
- Mitigate stormwater eroding Riverdale Park slopes.
- Develop long-term sediment removal maintenance plan with DEP Bluebelt program.

Spuyten Duyvil (2)

- Restore shoreline at unmanaged open space at mouth of Harlem River adjacent to Spuyten Duyvil train station.

Marble Hill (3)

- Coordinate with DEP in long term plan to daylight Tibbets Brook.

North of University Heights Bridge (4.a)

- Create a Waterfront Access Plan (WAP) to promote the redevelopment of this area, including the creation of Regatta Park.
- Explore opportunities for provision of recreational boating access based on the criteria described in the Citywide Strategy.

South of University Heights Bridge (4.b)

- Study redevelopment potential for residential or parkland to connect to Roberto Clemente State Park to the south and the Regatta Park to the north.
- Explore opportunities for boat launch based on the criteria described in the Citywide Strategy.

Depot Place / Harlem River Promenade (5)

- Improve access to waterfront by creating upland connections with appropriate crossings.
- Explore public recreational opportunities on City-owned site and on privately owned site.
- Restore the shoreline from the Highbridge to Roberto Clemente State Park.

Highbridge (5.a)

- Develop access point to Manhattan through rehab of the Highbridge.

Ped. Bridge over Major Deegan at 161st St. (6)

- Improve connectivity to Mill Pond Park over the Major Deegan pedestrian bridge by removing barriers impeding pedestrian crossing.

Harlem River

- Explore opportunities to reduce wave action to promote recreational boating and limit shoreline erosion.
- Identify locations to develop pedestrian upland connections to the waterfront.
- Identify an appropriate location for an environmental education center along the Harlem River.

REACH 6-*NORTHWEST BRONX*

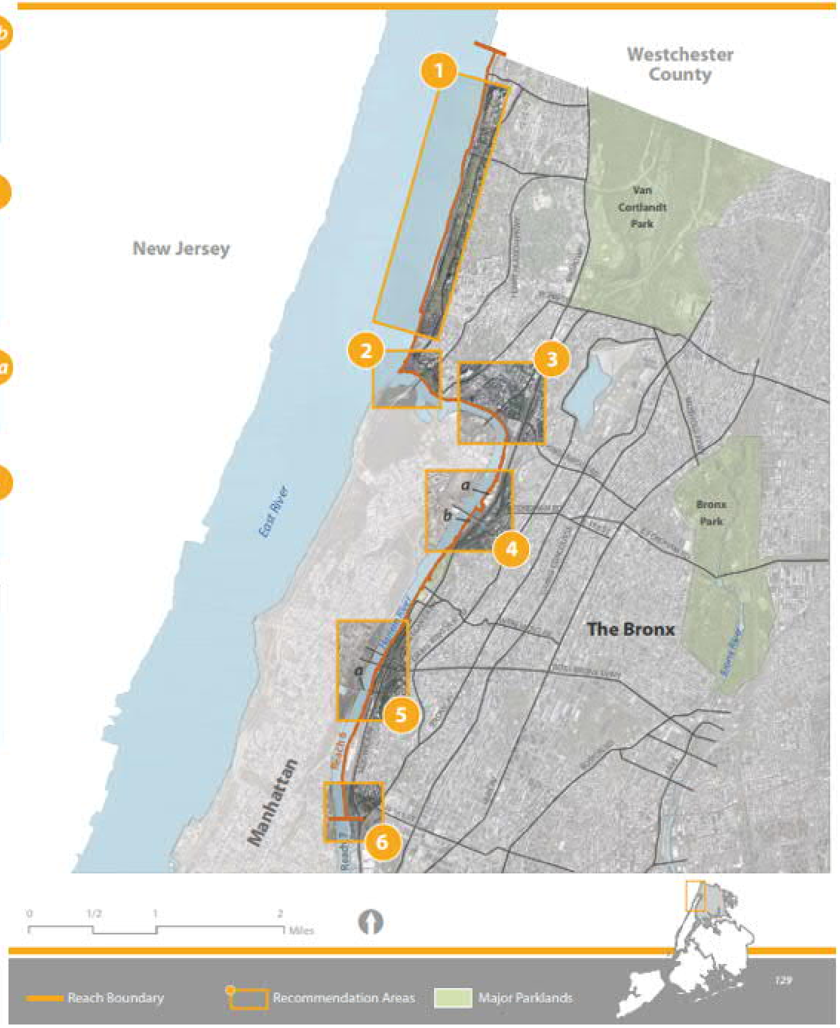


Figure 2.1-8. NYCDCP Vision 2020 Comprehensive Waterfront Plan – Reach 6

Neighborhood Strategies

Harlem River

- Explore opportunities to reduce wave action to promote recreational boating and limit shoreline erosion.

Lower Concourse / Harlem River WAP (1)

- Support the development of Lower Concourse Mixed Use Area and Special Waterfront District with required waterfront access, open space, and brownfield remediation.

Pier V (Former Velodrome Site) (1.a)

- Develop land for public use and open space.

144th St. (1.b)

- Fund acquisition and construction of proposed 2-acre park dependant on the redevelopment of the site north of the proposed park.

138th St. Bridge (Padded Wagon Site) (1.c)

- Plan for residential and commercial development of site (lease comes up in 2014).

Expansion of Harlem River WAP (2)

- Support waterfront redevelopment to increase public waterfront access and maximize economic development potential.
- Explore opportunity for public waterfront access and non-motorized boat launch at Park Ave. street end, based on the criteria described in the Citywide Strategy.

Bronx Kill (3)

- Explore improvements to support habitat restoration and, where feasible, the navigability of the Bronx Kill for kayaks and canoes.

North and South Brother Islands (4)

- Pursue additional funding for a comprehensive plan to integrate cultural, historical, and natural resource management on both islands.

Hunts Point / Port Morris (5)

- Complete improvements to the South Bronx Greenway.
- Identify opportunities to attract tall ships and other educational programming to the waterfront at Barretto Point Park and other recreational areas.
- Promote redevelopment of vacant land within the Significant Maritime and Industrial Area (SMIA) for industrial uses with preference for water-dependent maritime industries.
- Where feasible, preserve waterfront access to industrial properties and intermodal connections to facilitate waterborne movement of goods.
- Evaluate feasibility of developing a Hunts Point boat launch/docking facility that services recreational or freight vessels.
- Complete improvements at Hunts Point Waste Water Treatment Plant to reduce nitrogen discharge into the East River.

132nd St. / 134th St. (5.a)

- Study street ends for recreational or industrial purposes, including potential preservation of gantry cranes.

Hunts Point South (5.b)

- Study corrections site for potential redevelopment opportunities.

Farragut St. End & Marine Transfer Station (5.c)

- Support improvements at Farragut Street end.
- Balance needs of city's waste management with those of the community.
- Explore redevelopment of the Marine Transfer Station as a maritime use.

Hunts Point Market (5.d)

- Explore waterborne transportation modes for the movement of goods to and from the Food Distribution Center, as well as supporting infrastructure, such as a pier for fishing vessels and freight ferries.

Hunts Point-Riverside Park (6)

- Complete expansion of launch platform for canoes and small boats, consistent with the criteria described in the Citywide Strategy.

REACH 7 - *SOUTH BRONX*

Figure 2.1-9. NYCDCP Vision 2020 Comprehensive Waterfront Plan – Reach 7

Population Growth and Projected Flows

DEP routinely develops water consumption and dry-weather wastewater flow projections for planning purposes. In 2012, DEP projected an average per capita water demand of 75 gallons per day that was representative of future uses. The year 2040 was established as the planning horizon, and populations for that time were developed by the DCP and the New York Metropolitan Transportation Council.

The 2040 population projection figures were then used with the dry-weather per capita sewage flows to establish the 2040 dry-weather sewage flows for the Wards Island WRRF and North River WRRF sewersheds. Average daily dry-weather sanitary sewage flows for the landside model subcatchments for each sewershed were established by distributing the total dry-weather flows at the respective WRRFs to the upstream subcatchments in proportion to the upstream subcatchment populations.

Updated Landside Modeling

The majority of the Harlem River sewershed is included within the overall Wards Island WRRF collection system IW model. A smaller portion of the sewershed, at the northwestern end of Manhattan, is included within the North River WRRF collection system IW model. In 2012, 13 of DEP's IW landside models underwent recalibration. The recalibration process and results are included in the IW Citywide Recalibration Report (DEP, 2012a) required by the CSO Order. Following this report, DEP submitted to DEC a Hydraulic Analysis Report in December 2012 (DEP, 2012b). The general approach followed was to recalibrate the model in a stepwise fashion beginning with the hydrology module (runoff). The following summarizes the overall approach to model update and recalibration:

- ***Site Scale Calibration (Hydrology)*** – The first step was to focus on the hydrologic components of the model, which had been modified since 2007. Flow monitoring data were collected in upland areas of the collection systems, remote from (and thus largely unaffected by) tidal influences and in-system flow regulation, for use in understanding the runoff characteristics of the impervious surfaces. Data were collected in two phases – Phase 1 in the Fall of 2009, and Phase 2 in the Fall of 2010. The upland areas ranged from 15 to 400 acres in size. A range of areas with different land use mixes was selected to support the development of standardized sets of coefficients which could be applied to other unmonitored areas of NYC. The primary purpose of this element of the recalibration was to adjust pervious and impervious area runoff coefficients to provide the best fit of the runoff observed at the upland flow monitors.

- ***Area-wide Recalibration (Hydrology and Hydraulics)*** – The next step in the process was to focus on larger areas of the modeled systems where historical flow metering data were available, and which were neither impacted by tidal backwater conditions nor subjected to flow regulation. Where necessary, runoff coefficients were further adjusted to provide reasonable simulation of flow measurements made at the downstream end of these larger areas. The calibration process then moved downstream further into the collection system, where flow data were available in portions of the conveyance system where tidal backwater conditions could exist, as well as potential backwater conditions from throttling at the WRRFs. The flow measured in these downstream locations would further be impacted by regulation at in-system control points (regulator, internal reliefs, etc.). During this step in the recalibration, minimal changes were made to runoff coefficients.

The results of this effort were models with better representation of the collection systems and their tributary areas. A comprehensive discussion of the recalibration efforts can be found in the IW Citywide Recalibration Report (DEP, 2012a) and the Hydraulic Analysis Report (DEP, 2012b).

As part of the Citywide/Open Waters LTCP, additional flow metering was conducted to check the 2012 calibration. The additional model updates made in support of this LTCP are summarized below.

Wards Island IW Model

- Modifications were made to runoff coefficients, regulator configurations, and wastewater profiles as a result of the additional flow metering and model calibration/validation.
- The Tibbetts Brook project was added to the Baseline Conditions version of the Wards Island IW model. The Tibbetts Brook project will include base flow daylighting and Van Cortlandt Lake improvements and is anticipated to result in an approximately 228 MG reduction in average annual CSO volume at Outfall WIB-056.
- A simplified representation of retention-based GI at specified outfalls that results in the targeted CSO volume reductions was incorporated into the Baseline Conditions IW model.

North River IW Model

- Modifications were made to runoff coefficients, regulator configurations, and wastewater profiles as a result of the additional flow metering and model calibration/validation.
- A simplified representation of retention-based GI at specified outfalls that results in the targeted CSO volume reductions was incorporated into the Baseline Conditions IW model.

Review and Confirm Adequacy of Design Rainfall Year

In previous planning work for the WWFPs, DEP applied the 1988 annual precipitation characteristics to the landside IW models to develop loads from combined and separately sewered drainage areas. At that time, the year 1988 was considered representative of long term average conditions. Therefore, that year was used to analyze facilities where “typical” rather than extreme conditions served as the basis of design, in accordance with the EPA CSO Control Policy approach of using an “average annual basis” for analyses. However, in light of increasing concerns over climate change, with the potential for more extreme and possibly more frequent storm events, the use of 1988 as the average condition was re-considered. A comprehensive range of historical rainfall data were evaluated from 1970 to 2018 at four rainfall gauges (CPK, LGA, JFK, EWR). The 2008 JFK rainfall was determined to be the most representative of average annual rainfall across all four gauges. Figure 2.1-10 shows the annual rainfall at JFK for 1970 through 2018. As indicated in Figure 2.1-10, the JFK 2008 rainfall currently used for the LTCP typical year includes almost six inches more rainfall than the JFK 1988 rainfall that was used for the WWFP evaluations, and is more consistent with recent rainfall trends. As a result, the landside modeling analyses conducted as part of the LTCP process have used the 2008 JFK precipitation as the typical rainfall year in NYC, together with the 2008 tide observations.

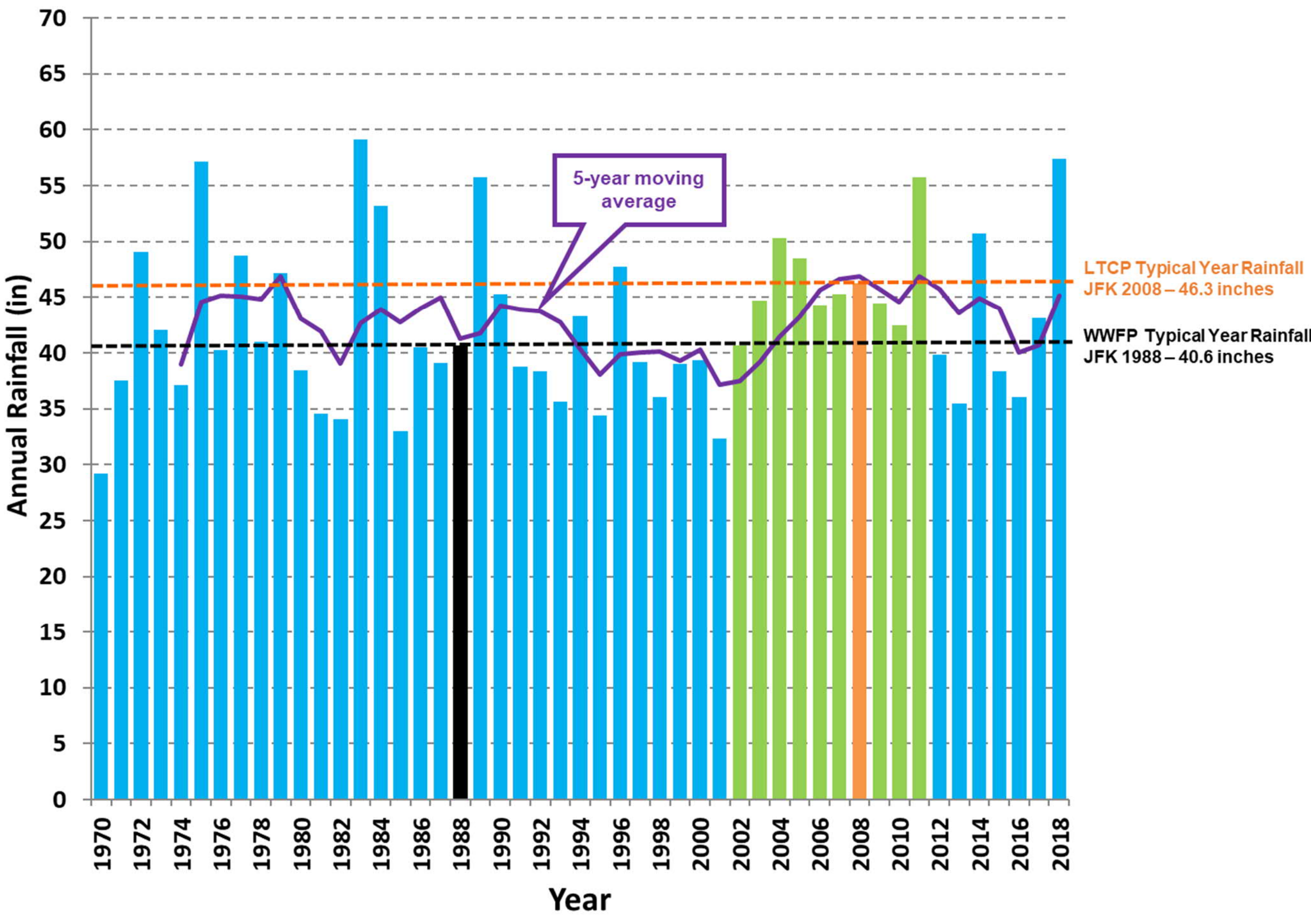


Figure 2.1-10. Annual Rainfall Data and Selection of the Typical Year

The rainfall from the JFK gauge for a 10-year period of 2002 to 2011 was also used to assess long term performance of the LTCP Recommended Plan (see Sections 6 and 8). A ten-year period of rainfall was selected between 2002 and 2011, representing a wetter period as indicated by the two peaks in the 5-year average. Each of the years during this period exceeded 40 inches of rainfall, while all other consecutive 10-year periods included one or more years with annual rainfall less than 35 inches. Based upon this analysis, the period from 2002 through 2011 was the wettest continuous period over the past 50 years and provides a high level of conservatism to the LTCP analyses.

2.1.a.2 Description of Sewer System

The Harlem River watershed/sewershed is served by two WRRFs. Figure 2.1-1 above shows the locations of the two WRRFs and their respective sewersheds. As shown in Figure 2.1-1, the northwestern shore of the watershed is served by the North River WRRF and its collection system. The majority of the eastern shore and the southwestern shore of the watershed area are served by the Wards Island WRRF. The Wards Island WRRF tributary area is the main contributor of CSO to the Harlem River and covers the most acreage.

Figure 2.1-4 and Table 2.1-1 above show the different land uses within the sewersheds of the Wards Island and North River WRRFs that are tributary to the Harlem River. Table 2.1-2 lists the CSO and stormwater outfalls that discharge to the Harlem River by ownership as documented by the Shoreline Survey Unit of the DEP. The locations of these outfalls are shown in Figure 2.1-11. No permitted dry-weather discharges exist along the Harlem River.

Table 2.1-2. Outfalls Discharging to the Harlem River

Identified Ownership of Outfalls	Number of Outfalls
DEP	DEP MS4 Permitted = 0
	DEP Non-MS4 Permitted = 49
	DEP CSO Permitted = 65
NYS Department of Transportation	144
Private	132
Unknown	30
Total	420

Overview of Drainage Area and Sewer System

The following sections describe the major features of the Wards Island, and North River WRRF sewersheds within the Harlem River watershed. Table 2.1-3 shows the areas served by the various drainage system categories.

Table 2.1-3. WRRF Sewersheds Tributary to the Harlem River: Acreage Per Sewer Category

Sewershed	Acres by Type of Tributary Area			
	Combined	Separate (MS4 and non-MS4)(1)	Direct Overland and Other(1)	Total
Wards Island	9,942	1,211	328	11,481
North River	366	0	14	381
Total	**10,308**	**1,211**	**342**	**11,861**

Note:

(1) Tributary drainage areas for direct drainage and other sources of stormwater have not been fully delineated by DEP or obtained from other agencies. These drainage areas were estimated based on GIS mapping, aerial photographs, land use maps, and topographic maps, rather than detailed topographic surveys and sewer maps.

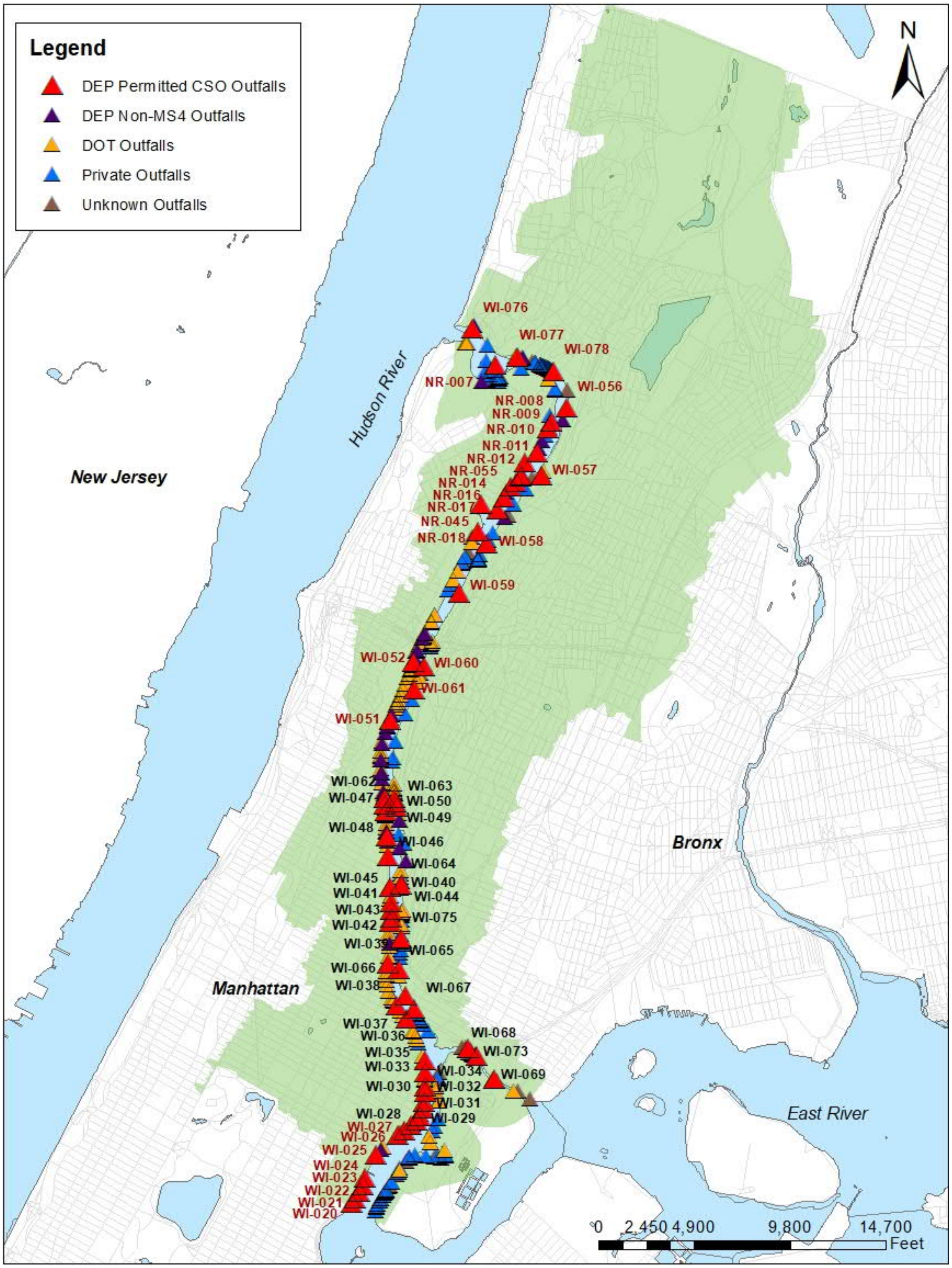


Figure 2.1-11. Outfalls Discharging to the Harlem River

Wards Island WRRF Drainage Area and Sewer System

The Wards Island WRRF is located at 7 Wards Island Bridge and occupies about a quarter of Wards Island in the East River. The Wards Island WRRF serves the sewered area in the western section of Bronx, including the communities of Spuyten Duyvil, Marble Hill, Kingsbridge, Fordham Manor, Fordham Heights, West Bronx, Morris Heights, Highbridge, and the eastern section of Manhattan, including the communities of East Harlem, Upper Manhattan, and Washington Heights. The major components of the Wards Island WRRF collection/transport system within the Harlem River sewershed are shown in Figure 2.1-12 and Figure 2.1-13. The total sewershed area tributary to the Wards Island WRRF is approximately 12,000 acres. Of that total area, approximately 9,100 acres are part of the Harlem River sewershed.

The Wards Island WRRF has a DDWF capacity of 275 MGD and is designed to receive a maximum flow of 550 MGD (2xDDWF) with 412.5 MGD (1.5xDDWF) receiving secondary treatment. Flows over 412.5 MGD receive primary treatment and disinfection. Under the First Amended Nitrogen Consent Judgment (FANCJ), the Wards Island WRRF has been upgraded for Biological Nitrogen Removal, which has resulted in significant decreases in nitrogen loadings into the East River. The Wards Island WRRF was also fitted with Stable High Ammonia Removal over Nitrite (Sharon) technology for additional nitrogen control in 2009.

A total of 52 CSO outfalls from the Wards Island WRRF system are permitted to discharge to the Harlem River during wet-weather. Table 2.1-4 lists the CSO outfalls that are tributary to the Harlem River from the Wards Island WRRF sewershed, along with their associated regulators/relief structures. Figure 2.1-12 and Figure 2.1-13 show the locations of the CSO outfalls and regulators/relief structures from the Wards Island WRRF system that discharge to the Harlem River.

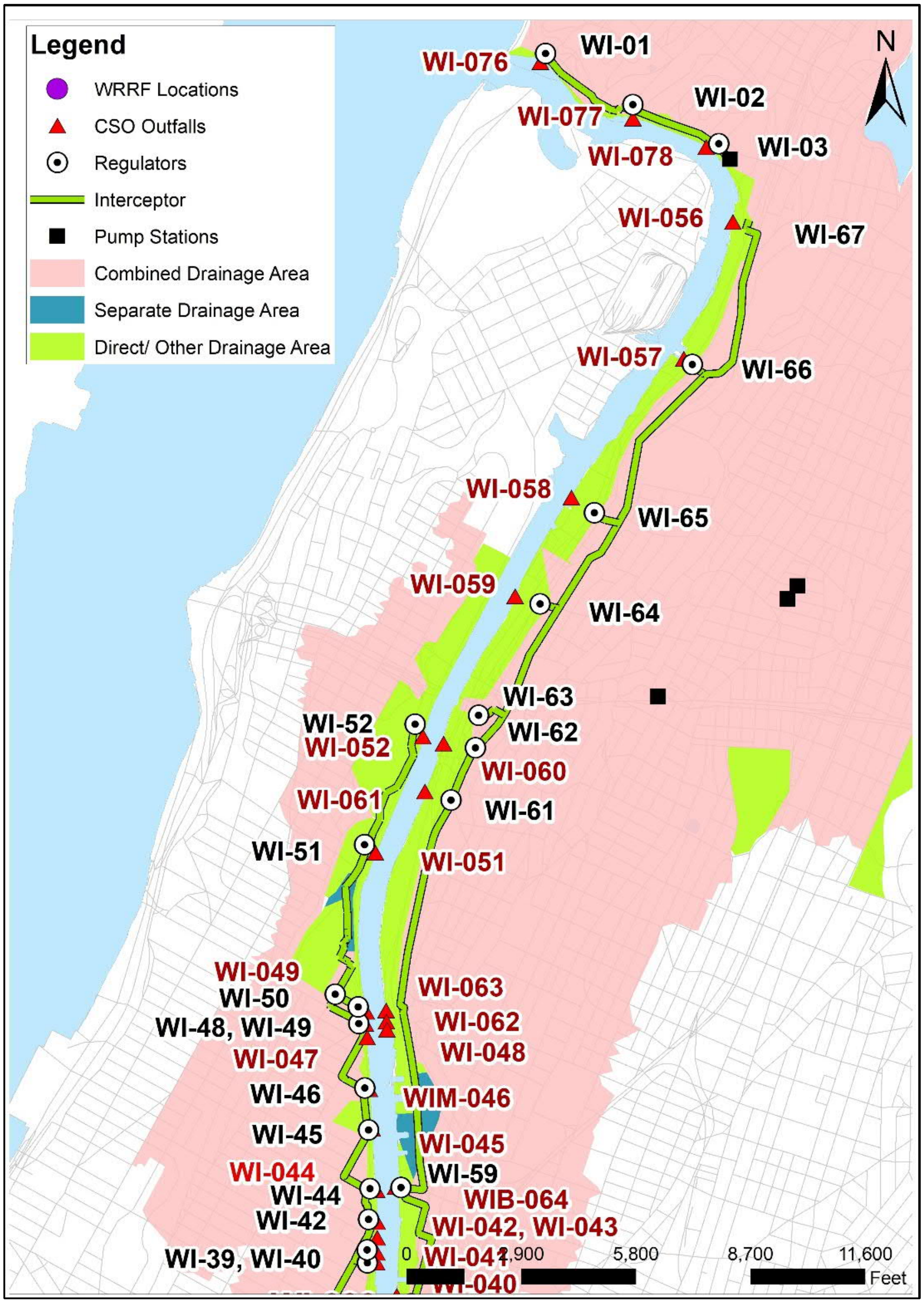


Figure 2.1-12. Wards Island WRRF Collection System (North End)

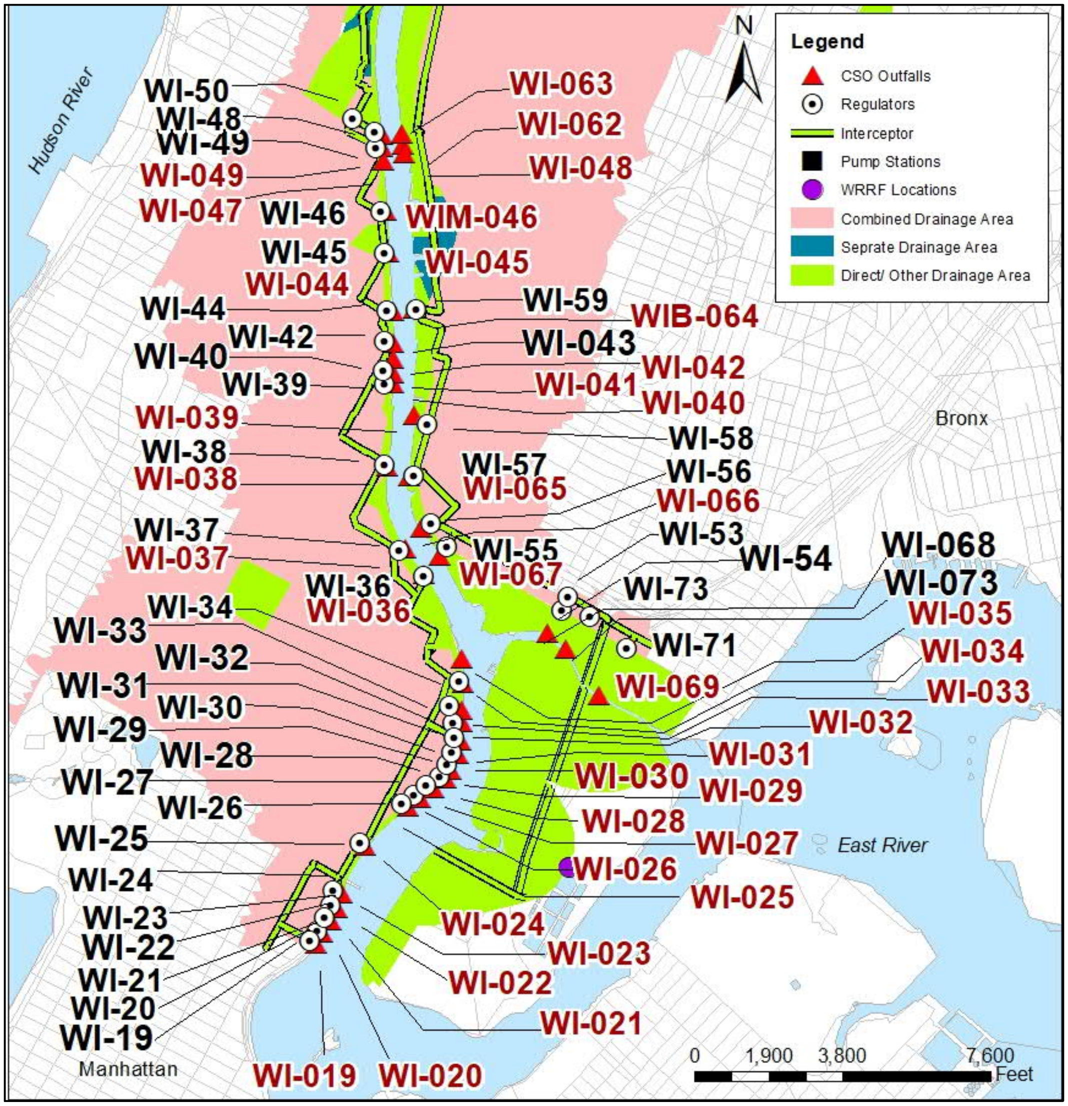


Figure 2.1-13. Wards Island WRRF Collection System (South End)

Table 2.1-4. CSO Outfalls Tributary to Harlem River from Wards Island WRRF Service Area

Outfall	Regulator(s)
WIM-020	REG #20
WIM-021	REG #21
WIM-022	REG #22
WIM-023	REG #23
WIM-024	REG #24
WIM-025	REG #25
WIM-026	REG #26
WIM-027	REG #27
WIM-028	REG #30
WIM-029	REG #31
WIM-030	REG #32
WIM-031	REG #33
WIM-032	REG #34
WIM-033	REG #35
WIM-034	REG #20
WIM-035	REG #21
WIM-036	REG #36
WIM-037	REG #37
WIM-038	REG #38
WIM-039	REG #39
WIM-040	REG #40
WIM-041	REG #41
WIM-042	REG #42
WIM-043	REG #19
WIM-044	REG #44
WIM-045	REG #45
WIM-046	REG #46
WIM-047	REG #47
WIM-048	REG #48
WIM-049	REG #60A
WIM-050	REG #50
WIM-051	REG #51
WIM-052	REG #52
WIB-056	REG #67
WIB-057	REG #66
WIB-058	REG #65
WIB-059	REG #64
WIB-060	REG #62
WIB-061	REG #61
WIB-062	REG #60, 60A
WIB-063	REG #72
WIB-064	REG #59
WIB-065	REG #57
WIB-066	REG #56
WIB-067	REG #55

Table 2.1-4. CSO Outfalls Tributary to Harlem River from Wards Island WRRF Service Area

Outfall	Regulator(s)
WIB-068	REG #53, 54
WIB-069	REG #71
WIB-073	REG #73
WIB-075	REG #58
WIB-076	REG #MH-1
WIB-077	REG #MH-2
WIB-078	REG #MH-3

North River WRRF Drainage Area and Sewer System

The North River WRRF is located on the Hudson River Greenway between 137th Street and 145th Street in the Hamilton Heights section of Manhattan, on a 28-acre reinforced concrete platform over the Hudson River. The North River WRRF serves an area in the northeastern section of Manhattan, including the community of Inwood. The major components of the North River WRRF collection/transport system within the Harlem River sewershed are shown in Figure 2.1-14. The total sewershed area tributary to the North River WRRF is approximately 5,500 acres. Of that total area, approximately 571 acres are part of the Harlem River sewershed.

The North River WRRF has a DDWF capacity of 170 MGD and is designed to receive a maximum flow of 340 MGD (2xDDWF) with 255 MGD (1.5xDDWF) receiving secondary treatment. Flows over 255 MGD receive primary treatment and disinfection.

A total of 13 CSO outfalls from the North River WRRF system are permitted to discharge to the Harlem River during wet-weather. Table 2.1-5 lists the CSO outfalls that are tributary to the Harlem River from the North River WRRF sewershed, along with their associated regulators/relief structures. Figure 2.1-14 shows the locations of the CSO outfalls and regulators/relief structures from the North River WRRF collection system that discharge into the Harlem River.

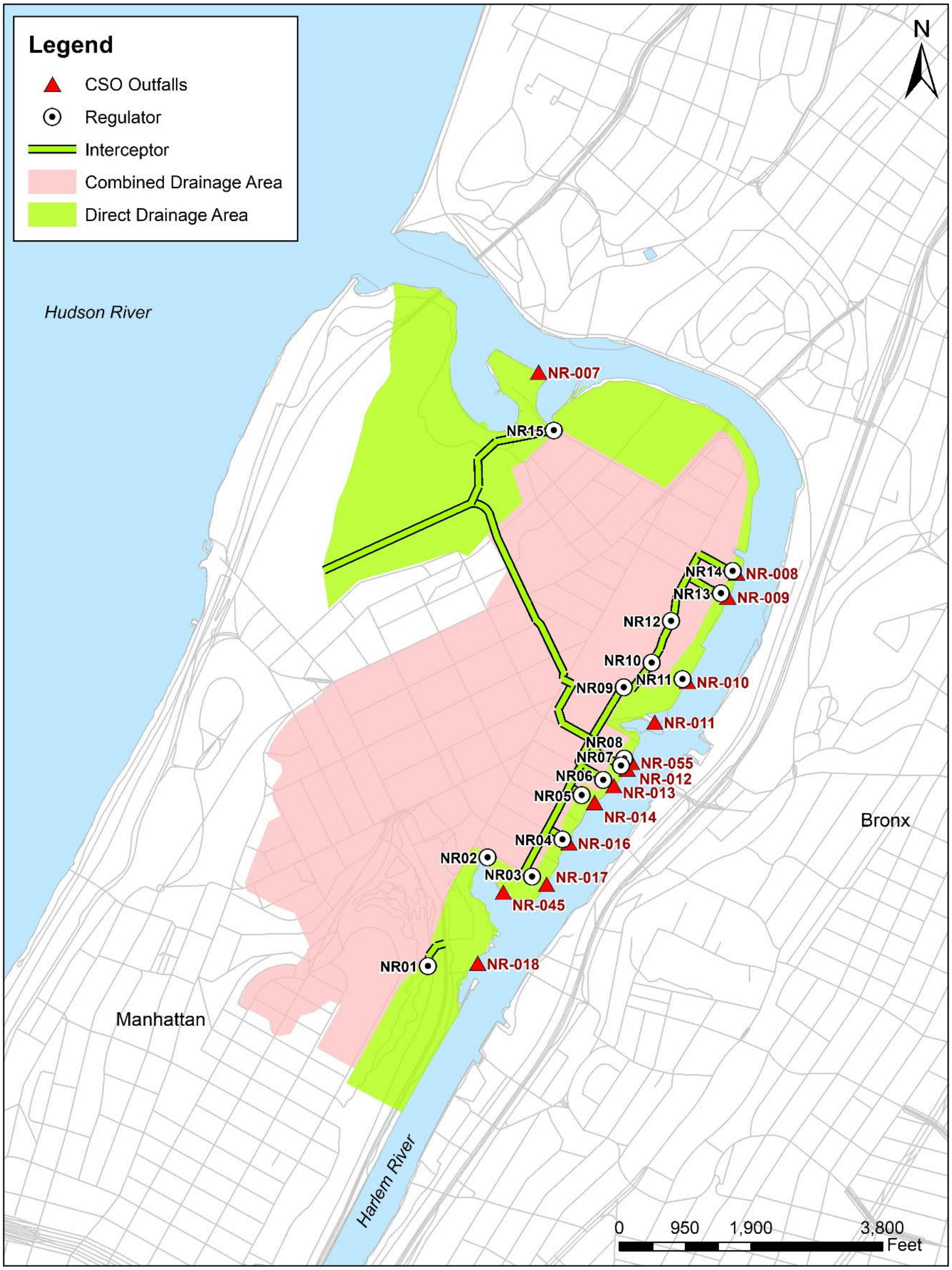


Figure 2.1-14. North River WRRF Collection System

Table 2.1-5. CSO Outfalls Tributary to Harlem River from North River WRRF Service Area

Outfall	Regulator(s)
NR-007	REG #N-15
NR-008	REG #N-14
NR-009	REG #N-13
NR-010	REG #N-10, N-11, N-12
NR-011	REG #N-9
NR-012	REG #N-7
NR-013	REG #N-6
NR-014	REG #N-5
NR-016	REG #N-4
NR-017	REG #N-3
NR-018	REG #N-1
NR-045	REG #N-2
NR-055	REG #N-7, N-8

Stormwater and Wastewater Characteristics

The constituent concentrations found in wastewater, combined sewage, and stormwater can vary based on a number of factors, including flow rate, runoff contribution, and the mix of the waste discharged to the system from domestic and non-domestic customers. Because the mix of these waste streams can vary, it can be challenging to identify a single concentration to use for analyzing the impact of discharges from these systems to receiving waters.

Data collected from sampling events were used to estimate concentrations for fecal coliform and *Enterococci* bacteria to use in calculating loadings from various sources. CSO concentrations were measured in 2016 to provide site-specific information for Outfalls WIB-056 and WIB-060. The CSO bacteria concentrations were characterized by direct measurements of at least four CSO events during various storms occurring during the months of April 2016 through November 2016. These concentrations are shown in the form of a cumulative frequency distribution in Figure 2.1-15 and Figure 2.1-16. Individual sample points are shown, as well as the trend line that best fits the data distribution. For both outfalls, measured fecal coliform and *Enterococci* concentrations were log-normally distributed. Table 2.1-6 below provides the geometric mean and ranges of the measured CSO fecal coliform and *Enterococci* concentrations for each outfall.

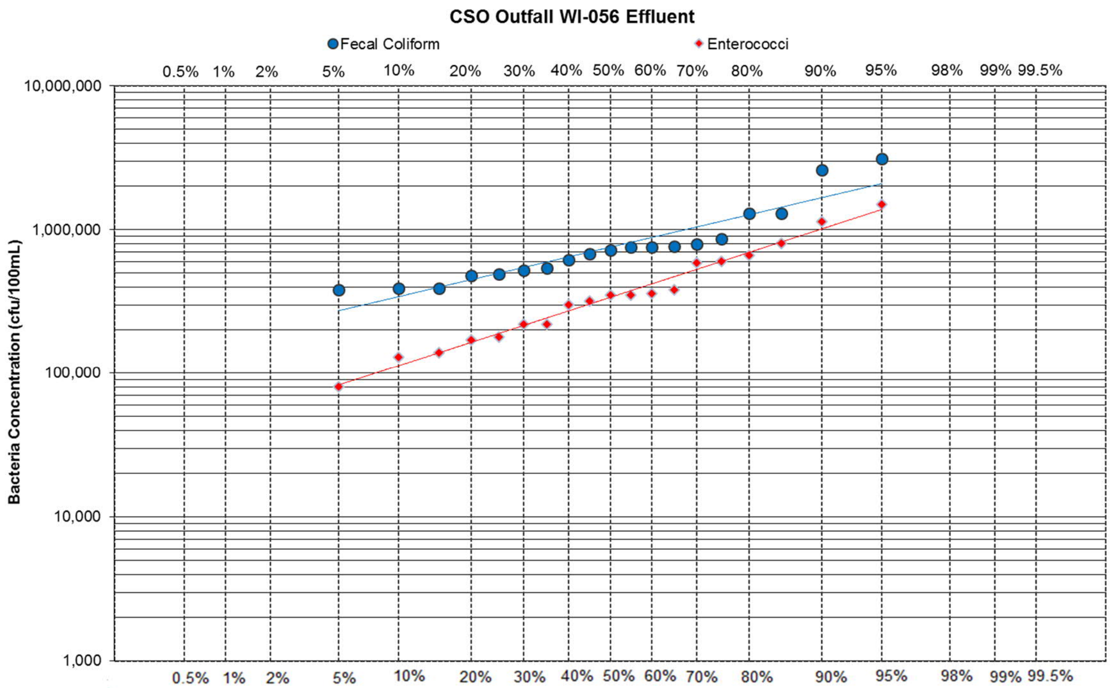


Figure 2.1-15. Outfall WIB-056 Measured CSO Bacteria Concentrations

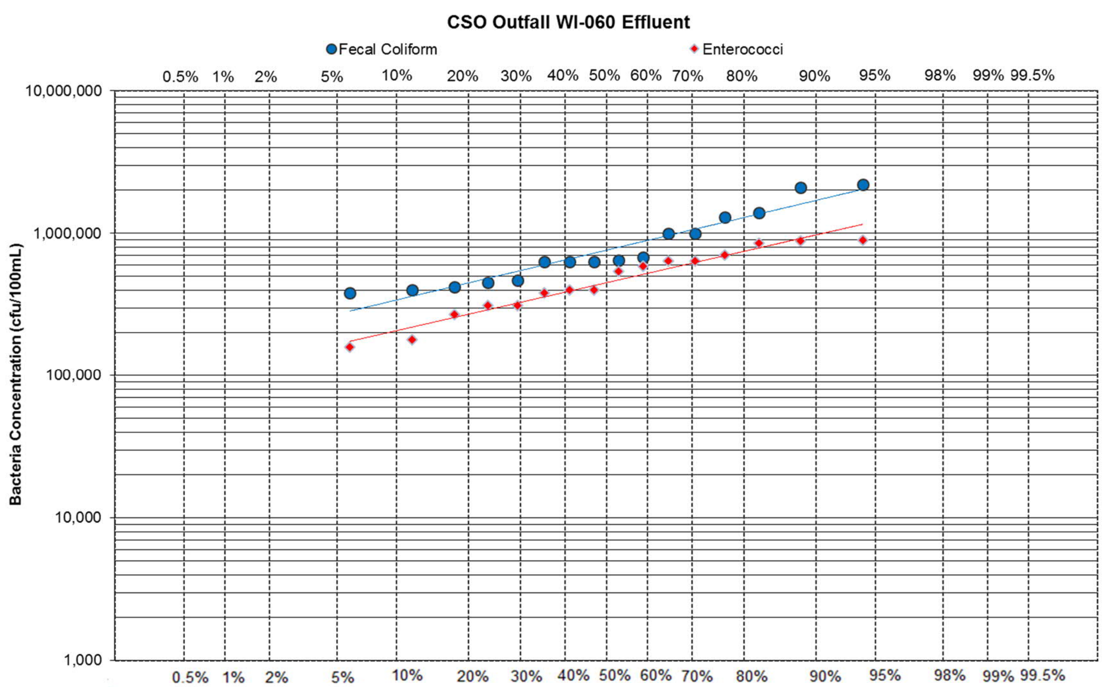


Figure 2.1-16. Outfall WIB-060 Measured CSO Bacteria Concentrations

Table 2.1-6. Harlem River Measured CSO Bacteria Concentrations

Outfall	Fecal Coliform (cfu/100mL)		*Enterococci* (cfu/100mL)	
	Geometric Mean	Range	Geometric Mean	Range
WIB-056	754,767	380,000 – 3,100,000	337,813	80,000 – 1,500,000
WIB-060	760,607	380,000 – 2,200,000	449,351	160,000 – 880,000

Flow monitoring data were collected for CSO Outfalls WIB-056 and WIB-060 to support the development of the Citywide/Open Waters LTCP. Descriptions of the Wards Island WRRF IW model updates and calibration processes based on the flow monitoring data gathered for Outfalls WI-056 and WI-060 was provided above under “Updated Landside Modeling.”

Sampling, data analyses, and water quality modeling calibration resulted in the assignment of flows and loadings to these sources for inclusion in the calibration/validation of the water quality model. The CSO and stormwater concentrations used for the water quality evaluations are described in Section 6 of this LTCP.

Hydraulic Analysis of Sewer System

A citywide hydraulic analysis was completed in December 2012 to provide further insight into the hydraulic capacities of key system components and system responses to various wet-weather conditions. The hydraulic analyses were divided into the following major components:

- Annual simulations to estimate the number of annual hours that the WRRFs are predicted to receive and treat up to 2xDDWF for the rainfall years 2008 and 2011 with projected 2040 DWFs; and
- Estimation of peak conduit/pipe flow rates that would result from a significant single-event with projected 2040 DWFs. The storm event assessed was the July 29, 1980 storm, with an approximately 5-year return frequency, total depth of 3.45 inches of rain, peak intensity of 1.78 inches/hour, and duration of 7 hours.

Detailed presentations of the data were included in the December 2012 Hydraulic Analysis Report (DEP, 2012b) submitted to DEC. The objective of each evaluation and the specific approach undertaken are briefly described below for the Wards Island and North River WRRFs.

Wards Island - Annual Hours at 2xDDWF for 2008 with Projected 2040 DWF

Model simulations were conducted to estimate the annual number of hours that the Wards Island WRRF would be expected to treat 2xDDWF for the 2008 precipitation year. These simulations were conducted using projected 2040 DWF for two model input conditions:

- The recalibrated model conditions as described in the December 2012 IW Citywide Recalibration Report (DEP, 2012a), and
- The Cost-Effective Grey (CEG) alternatives defined for the sewershed.

The CEG elements represent the CSO controls that became part of the CSO Order. No CEG elements were implemented in the Wards Island WRRF sewershed. For these simulations, the primary input conditions applied were as follows:

- Projected 2040 DWF conditions.
- 2008 tides and precipitation data.
- Wards Island WRRF at 2xDDWF capacity of 550 MGD.
- No sediment in the combined sewers (i.e., clean conditions).
- Sediment in interceptors representing the post-interceptor sediment conditions after the inspection and cleaning program completed in 2011 and 2012.
- No green infrastructure.

Key observations/findings are summarized below:

- Simulation of the 2008 annual rainfall year resulted in a prediction that the Wards Island WRRF would operate at its 2xDDWF capacity for 35 hours under the no CEG condition. Since no CEG elements were included in the Wards Island WRRF sewershed, the CEG conditions did not change the annual number of hours at 2xDDWF (35 hours).
- The total volume (dry- and wet-weather combined) treated annually at the Wards Island WRRF for the 2008 non-CEG condition was predicted to be about 81,358 MG, while the 2008 with-CEG condition resulted in no change in annual volume.
- The total annual CSO volume predicted for the outfalls in the Wards Island sewershed were as follows:
  - 2008 non-CEG: 3,837 MG
  - 2008 with-CEG: 3,837 MG

The above results indicate that system-wide implementation of CEG projects had no impact on flows and volumes in the Wards Island sewershed, since no CEG projects were located in the sewershed.

North River - Annual Hours at 2xDDWF for 2008 with Projected 2040 DWF

Model simulations were conducted to estimate the annual number of hours that the North River WRRF would be expected to treat 2xDDWF for the 2008 precipitation year. These simulations were conducted using projected 2040 DWF with the 2012 recalibrated models for conditions with and without the CEG alternatives defined for the sewershed. No CEG elements were implemented in the North River WRRF sewershed. For these simulations, the primary input conditions applied were as follows:

- Projected 2040 DWF conditions.
- 2008 tides and precipitation data.

- North River WRRF at 2xDDWF capacity of 340 MGD.
- No sediment in the combined sewers (i.e., clean conditions).
- Sediment in interceptors representing the post-interceptor sediment conditions after the inspection and cleaning program completed in 2011 and 2012.
- No green infrastructure.

Key observations/findings are summarized below:

- Simulation of the 2008 annual rainfall year resulted in a prediction that the North River WRRF would operate at its 2xDDWF capacity for 101 hours under the non-CEG condition. Since no CEG elements were included in the North River WRRF sewershed, the CEG conditions did not change the annual number of hours at 2xDDWF (101 hours).
- The total volume (dry- and wet-weather combined) treated annually at the North River WRRF for the 2008 non-CEG condition was predicted to be about 49,223 MG, while the 2008 with-CEG condition resulted in no change in annual volume.
- The total annual CSO volume predicted for the outfalls in the North River sewershed were as follows:
    - 2008 non-CEG: 585 MG
    - 2008 with-CEG: 585 MG

The above results indicate that system-wide implementation of CEG projects had no impact on flows and volumes in the North River WRRF sewershed, since no CEG projects were located in the sewershed.

Identification of Areas Prone to Flooding and History of Confirmed Sewer Back-ups

DEP maintains and operates the collection systems throughout the five boroughs. To do so, DEP employs a combination of reactive and proactive maintenance techniques. NYC's "311" system routes public complaints of sewer issues to DEP for response and resolution. Although not every call that reports flooding or sewer back-ups corresponds to an actual issue with the municipal sewer system, each call to 311 is responded to. Sewer functionality impediments identified during a DEP response effort are corrected as necessary.

Findings from Interceptor Inspections

DEP has several programs with staff devoted to sewer maintenance, inspection, and analysis, and regularly inspects and cleans its sewers, as reported in the SPDES BMP Annual reports. In the last decade, DEP has implemented advanced technologies and procedures to enhance its proactive sewer maintenance practices. GIS and Computerized Maintenance and Management Systems provide DEP with expanded data tracking and mapping capabilities, through which it can identify and respond to trends to better serve its customers. Both reactive and proactive system inspections result in maintenance, including cleaning and repairing, as necessary**.** Figure 2.1-17 and Figure 2.1-18 illustrate the intercepting sewers that were inspected in 2018 in the Boroughs of Manhattan and Bronx, respectively, encompassing the entire Harlem River watershed. Throughout 2018, 5,674 cubic yards of sediment were removed from Wards Island WRRF intercepting sewers. No sediment was removed from North River WRRF intercepting sewers. Citywide, the inspection of 145,911 linear feet of intercepting sewers resulted in the removal of 6,112 cubic yards of sediment.

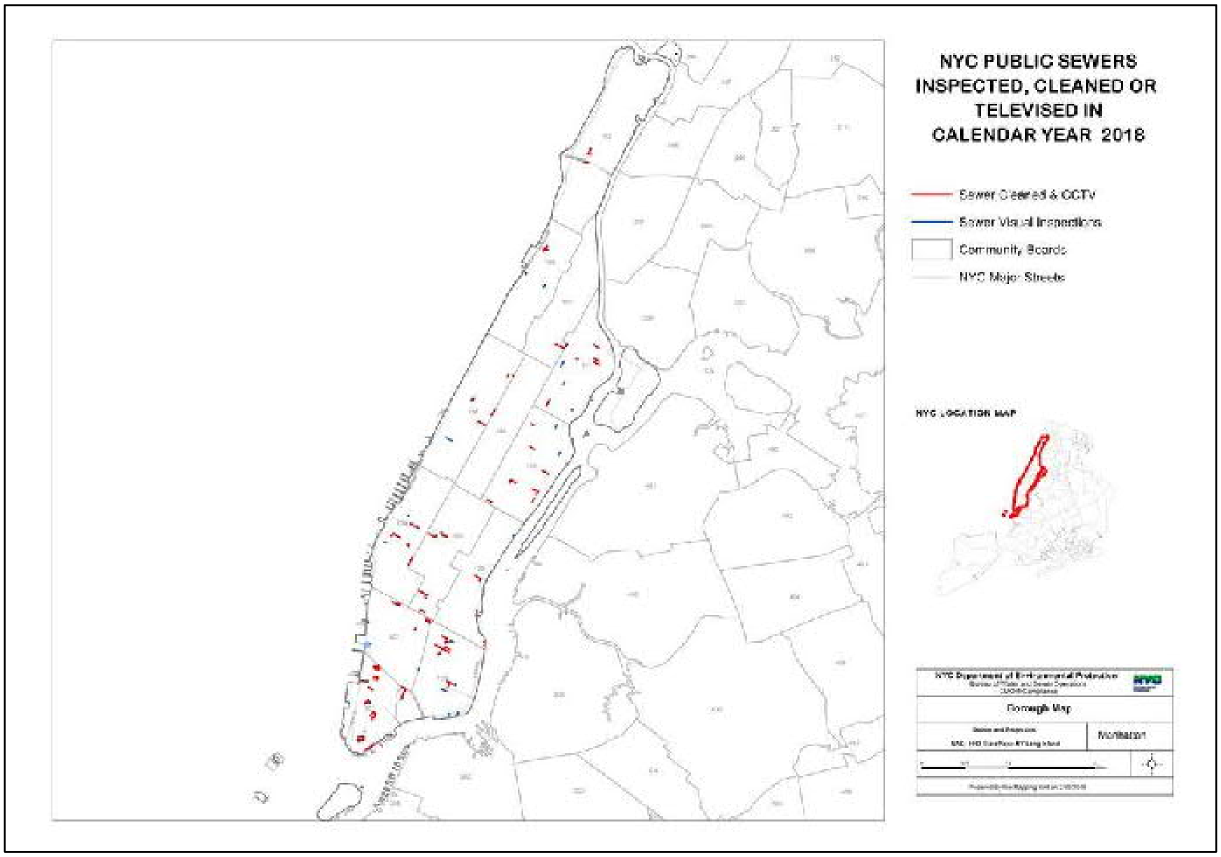


Figure 2.1-17. Sewers Inspected and Cleaned in Manhattan Throughout 2018

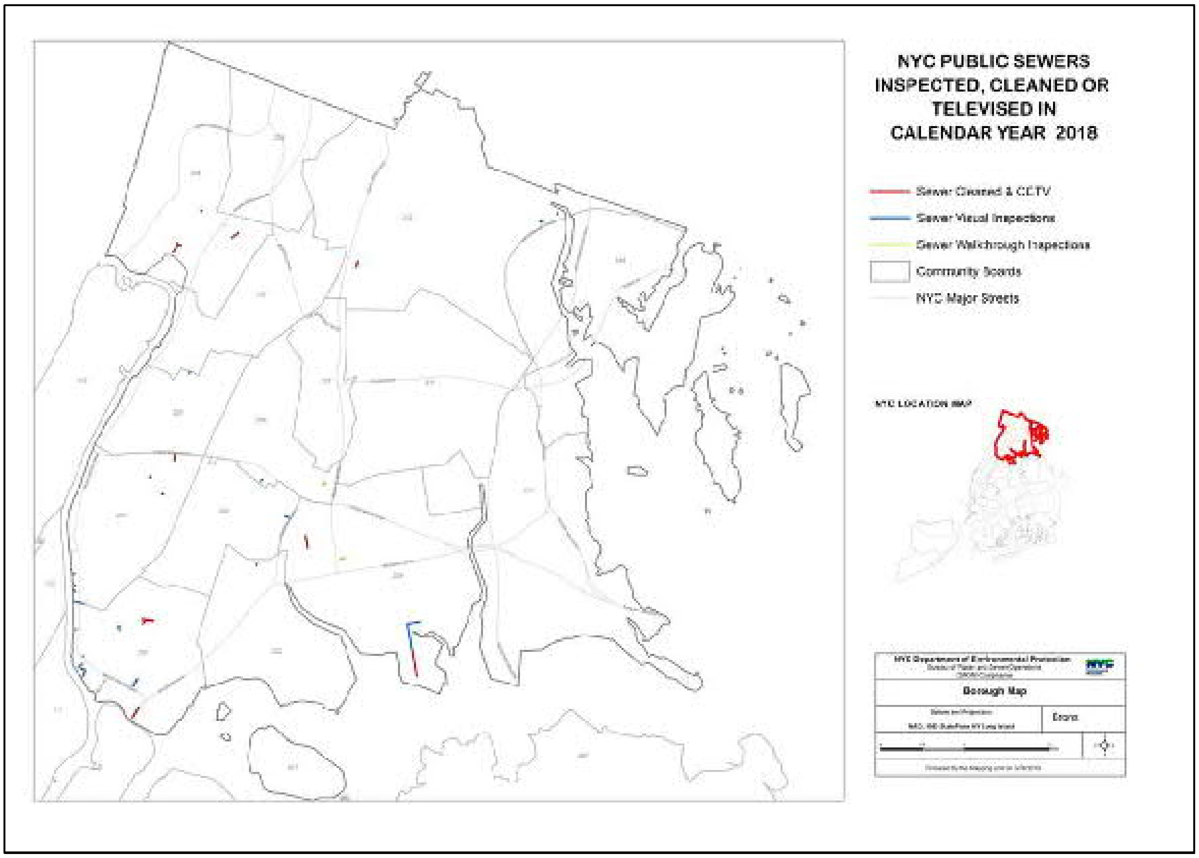


Figure 2.1-18. Sewers Inspected and Cleaned in Bronx Throughout 2018

DEP recently conducted a sediment accumulation analysis to quantify levels of sediments in the CSS. For this analysis, a statistical approach was used to randomly select a sample subset of collection sewers representative of the modeled systems as a whole, with a confidence level commensurate to that of the IW watershed models. Field crews investigated each location, and estimated sediment depth using a rod and measuring tape. Field crews also verified sewer pipe sizes shown on maps, and noted physical conditions of the sewers. The data were then used to estimate the sediment levels as a percentage of overall sewer cross-sectional area. The aggregate mean sediment level for the entire NYC system was approximately 1.25 percent, with a standard deviation of 2.02 percent.

2.1.b Waterbody Characteristics

This section describes the features and attributes of the Harlem River. Characterizing the features of the waterbody is important for assessing the impact of wet-weather inputs and creating approaches and solutions that mitigate the impact from wet-weather discharges.

2.1.b.1 Description of Waterbody

The Harlem River is located at the north end of Manhattan, separating the island from the Bronx. The eight-mile long tidal strait flows between the Hudson River and the East River. The Harlem River is greatly influenced by its neighboring waterbodies. Tidal oscillations cause dramatic fluctuations of the Harlem River's currents and may influence the spread of sediments, pollutants, and other particles throughout the connecting waterways. Water quality in the Harlem River is influenced by CSO discharges, direct drainage runoff, and tidal exchanges with the Hudson River and the East River. The following section describes the current water quality characteristics of the Harlem River, along with its uses.

2.1.b.2 Current Waterbody Classification(s) and Water Quality Standards

New York State Policies and Regulations

In accordance with the provisions of the CWA, the State of New York has established WQS for all navigable waters within its jurisdiction. The State has developed a system of waterbody classifications based on designated uses that include five classifications for saline waters. Class SA and Class SB classifications support primary and secondary contact recreation and fishing. Classes SC, I, and SD support aquatic life and recreation. DEC has classified Harlem River as a Class I waterbody (Figure 2.1-19), where best uses are secondary contact recreation and fishing, and the waters are suitable for fish, shellfish, and wildlife propagation and survival.

Numerical standards corresponding to these waterbody classifications are shown in Table 2.1-7. As indicated in Table 2.1-7, total and fecal coliform bacteria concentrations are the numerical criteria that DEC uses to establish whether a waterbody supports recreational uses in non-coastal waterbodies, while fecal coliform and *Enterococci* criteria apply to coastal primary recreational waters. The Harlem River is defined as a non-coastal tributary waterbody, so the *Enterococci* criteria do not apply to the Harlem River. DO is the numerical standard that DEC uses to establish whether a waterbody supports aquatic life uses. In addition to numerical standards, NYS has narrative criteria to protect aesthetics in all waters within its jurisdiction, regardless of classification (Table 2.1-8). As indicated in Table 2.1-8, these narrative criteria apply to all five classes of saline waters.

Figure 2.1-19. Waterbody Classifications for the Harlem River

Table 2.1-7. NYS Numerical WQ Criteria and Best Uses

Class	Usage	Dissolved Oxygen (mg/L)	Total Coliform (cfu/100mL)	Fecal Coliform (cfu/100mL)	Coastal Primary Recreational Waters	
					Enterococci **Geometric Mean (cfu/100mL)**	***Enterococci*** **30-day STV (cfu/100mL)**
SA	Best usages are shellfishing for market purposes, primary and secondary contact recreation, and fishing. Suitable for fish, shellfish, and wildlife propagation and survival.	≥ 4.8[(1)] ≥ 3.0[(2)]	≤ 70[(3)]	N/A	≤ 35[(7)]	≤ 130[(8)]
SB	Best usages are primary and secondary contact recreation and fishing. Suitable for fish, shellfish, and wildlife propagation and survival.	≥ 4.8[(1)] ≥ 3.0[(2)]	≤ 2,400[(4)] ≤ 5,000[(5)]	≤ 200[(6)]	≤ 35[(7)]	≤ 130[(8)]
SC	Best usage is fishing. Suitable for fish, shellfish, and wildlife propagation and survival. The water quality shall be suitable for primary and secondary contact recreation, although other factors may limit the use for these purposes.	≥ 4.8[(1)] ≥ 3.0[(2)]	≤ 2,400[(4)] ≤ 5,000[(5)]	≤ 200[(6)]	N/A	N/A
I	Best usages are secondary contact recreation and fishing. Suitable for fish, shellfish, and wildlife propagation and survival.	≥ 4.0[(2)]	≤ 2,400[(4)] ≤ 5,000[(5)]	≤ 200[(6)]	N/A	N/A
SD	Best usage is fishing. Suitable for fish, shellfish, and wildlife survival. Waters with natural or man-made conditions that cannot meet the requirements for fish propagation.	≥ 3.0[(2)]	≤ 2,400[(4)] ≤ 5,000[(5)]	≤ 200[(6)]	N/A	N/A

Table 2.1-7. NYS Numerical WQ Criteria and Best Uses

Class	Usage	Dissolved Oxygen (mg/L)	Total Coliform (cfu/100mL)	Fecal Coliform (cfu/100mL)	Coastal Primary Recreational Waters	
					Enterococci **Geometric Mean (cfu/100mL)**	***Enterococci*** **30-day STV (cfu/100mL)**

(1) Chronic standard based on daily average. The DO concentration may fall below 4.8 mg/L for a limited number of days, as defined by the formula:

$$DO_i = \frac{13.0}{2.80 + 1.84e^{-0.1t_i}}$$

where DO_i = DO concentration in mg/L between 3.0 – 4.8 mg/L and t_i = time in days. This equation is applied by dividing the DO range of 3.0 – 4.8 mg/L into a number of equal intervals. DO_i is the lower bound of each interval (i) and t_i is the allowable number of days that the DO concentration can be within that interval. The actual number of days that the measured DO concentration falls within each interval (i) is divided by the allowable number of days that the DO can fall within interval (t_i). The sum of the quotients of all intervals (i …n) cannot exceed 1.0: i.e.,

$$\sum_{i=1}^{n} \frac{t_i(actual)}{t_i(allowed)} < 1.$$

(2) Acute standard (never less than).
(3) Median most probable number (MPN) value in any series of representative samples.
(4) Monthly median value of five or more samples, for the primary contact recreational season (May 1st through October 31st), and in any other instance where the Department determines it necessary to protect human health.
(5) Monthly 80th percentile of five or more samples, for the primary contact recreational season (May 1st through October 31st), and in any other instance where the Department determines it necessary to protect human health.
(6) Monthly GM of five or more samples.
(7) Geometric mean of samples collected over any consecutive 30-day period, for the primary contact recreational season (May 1st through October 31st).
(8) 90th percentile value of samples collected over any consecutive 30-day period, for the primary contact recreational season (May 1st through October 31st).

Table 2.1-8. New York State Narrative WQS

Parameters	Classes	Standard
Taste-, color-, and odor-producing toxic and other deleterious substances	SA, SB, SC, I, SD A, B, C, D	None in amounts that will adversely affect the taste, color, or odor thereof, or impair the waters for their best usages.
Turbidity	SA, SB, SC, I, SD A, B, C, D	No increase that will cause a substantial visible contrast to natural conditions.
Suspended, colloidal and settleable solids	SA, SB, SC, I, SD A, B, C, D	None from sewage, industrial wastes, or other wastes that will cause deposition or impair the waters for their best usages.
Oil and floating substances	SA, SB, SC, I, SD A, B, C, D	No residue attributable to sewage, industrial wastes or other wastes, nor visible oil film nor globules of grease.
Garbage, cinders, ashes, oils, sludge and other refuse	SA, SB, SC, I, SD A, B, C, D	None in any amounts.
Phosphorus and nitrogen	SA, SB, SC, I, SD A, B, C, D	None in any amounts that will result in growth of algae, weeds and slimes that will impair the waters for their best usages.

As noted above, the *Enterococci* WQ criteria only apply to coastal primary recreational Class SB and SA waters. Therefore, these criteria do not apply to the Class I waters of the Harlem River.

Interstate Environmental Commission

The States of New York, New Jersey, and Connecticut are signatories to the Tri-State Compact that designated the Interstate Environmental District and created the Interstate Environmental Commission (IEC). The IEC includes all saline waters of greater NYC. Harlem River is an interstate water and is regulated by IEC as Class B-1 waters. Numerical standards for IEC-regulated waterbodies are shown in Table 2.1-9, while narrative standards are shown in Table 2.1-10.

The IEC also restricts CSO discharges to within 24 hours of a precipitation event, consistent with the DEC definition of a prohibited dry-weather discharge. IEC effluent quality regulations do not apply to CSO discharges if the CSS is being operated with reasonable care, maintenance, and efficiency. Although IEC regulations are intended to be consistent with State WQS, the three-tiered IEC system and the five NYS saline classifications in New York Harbor do not spatially overlap exactly.

Table 2.1-9. IEC Numeric WQS

Class	Usage	DO (mg/L)	Waterbodies
A	All forms of primary and secondary contact recreation, fish propagation, and shellfish harvesting in designated areas	≥ 5.0	East River, east of the Whitestone Bridge; Hudson River north of confluence with the Harlem River; Raritan River east of the Victory Bridge into Raritan Bay; Sandy Hook Bay; Lower New York Bay; Jamaica Bay, Atlantic Ocean
B-1	Fishing and secondary contact recreation, growth, and maintenance of fish and other forms of marine life naturally occurring therein, but may not be suitable for fish propagation.	≥ 4.0	Hudson River, south of confluence with Harlem River; upper New York Harbor; East River from the Battery to the Whitestone Bridge; Harlem River; Arthur Kill between Raritan Bay and Outerbridge Crossing
B-2	Passage of anadromous fish, maintenance of fish life	≥ 3.0	Arthur Kill north of Outerbridge Crossing; Newark Bay; Kill Van Kull

Table 2.1-10. IEC Narrative Regulations

Classes	Regulation
A, B-1, B-2	All waters of the Interstate Environmental District (whether of Class A, Class B, or any subclass thereof) shall be of such quality and condition that they will be free from floating solids, settleable solids, oil, grease, sludge deposits, color or turbidity to the extent that none of the foregoing shall be noticeable in the water or deposited along the shore or on aquatic substrata in quantities detrimental to the natural biota; nor shall any of the foregoing be present in quantities that would render the waters in question unsuitable for use in accordance with their respective classifications.
A, B-1, B-2	No toxic or deleterious substances shall be present, either alone or in combination with other substances, in such concentrations as to be detrimental to fish or inhibit their natural migration or that will be offensive to humans or which would produce offensive tastes or odors or be unhealthful in biota used for human consumption.
A, B-1, B-2	No sewage or other polluting matters shall be discharged or permitted to flow into, or be placed in, or permitted to fall or move into the waters of the District, except in conformity with these regulations.

EPA Policies and Regulations

EPA guidance regarding bathing beaches and the EPA Recreational Water Quality Criteria (RWQC) recommendations are not applicable to the Harlem River, given its Class I classification and the lack of New York City Department of Health and Mental Hygiene (DOHMH)-permitted beaches.

2.1.b.3 Physical Waterbody Characteristics

The northern end of the Harlem River connects to the Hudson River in an area known as Spuyten Duyvil. The southern end of the Harlem River connects to the East River in an area known as Hell Gate, and the Bronx Kill near Randall's Island. The Harlem River is approximately eight miles long and between 400 to 500 feet wide, encompassing approximately 33 acres. The average depth is approximately 15 feet.

Shoreline Physical Characterization

The shorelines of Harlem River are composed of a mix of bulkheads, riprap, and natural areas, as shown in Figure 2.1-20. Figure 2.1-21 and Figure 2.1-22 present examples of the predominant shoreline characteristics along the Harlem River. Figure 2.1-21 shows the typical riprap protection found throughout the Harlem River and natural shoreline can be seen in the background. Figure 2.1-22 shows an example of riprap on the western shoreline and a bulkhead on the eastern shoreline.

Shoreline Slope

Shoreline slope has been qualitatively characterized along shoreline banks where applicable, and where the banks are not channelized or otherwise developed with regard to physical condition. “Steep” is defined as greater than 20 degrees, or 80-foot vertical rise for each 200-foot horizontal distance perpendicular to the shoreline. “Intermediate” is defined as 5 to 20 degrees. “Gentle” is defined as less than 5 degrees, or 18-foot vertical rise for each 200-foot horizontal distance. The northern end of the Harlem River is characterized by “intermediate” to “steep” shorelines with a notable cliff landmark at Spuyten Duyvil. “Gentle” and “intermediate” slopes characterize the natural or vegetated shorelines of Harlem River.

Waterbody Sediment Surficial Geology/Substrata

The bottom of the Harlem River is predominantly composed of mud/silt/clay with areas of sand, according to data from previous studies. A recent study from Queens College characterized the sediment types at south end of the Harlem River to Hell Gate as being predominately muddy sands. The mid to upper portions of the Harlem River are relatively clean, medium-grained sands with some gravel and the confluence with the Hudson River is underlain by fine-grained, muddy sands (Coch et al, 2017).

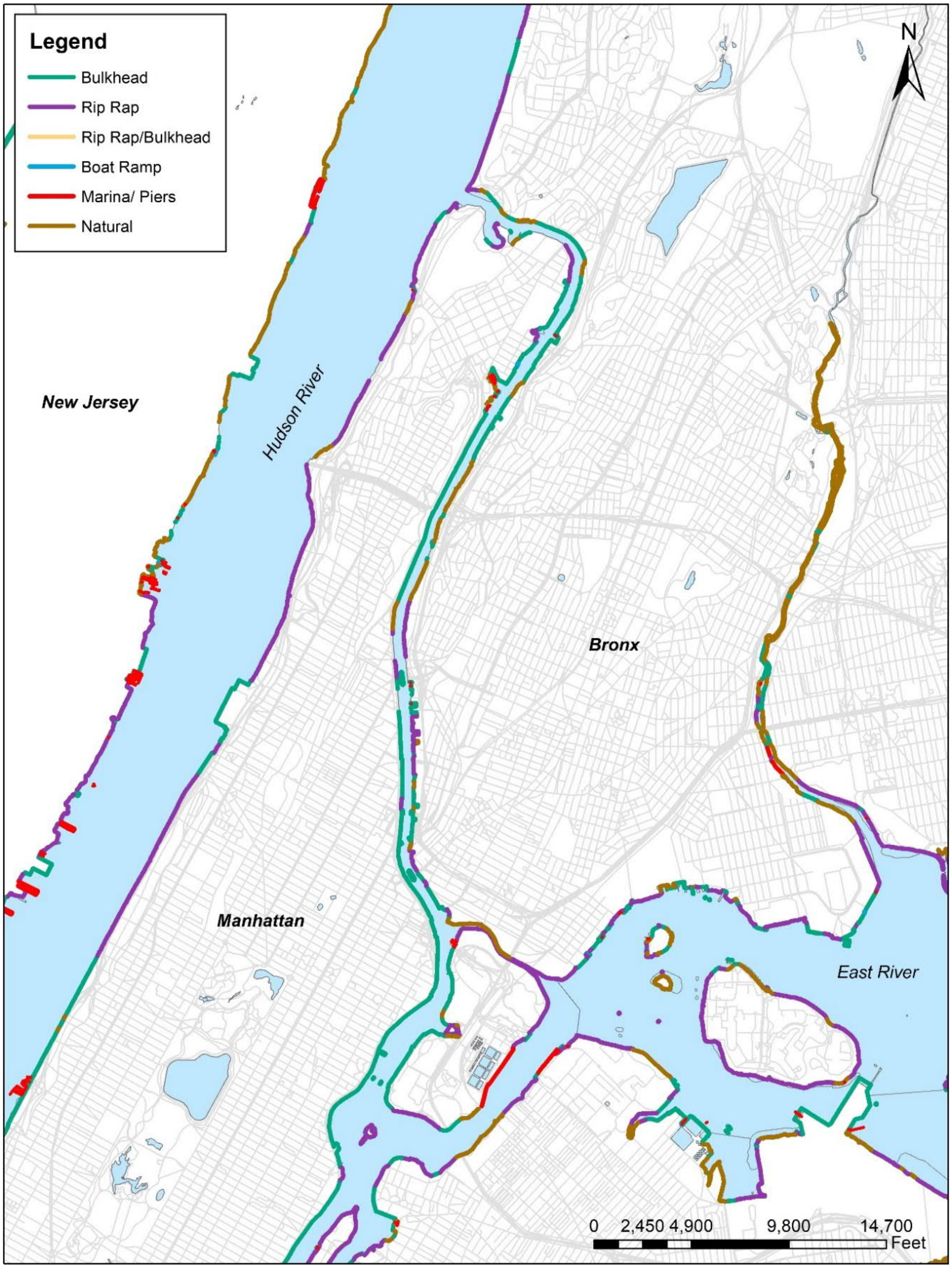


Figure 2.1-20. Harlem River Shoreline Characteristics

Figure 2.1-21. Riprap and Natural Shoreline View of Harlem River

Figure 2.1-22. Riprap and Bulkhead Shoreline of Harlem River

Tidal/Estuarine Systems Biological Systems

Tidal/Estuarine Wetlands

Tidal/estuarine wetlands reported by the U.S. Fish and Wildlife Service (USFWS) National Wetlands Inventory (NWI) maps show limited tidal/estuarine wetlands at the northern end of the Harlem River, as shown in Figure 2.1-23. The three estuarine wetlands areas indicated in Figure 2.1-23 include Inwood Hill Park cove (11.58 acres), Muscota Marsh (2.68 acres), and Sherman Creek (4.58 acres). These three wetland areas have been assigned an NWI classification code of "E2USM - Estuarine, Intertidal, Unconsolidated Shore, Irregularly Exposed."

Aquatic and Terrestrial Communities

The DCP Plan for the Manhattan and Bronx Waterfronts (DCP, 1993) reports a diverse range of species supported by the habitat in the Harlem River area.

Biological Systems

One generalized freshwater wetlands area is shown in DEC's Freshwater Wetlands Maps. Within the Harlem River watershed, this area is mapped in Van Cortlandt Park.

2.1.b.4 Current Public Access and Uses

In the Harlem River, secondary contact recreation opportunities are facilitated by access points along Harlem River as shown in Figure 2.1-24. Figure 2.1-25 presents a photograph of the Peter Jay Sharp Boathouse, a public boat/kayak launch located in Swindler's Cove on the western shore of the Harlem River. Swimming (primary contact recreation use) is not identified as a "best use" in the Harlem River as defined by New York State Codes, Rules, and Regulations for Class I waterbodies.

2.1.b.5 Identification of Sensitive Areas

The Federal CSO Policy requires that the LTCP give the highest priority to controlling overflows to sensitive areas. The Policy defines sensitive areas as:

- Waters designated as Outstanding National Resource Waters (ONRW);
- National Marine Sanctuaries;
- Public drinking water intakes;
- Waters designated as protected areas for public water supply intakes;
- Shellfish beds;
- Water with primary contact recreation;
- Waters with threatened or endangered species and their habitat; and
- Additional areas determined by the Permitting Authority (i.e., DEC).

Figure 2.1-23. National Wetlands Inventory Source: NYS GIS Clearinghouse - 2014

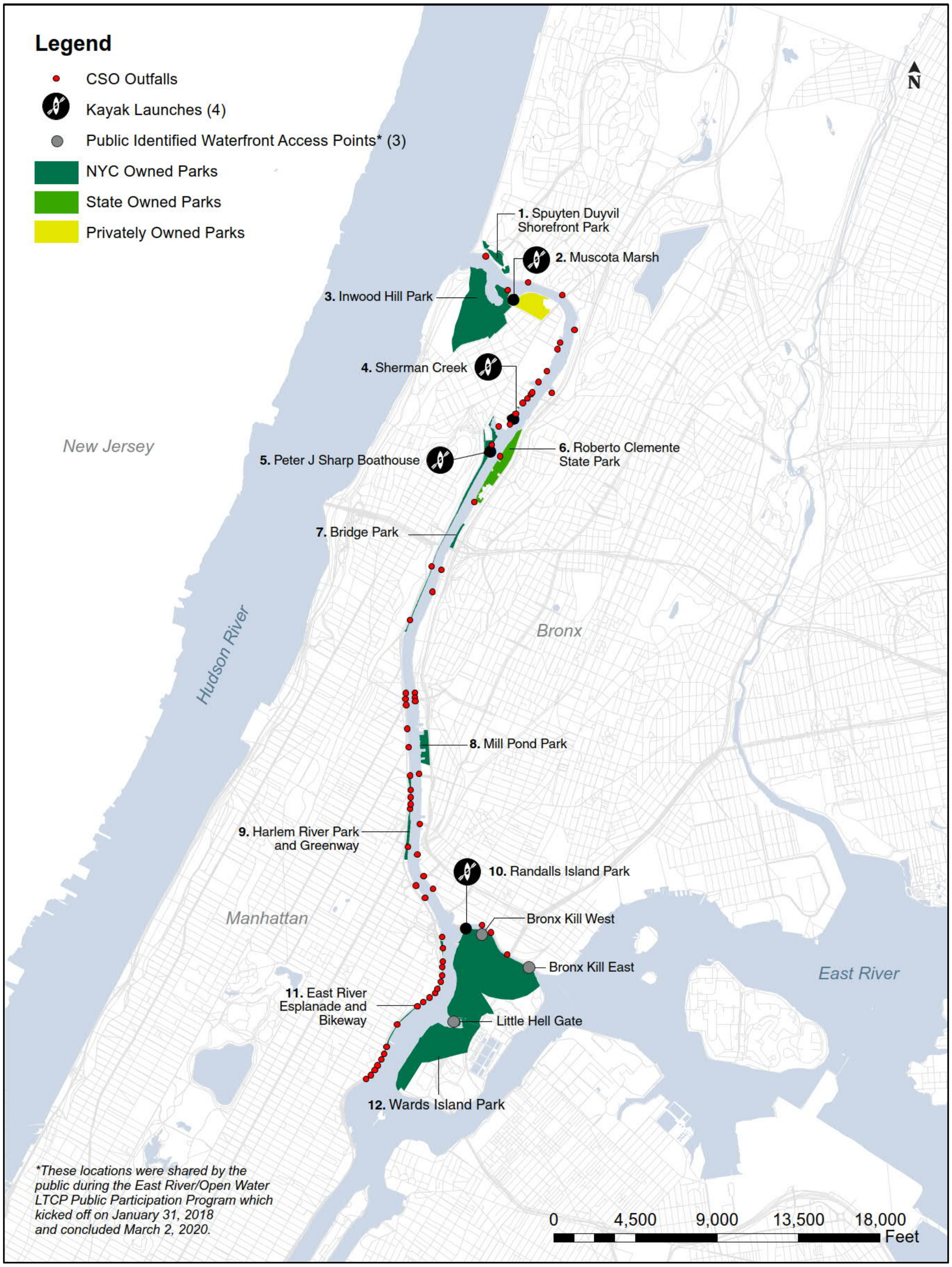


Figure 2.1-24. Access Points to Harlem River

Figure 2.1-25. Boat/Kayak Launch at Peter Jay Sharp Boathouse

The presence/status of sensitive areas in the Harlem River as defined by the Federal CSO Policy is summarized in Table 2.1-11. Sources of information supporting the status are included in the footnotes to the table.

Table 2.1-11. Sensitive Areas Assessment

CSO Discharge Receiving Water Segment	Presence/Status of Sensitive Area Classifications or Designations(1)						
	Outstanding National Resource Water	National Marine Sanctuaries	Waters with Threatened or Endangered Species and their Habitat	Best Use - Primary Contact Recreation	Public Water Supply Intake	Public Water Supply Protected Area	Shellfish Bed
Harlem River	No(2)	No(3)	Yes(4)	No(5)	No(6)	No(6)	No(7)

Notes:
(1) Classifications or Designations per CSO Policy.
(2) EPA; DEC Protection of Waters Program and Environmental Resource Mapper.
(3) National Oceanic and Atmospheric Administration (NOAA).
(4) United States Fish and Wildlife Service (USFWS); NOAA; DEC New York Natural Heritage Program (NYNHP).
(5) Best uses for Class I water defined as secondary contact recreation and fishing.
(6) Harlem River is saline.
(7) 6CRR-NY part 41.

As indicated in Table 2.1-11, for the Harlem River, the only sensitive area classification applicable to the Harlem River is “Waters with Threatened or Endangered Species and their Habitat.” The USFWS lists the following with the potential to occur in the Citywide/Open Waters project area:

- Piping Plover (*Charadrius melodus)*
- Red Knot (*Calidris canutus rufa*)
- Roseate Tern (*Sterna dougallii dougallii*)
- Bog Turtle (*Clemmys muhlenbergii*)
- Indiana Bat (*Myotis sodalist*)
- Northern Long-eared Bat (*Myotis septentrionalis*)
- Sandplain Gerardia (*Agalinis acuta*)
- Seabeach Amaranth (*Amarnthus pumilus*)

The NYNHP List of Threatened and Endangered Species with the Potential to Occur identifies the peregrine falcon (*Falco peregrinus*) for the Harlem River. None of the species on the USFWS or NYNHP lists were identified as having critical habitat in or along the Hudson River.

2.1.b.6 Compilation and Analysis of Existing Water Quality Data

DEP has been collecting New York Harbor water quality data since 1909. These data are utilized by regulators, scientists, educators, and citizens to assess impacts, trends, and improvements in the water quality of New York Harbor. The Harbor Survey Monitoring (HSM) Program has been the responsibility of DEP’s Marine Sciences Section for the past 27 years. These initial surveys were performed in response to public complaints about quality-of-life near polluted waterways. The initial effort has grown into a survey that consists of 72 stations distributed throughout the open waters of the Harbor and smaller tributaries within NYC. The number of water quality parameters measured has also increased from 5 in 1909, to over 20 at present.

Harbor water quality has improved dramatically since the initial surveys. Infrastructure improvements and the capture and treatment of virtually all dry-weather sewage are the primary reasons for this improvement. During the last decade, water quality in New York Harbor has improved to the point that the waters are now utilized for recreation and commerce throughout the year.

The HSM program focuses on the water quality parameters of fecal coliform and *Enterococci* bacteria, DO, chlorophyll 'a', and Secchi disk transparency. HSM data are organized into four geographic regions within the Harbor, and the Harlem River is located within the Upper East River – Western Long Island Sound (UER-WLIS) section. The Harlem River has one Harbor Survey Monitoring station, H3, shown in Figure 2.1-26.

In addition to the HSM program, DEP also operates a Sentinel Monitoring (SM) Program, targeted at identifying illicit discharges to the waterbodies through changes to baseline sampling concentrations. The SM program collects quarterly dry-weather fecal coliform data from four stations in the Harlem River (S54, S55, S56, S57), also shown in Figure 2.1-26.

To gain an understanding of recent water quality conditions, data collected within the Harlem River from sampling conducted by DEP’s HSM program for the period from 2013 to 2016 were analyzed in conjunction with data from extensive sampling conducted from April through November 2016 to support the Citywide/Open Waters LTCP. LTCP sampling was conducted at six stations along the Harlem River. The sampling locations of the HSM, SM, and LTCP programs are shown in Figure 2.1-26. Figure 2.1-27 and

Figure 2.1-28 show the GM, minimum, maximum, 25th percentile, and 75th percentile values for fecal coliform and *Enterococci*, respectively, for the LTCP sampling data. Figure 2.1-29 and Figure 2.1-30 show similar data for the HSM sampling program for the periods of 2014 to 2016.

The fecal coliform levels measured throughout the LTCP sampling program in wet-weather were generally higher than the levels measured during dry-weather, indicative of the impacts of wet-weather pollution sources on the Harlem River. However, as shown in Figure 2.1-27, the wet-weather geometric means at each of the Harlem River LTCP sampling stations were all below 200 cfu/100mL, indicating that the wet-weather impacts were relatively limited. The LTCP *Enterococci* data generally followed a similar trend as the fecal coliform data. The dry-weather geometric means were below 30 cfu/100mL at all stations while the wet-weather geometric means were higher than 30 cfu/100mL at Harlem River Stations HAR-1 through HAR-4.

The HSM fecal coliform data presented in Figure 2.1-29 were also consistent with the LTCP data. The dry-weather geometric means were below 200 cfu/100mL for all years, while the wet-weather fecal coliform geometric mean at Station H3 was above 200 cfu/100mL in 2016 only. The HSM *Enterococci* data generally followed a similar trend as the fecal coliform data, with wet-weather geometric means higher than dry-weather geometric means. The wet-weather *Enterococci* geometric means were above 30 cfu/100mL during 2013 and 2016, while the dry-weather geometric means were below 30 cfu/100mL for all years (Figure 2.1-30).

Data collected by the Riverkeeper Group and the Citizens Testing Group is also made available to the public at the Riverkeeper Group's website: http://www.riverkeeper.org/. This dataset is limited to *Enterococci* bacteria concentrations collected during the recreational season only (May 1st through October 31st) at seven sampling stations along the Harlem River shoreline, as shown in Figure 2.1-26. Consistent with the LTCP and HSM data, the data showed a relationship between wet-weather conditions and higher *Enterococci* concentrations.

Figure 2.1-31 shows the arithmetic mean, minimum, maximum, 25th percentile, and 75th percentile values for DO from the LTCP April-November 2016 sampling program. As indicated in Figure 2.1-31, average DO values were all above 6.0 mg/L, while minimum DO values were observed below 4.0 mg/L at all stations. Figure 2.1-32 shows the arithmetic mean, minimum, maximum, 25th percentile, and 75th percentile values for DO from the HSM sampling program for 2013 to 2016. As indicated in Figure 2.1-32, average DO values were above 6.0 mg/L for all years. Minimum DO values were observed below 4.0 mg/L at HSM Station H3 in 2015, but were above 4.0 mg/L in the other years.

2.1.b.7 Water Quality Modeling

In addition to the collection, compilation, and analysis of sampling data described in Section 2.1.b.6, water quality modeling was also used to characterize and assess Harlem River water quality. The LTCP Regional Model (LTCPRM) used for water quality modeling for the Citywide/Open Waters LTCP evolved from the System-Wide Eutrophication Model (SWEM). SWEM underwent peer review by model evaluation groups (MEGs) in 1994, 1997, and 1999. A similar LTCPRM is currently undergoing a MEG review as part of the NJ CSO LTCP Development. Like SWEM, LTCPRM has 10 vertical layers and uses grid cells to represent water quality. The LTCPRM increases the density of the SWEM grid cells from a 48x84-cell grid to a 124x209-cell grid to improve resolution near CSO outfalls. The model computational grid associated with the LTCPRM, as well as further details on this model, are presented in Section 6 of this LTCP.

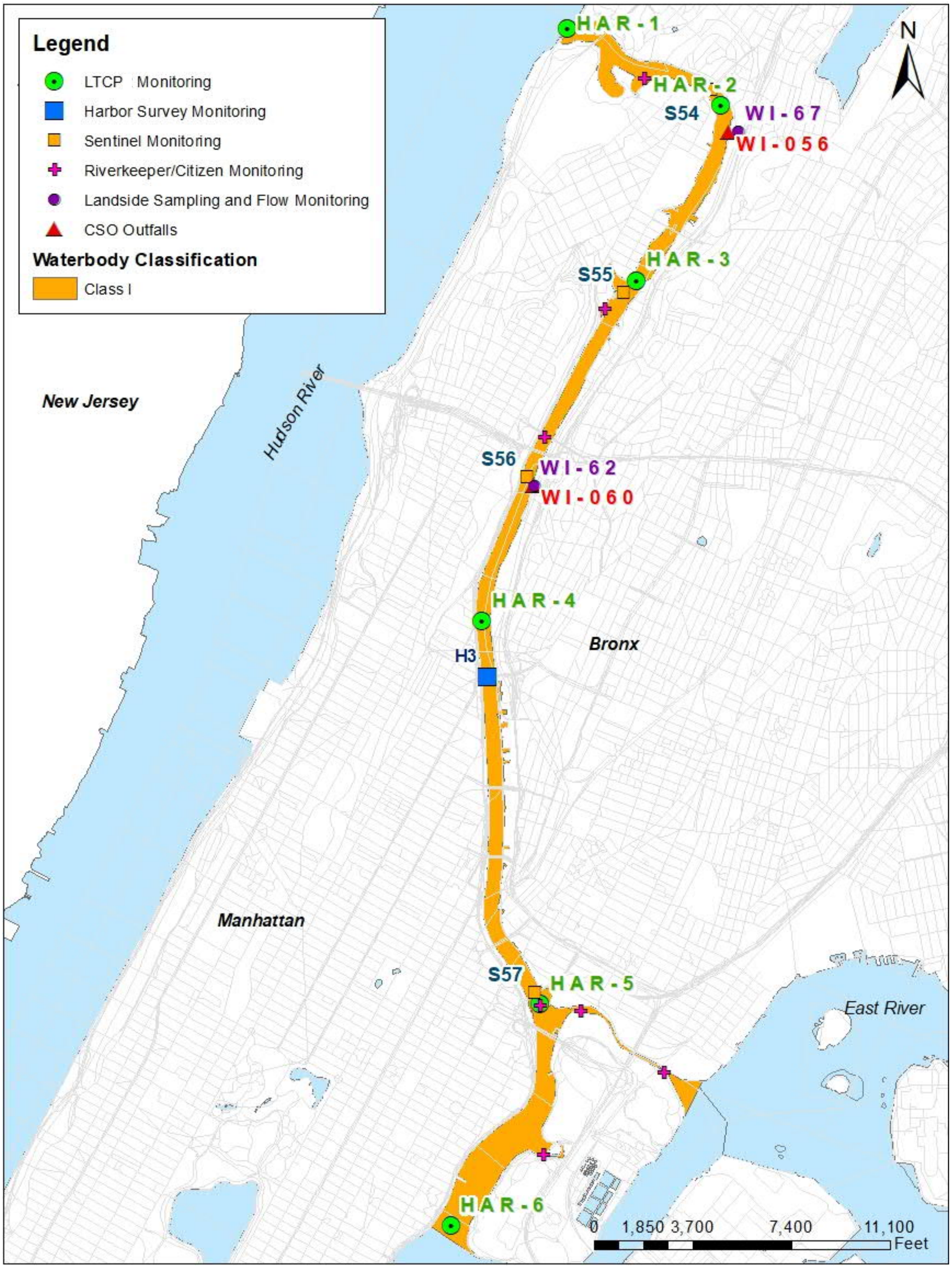


Figure 2.1-26. Water Quality Monitoring Sampling Locations within the Harlem River

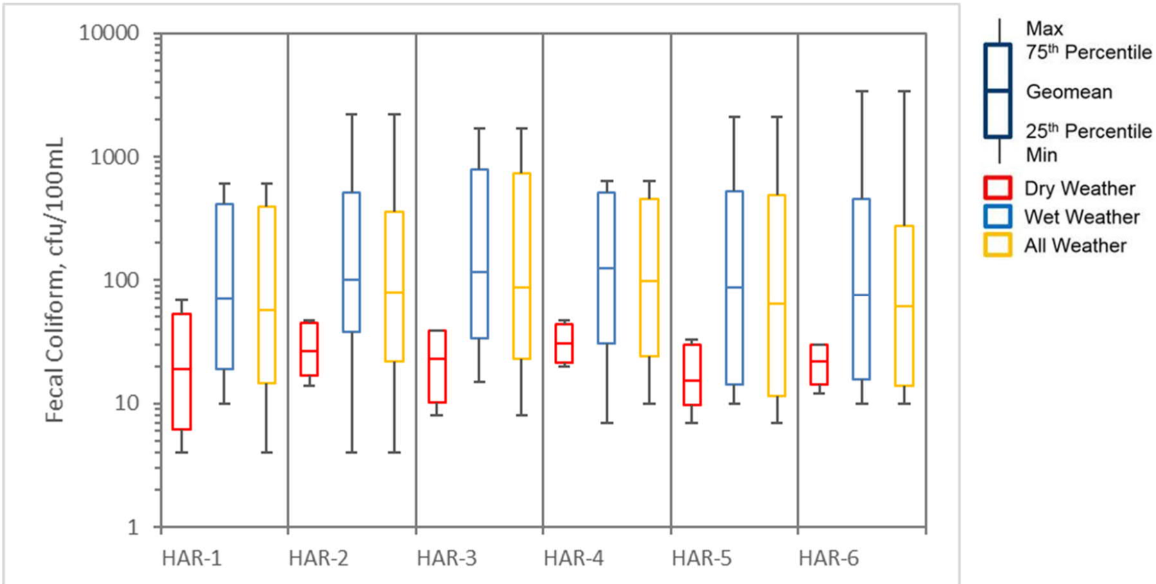


Figure 2.1-27. Fecal Coliform Concentrations at LTCP Sampling Stations in Harlem River April – November 2016

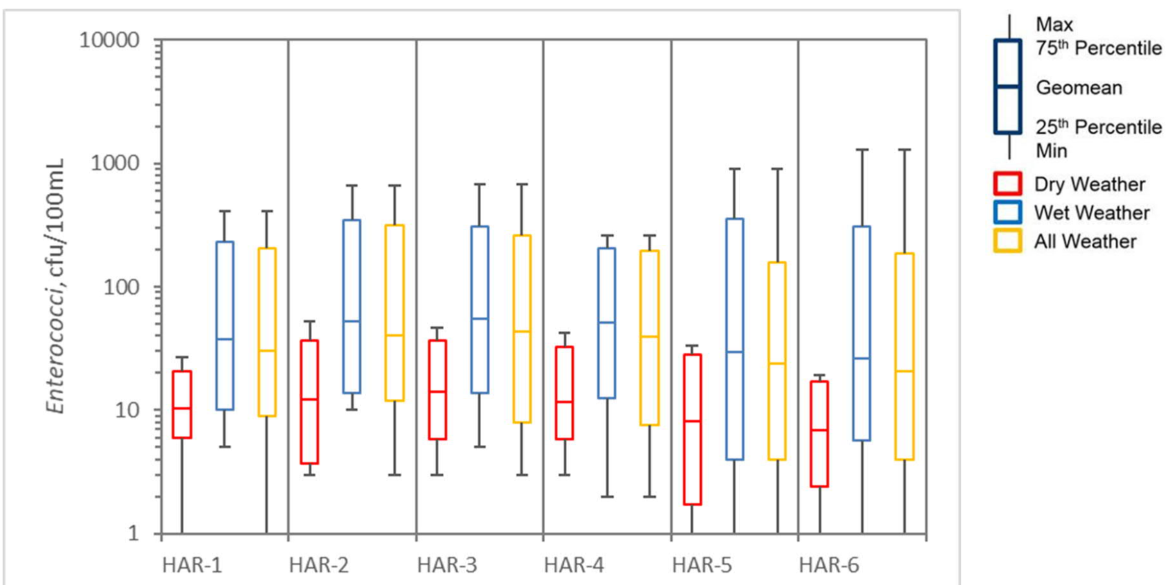


Figure 2.1-28. *Enterococci* Concentrations at LTCP Sampling Stations in Harlem River April – November 2016*

*Note: *Enterococci* WQ Criteria do not apply to the Harlem River. *Enterococci* data are presented for informational purposes.

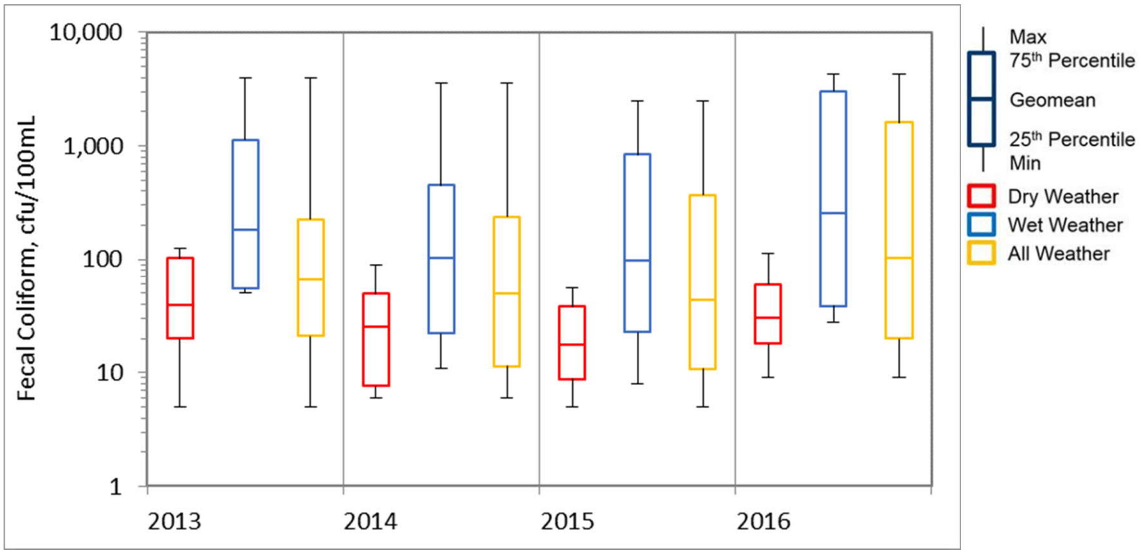


Figure 2.1-29. Fecal Coliform Concentrations at HSM Sampling Station H3 in Harlem River

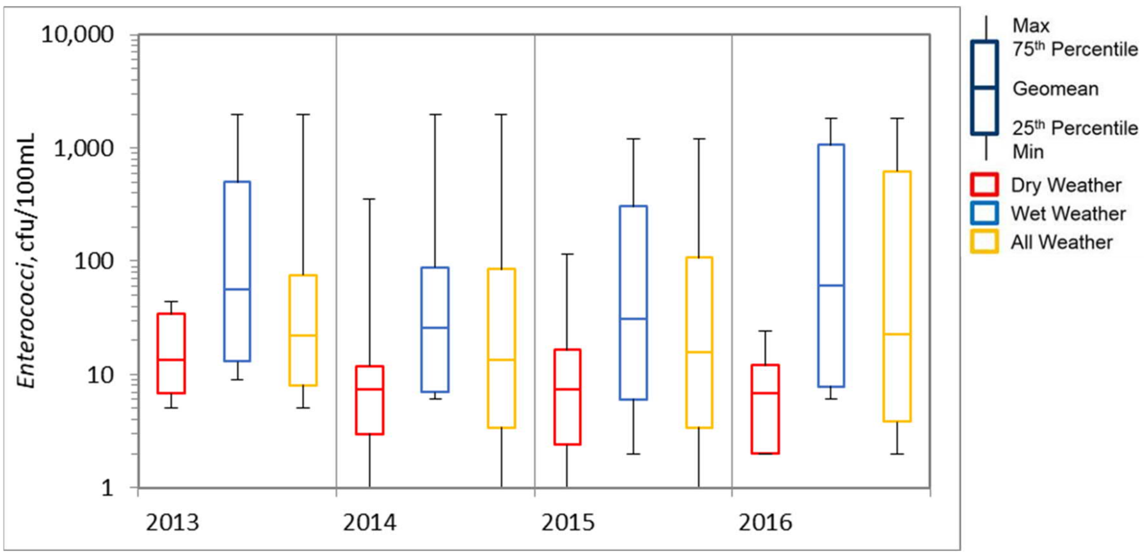


Figure 2.1-30. *Enterococci* Concentrations at HSM Sampling Station H3 in Harlem River*

*Note: *Enterococci* WQ Criteria do not apply to the Harlem River. *Enterococci* data are presented for informational purposes.

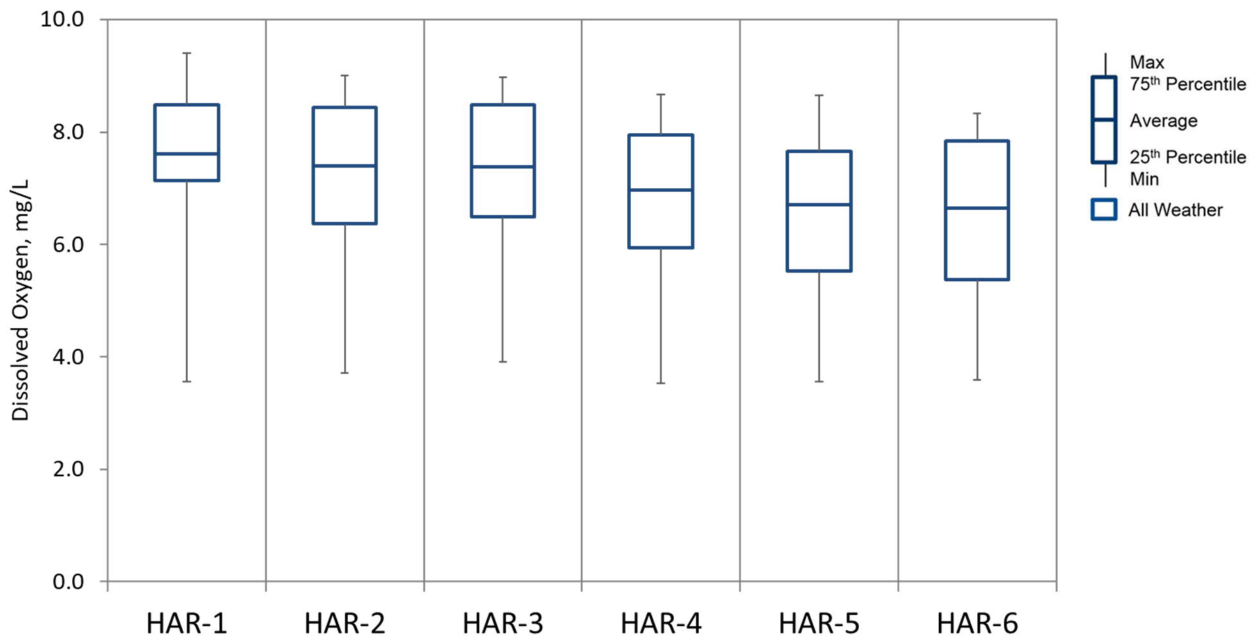


Figure 2.1-31. Dissolved Oxygen Concentrations at LTCP Sampling Stations in Harlem River April – November 2016

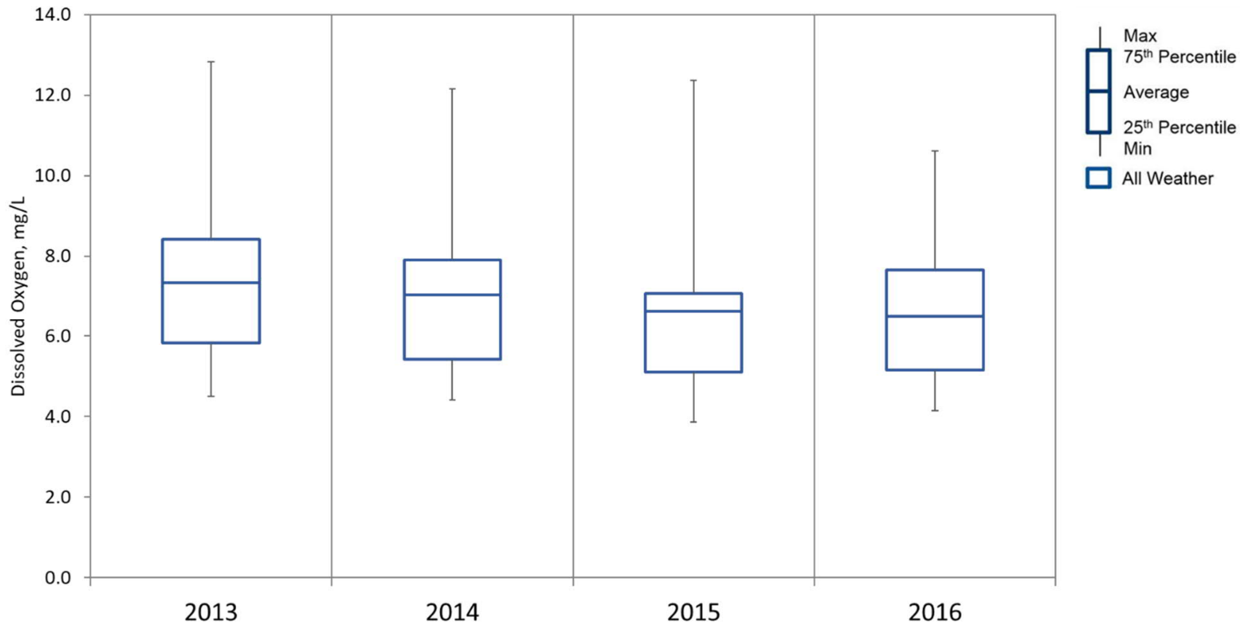


Figure 2.1-32. Dissolved Oxygen Concentrations at HSM Sampling Station H3 in Harlem River April – November 2016

2.2 Hudson River

This section summarizes the major characteristics of the Hudson River watershed and waterbody, building upon earlier documents that characterize the area. Section 2.2.a addresses watershed characteristics and Section 2.2.b addresses waterbody characteristics.

2.2.a Watershed Characteristics

The Hudson River watershed is highly urbanized and is primarily composed of residential areas with some commercial, industrial, institutional, and open space/outdoor recreation areas within the Boroughs of Bronx and Manhattan, NY. Notable outdoor recreation areas in New York City within this watershed include the State-owned Riverbank State Park and City-owned parks such as Inwood Hill Park, Fort Washington Park, Riverside Park, and Battery Park.

This subsection contains a summary of the watershed characteristics as they relate to the land use, zoning, permitted discharges and their characteristics, sewer system configuration, performance, and impacts to the adjacent waterbodies, as well as the modeled representation of the collection system used to analyze system performance and CSO control alternatives.

2.2.a.1 Description of Watershed/Sewershed

The Hudson River is a 315-mile long river that originates in the Adirondack Mountains and flows southward through the Hudson Valley and New York City, draining into the Upper New York Bay. The River also serves as a navigable tidal channel and a political boundary which separates New York from New Jersey. Based on topography alone, the entire watershed of Hudson River covers approximately 12,800 square miles. However, the focus of this Long Term Control Plan will be on the 21-mile long portion of the Hudson River that flows through New York City, from Riverdale in the Bronx, into the Upper New York Harbor at The Battery.

Elevations within the watershed range from sea level to a maximum of approximately 260 feet above sea level. The sewer system that has been constructed in the Hudson River watershed has altered the natural flow path within the watershed by intercepting and diverting flow that would normally drain to the River. The land area that is actually tributary to Hudson River as a result of the combined and separate storm sewer systems (the sewershed) is approximately 6,635 acres in New York City. Since the sewershed defines the limits of the combined sewer tributary area, this LTCP focuses on the sewershed of Hudson River. The Hudson River sewershed encompasses portions of the Boroughs of Manhattan and Bronx in New York, and is shown in Figure 2.2-1.

The Hudson River has been modified over the last 150 years by dredging and filling activities that have altered islands and shorelines, bulkheading to stabilize and protect shorelines, dredging of channels and borrow areas that have altered bottom contours and flow patterns, and the filling of natural tributaries. These activities have eradicated natural habitats, negatively impacted water quality, and modified the rich ecosystem that characterized the Hudson up until the mid-nineteenth century.

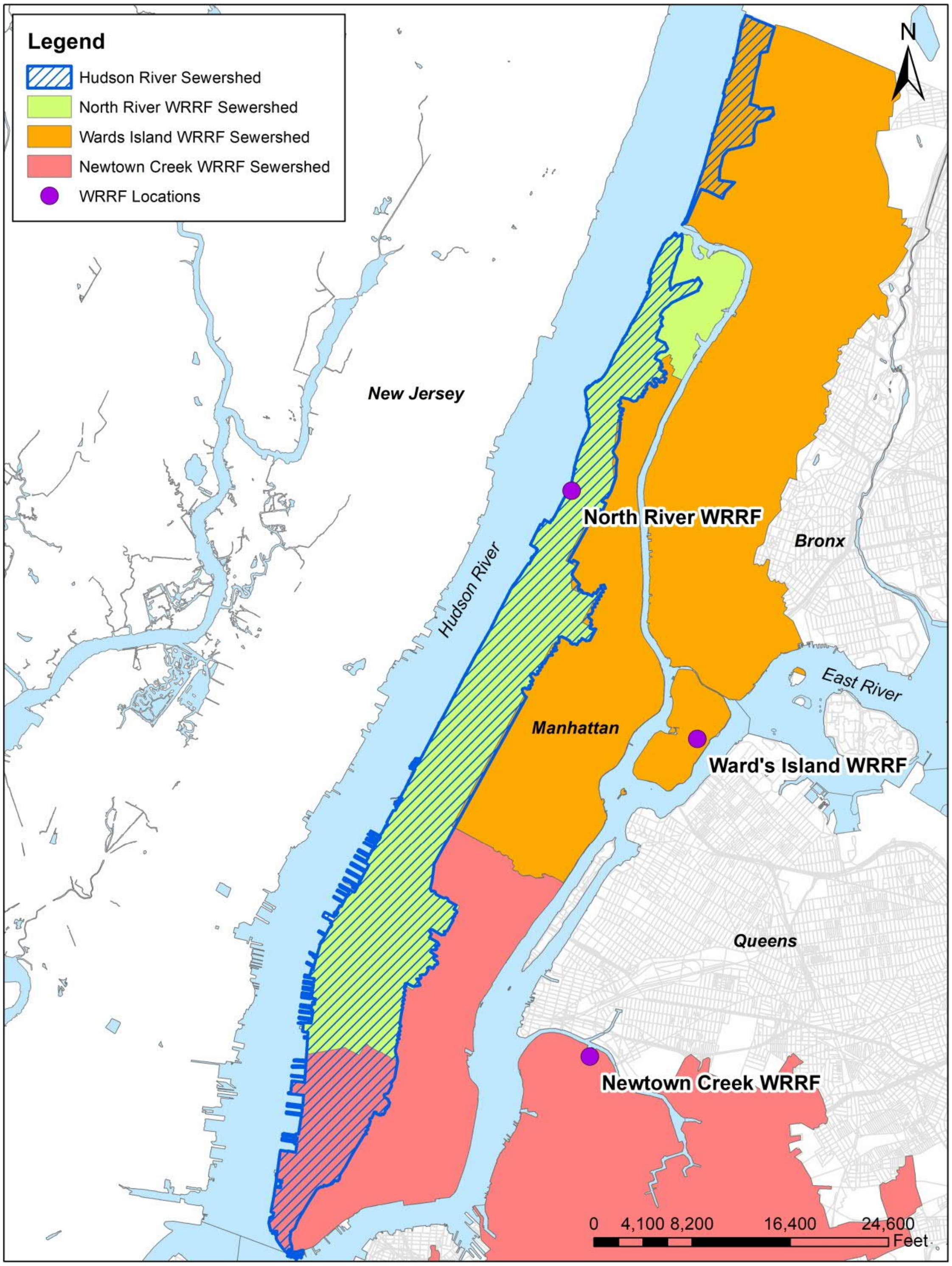


Figure 2.2-1. Hudson River Sewershed

The urbanization of NYC and the Hudson River watershed has led to the creation of a large combined sewer system (CSS), as well as areas of separate and direct drainage, primarily in areas adjacent to the Hudson River. Three WRRFs are located within the Hudson River sewershed: Wards Island (275 MGD DDWF), North River (170 MGD DDWF), and Newtown Creek (310 MGD DDWF). These WRRFs are permitted pursuant to DEC issued SPDES permits. During dry-weather, the combined and sanitary sewer systems convey sewage to the WRRFs for treatment. During wet-weather, combined storm and sanitary flow is conveyed by the sewer system to the WRRFs. If the sewer system or WRRF is at full capacity, a diluted mixture of combined storm and sanitary flow may discharge through one or more of the 52 SPDES permitted CSO Outfalls to Hudson River. Figure 2.2-2 shows the locations of the CSO outfalls along the Hudson River, along with the delineations of the combined sewer area, separate stormwater area, and direct drainage area.

Several large transportation corridors cross the Hudson River sewershed to provide access between industrial, commercial, and residential areas. The major east/west transportation corridor is the Long Island Expressway (Route 495) which connects Long Island to Manhattan through the Midtown Tunnel, continues across Manhattan via 37th Street, and connects to New Jersey via the Lincoln Tunnel. The Cross-Bronx Expressway (Route 95) is another major east/west corridor at the northern end of Manhattan that connects to New Jersey via the George Washington Bridge. The major north/south transportation corridors include the Henry Hudson Parkway (Route 9A) and Harlem River Drive. Pennsylvania Station of the Long Island Railroad, six PATH stations, the Spuyten Duyvil and Riverdale stations of the Metro-North Railroad are located in the sewershed, and the A, C, E, B, D, F, M, N, R, Q, W, S, L, 1, 2, 3, and 7 subway lines traverse the sewershed. These transportation corridors limit access to some portions of the waterbody and are taken into consideration when developing CSO control solutions. These features are shown in Figure 2.2-3.

Existing and Future Land Use and Zoning

The current land use in the Hudson River sewershed is largely attributable to historical urbanization and development within the sewershed. Future use and development is controlled by zoning, land use proposals, and evolving land use policies. Figure 2.2-4 shows the distribution of land uses in the overall Hudson River sewershed. Table 2.2-1 summarizes the relative percentages of the various land use categories both for the overall sewershed, and for the portions of the sewershed within 0.25 miles of the shoreline.

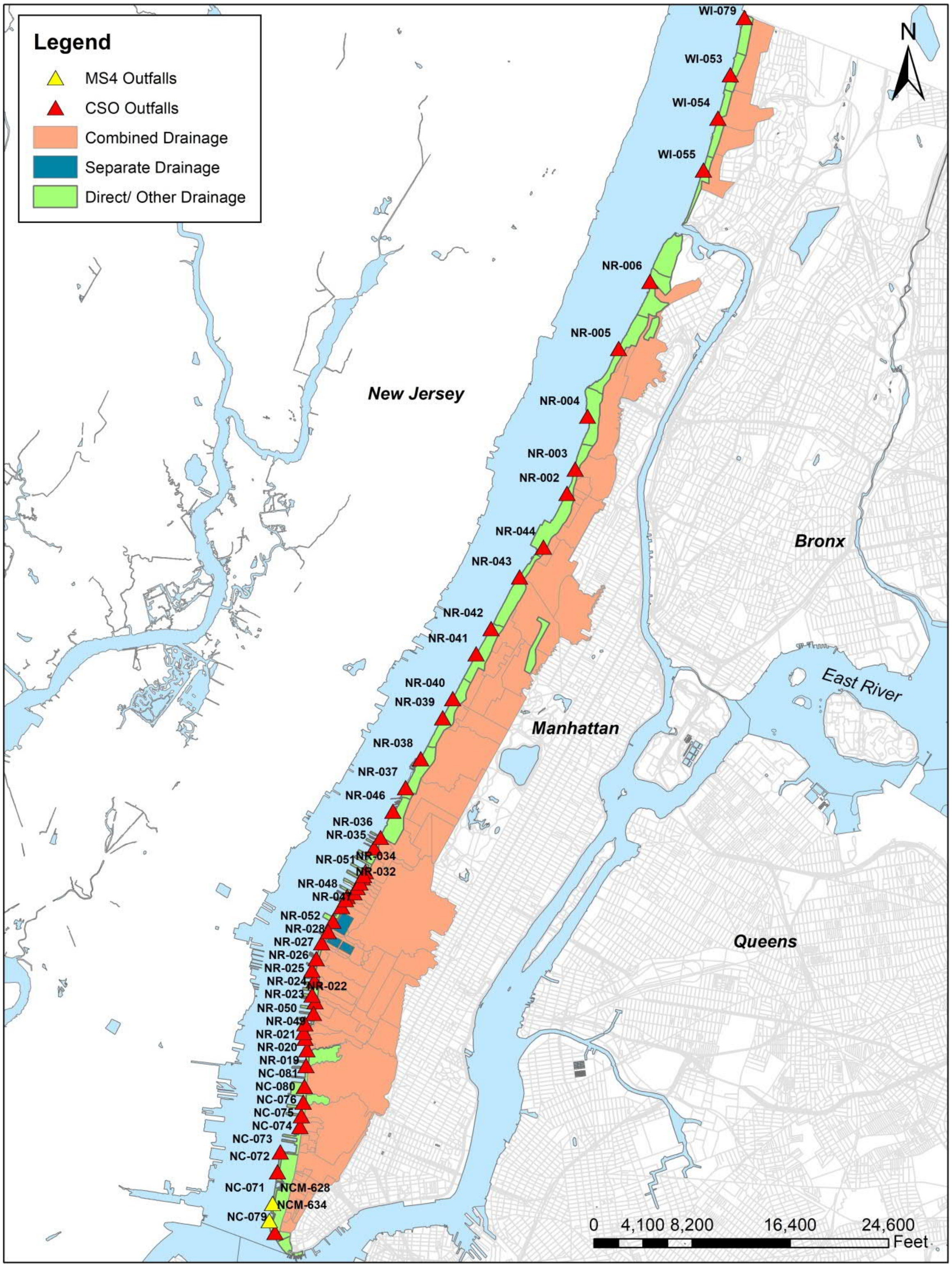


Figure 2.2-2. Components of the Hudson River Sewershed

Figure 2.2-3. Major Transportation Features

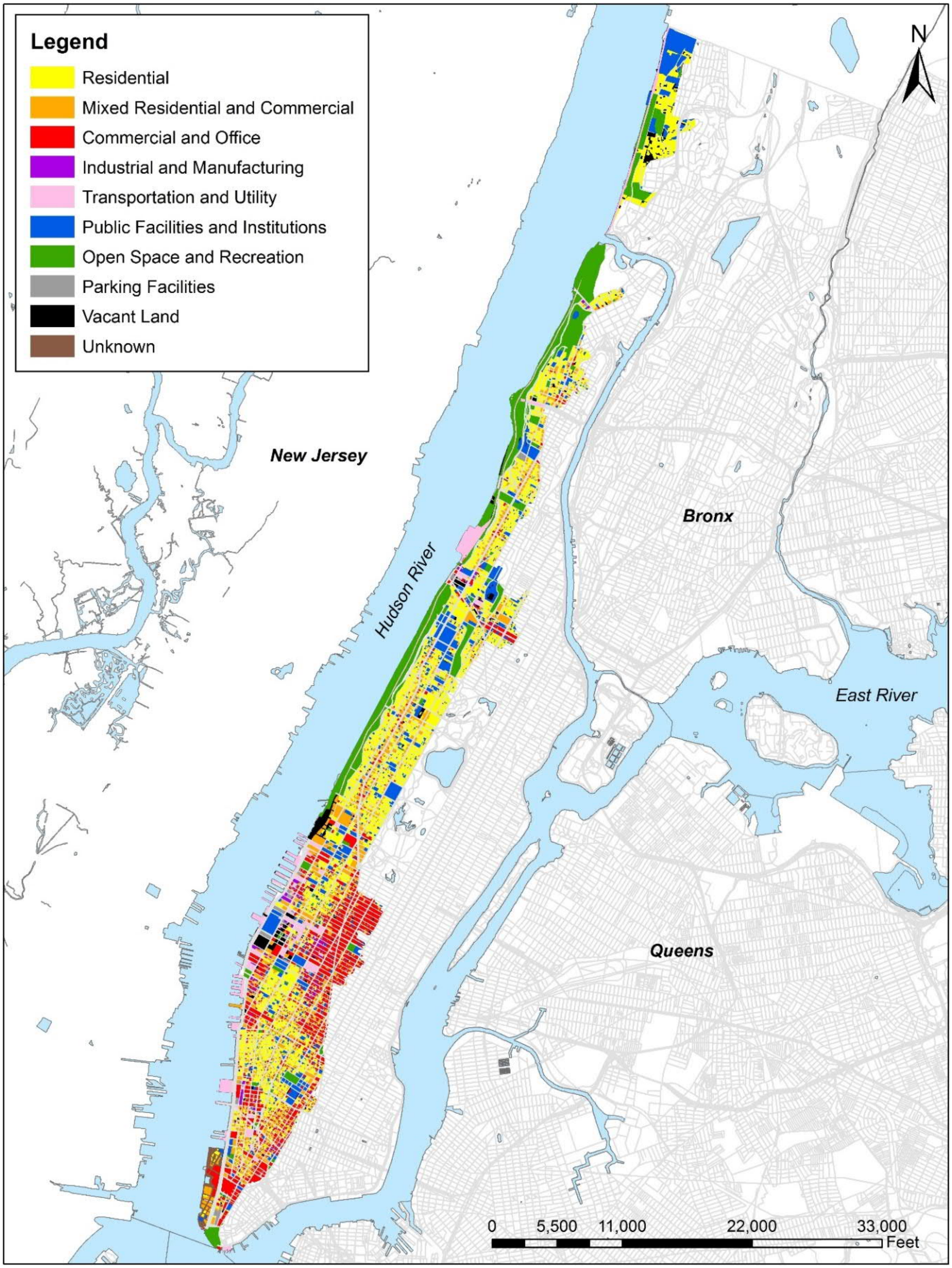


Figure 2.2-4. Land Use in the Hudson River Sewershed

Table 2.2-1. Existing Land Use within the Hudson River Sewershed Area

Land Use Category	Percent of Area	
	Within Sewershed	Within 1/4-mile of Shoreline
Residential	29.7	18.8
Mixed Residential and Commercial	12.9	8.0
Commercial and Office	13.7	6.7
Industrial and Manufacturing	1.5	1.4
Transportation and Utility	6.6	12.8
Public Facilities and Institutions	12.7	9.7
Open Space and Outdoor Recreation	17.0	33.8
Parking Facilities	1.5	1.9
Vacant Land	3.1	4.5
Unknown	1.2	2.6

As indicated in Table 2.2-1, approximately 30 percent of the Hudson River sewershed consists of residential uses with primarily multi-family housing. Open space and recreation makes up 17 percent of the uses within the sewershed, largely due to the numerous City parks which cover a significant amount of area. The sewershed contains nine City parks including Riverdale Park, Inwood Hill Park, Fort Washington Park, West Harlem Piers, Riverside Park, Riverside Park South, Rockefeller Park, Robert F. Wagner Jr. Park, and Battery Park. The sewershed also contains one State park (Riverbank State Park). Approximately 13 percent of the uses in the watershed consists of public facilities and institutions while the remaining 40 percent is mixed use, transportation, utility, industrial, manufacturing, office and commercial, and vacant or other uses.

Within the riparian areas immediately surrounding the Hudson River (including all blocks which are wholly or partially within a quarter-mile of the River), the uses are dominated by open space and recreation (34 percent), residential (19 percent), and transportation (13 percent).

Figure 2.2-5 presents a map of the established zoning within the riparian areas surrounding the Hudson River. Residential properties are the predominant zoning classification making up to 35 percent of the quarter-mile buffer, with 53 percent of the residential zoned area being high-density housing of districts R8 or higher. Park properties cover approximately 33 percent of the area within a quarter-mile of the shoreline while manufacturing and commercial zones cover 15 and 12 percent, respectively. Approximately five percent of the area near the shoreline is classified under Battery Park City zoning.

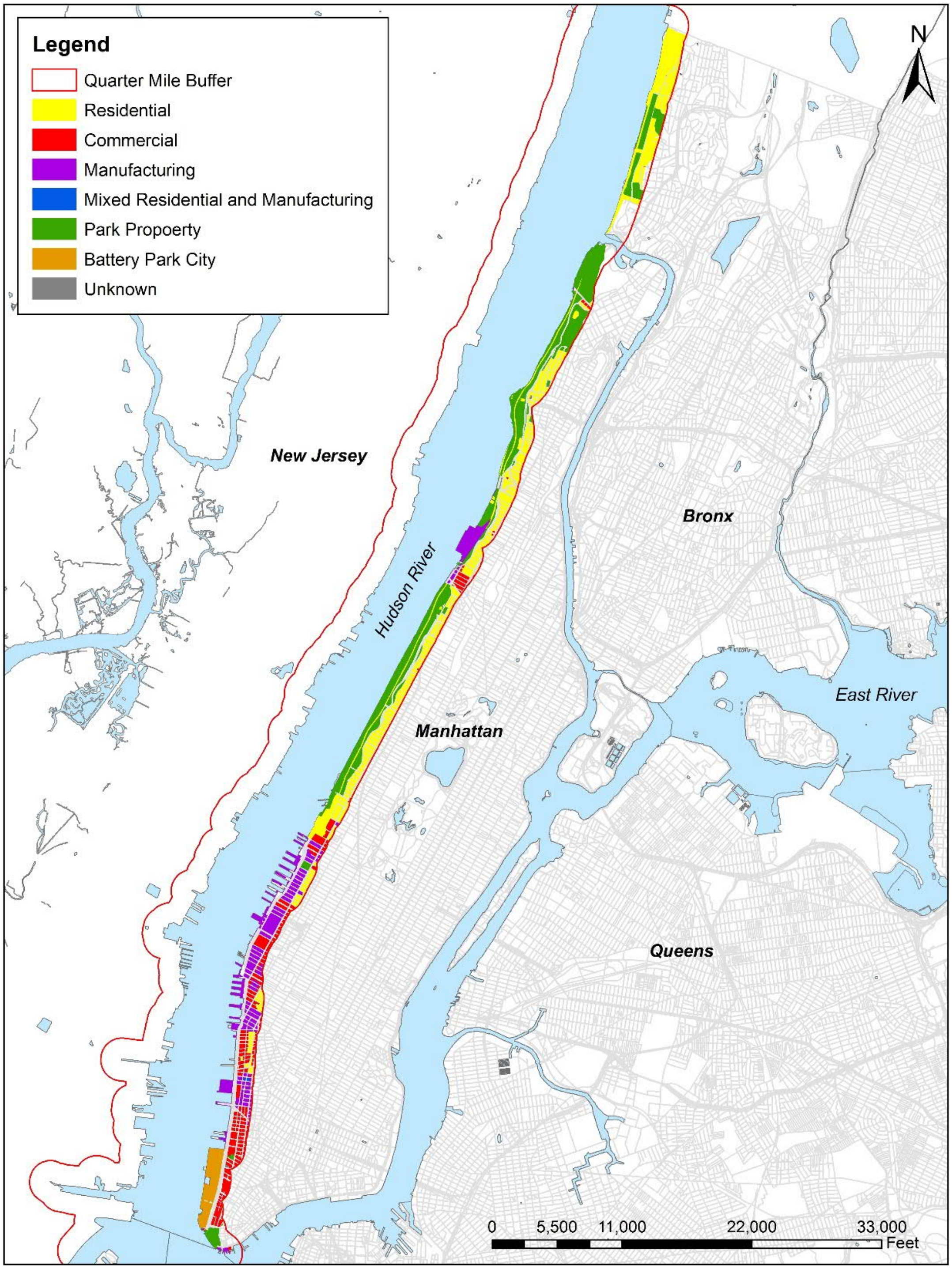


Figure 2.2-5. Zoning within 1/4 Mile of Shoreline

The Hudson River is located within the Coastal Zone Boundary as designated by DCP. DCP has also identified several recognized ecological complexes within the Hudson River watershed, including Seton Park, Wallenberg Forest Preserve, Spuyten Duyvil, Inwood Park, Fort Tryon Park, Fort Washington Park, and Riverside Park. DCP has designated several areas along the waterfront as significant maritime and industrial areas.

In addition to the standard zoning classifications, 21 "Special Use Districts" are located within the Hudson River sewershed. Special use districts are defined within the Zoning Resolution as areas designated "to achieve the specific planning and urban design objectives in areas with unique characteristics." The following "Special Use Districts" are located within the Hudson River sewershed area:

- The *125th Street District* is part of a City initiative to support and enhance Harlem's "Main Street" as a major arts/entertainment destination and regional business district. Further details on the 125th Street District are presented in Section 2.1.a.1 under the Harlem River subsection.

- *The Battery Park City District* was created to govern extensive residential and commercial development in an area on the Hudson River close to the business core of Lower Manhattan. Major components of the master plan include an office complex flanked by two large residential neighborhoods extending south to The Battery and north to Chambers Street, and a continuous esplanade providing public access to the Hudson River waterfront.

- The *Clinton District* is located between West 41st Street and West 59th Street west of Eighth Avenue and was created to preserve and strengthen the residential character of a community bordering Midtown, maintain a broad mix of incomes and ensure that the community is not adversely affected by new development.

- *Enhanced Commercial Districts 2 and 3* (Columbus & Amsterdam Aves and Broadway) promote and maintain a lively, engaging, and varied pedestrian experience along with specific commercial avenues.

- The *Garment Center District* was created to maintain opportunities for apparel production, and wholesale and showroom uses in existing buildings in designated Preservation Areas west of Broadway.

- The *Hudson River Park* was established to allow a transfer of floor area from Pier 40 to the St. John's Terminal Building to facilitate its redevelopment with a mix of residential and commercial uses and open areas. The district also supports the repair and rehabilitation of Pier 40.

- The *Hudson Square District* comprises 18 blocks bounded by West Houston Street, Canal Street, Greenwich Street, and Sixth Avenue. This district promotes a vibrant mixed-use neighborhood by preserving a former warehouse and manufacturing district with a concentration of large, industrial buildings while encouraging residential and retail development. Height limitations prevent out-of-scale developments that could disrupt the neighborhood character.

- The *Hudson Yards District* was established to promote a mixed-use, mixed-density area, provide new publicly accessible open spaces, provide opportunities for substantial new office and hotel development, reinforce existing residential neighborhoods, and encourage new housing on Manhattan's Far West Side. The special district includes two new corridors for high-density commercial and residential development supported by a subway line extension, new parks and an urban boulevard. New mid-density residential development will form a transition to existing residential neighborhoods and the Special Garment Center District to the east.

- The *Lincoln Square District* preserves and enhances the area surrounding the Lincoln Center as an international center for the performing arts. Limited commercial development and regulations on types of street level uses help encourage desirable urban design and activities.

- A *Limited Commercial District* preserves the character of commercial areas within historic districts by permitting only those that have commercial uses compatible with the historic district and by mandating that all commercial uses be in completely enclosed buildings. This district is located in Greenwich Village.

- The *Little Italy District* was established to preserve and enhance the historic and commercial character of this traditional community. Regulations protect the retail area along Mulberry Street and encourage residential rehabilitation and new development consistent with the existing scale and discourage the demolition of noteworthy buildings in the area.

- The *Lower Manhattan District* enhances the vitality of Lower Manhattan by allowing for the conversion of older commercial buildings to residential use and encouraging a dynamic mixed--use area while protecting its distinctive skyline and old street patterns. The pedestrian environment is enhanced by mandates for retail continuity, pedestrian circulation space, and subway improvements. This district includes the two sub districts: South Street Seaport and the Historic and Commercial Core. The South Street Seaport Subdistrict protects the scale and character of the 18^{th} and 19^{th} century mercantile buildings by allowing the transfer of development rights to designated receiving lots. The Historic and Commercial Core ensures that new development in the area will be compatible with existing buildings that line the streets mapped in the Street-plan of New Amsterdam and Colonial New York, a street layout accorded landmark status by the NYC Landmarks Preservation Commission.

- The *Midtown District* includes the subdistricts of Fifth Avenue, Grand Central, Penn Center, Preservation and Theater and offers a floor area bonus for public plazas, subway station improvements, or theater rehabilitation in some of these subdistricts. The main goals of this special use district are growth, stabilization, and preservation of each area's character as a showcase tourist and shopping destination and transportation hub.

- The *Manhattanville Mixed Use District* in West Harlem allows for a greater density and wider variety of land uses to facilitate commercial and residential development, as well as Colombia University's planned expansion into a new campus with educational and research facilities that will incorporate below-grade development. This district provides visual and pedestrian connections and encourages a community-oriented waterfront and active ground floor spaces.

- *Mixed-Use Districts 6 and 15* (Hudson Square and West Harlem) were established to encourage investment in, and enhance the vitality of, existing neighborhoods with mixed residential and industrial uses in close proximity and create expanded opportunities for mixed-use communities.

- *Natural Area District 2* (Riverdale, Sputen Duyvil, and Fieldston) guides new development and site alterations in areas endowed with unique natural characteristics, including forests, rock outcrops, steep slopes, creeks, and a variety of botanic and aquatic environments. These natural features are protected by limiting modifications in topography and by encouraging clustered development.

- The *Tribeca Mixed Use District* was revised in 2010 to limit the size of ground floor retail uses and hotels in an otherwise commercially-zoned area. New mixed-use buildings house a growing residential community and special rules encourage a mix of uses by allowing light industries.

- The *Union Square District* was established to revitalize the area around Union Square by encouraging mixed-use development with mandated ground floor retail uses, off-street relocation of subway stairs and continuity of street walls. A floor bonus for subway improvements is also available.

- The *Special West Chelsea District* encompasses 13 full blocks and two partial blocks between West 16th Street and West 30th Street, and Tenth and Eleventh Avenues. The purpose of this special use district is to support the mixed-use character of West Chelsea through residential and arts-related development. Additionally, the district supports the character of the High Line open space area and seeks to provide a transition to the lower-scale Chelsea Historic District to the east and the Hudson Yards area to the north.

Plans for significant development and redevelopment within the Hudson River sewershed include the following:

- The *Staten Island/Bronx Special Districts Zoning Text Amendment* will create ecological areas across the special district based on proximity to the most sensitive natural resources. Regulations for development focus on lot coverage, impervious area, and planting controls, which will vary depending on adjacency of sites to these natural areas.

- The *Special Garment Center District Zoning Text Amendment* will remove manufacturing preservation requirements and promote a healthy mix of uses.

- The *Resilient Neighborhood Studies* (Lower Manhattan and West Chelsea) identifies local planning strategies to increase the neighborhood's ability to withstand and recover from coastal storms and flooding and seeks to improve access to the waterfront, as well as enhance public spaces in the community.

- The *Hudson River Greenway: Closing the Loop,* when complete, will provide 32.5 miles of connected green spaces totaling more than 1,000 acres and running continuously around Manhattan. Currently, several gaps in the greenway and two areas of existing pathway are in need of significant improvements as shown in Figure 2.2-6.

- The *Inwood NYC Planning Initiative* is a comprehensive plan that involves rezoning and land use actions to ensure that Inwood remains an affordable, attractive neighborhood for working and immigrant families. The plan will also serve to restore parks, create waterfront accessibility, provide new STEM opportunities, and support small businesses.

- The *Department of City Planning's Vision 2020 Comprehensive Waterfront Plan* builds on NYC's success in opening up to the public miles of shoreline that had been inaccessible for decades and supporting expansion of the maritime industry (DEP, 2010c). Vision 2020 set the stage for expanded use of waterfront parks, use of waterways for transportation, housing and economic development, and recreation and natural habitats. The 10-year plan lays out a vision for the future with new citywide policies and site-specific recommendations. The Hudson River spans Reaches 2, 3, 4, 5, and 6 within the Vision 2020 plan and consists of 20 site-specific waterfront revitalization strategies. Figure 2.2-7 through Figure 2.2-9 present the strategies for Reaches 2, 3, and 4. The strategies for Reaches 5 and 6 are presented in the Harlem River Section 2.1.a.1.

Figure 2.2-6. Hudson River Waterfront: Closing the Loop

REACH 2-LOWER MANHATTAN

Neighborhood Strategies

Reachwide

- Test feasibility of commuter ferry service on the East River connecting Brooklyn/Queens with Manhattan.

Brooklyn Bridge Area (1)

- Explore path alternatives and improve upland connections to the waterfront.
- Improve west side of South St. sidewalk through widening tree plantings, seating, signage, art, and paving to provide safer access to waterfront.

East River Esplanade South (2)

- Complete construction of esplanade between the Battery Maritime Building and Pier 35, including Pier 15 to feature water dependent uses, educational uses and cafe.

New Market Building (2.a)

- Support redevelopment for interim or permanent use.
- Provide public waterfront access and amenities.

Pier 17 and TIN Building (2.b)

- Improve waterfront access and connectivity.
- Encourage water-dependent uses as part of a mixed-use development.

Pier 16 (2.c)

- Improve with seating, railing, and landscaping.
- Create infrastructure to allow for future possibility of various in-water recreation activities, provided there are necessary measures to ensure safety.
- Promote continued use for historic vessels.

Pier 13 (2.d)

- Advance construction of pier before permit expires.
- Explore opportunities for educational resources, passive recreation, in-water recreation, based on the criteria described in the Citywide Strategy or other water-dependent uses.

The Battery (3)

- Create continuous waterfront access from East River esplanade to Hudson River esplanade.
- Study means to improve pedestrian connectivity between Peter Minuit Plaza and the East River Esplanade South—options include moving the Battery Tunnel entrance further north and creating a plaza above the existing entrance in front of the Battery Maritime Building.
- Complete Battery Bikeway as part of Manhattan Waterfront Greenway.

Battery Maritime Building (3.a)

- Provide elevated views to waterfront.
- Develop hotel, restaurant and community use.
- Consider expanded uses for ferry terminal.

Coast Guard Station (3.b)

- Work with Coast Guard to incorporate esplanade.

Esplanade at the Battery (3.c)

- Work with National Park Service to explore options for relocating Liberty Island screening tents.

Pier A (3.d)

- Complete renovation and restoration for a vibrant public use.

Governors Island (4)

- Commence development of Phase I Governors Island Park and Public Space Master Plan, including restoration of historic open spaces and improvements to all gateway dock facilities.
- Support planned development of the Urban Assembly New York Harbor School.
- Encourage adaptive re-use of buildings.
- Explore possibility of boat tie-ups.
- Provide ball fields, active recreation space, and community gardening.

Statue of Liberty & Ellis Island (5)

- Work with National Park Service to improve transportation access to destinations.

Figure 2.2-7. NYCDCP Vision 2020 Comprehensive Waterfront Plan – Reach 2

Neighborhood Strategies

Reachwide

- Study improved pedestrian and bicycle access to park from upland neighborhoods.
- Promote existing water taxi service.
- Explore opportunities for boat launches based on the criteria described in the Citywide Strategy.
- Expand Hudson River Park by completing construction for upland esplanade between Laight and N. Moore Streets and investing in bulkhead reconstruction between 39th and 43rd streets.

Pier 26 (1)

- Advance plans to build the Estuarium, as designated in the Hudson River Park Act.

Pier 40 (2)

- Repair and stabilize existing structure.
- Given need for revenue to support maintenance of Hudson River Park, evaluate Pier 40 for commercial uses with waterfront access and in-water recreation, possibly including a mooring field.

Piers 32 and 46 (3)

- Promote substantially deteriorated pile fields as fish habitat.

Pier 52 (4.a)

- Provide perimeter waterfront access around new waste-transfer station.

Pier 54 (4.b)

- Pursue funding and development of park.

Pier 57 (5)

- Advance plans made by Hudson River Park Trust and its private partner for a multi-use pier including public market, art gallery, and rooftop park.
- Explore opportunities for in-water recreation based on the criteria described in the Citywide Strategy.

W. 30th St. Heliport (6)

- Explore opportunities for site redevelopment after vacated.

W. 49th to W. 52nd St. (7)

- Explore creation of elevated viewing deck overlooking cruise terminals.
- Improve pedestrian and bicycling paths along cruise terminals.

Piers 92 & 94 (8)

- Support DOT and Merchandise Mart plans to reconfigure drive lanes and pedestrian paths in front of Piers 92 and 94 to facilitate pedestrian access to Piers 92, 94 and 96 and Clinton Cove section of Hudson River Park.

Pier 97 (9)

- Commence reconstruction of pier.
- Support relocation of Department of Sanitation parking and development with active recreation uses and ship berths.

REACH 3-*LOWER WEST SIDE MANHATTAN*

Figure 2.2-8. NYCDCP Vision 2020 Comprehensive Waterfront Plan – Reach 3

Neighborhood Strategies

Reachwide

- Improve access through enhanced streetscape, more lighting, better signage, and more wayfinding to and within Riverside Park and Riverside Park South.
- Examine opportunities for enhanced overlooks of the waterfront.

Riverside Park South (1)

- Explore tunneling of the Miller Highway.

69th St. Transfer Bridge (2)

- Support adaptive reuse as a public pier.

79th St. Boat Basin (3)

- Dredge and improve the 79th St. boat basin.
- Restore the landmarked 79th St. rotunda and fountain court.

Riverside Park (4)

- Create dedicated pedestrian and bike pathways.
- Evaluate for commercial uses on the waterfront, such as restaurants.
- Provide additional access points from Riverside Park to the waterfront through bridges over the highway or other means.

W.125th St. (5)

- Explore provision of boat storage near existing launch site, consistent with criteria described in the Citywide Strategy.
- Activate West Harlem Piers Park's excursion boat pier and ferry barge.

Figure 2.2-9. NYCDCP Vision 2020 Comprehensive Waterfront Plan – Reach 4

Impervious Cover Analysis

The impervious cover analysis conducted for the Hudson River sewershed is similar to the analysis described for the Harlem River (see Section 2.1.a.1).

Population Growth and Projected Flows

DEP routinely develops water consumption and dry-weather wastewater flow projections for planning purposes. In 2012, DEP projected an average per capita water demand of 75 gallons per day that was representative of future uses. The year 2040 was established as the planning horizon, and populations for that time were developed by the DCP and the New York Metropolitan Transportation Council.

The 2040 population projection figures were then used with the dry-weather per capita sewage flows to establish the dry-weather sewage flows for the Wards Island WRRF, North River WRRF, and Newtown Creek WRRF sewersheds. Average daily dry-weather sanitary sewage flows for the landside model subcatchments for each sewershed were established by distributing the total dry-weather flows at the respective WRRFs to the upstream subcatchments in proportion to the upstream subcatchment populations.

Updated Landside Modeling

The majority of the Hudson River sewershed is included within the North River WRRF collection system IW model. Smaller portions of the sewershed are represented by IW models for the Wards Island WRRF collection system in the Bronx and by the Newtown Creek WRRF collection system in the southern end of Manhattan. In 2012, 13 of DEP's IW landside models underwent recalibration. This recalibration process is described in Section 2.1.a.1.

As part of the Citywide/Open Waters LTCP, additional flow metering was conducted to check the 2012 calibration. The additional flow metering program and model verification activities are described in the 2020 Citywide/Open Waters Water Quality and Sewer System Modeling Report. The additional model updates made in support of this LTCP for the North River and Wards Island system models are described in Section 2.1.a.1. Updates to the Newtown Creek IW model that were implemented as part of the Newtown Creek LTCP are summarized in Section 2 of that document. Additional model updates to the Newtown Creek system model implemented as part of the Citywide/Open Waters LTCP development are summarized as follows:

- Modifications to runoff coefficients, regulator configurations, and wastewater profiles associated with Best Management Practices (BMP) metering and model calibration/validation
- A simplified representation of retention-based GI at specified outfalls that results in the targeted CSO reductions

Review and Confirm Adequacy of Design Rainfall Year

The 2008 rainfall from the JFK rain gauge was determined to be the most representative of average annual rainfall conditions based on a review of rain gage data from 1969 to 2010 at four rainfall gauges (CPK, LGA, JFK, EWR). As a result, the landside modeling analyses conducted as part of the LTCP process used the 2008 JFK precipitation as the typical rainfall year in NYC, together with the 2008 tide observations. The rainfall from the JFK gauge for a 10-year period of 2002 to 2011 was also used to assess long term performance of the LTCP Recommended Plan (see Sections 6 and 8). The period from

2002 through 2011 was the wettest continuous 10-year period over the past 50 years and provides a high level of conservatism to the LTCP analyses. Section 2.1.a.1 provides additional detail on selection of the typical year rainfall period.

2.2.a.2 Description of Sewer System

The Hudson River watershed/sewershed is located within the Boroughs of Manhattan (New York County, within NYC) and the Bronx (Bronx County, within NYC) and is served by three WRRFs. The northern tip of the sewershed, in the Bronx and Northeast Manhattan, is served by the Wards Island WRRF and its collection system. The majority of the western eastern shore of Manhattan is served by the North River WRRF while the Newtown Creek WRRF serves the area at the southern tip of Manhattan. The North River WRRF tributary area is the main contributor of CSO to the Hudson River and covers the most acreage. Figure 2.2-4 and Table 2.2-1 show the different land uses within the sewersheds of the Wards Island, North River, and Newtown Creek WRRFs that are tributary to Hudson River. The locations of these wastewater treatment facilities and the respective boundaries are shown in Figure 2.2-1. Table 2.2-2 lists the CSO and stormwater outfalls that discharge to the Hudson River by ownership as documented by the Shoreline Survey Unit of the DEP. The locations of these outfalls are shown in Figure 2.2-10. In addition to the outfalls listed in Table 2.2-2, the North River WRRF also discharges to the Hudson River.

Table 2.2-2. Outfalls Discharging to Hudson River

Identified Ownership of Outfalls	Number of Outfalls
DEP	DEP MS4 Permitted = 2
	DEP Non-MS4 Permitted = 9
	DEP CSO Permitted = 52
DEC	1
NYS Department of Transportation	66
Private	48
Unknown	87
Total	266

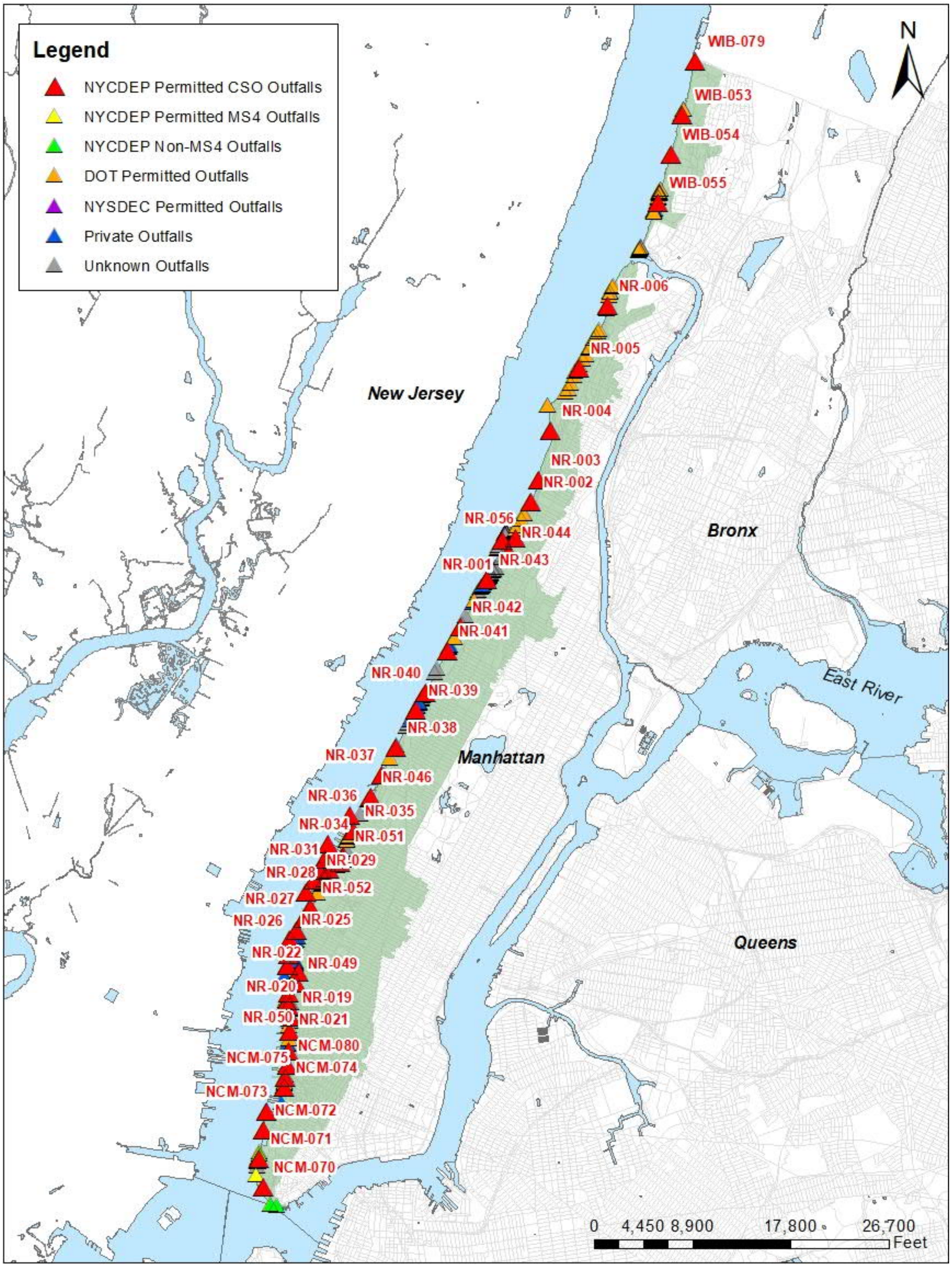


Figure 2.2-10. All Outfalls Discharging to Hudson River

Based on data available on-line at the time of preparation of this LTCP, a total of 12 State-significant industrial SPDES permit holders are operating facilities located in the sewershed, as listed in Table 2.2-3.

Table 2.2-3. Industrial SPDES Permits within the Hudson River Watershed

Permit Number	Owner	Location
NY0026247	NYCDEP NR WRRF	135th Street and 12th Avenue
NY0005134	CONED 59th Street Station	850 12th Avenue
NY0005151	CONED Hudson Avenue Station	1 Hudson Avenue
NY0072281	New York Plaza	One New York Plaza
NY0200778	CONED 60th Street Station	514 East 60th Street
NY0006033	PATH Tunnels A & B	One World Trade Center
NY0037079	Goethals Bridge	One World Trade Center
NY0109932	World Financial Center	200 Vesey Street
NYU700380	Kings Point Investors LLC	421 Hudson Street
NYU000024	MTA - NYC Transit II (Bus Depots)	1381 Amsterdam Avenue
NYU000023	MTA - NYC Transit II (Bus Depots)	666 West 133rd Street
NYR00E702	DHL Express	460 12th Avenue 2nd Floor

Overview of Drainage Area and Sewer System

The following sections describe the major features of the Wards Island, North River, and Newtown Creek WRRF sewersheds within the Hudson River watershed. The total acreage of combined sewer, separate stormwater, and direct drainage tributary area to the Hudson River is presented in Table 2.2-4.

Table 2.2-4. WRRF Sewersheds Tributary to the Hudson River: Acreage Per Sewer Category

Sewershed	Acres by Type of Tributary Area			
	Combined	Separate (MS4 and non-MS4)(1)	Direct Overland and Other(1)	Total
Wards Island	0	0	0	0
North River	4,011	25	49	4,085
Newtown Creek	909	0	258	1,167
Total	**4,920**	**25**	**307**	**5,252**

Note:
(1) Tributary drainage areas for direct drainage and other sources of stormwater have not been fully delineated by DEP or obtained from other agencies. These drainage areas were estimated based on GIS mapping, aerial photographs, land use maps, and topographic maps, rather than detailed topographic surveys and sewer maps.

Wards Island WRRF Drainage Area and Sewer System

The Wards Island WRRF sewershed and sewer system are described in Section 2.1.a.2. Figure 2.2-11 shows the main features of the Wards Island collection/transport system for the Bronx portion of the sewershed, along with the sewershed area tributary to the Hudson River. A total of four CSO outfalls from the Wards Island WRRF system are permitted to discharge to the Hudson River during wet-weather. Table 2.2-5 lists the CSO outfalls that are tributary to the Hudson River from the Wards Island WRRF sewershed, along with their associated regulators/relief structures.

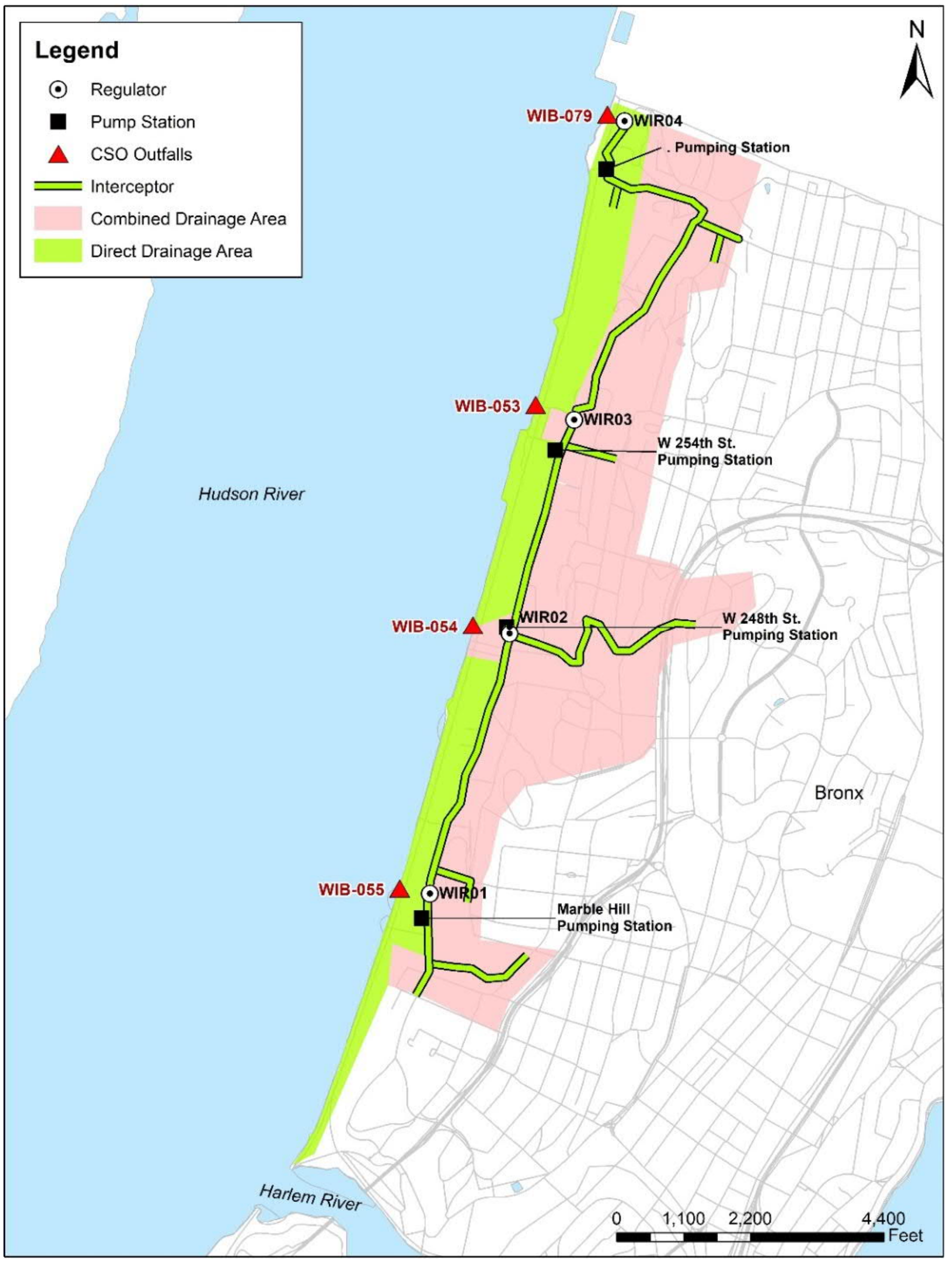


Figure 2.2-11.Wards Island WRRF Collection System

Table 2.2-5. CSO Outfalls Tributary to Hudson River from Wards Island WRRF Service Area

Outfall	Regulator(s)
WIB-053	REG #R-3
WIB-054	REG #R-2
WIB-055	REG #R-1
WIB-079	REG #R-4

North River WRRF Drainage Area and Sewer System

The North River WRRF sewershed and sewer system are described in Section 2.1.a.2. Figure 2.2-12 shows the main features of the North River collection/transport system for the northern Manhattan portion of the sewershed, along with the sewershed area tributary to the Hudson River. A total of 39 CSO outfalls from the North River WRRF system are permitted to discharge to the Hudson River during wet-weather. Table 2.2-6 lists the CSO outfalls that are tributary to the Hudson River from the North River WRRF sewershed, along with their associated regulators/relief structures.

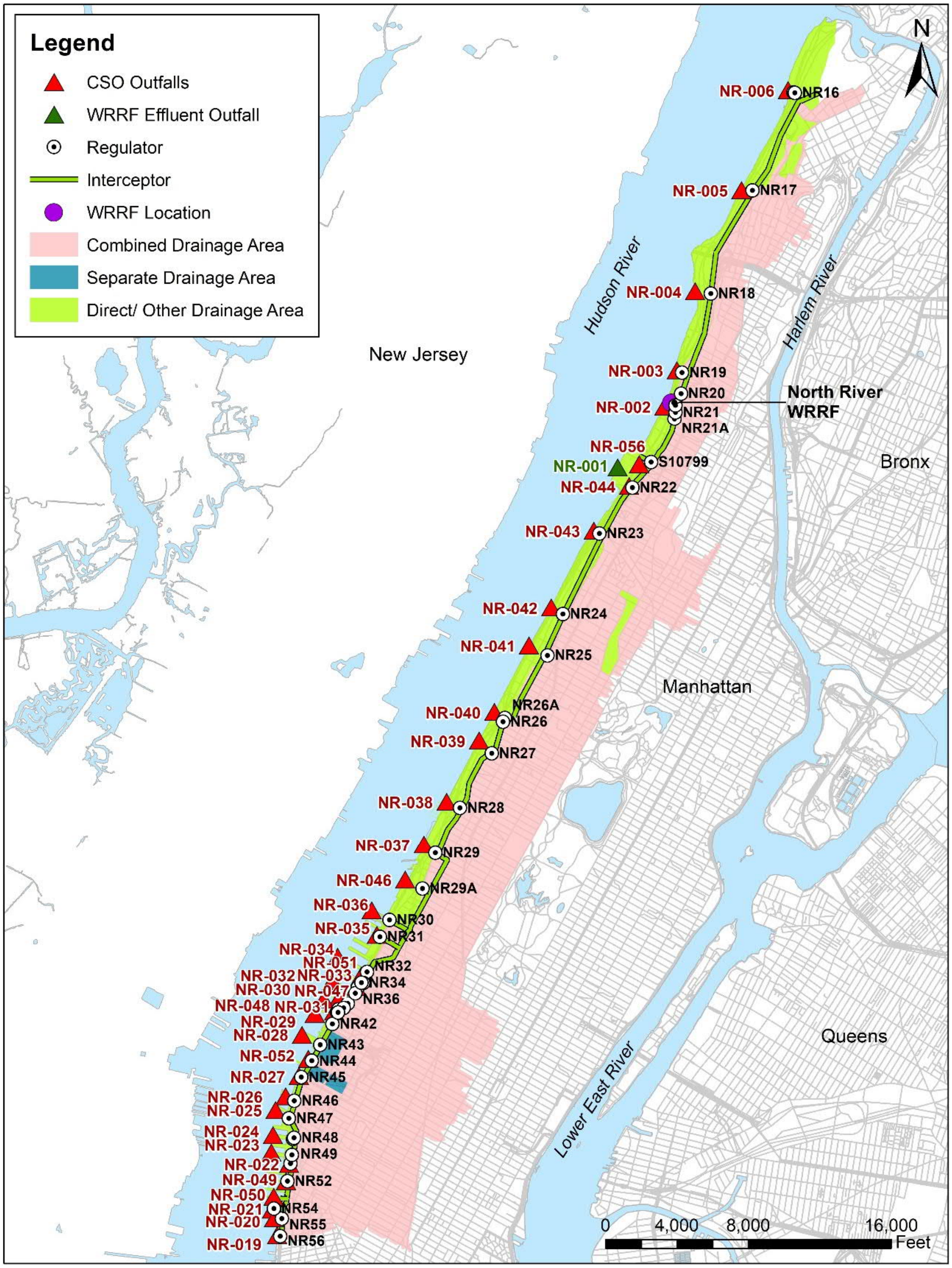


Figure 2.2-12. North River WRRF Collection System

Table 2.2-6. CSO Outfalls Tributary to Hudson River from North River WRRF Service Area

Outfall	Regulator(s)
NR-002	REG #N-20, N-21, N-21A, N-21B
NR-003	REG #N-19
NR-004	REG #N-18
NR-005	REG #N-17
NR-006	REG #N-16
NR-019	REG #N-56
NR-020	REG #N-55
NR-021	REG #N-54
NR-022	REG #N-51
NR-023	REG #N-50
NR-024	REG #N-48, N-49
NR-025	REG #N-47
NR-026	REG #N-46
NR-027	REG #N-45
NR-028	REG #N-43
NR-029	REG #N-42
NR-030	REG #N-39, N-40
NR-031	REG #N-38
NR-032	REG #N-36, N-37
NR-033	REG #N-33, N-34
NR-034	REG #N-32
NR-035	REG #N-31
NR-036	REG #N-30
NR-037	REG #N-29
NR-038	REG #N-28
NR-039	REG #N-27
NR-040	REG #N-26, N-26A
NR-041	REG #N-25
NR-042	REG #N-24
NR-043	REG #N-23
NR-044	REG #N-22
NR-046	REG #N-29A
NR-047	REG #N-35
NR-048	REG #N-40, N-41
NR-049	REG #N-52
NR-050	REG #N-53
NR-051	N/A
NR-052	REG #N-44
NR-056	REG #N-22A

Newtown Creek WRRF Drainage Area and Sewer System

The portion of the Hudson River watershed served by the Newtown Creek WRRF is located at the southern end of Manhattan. The Newtown Creek WRRF is located at 327 Greenpoint Avenue, in the Greenpoint neighborhood of Brooklyn, on a 53-acre site. The Newtown Creek WRRF serves the sewered area in Lower Manhattan, northeast Brooklyn, and western Queens, including the communities of West Village, Greenwich Village, Soho, Little Italy, Tribeca, East Village, Noho, Lower East Side, Stuyvesant Town, Gramercy, Murray Hill, Tudor City, Turtle Bay, Sutton Place, Chinatown, Civic Center, Battery Park, Financial District, Greenpoint, North Side, Southside, Williamsburg, East Williamsburg, Bedford Stuyvesant, Bushwick, Ridgewood, Glendale, Maspeth, Middle Village, Blissville, Ocean Hill, and Weeksville. A total of 593 miles of sanitary, combined, and interceptor sewers feed into the Newtown Creek WRRF.

The portion of the Newtown Creek WRRF sewershed within Manhattan influences the CSO discharges to the Hudson River. A total of 1,167 acres of the Hudson River watershed area on the west side of Manhattan are served by the Newtown Creek WRRF. An interceptor conveys flow from the west side of Manhattan to the Manhattan Pumping Station, where flow is pumped across the East River directly to the Newtown Creek WRRF. The Newtown Creek WRRF also receives flow from the Brooklyn/Queens Pumping Station. The Manhattan Pumping Station has a rated capacity of 400 MGD. However, the Wet Weather Operating Plan (WWOP) for the Newtown Creek WRRF provides that under peak wet-weather flow conditions, the Brooklyn/Queens Pumping Station will be operated up to its full capacity (400 MGD) and, if necessary, flow from the Manhattan Pumping Station may be limited to a maximum of 300 MGD to maximize treatment of wet--weather flow. The SPDES permit for the Newtown Creek WRRF requires that during wet-weather the WRRF have the capacity to receive and treat 700 MGD, which is greater than the WRRF’s 2xDDWF of 620 MGD.

A total of 9 CSO outfalls from the Newtown Creek WRRF system are permitted to discharge to the Hudson River during wet-weather. Figure 2.2-13 shows the main features of the Newtown Creek collection/transport system for the portion of the sewershed tributary to the Hudson River. Table 2.2-7 lists the CSO outfalls that are tributary to the Hudson River from the Newtown Creek WRRF sewershed, along with their associated regulators/relief structures.

Figure 2.2-13. Newtown Creek WRRF Collection System

Table 2.2-7. CSO Outfalls Tributary to Hudson River from Newtown Creek WRRF Service Area

Outfall	Regulator(s)
NCM-070	M9
NCM-071	M6
	M7
NCM-072	M5
NCM-073	M4
NCM-074	M3
NCM-075	M2
NCM-076	M1
NCM-080	TG-2
NCM-081	TG-1

Stormwater and Wastewater Characteristics

Data collected from sampling events were used to estimate concentrations for fecal coliform bacteria and *Enterococci* bacteria to use in calculating loadings from the various sources discharging to the Hudson River. CSO concentrations were measured in 2016 to provide site-specific information for Outfalls NR-043 and NC-076. The CSO bacteria concentrations were characterized by direct measurements of at least four CSO events during various storms occurring during the months of April 2016 through November 2016. These concentrations are shown in the form of a cumulative frequency distribution in Figure 2.2-14 and Figure 2.2-15. Individual sample points are shown, as well as the trend line that best fits the data distribution. For both outfalls, measured fecal coliform and *Enterococci* concentrations were log-normally distributed. Table 2.2-8 below provides the ranges of the measured CSO fecal coliform and *Enterococci* concentrations for each outfall.

Flow monitoring data were collected for CSO Outfalls NR-043 and NC-076 to support the development of the Hudson River LTCP. Descriptions of the North River WRRF and Newtown Creek WRRF IW model updates and calibration processes based on the flow monitoring data gathered for Outfalls NR-043 and NC-076 was provided earlier in Section 2.2.a.1.

Sampling, data analyses, and water quality modeling calibration resulted in the assignment of flows and loadings to these sources for inclusion in the calibration/validation of the water quality model. The CSO and stormwater concentrations used for the water quality evaluation in this LTCP are described in Section 6 of this LTCP.

Table 2.2-8. Hudson River Measured CSO Bacteria Concentrations

	Fecal Coliform (cfu/100mL)		*Enterococci* (cfu/100mL)	
Outfall	**Geometric Mean**	**Range**	**Geometric Mean**	**Range**
NR-043	339,266	100,000 - 1,700,000	219,540	107,000 - 810,000
NC-076	628,304	140,000 – 2,200,000	485,023	109,000 - 2,680,000

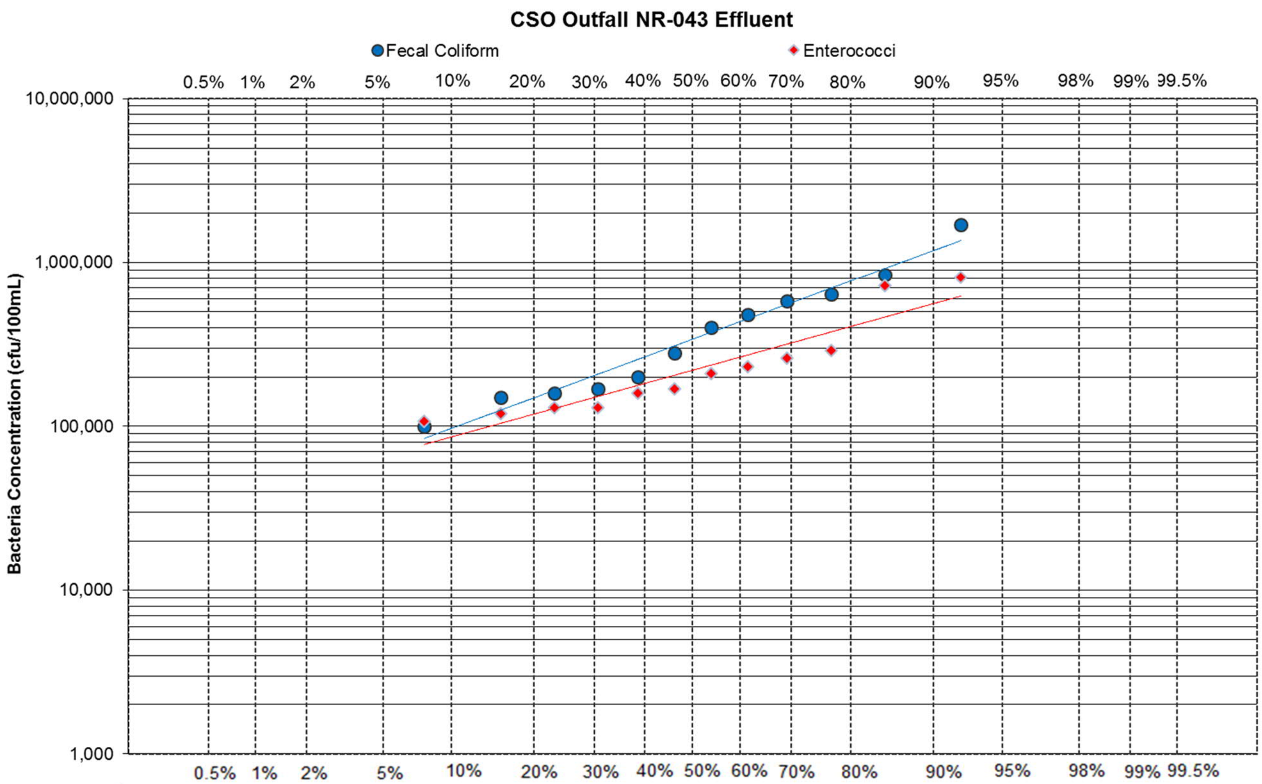


Figure 2.2-14. Outfall NR-043 Measured CSO Bacteria Concentrations

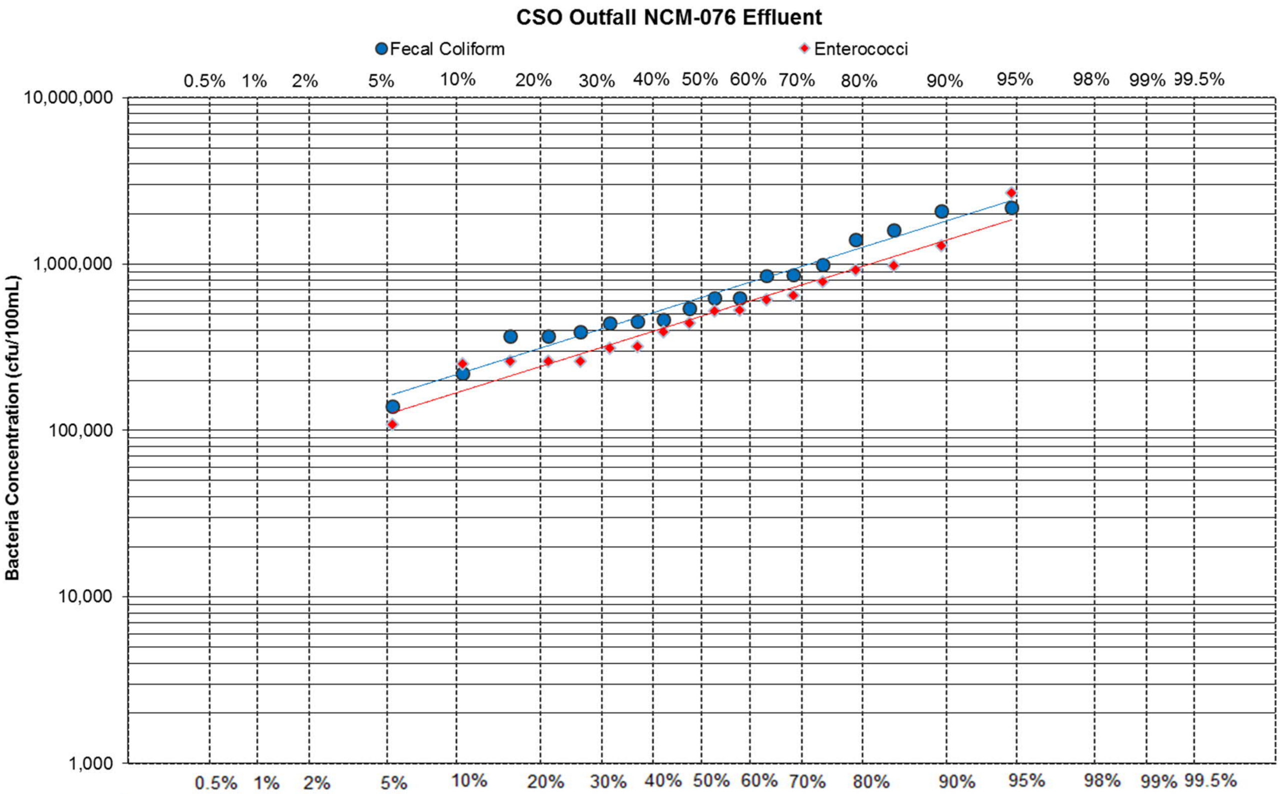


Figure 2.2-15. Outfall NC-076 Measured CSO Bacteria Concentrations

Hydraulic Analysis of Sewer System

A citywide hydraulic analysis was completed in December 2012 to provide further insight into the hydraulic capacities of key system components and system responses to various wet-weather conditions. The results of this analysis for the Wards Island and North River WRRFs are described in Section 2.1.a.2. Following is a summary of the results for the Newtown Creek WRRF.

Newtown Creek - Annual Hours at Wet-Weather Flow Capacity for 2008 with Projected 2040 DWF

Model simulations were conducted to estimate the annual number of hours that the Newtown Creek WRRF would be expected to operate at its wet-weather flow capacity (700 MGD) for the 2008 precipitation year. These simulations were conducted using projected 2040 DWF for two model input conditions – the recalibrated model conditions as described in the December 2012 IW Citywide Recalibration Report (DEP, 2012a), and the CEG alternative defined for the sewershed. The CEG elements represent the CSO controls that became part of the CSO Order. The CEG conditions applicable to the Newtown Creek WRRF sewershed included continued operation of the Brooklyn/Queens PS at up to 400 MGD during wet-weather, and bending weir/underflow baffle installations at four regulators: B-01 (NCB-015), Q-01 (NCQ-077), B-2 (NCB-083), and BB-L4 (BB-026). For these simulations, the primary input conditions applied were as follows:

- Projected 2040 DWF conditions.

- 2008 tides and precipitation data.
- Newtown Creek WRRF at capacity of 700 MGD (above the WWRF's 2xDDWF of 620 MGD).
- No sediment in the combined sewers (i.e., clean conditions).
- Sediment in interceptors representing the post-interceptor sediment conditions after the inspection and cleaning program completed in 2011 and 2012.
- No green infrastructure.

Key observations/findings are summarized below:

- Simulation of the 2008 annual rainfall year resulted in a prediction that the Newtown Creek WRRF would operate at its 700 MGD capacity for 24 hours under the non-CEG condition. When the CEG conditions were applied in the model, the annual number of hours at 700 MGD increased to 53 hours.
- The total volume (dry- and wet-weather combined) treated annually at the Newtown Creek WWRF for the 2008 non-CEG condition was predicted to be 92,845 MG, while the 2008 with CEG condition resulted in a prediction that 92,981 MG would be treated at the plant – an increase of 136 MG.
- The total annual CSO volume predicted for the outfalls in the Newtown Creek WRRF sewershed were as follows:
    - 2008 non-CEG: 3,362 MG
    - 2008 with CEG: 3,224 MG

The above results indicate an increase in the number of hours at the wet-weather flow operating capacity for the Newtown Creek WRRF, an increased annual volume being delivered to the WRRF, and a decrease in CSO volume from the outfalls in the service areas as a result of the CEG projects.

Identification of Areas Prone to Flooding and History of Confirmed Sewer Backups

DEP maintains and operates the collection systems throughout the five boroughs. To do so, DEP employs a combination of reactive and proactive maintenance techniques. NYC's "311" system routes public complaints of sewer issues to DEP for response and resolution. Although not every call that reports flooding or sewer backups corresponds to an actual issue with the municipal sewer system, each call to 311 is responded to. Sewer functionality impediments identified during a DEP response effort are corrected as necessary.

Findings from Interceptor Inspections

DEP has several programs with staff devoted to sewer maintenance, inspection and analysis, and regularly inspects and cleans its sewers, as reported in the SPDES BMP Annual reports. In the last decade, DEP has implemented advanced technologies and procedures to enhance its proactive sewer maintenance practices. GIS and Computerized Maintenance and Management Systems provide DEP with expanded data tracking and mapping capabilities, through which it can identify and respond to trends to better serve its customers. Both reactive and proactive system inspections result in maintenance, including cleaning and repairing, as necessary**.** Figure 2.2-16 and Figure 2.2-17 illustrate the intercepting sewers that were inspected in the Boroughs of Manhattan and Bronx, respectively, encompassing the entire Hudson River watershed. Throughout 2018, 5,674 cubic yards of sediment were removed from Wards Island WRRF intercepting sewers, and no sediment was removed from North River or Newtown Creek WRRF intercepting sewers. Citywide, the inspection of 145,911feet of intercepting sewers resulted in the removal of 6,112 cubic yards of sediment for 2018.

As described in Section 2.1.a.2 DEP's recent sediment accumulation analysis found that the aggregate mean sediment level for the entire NYC system was approximately 1.25 percent of sewer cross-sectional area, with a standard deviation of 2.02 percent.

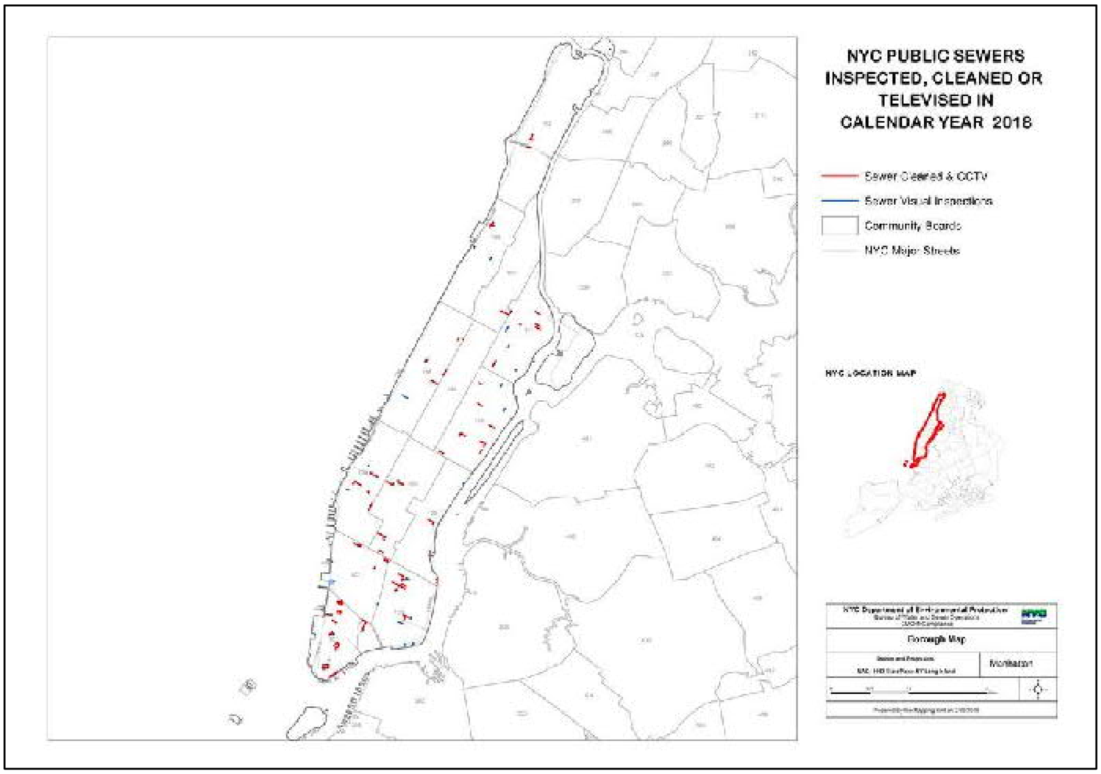


Figure 2.2-16. Sewers Inspected and Cleaned in Manhattan Throughout 2018

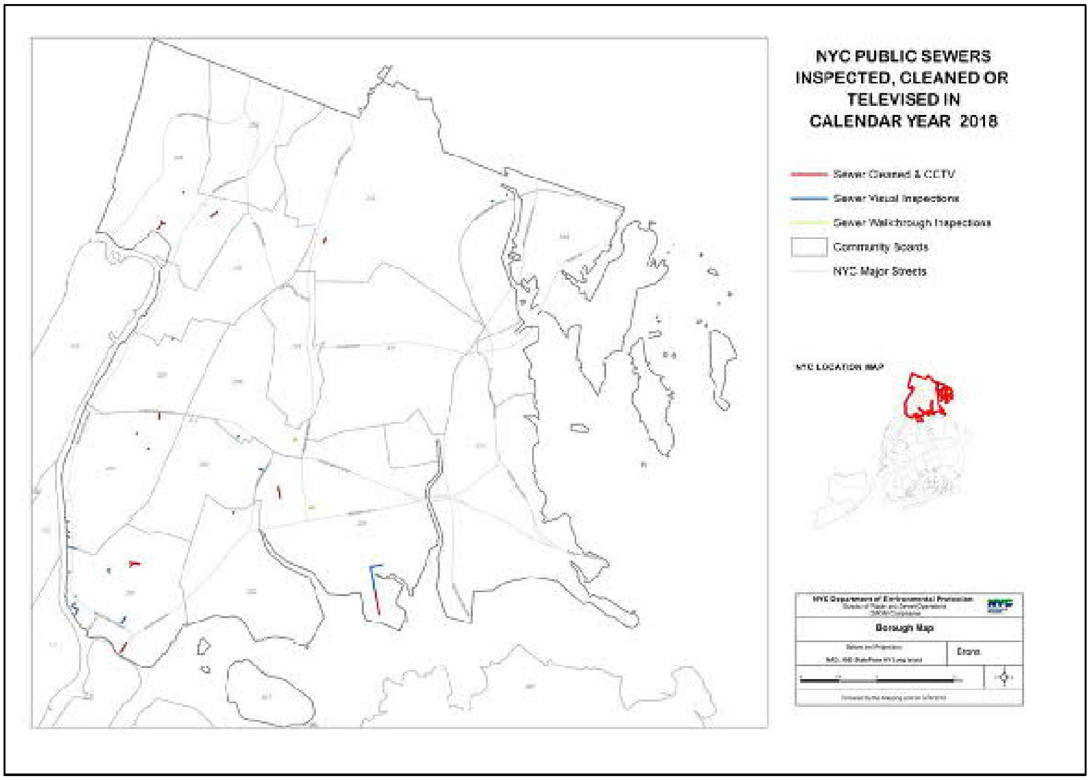


Figure 2.2-17. Sewers Inspected and Cleaned in Bronx Throughout 2018

2.2.b Waterbody Characteristics

This section describes the features and attributes of Hudson River. Characterizing the features of the waterbody is important for assessing the impact of wet-weather inputs and creating approaches and solutions that mitigate the impact from wet-weather discharges.

2.2.b.1 Description of Waterbody

The Hudson River is located along the west shoreline of Manhattan, running between Manhattan and New Jersey. The Hudson River is greatly influenced by its neighboring waterbodies. Tidal oscillations cause dramatic fluctuations of the Hudson River's currents and may influence the spread of sediments, pollutants, and other particles throughout the connecting waterways. Water quality in the Hudson River is influenced by CSO discharges and tidal exchanges with the Harlem River and the New York Bay. The following section describes the current water quality characteristics of the Hudson River, along with its uses.

2.2.b.2 Current Waterbody Classification(s) and Water Quality Standards

New York State Policies and Regulations

In accordance with the provisions of the CWA, the State of New York has established WQS for all navigable waters within its jurisdiction. DEC has classified the Hudson River north of Spuyten Duyvil as a Class SB waterbody, and the portion south of Spuyten Duyvil to The Battery as a Class I waterbody (Figure 2.2-18).

Numerical standards corresponding to these waterbody classifications are shown in Table 2.1-5 (Section 2.1.b.2), while narrative WQS criteria are presented in Table 2.1-6 (Section 2.1.b.2).

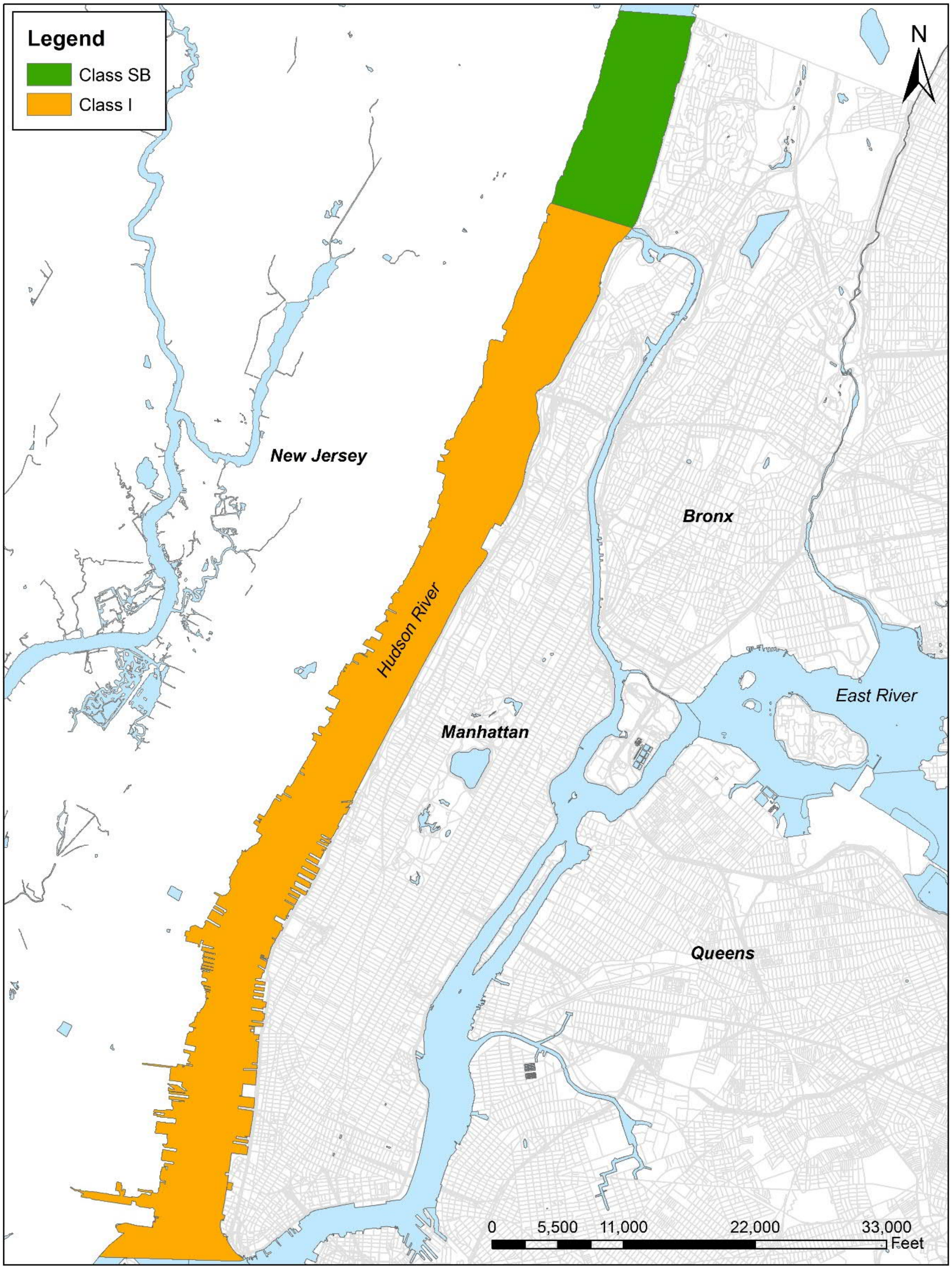


Figure 2.2-18. Waterbody Classifications for the Hudson River

Interstate Environmental Commission

The States of New York, New Jersey, and Connecticut are signatories to the Tri-State Compact that designated the Interstate Environmental District and created the Interstate Environmental Commission (IEC). The IEC includes all saline waters of greater NYC. Hudson River is an interstate water and is regulated by IEC as Class A (Bronx portion) and Class B-1 (Manhattan portion) waters. Numerical and narrative standards for IEC-regulated waterbodies are shown in Table 2.1-7 (Section 2.1.b.2) and Table 2.1-8 (Section 2.1.b.2).

EPA Policies and Regulations

No DOHMH-permitted beaches are located on the Hudson River, and the Hudson River is classified as a non-coastal tributary waterbody, so the 2012 RWQC recommendations do not apply to the Hudson River.

2.2.b.3 Physical Waterbody Characteristics

Within NYC, the Hudson River runs along the western shoreline of Manhattan and the Bronx. The northern end of the Hudson River in NYC intersects with the Harlem River in an area known as Spuyten Duyvil. The southern end of the Hudson River converges with the East River to form the Upper New York Bay at The Battery. The reach of the River between The Battery and the northern border of the Bronx is approximately 21 miles long and one mile wide, encompassing approximately 15,360 acres. The average depth is approximately 50 feet.

Shoreline Physical Characterization

The shorelines of the Hudson River are composed of a mix of bulkheads, riprap, and natural areas, as shown in Figure 2.2-19. Figure 2.2-20 and Figure 2.2-21 show examples of the predominant shoreline characteristics along the Hudson River. Figure 2.2-20 shows the natural shoreline seen on the western shore of the Hudson River. Figure 2.2-21 shows typical riprap protection and a pier on the eastern shoreline.

Shoreline Slope

Shoreline slope has been qualitatively characterized along shoreline banks where applicable, and where the banks are not channelized or otherwise modified. “Steep” is defined as greater than 20 degrees, or 80-foot vertical rise for each 200-foot horizontal distance perpendicular to the shoreline. “Intermediate” is defined as 5 to 20 degrees. “Gentle” is defined as less than 5 degrees, or 18-foot vertical rise for each 200-foot horizontal distance. The natural or vegetated shorelines of the Hudson River are characterized by “gentle” and “intermediate” slopes. The eastern (New Jersey) shore of the Hudson River is characterized by steep cliffs of the Palisades at the northern end, with regions of gentle to intermediate slopes and artificial shorelines further south. The western shoreline follows a similar trend with intermediate to steep slopes along the shorelines of the Bronx and northern Manhattan, while the majority of Manhattan is fully urbanized and low-lying.

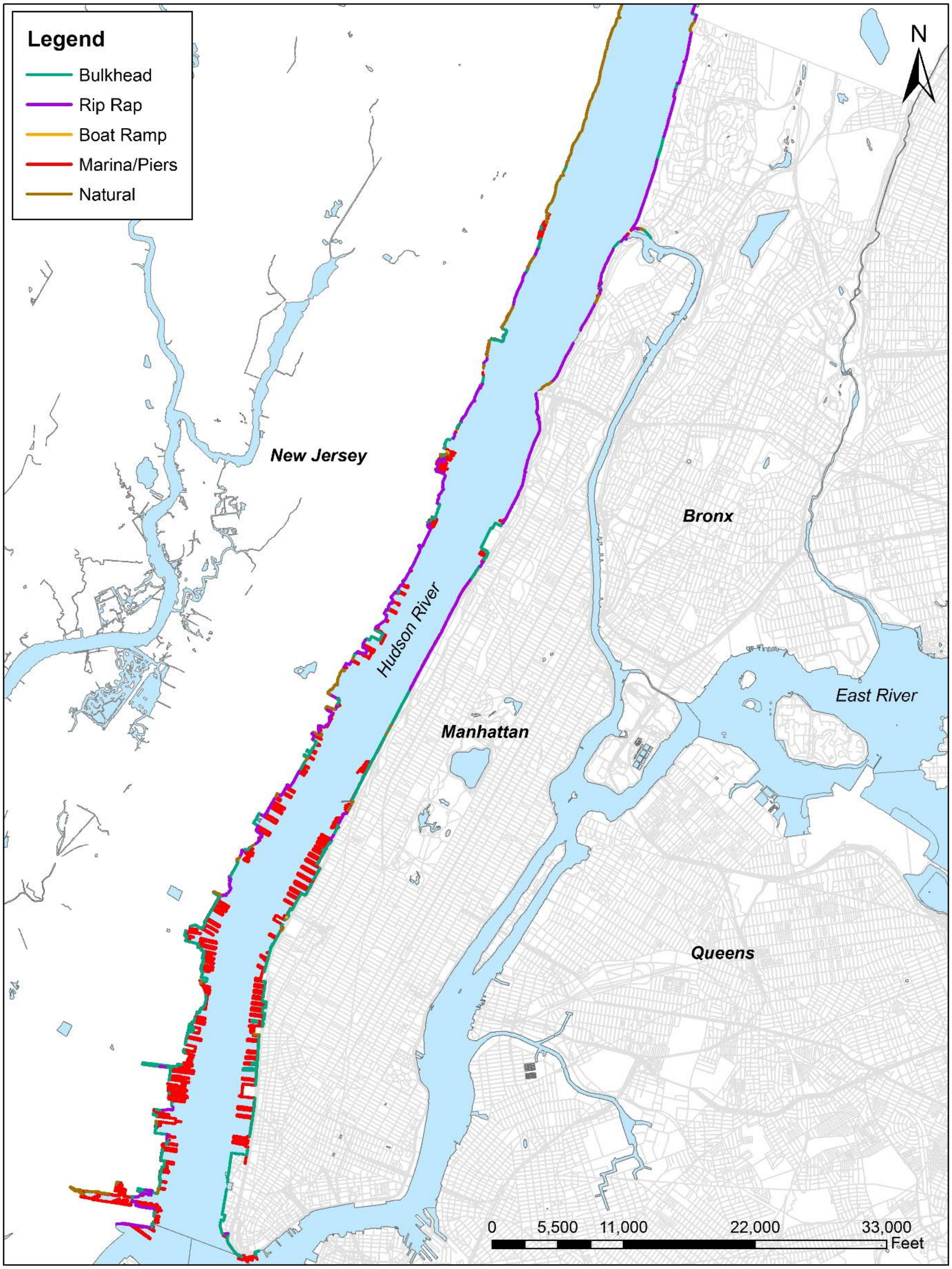


Figure 2.2-19. Hudson River Shoreline Characteristics

Figure 2.2-20. Natural Shoreline View of Hudson River

Figure 2.2-21. Rip Rap and Pier Shoreline of Hudson River

Waterbody Sediment Surficial Geology/Substrata

The bottom of the Hudson River is predominantly composed of muddy sand with a small proportion of gravel, according to data from previous studies. Sampling conducted by HydroQual in 2003 indicated a predominantly mud/sand/gravel bottom with some areas of sand bottom (HydroQual, 2003). The composition of the mud/silt/clay designated areas ranged from 66 percent to 99 percent mud/silt/clay and zero to seven percent gravel.

Tidal/Estuarine Systems Biological Systems

Tidal/Estuarine Wetlands

Tidal/estuarine wetlands reported by the U.S. Fish and Wildlife Service (USFWS) National Wetlands Inventory (NWI) maps show limited tidal/estuarine wetlands only on the Hudson River's western shoreline in New Jersey. The two estuarine wetlands areas are identified in Figure 2.2-22 and described in Table 2.2-9.

Table 2.2-9. NWI Classification Codes

NWI Classification	Description
E2AB1N	Estuarine, Intertidal, Aquatic Bed, Algal, Regularly Flooded
E2EM1N	Estuarine, Intertidal, Emergent, Persistent, Regularly Flooded

Aquatic and Terrestrial Communities

The DCP Plan for the Manhattan and Bronx Waterfronts (DCP, 1993) reports a diverse range of species supported by the habitat in the Hudson River area.

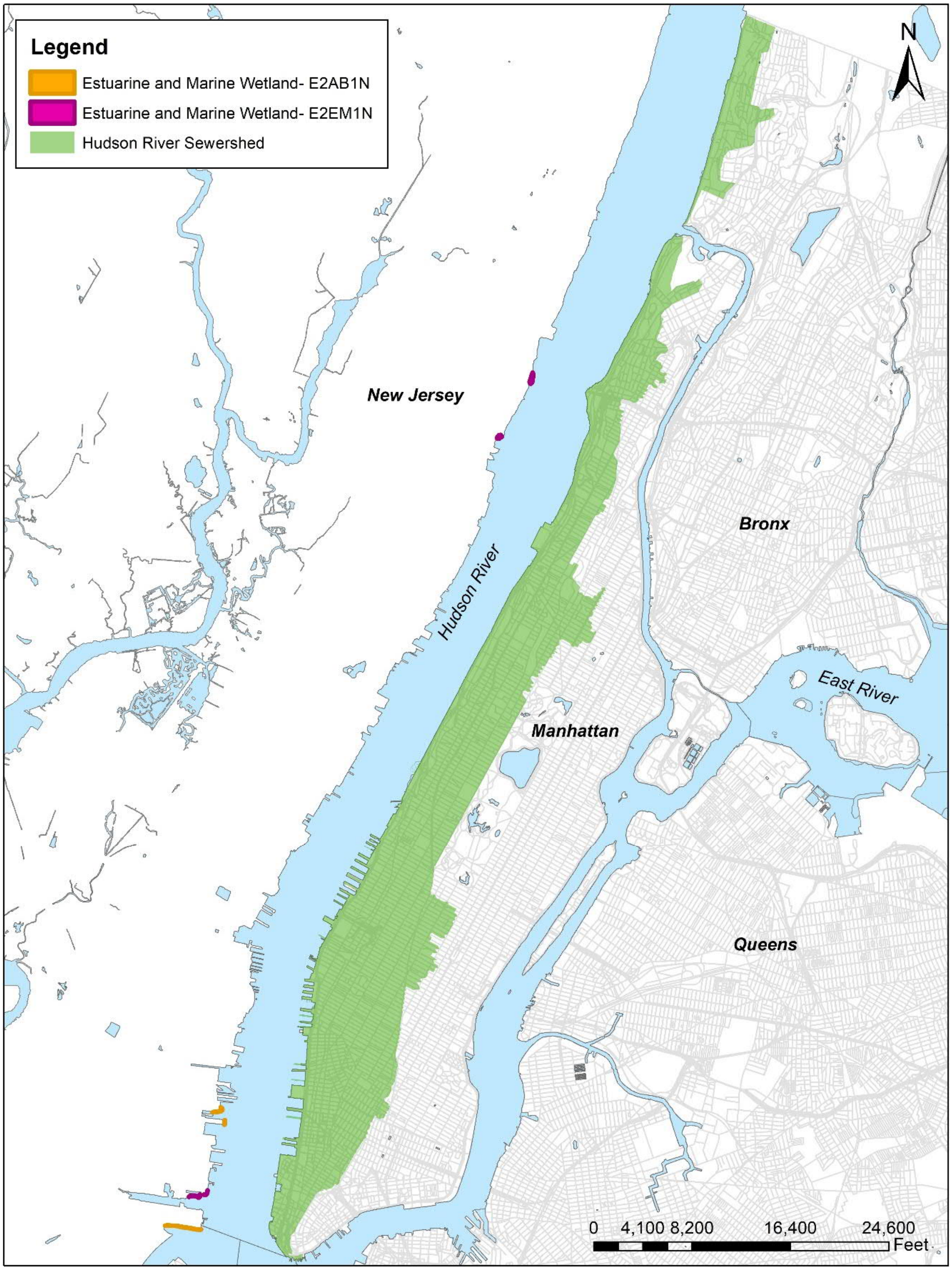


Figure 2.2-22. National Wetlands Inventory Source: NYS GIS Clearinghouse 2014

AECOM with Hazen

Biological Systems

According to DEC's Freshwater Wetlands Maps, no freshwater wetlands are located within the Hudson River watershed.

2.2.b.4 Current Public Access and Uses

The Bronx portion of the Hudson River is classified as suitable for primary and secondary contact recreation and fishing. In the Manhattan portion of the Hudson River, swimming (primary contact recreation use) is not the best use, as defined by New York State Codes, Rules and Regulations for Class I waterbodies. Secondary contact recreation opportunities are facilitated by access points along Hudson River as shown in Figure 2.2-23. Figure 2.2-24 shows an example of a public boat/kayak launch at the West Harlem Piers Park.

2.2.b.5 Identification of Sensitive Areas

Federal CSO Policy requires that the LTCP give the highest priority to controlling overflows to sensitive areas. The Policy defines sensitive areas as:

- Waters designated as Outstanding National Resource Waters (ONRW);
- National Marine Sanctuaries;
- Public drinking water intakes;
- Waters designated as protected areas for public water supply intakes;
- Shellfish beds;
- Water with primary contact recreation;
- Waters with threatened or endangered species and their habitat; and
- Additional areas determined by the Permitting Authority (i.e., DEC).

The presence/status of sensitive areas in the Hudson River as defined by the Federal CSO Policy is summarized in Table 2.2-10. Sources of information supporting the status are included in the footnotes to the table.

As indicated in Table 2.2-10, the Hudson River north of the Harlem River falls under the category of "Best Use – Primary Contact Recreation", by virtue of its Class SB water quality classification. The Hudson River north and south of the Harlem River falls into the category of "Waters with Threatened or Endangered Species and their Habitat". Based on the lists produced by NOAA and the New York Natural Heritage Program, threatened and endangered species with the potential to occur in the Hudson River include the following:

- Atlantic Sturgeon (*Acipenser oxyrhynchus oxyrhynchus*)
- Shortnosed Sturgeon (*Acipenser brevirostrum*)
- Peregrine Falcon (*Falco peregrinus*)

The US Fish and Wildlife Service lists the following with the potential to occur in the Citywide/Open Waters project area:

Table 2.2-10. Sensitive Areas Assessment

CSO Discharge Receiving Water Segments	Presence/Status of Sensitive Areas Classifications or Designations(1)						
	Outstanding National Resource Water	National Marine Sanctuaries	Waters with Threatened or Endangered Species and their Habitat	Best Use - Primary Contact Recreation	Public Water Supply Intake	Public Water Supply Protected Area	Shellfish Bed
Hudson River north of Harlem River	No(2)	No(3)	Yes(4)	Yes(5)	No(6)	No(6)	No(7)
Hudson River south of Harlem River	No(2)	No(3)	Yes(4)	No(8)	No(6)	No(6)	No(7)

Notes:
1. (1) Classifications or Designations per CSO Policy.
2. (2) EPA; DEC Protection of Waters Program and Environmental Resource Mapper.
3. (3) NOAA.
4. (4) USFWS; NOAA; DEC NYNHP.
5. (5) Waterbody is Class SB.
6. (6) Harlem River is saline.
7. (7) 6CRR-NY part 41.
8. (8) Best uses for Class I water defined as secondary contact recreation and fishing.

- Piping Plover (*Charadrius melodus)*
- Red Knot (*Calidris canutus rufa*)
- Roseate Tern (*Sterna dougallii dougallii*)
- Bog Turtle (*Clemmys muhlenbergii*)Indiana Bat (*Myotis sodalist*)
- Northern Long-eared Bat (*Myotis septentrionalis*)
- Sandplain Gerardia (*Agalinis acuta*)
- Seabeach Amaranth (*Amarnthus pumilus*)

Of the species listed above, only the Atlantic Sturgeon (*Acipenser oxyrhynchus oxyrhynchus*) was identified as having critical habitat present in the project area.

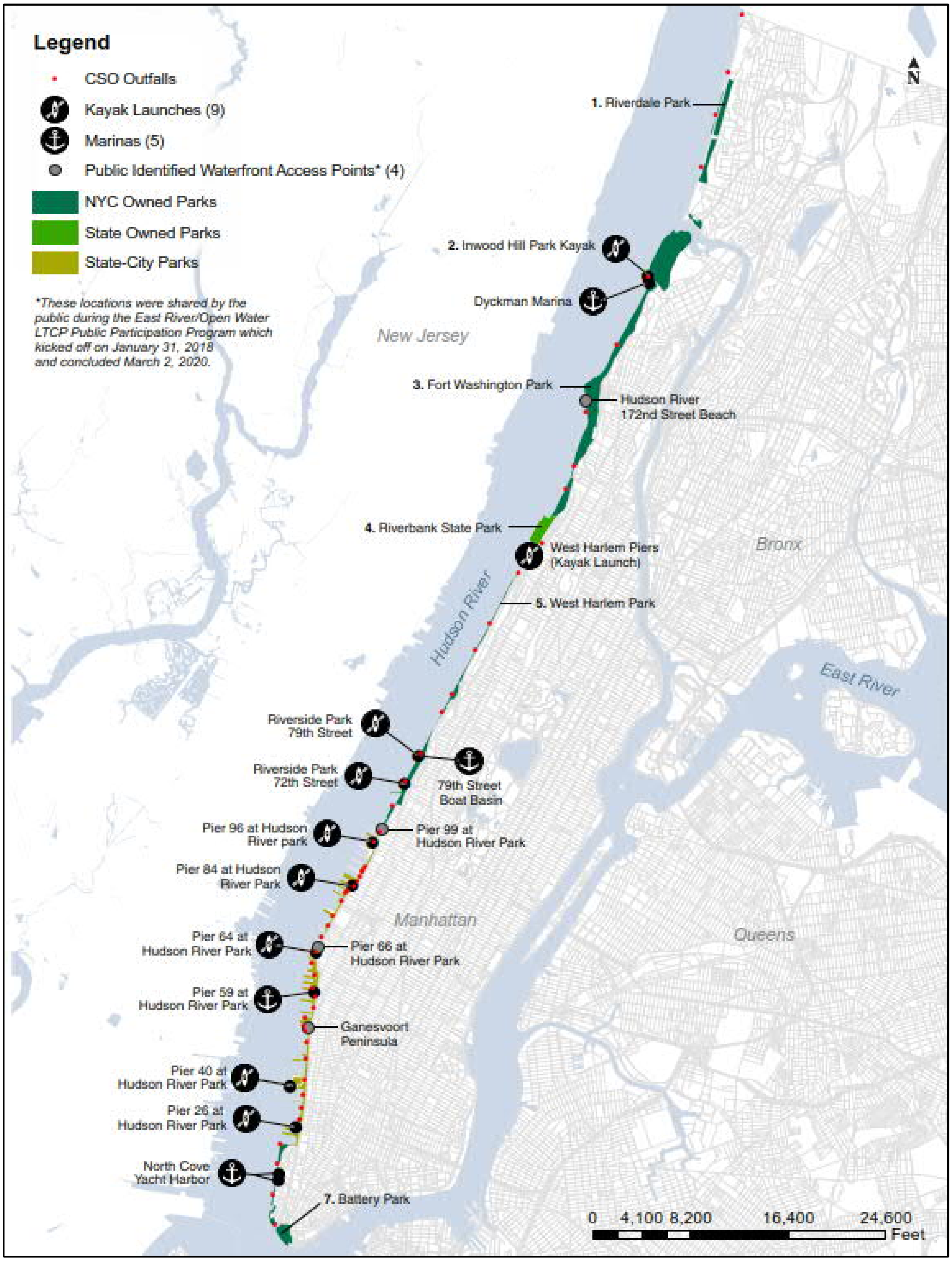


Figure 2.2-23. Waterfront Access Points to the Hudson River

Figure 2.2-24. Boat/Kayak Launch at West Harlem Piers Park (Source: NYC Parks)

2.2.b.6 Compilation and Analysis of Existing Water Quality Data

Hudson River water quality data are available from sampling conducted by DEP's HSM program from 2007 to 2018, and from intensive sampling conducted from April through November 2016 to support the Citywide/Open Waters LTCP. The sampling locations for both programs are shown in Figure 2.2-25. The DEP's HSM program focuses on the water quality parameters of fecal coliform and *Enterococci* bacteria, DO, chlorophyll 'a', and Secchi disk transparency. HSM data are organized into four geographic regions within the Harbor, and the Hudson River is located within the Inner Harbor section. The Hudson River has five HSM stations, designated as N1, NR1, N3B, N4, and N5. In addition to the HSM program, DEP also operates a Sentinel Monitoring (SM) Program, targeted at identifying illicit discharges to the waterbodies through changes to baseline sampling concentrations. The SM program collects quarterly dry-weather fecal coliform data from six stations in the Hudson River (S47 to S53). LTCP sampling was conducted at 10 stations along the Hudson River. The HSM, SM, and LTCP sampling locations are all shown in Figure 2.2-25. Figure 2.2-26 and Figure 2.2-27 show the GM, minimum, maximum, 25th percentile, and 75th percentile values for fecal coliform and *Enterococci*, respectively, for the LTCP sampling data from the period of April to November 2016. Figure 2.2-28 and Figure 2.2-29 show similar data for the HSM sampling program for the periods of 2014 to 2016.

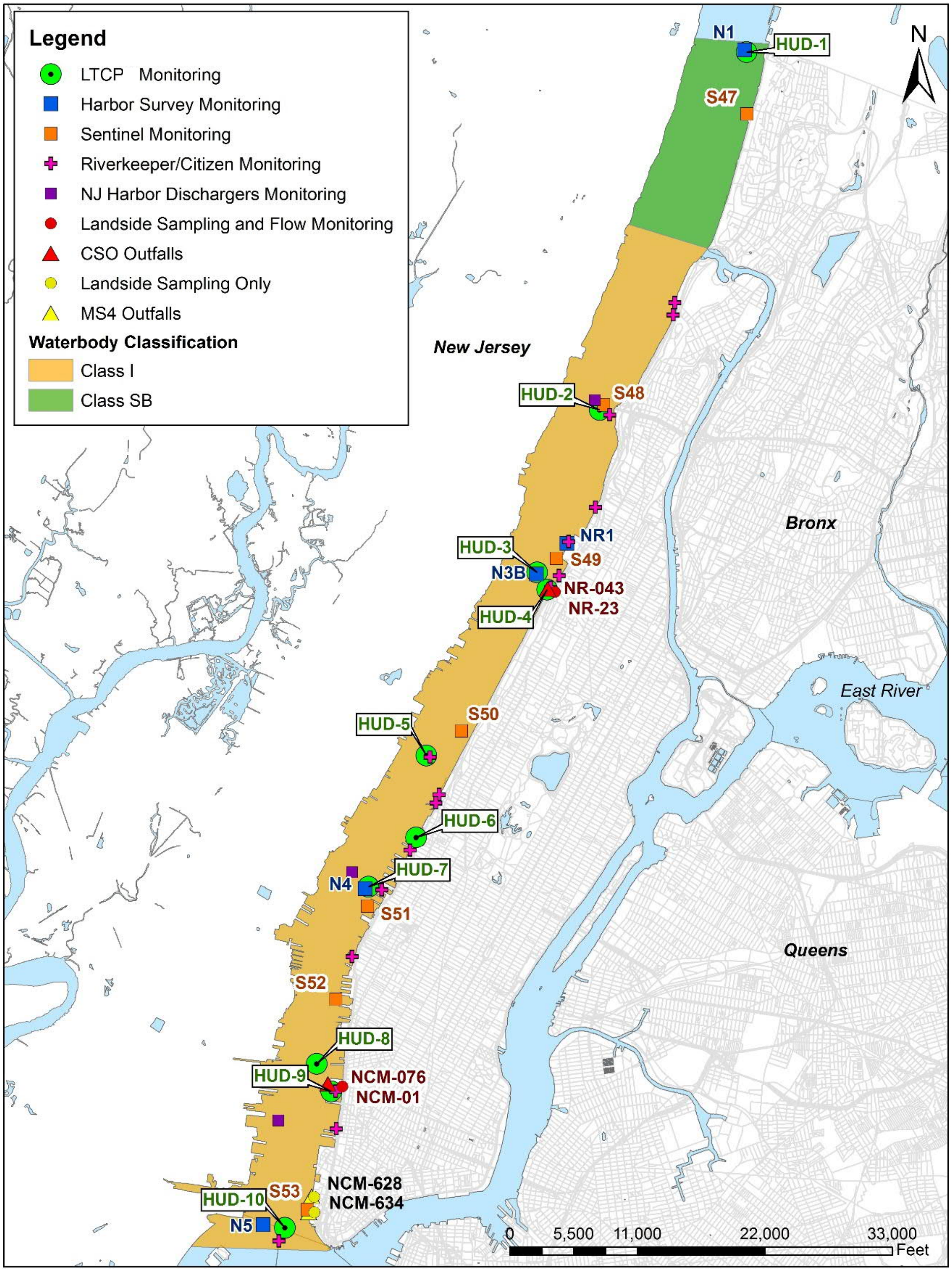


Figure 2.2-25. Water Quality Monitoring Sampling Locations within the Hudson River

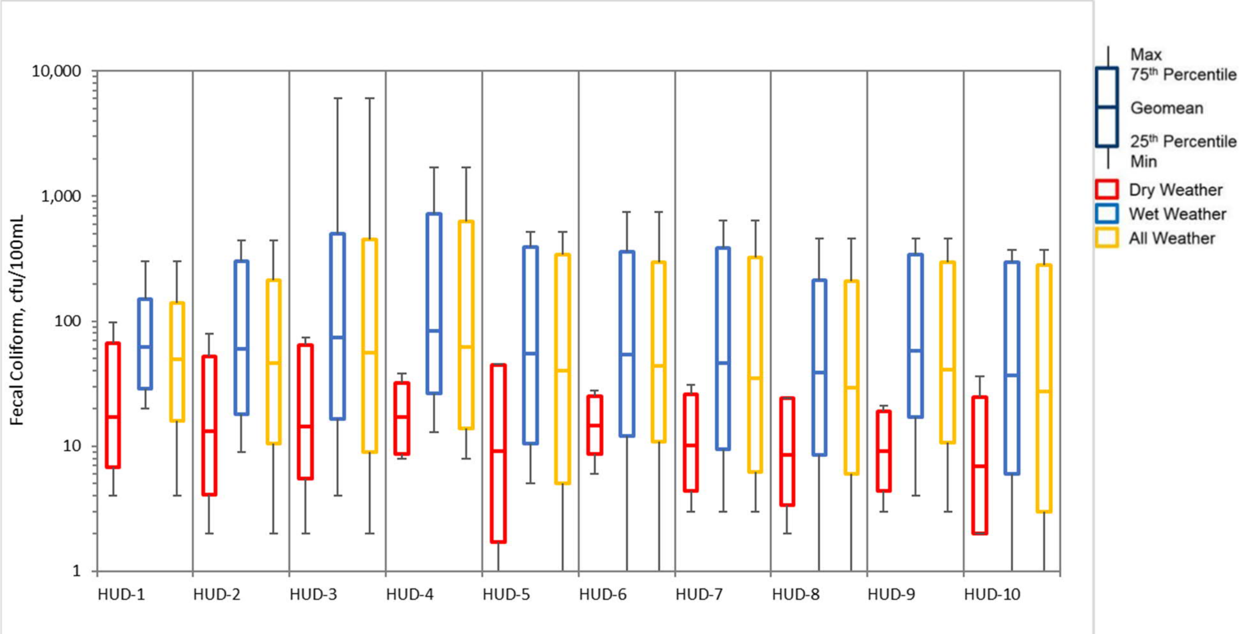


Figure 2.2-26. Fecal Coliform Concentrations at LTCP Sampling Stations in Hudson River April – November 2016

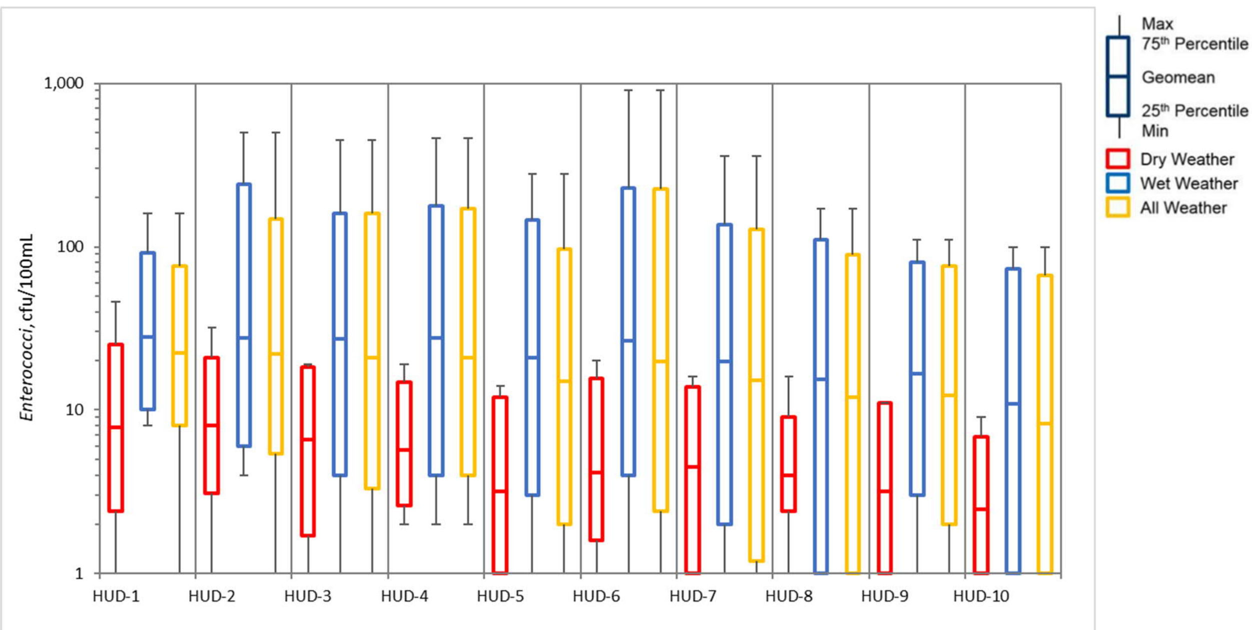


Figure 2.2-27. *Enterococci* Concentrations at LTCP Sampling Stations in Hudson River April – November 2016*

*Note: Enterococci WQ Criteria do not apply to the Hudson River. Enterococci data are presented for informational purposes.

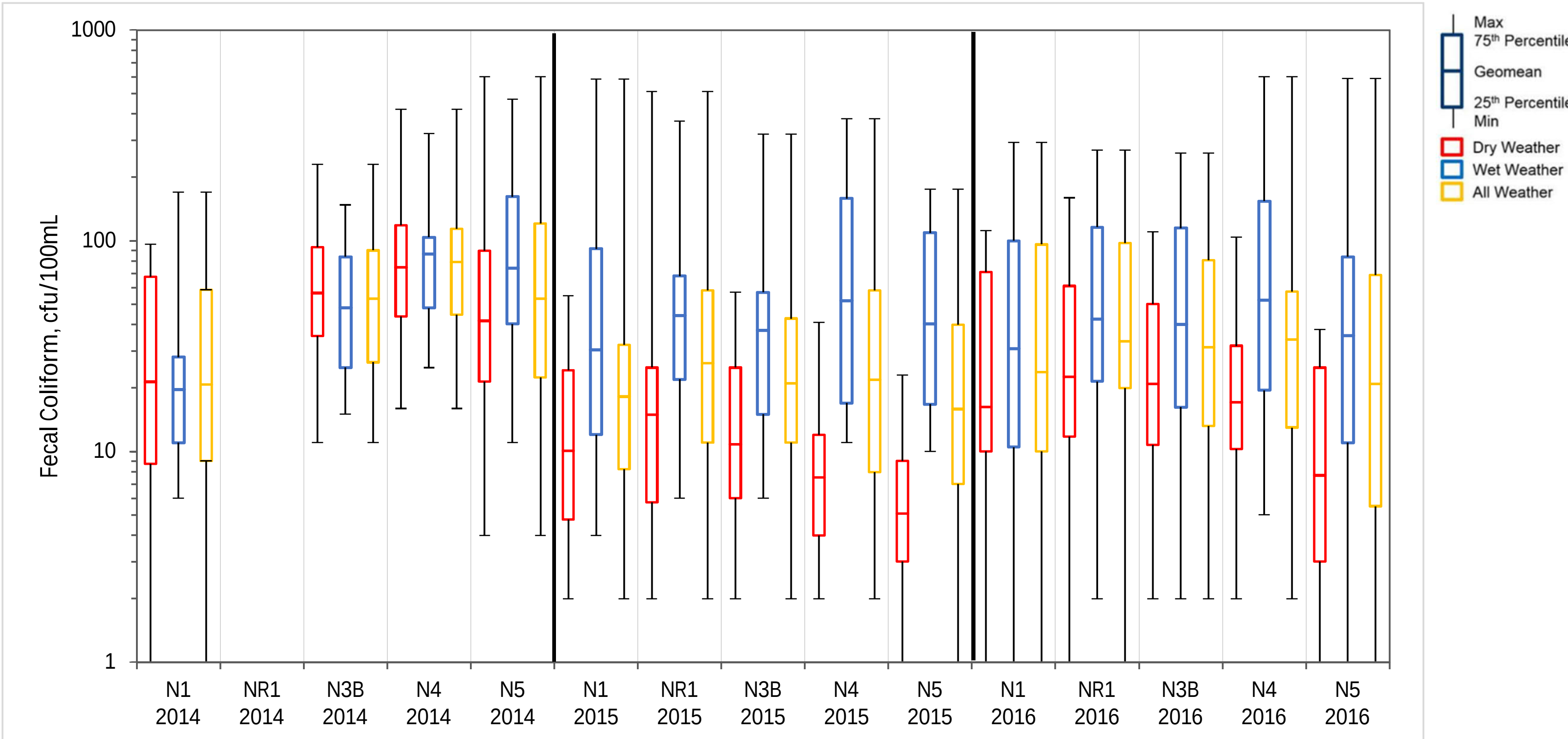


Figure 2.2-28. Fecal Coliform Concentrations at HSM Sampling Stations in the Hudson River

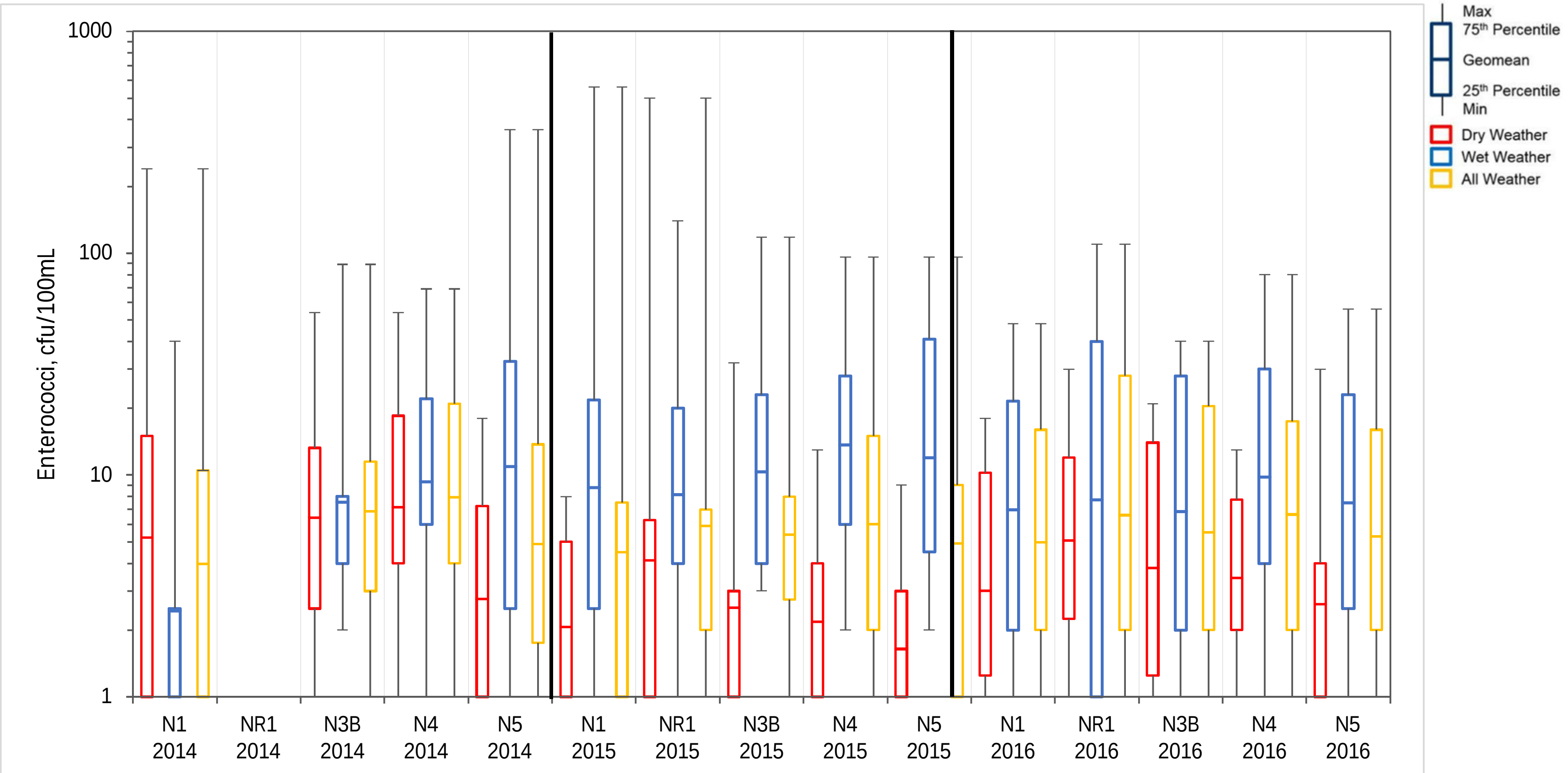


Figure 2.2-29. *Enterococci* Concentrations at HSM Sampling Station in the Hudson River*

*Note: Enterococci WQ Criteria do not apply to the Hudson River. Enterococci data are presented for informational purposes.

The fecal coliform levels measured throughout the LTCP sampling program in wet-weather were generally higher than the levels measured during dry-weather, indicative of the impacts of wet-weather pollution sources on the Hudson River. However, as indicated in Figure 2.2-26, the wet-weather geometric means at each of the Hudson River LTCP sampling stations were all below 200 cfu/100mL, indicating that the wet-weather impacts were relatively limited. The LTCP *Enterococci* data generally followed a similar trend as the fecal coliform data, with wet-weather geometric means higher than dry-weather geometric means, but the wet-weather geometric means were all below 30 cfu/100mL (Figure 2.2-27).

The HSM fecal coliform data presented in Figure 2.2-28 are also consistent with the LTCP data. While a wet-weather impact is evident, the geometric means of the fecal coliform data were all below 200 cfu/100mL. HSM *Enterococci* data showed generally a similar pattern (Figure 2.2-29).

Data collected by the Citizens Testing Group is also made available to the public by the Riverkeeper Group. This dataset is limited to *Enterococci* bacteria concentrations at several stations along the western shoreline of the Hudson River, as shown in Figure 2.2-25. These data are available at the Riverkeeper Group's website http://www.riverkeeper.org/ and, consistent with the LTCP and HSM data, showed a relationship between wet-weather conditions and higher *Enterococci* concentrations throughout the years 2014, 2015, and 2016.

Figure 2.2-30 shows the arithmetic mean, minimum, maximum, 25th percentile, and 75th percentile values for DO from the LTCP April-November 2016 sampling program. As indicated in Figure 2.2-30, all of the minimum values were above 4.0 mg/L. The HSM DO data from 2014 to 2016 are shown in Figure 2.2-31. These data indicate average values all above 6.0 mg/L, with some minimum values approaching 4.0 mg/L.

2.2.b.7 Water Quality Modeling

In addition to the collection, compilation, and analysis of measurements described in Section 2.2.b.6, water quality modeling was also used to characterize and assess Hudson River water quality. The LTCP Regional Model (LTCPRM) was used for water quality modeling for the Citywide/Open Waters LTCP. This model evolved from the System-Wide Eutrophication Model (SWEM) that underwent peer review by model evaluation groups (MEGs) in 1994, 1997, and 1999. The model computational grid associated with the LTCPRM, as well as further details on this model, are presented in Section 6 of this LTCP.

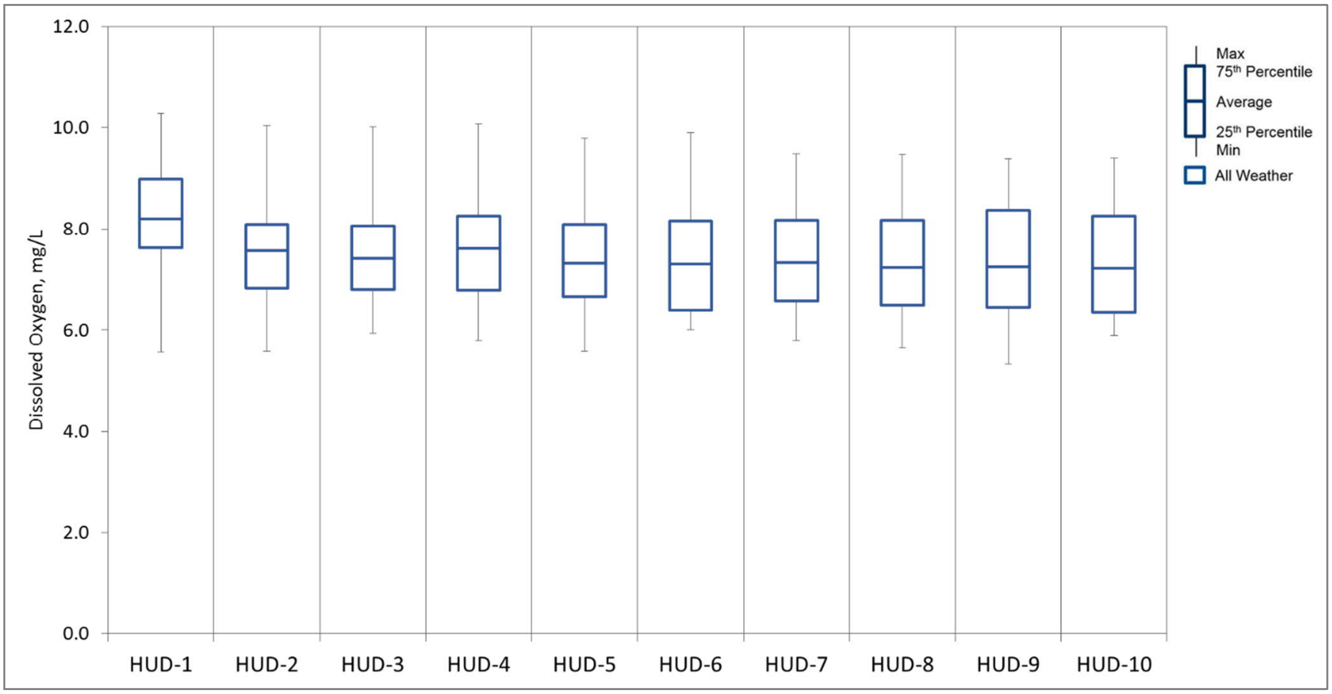


Figure 2.2-30. Dissolved Oxygen Concentrations at LTCP Sampling Stations in the Hudson River

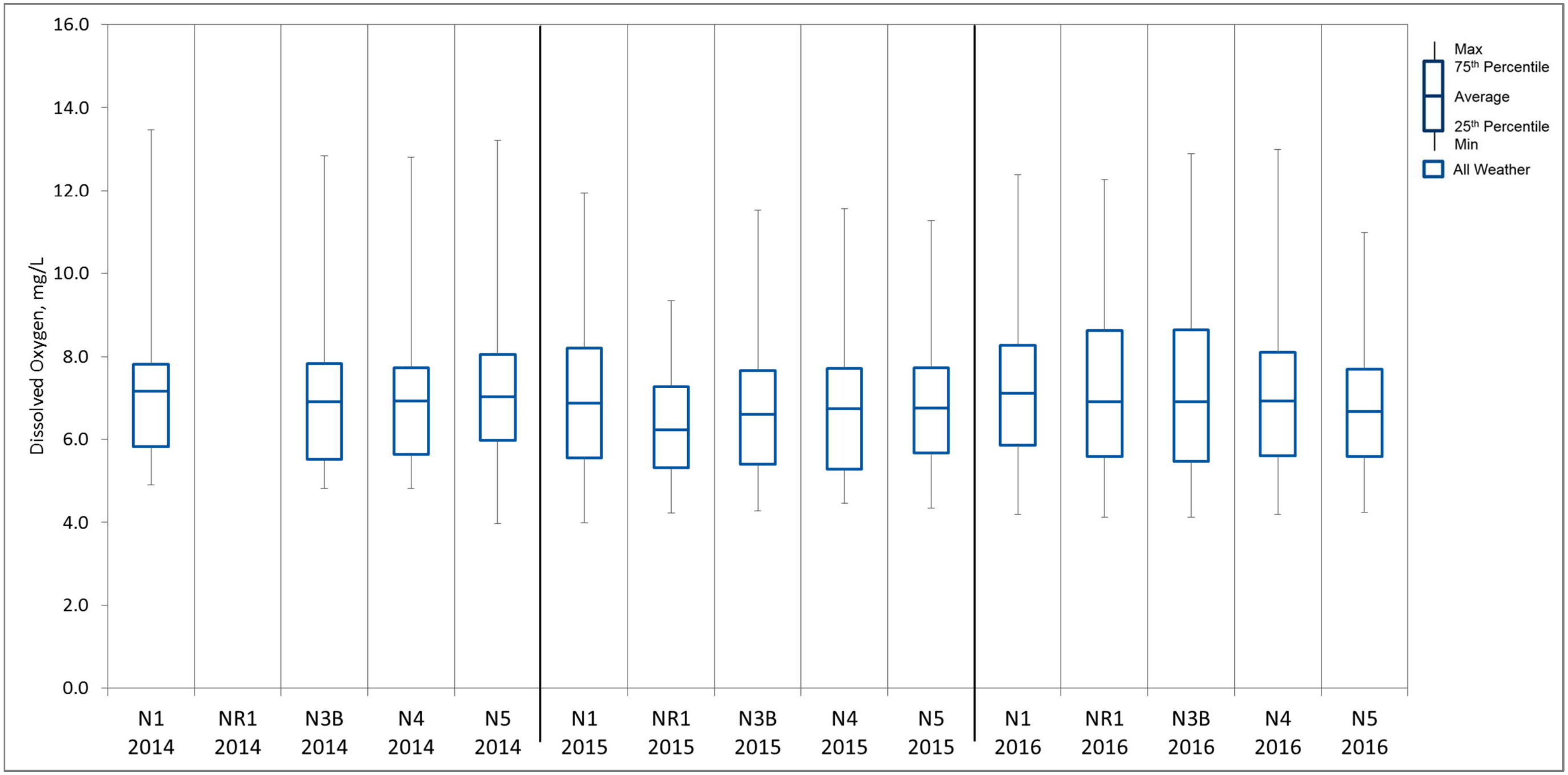


Figure 2.2-31. Dissolved Oxygen Concentrations at HSM Sampling Stations in the Hudson River

2.3 East River and Long Island Sound

This section summarizes the major characteristics of the East River and Long Island Sound watershed and waterbodies, building upon earlier documents that characterized the area. Section 2.3.a addresses watershed characteristics and Section 2.3.b addresses waterbody characteristics.

2.3.a Watershed Characteristics

The East River and Long Island Sound watershed is highly urbanized and is primarily composed of residential areas with some commercial, industrial, institutional, and open space/outdoor recreation areas within the Boroughs of Bronx, Manhattan, Queens, and Brooklyn, NY. Notable outdoor recreation areas within this watershed include State and City-owned parks such as Pelham Bay Park, Ferry Point Park, Randall's Island, Wards Island Park, and several parks on Roosevelt Island.

This subsection presents a summary of the watershed characteristics as they relate to the land use, zoning, permitted discharges and their characteristics, sewer system configuration, performance, and impacts to the adjacent waterbodies, as well as the modeled representation of the collection system used to analyze system performance and CSO control alternatives.

2.3.a.1 Description of Watershed/Sewershed

The East River is a navigable 16-mile long river that connects Upper New York Bay on its south end to Long Island Sound on its north end. The River also has connections to the Hudson River at the southern confluence with New York Bay and to the Harlem River at Hell Gate. Flushing Bay and several tributaries including Newtown Creek, the Bronx River, Westchester Creek, and the Hutchinson River also drain into the East River. The Long Island Sound is a tidal estuary that also serves as a political boundary separating Long Island from Connecticut. From west to east, the entire sound is 110 miles long, with a width extending up to 21 miles at its widest point. The focus of this LTCP is on the entire 16 miles of the East River and the western portion of Long Island Sound that flows through New York City, and includes Eastchester Bay. Subsequently, when "Long Island Sound" is referenced in this LTCP, it is intended to mean the western portion, within the NYC limits, that is being addressed in this LTCP.

Elevations within the watershed range from sea level to a maximum of approximately 260 feet above sea level. However, the sewer system that has been constructed in the East River and Long Island Sound watershed has altered the natural flow path within the watershed by intercepting and diverting flow that would normally drain to the River. The land area that is actually tributary to the East River and Long Island Sound is approximately 30,000 acres in New York City. Since the sewershed defines the limits of the combined sewer system, this LTCP focuses on the sewershed of East River and Long Island Sound. The sewershed encompasses portions of the Boroughs of Manhattan, Bronx, Queens, and Brooklyn in New York (Figure 2.3-1).

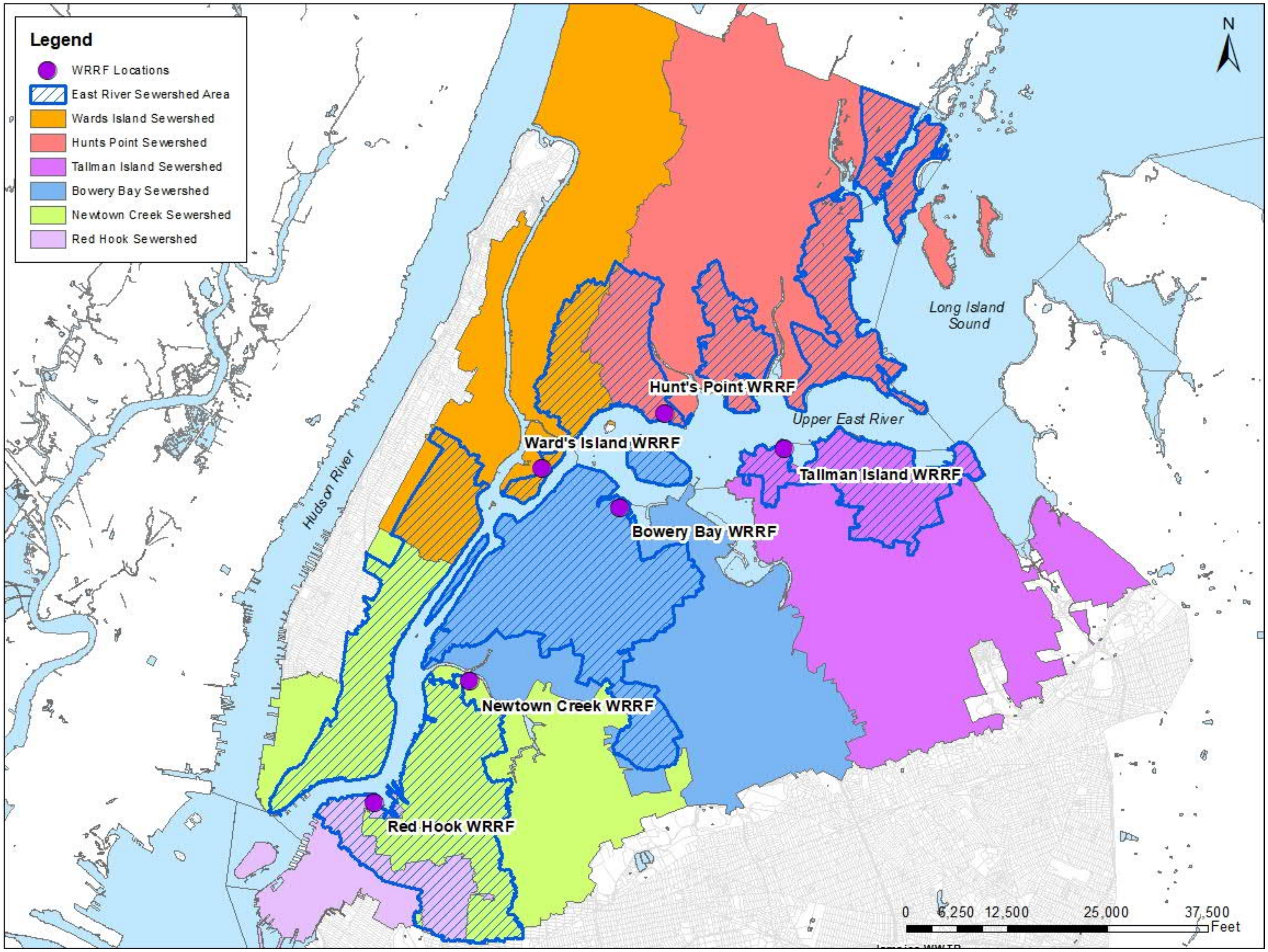


Figure 2.3-1. East River and Long Island Sound Sewershed

The East River and Long Island Sound has been modified over the last 150 years by dredging and filling activities that have altered islands and shorelines, bulkheading to stabilize and protect shorelines, dredging of channels and borrow areas that have altered bottom contours and flow patterns, and the filling of natural tributaries. These activities have eradicated natural habitats, negatively impacted water quality, and modified the rich ecosystem that characterized the watershed up until the mid-nineteenth century.

The urbanization of NYC and the East River and Long Island Sound watershed has led to the creation of large combined sewer systems), as well as areas of separate and direct drainage, primarily in areas adjacent to the East River and the Sound. Six WRRFs are located within the East River and Long Island Sound sewershed: Hunts Point (200 MGD DDWF), Wards Island (275 MGD DDWF), Tallman Island (80 MGD DDWF), Bowery Bay (150 MGD DDWF), Newtown Creek (310 MGD DDWF), and Red Hook (60 MGD DDWF). These WRRFs discharge in accordance with DEC-issued SPDES permits. During dry-weather, the combined and sanitary sewer systems convey sewage to the WRRFs for treatment. During wet-weather, combined storm and sanitary flow is conveyed by the sewer system to the WRRFs. If the sewer system or WRRF is at full capacity, a diluted mixture of combined storm and sanitary flow may discharge through one or more of the 139 SPDES permitted CSO Outfalls to the East River and Long Island Sound. Figure 2.3-2 shows the delineations of the combined sewer area, separate stormwater area, and direct drainage area tributary to the East River. The locations of the outfalls are shown below in Figure 2.3-16.

Several large transportation corridors cross the East River and Long Island Sound sewershed. The major east/west transportation corridor is the Long Island Expressway (Route 495), which connects Long Island to Manhattan through the Midtown Tunnel. The major north/south transportation corridors include the FDR Drive, and Interstate Routes I-95, I-295, I-678, and I-278. The A, C, E, B, D, F, J, M, G, N, R, Q, W, L, Z, 2, 3, 4, 5, 6, and 7 subway lines and the Metro-North and Long Island Railroads also traverse the sewershed. These transportation corridors limit access to some portions of the waterbody and are taken into consideration when developing CSO control solutions. These features are shown in Figure 2.3-3.

In addition to the landside transportation routes, NYC Ferry operates multiple commuter ferry routes in the East River, including the East River, South Brooklyn, Rockaway, Astoria, Soundview, and Lower East Side Routes. These routes have multiple ferry landings located along the shoreline of the East River.

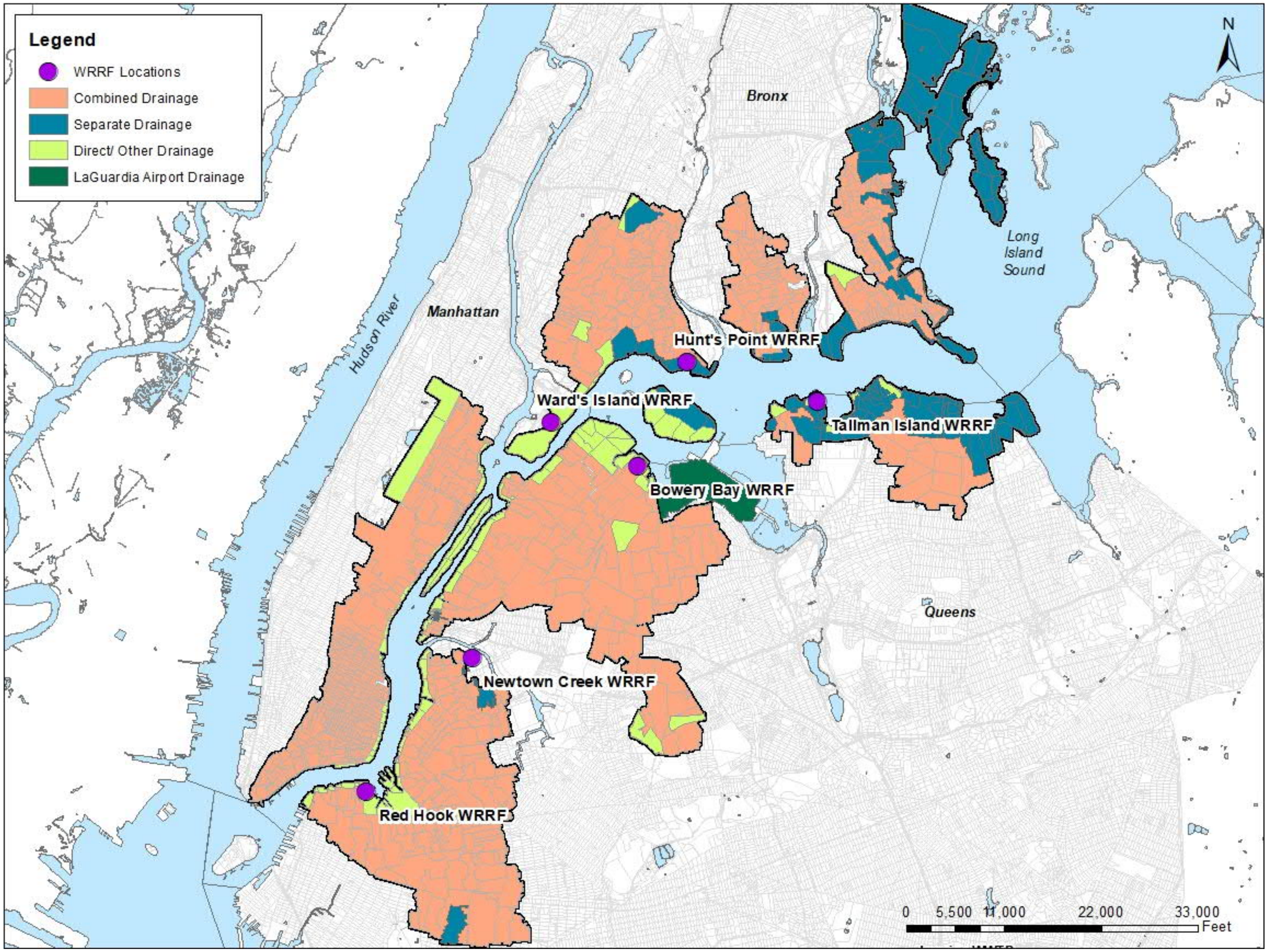


Figure 2.3-2. Components of the East River and Long Island Sound Watershed

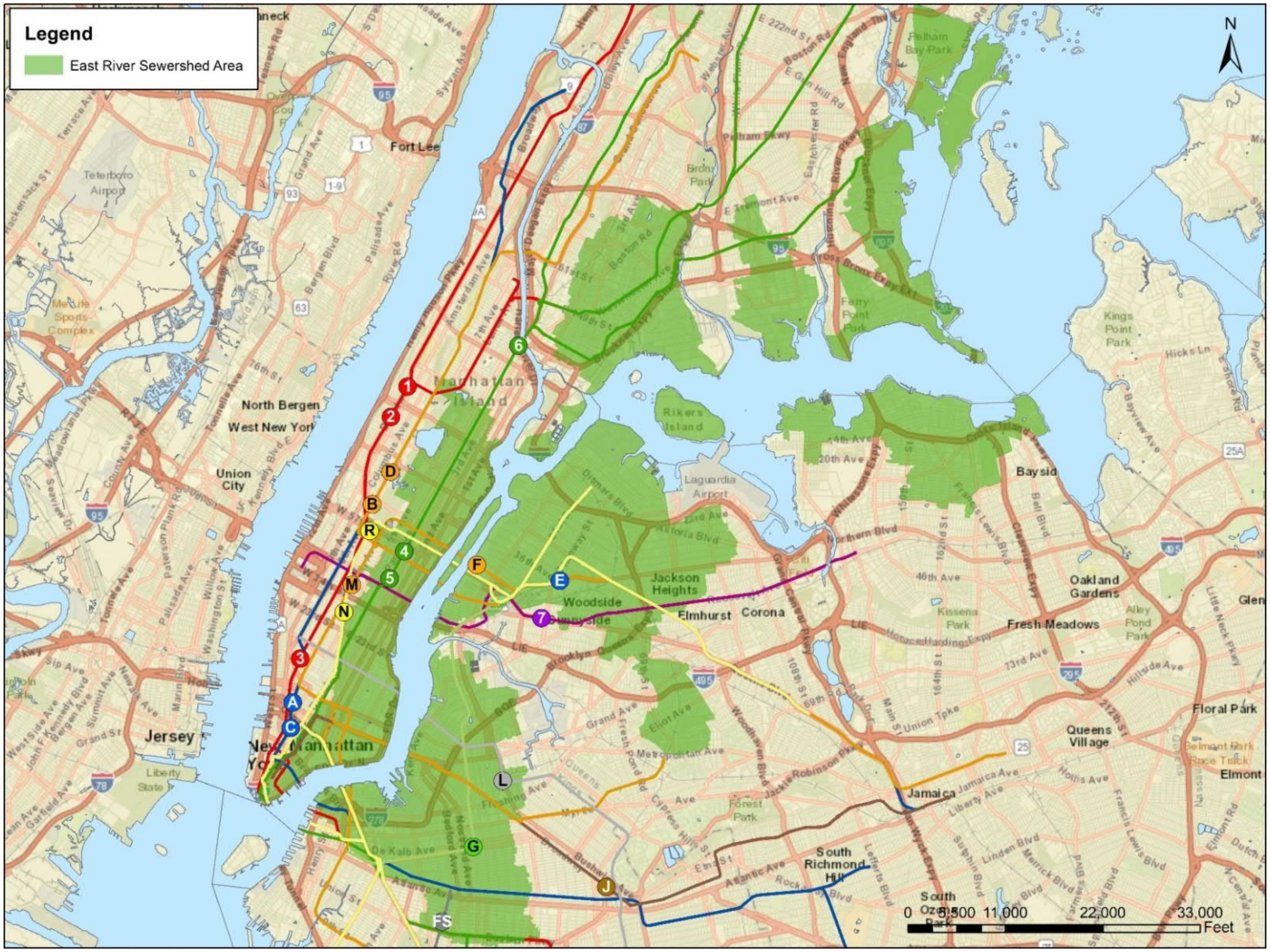


Figure 2.3-3. Major Transportation Features

Existing and Future Land Use and Zoning

The current land use in the East River and Long Island Sound sewershed is largely attributable to historical urbanization and development within the sewershed. Future use and development is controlled by zoning, land use proposals, and evolving land use policies. Figure 2.3-4 shows the distribution of land uses in the East River and Long Island Sound sewershed. Table 2.3-1 summarizes the relative percentages of the various land use categories both for the overall sewershed, and for the portions of the sewershed within 0.25 miles of the shoreline.

Table 2.3-1. Existing Land Use within the East River and Long Island Sound Sewershed Area

Land Use Category	Percent of Area	
	Within Sewershed	Within 1/4-mile of Shoreline
Residential	42.1	28.9
Mixed Residential and Commercial	7.0	5.6
Commercial and Office	5.8	2.7
Industrial and Manufacturing	5.3	7.8
Transportation and Utility	6.6	14.9
Public Facilities and Institutions	9.6	14.9
Open Space and Outdoor Recreation	17.9	17.1
Parking Facilities	2.0	1.6
Vacant Land	2.6	4.4
Unknown	1.1	2.2

As indicated in Table 2.3-1, approximately 42 percent of the East River and Long Island Sound sewershed consists of residential uses with primarily multi-family homes. Open space also makes up a significant percentage of the sewershed (18 percent) due to the presence of State, City, and local park properties and facilities. The sewershed features 11 State-owned parks, including the Franklin D. Roosevelt Four Freedoms State Park on Roosevelt Island, one State park in Brooklyn (East River State Park) and one State park in Queens (Gantry Plaza State Park). The Brooklyn Bridge Park and the Empire-Fulton Ferry Park are owned by a City/State-run non-profit public-private partnership. The sewershed also has 61 City-owned parks, many smaller neighborhood parks and playgrounds, and 20 privately-owned parks. The Pelham Bay Park is the largest park in the East River sewershed, consisting of approximately 2,057 acres. Commercial and industrial land uses make up a relatively small proportion of the sewershed (six and five percent, respectively).

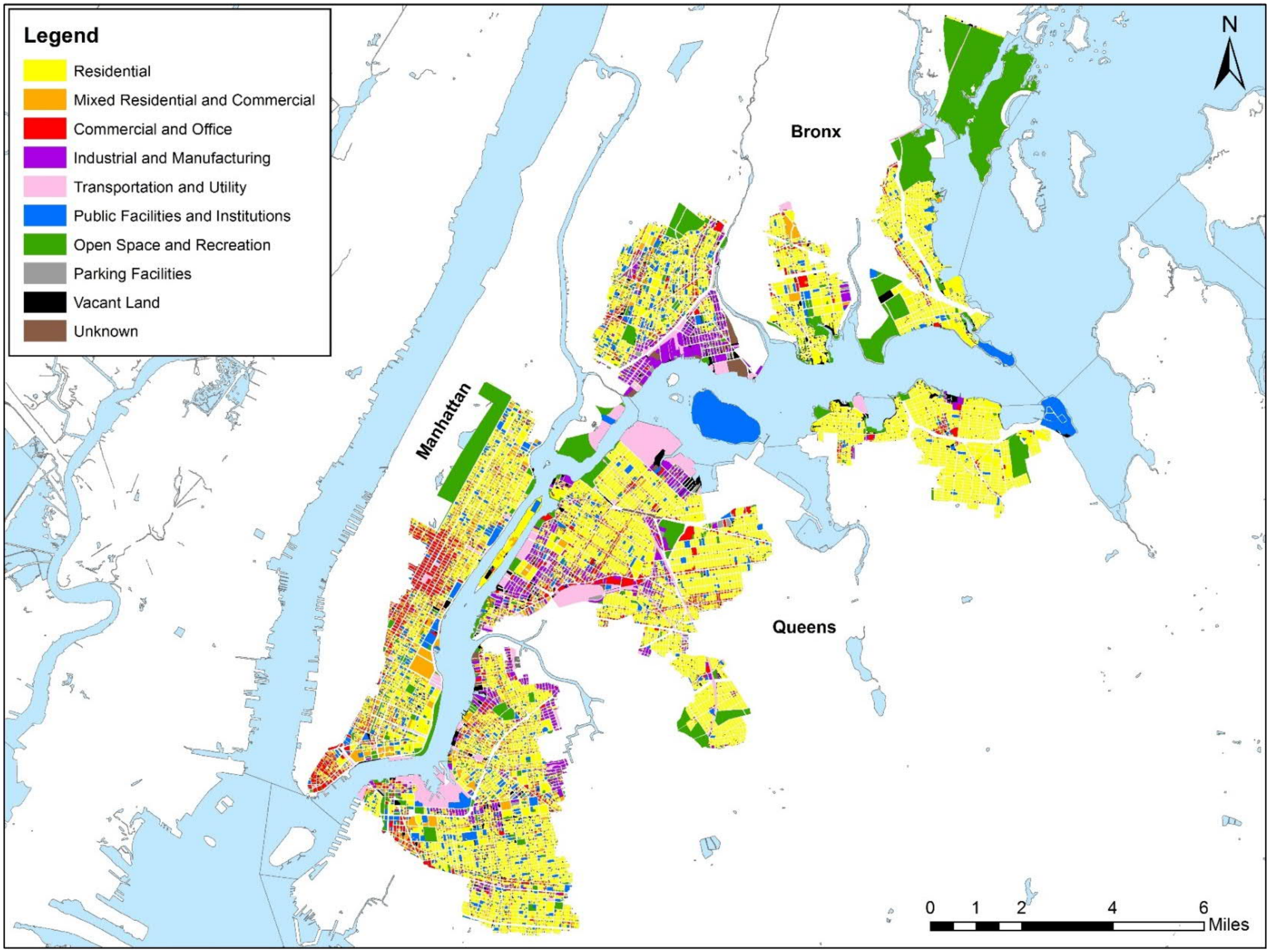


Figure 2.3-4. Land Use in the East River and Long Island Sound Sewershed

Within the riparian areas along the shoreline of the East River and Long Island Sound, the uses are predominantly residential (29 percent), open space/recreational (17 percent), transportation/utility (15 percent) and public facilities/institutional (15 percent).

Figure 2.3-5 identifies the zoning classifications within a quarter mile of the shoreline of the East River and Long Island Sound. Residential properties are the predominant zoning classification making up to 42 percent of the quarter-mile buffer, with low-density residential districts making up to 50 percent of that area. Manufacturing zones cover approximately 27 percent of the area within a quarter mile of shoreline while park properties cover 16 percent and commercial zones cover approximately 13 percent of the area.

The East River and Long Island Sound are located within the Coastal Zone Boundary as designated by the New York City Waterfront Revitalization Program (WRP). This boundary encompasses all land and water that could have a direct and significant impact on coastal waters. The WRP has identified four Special Area Designations within the watershed, as shown in Figure 2.3-6. Several areas along the waterfront have been designated Significant Maritime and Industrial Areas (SMIAs) which are especially valuable as industrial areas and working waterfronts. A priority policy of the WRP is to promote water-dependent and industrial uses within these SMIAs. Priority Marine Activity Zones (PMAZ) are identified in the WRP in order to support the ongoing maintenance at transportation ports to promote water-dependent uses. DCP has designated other waterfront areas as Special Natural Waterfront Areas (SNWAs). As defined by DCP, SNWA is a large area of concentrated natural resources, such as wetlands and natural habitats, which possesses a combination of important coastal ecosystem features. One of the Priority Policies of the WRP is to protect and restore the ecological quality and component habitats and resources within the SNWA. The WRP has also identified several recognized ecological complexes (RECs) within the East River and Long Island Sound sewershed. RECs are clusters of valuable natural features which are more fragmented than those in the SNWAs and are often scattered within developed areas. A WRP priority policy is to identify, remediate, and restore ecological functions within these RECs.

In addition to the standard zoning classifications, 24 “Special Use Districts” are located within the East River and Long Island Sound sewershed. Special use districts are defined within the Zoning Resolution as areas designated “to achieve the specific planning and urban design objectives in areas with unique characteristics”. The following Special Use Districts are located within the East River and Long Island Sound sewershed:

- The *Special City Island District* covers the entire City Island in Long Island Sound, and was established to preserve its nautical heritage and low-rise residential characters, as well as the “village” quality of its commercial center.
- The *Downtown Brooklyn District* established height and setback regulations and urban design guidelines to promote the continued growth of the unique mixed-use area. This district has two sub-districts: Atlantic Avenue and Fulton Mall. Each sub-district has its own bulk and use regulations to preserve the scale and character of the area and create an attractive shopping environment.
- *Enhanced Commercial District 4* (Bedford Stuyvesant) promotes and maintains a lively, engaging, and varied pedestrian experience along specific commercial avenues.

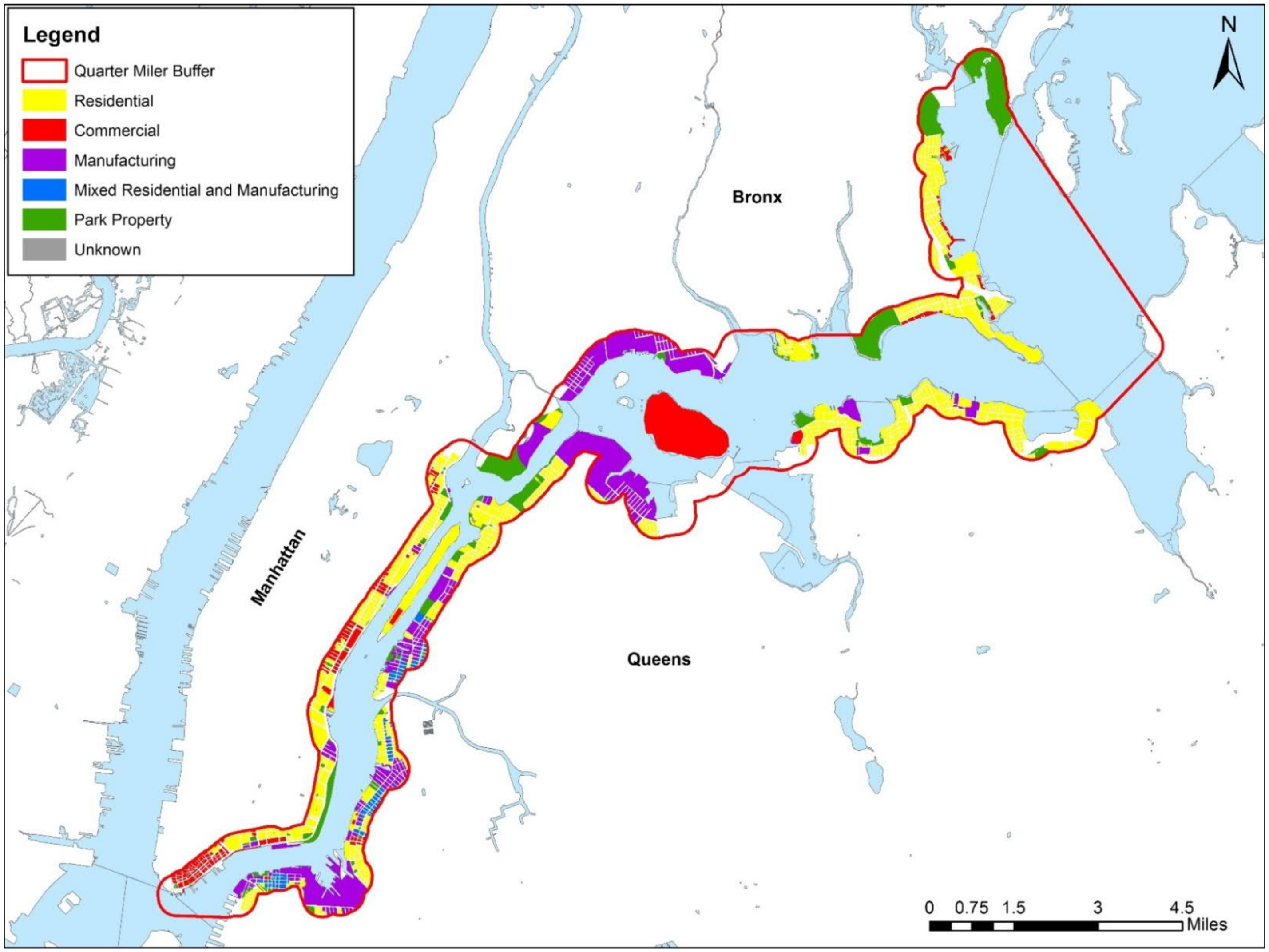


Figure 2.3-5. Zoning within 1/4 Mile of Shoreline

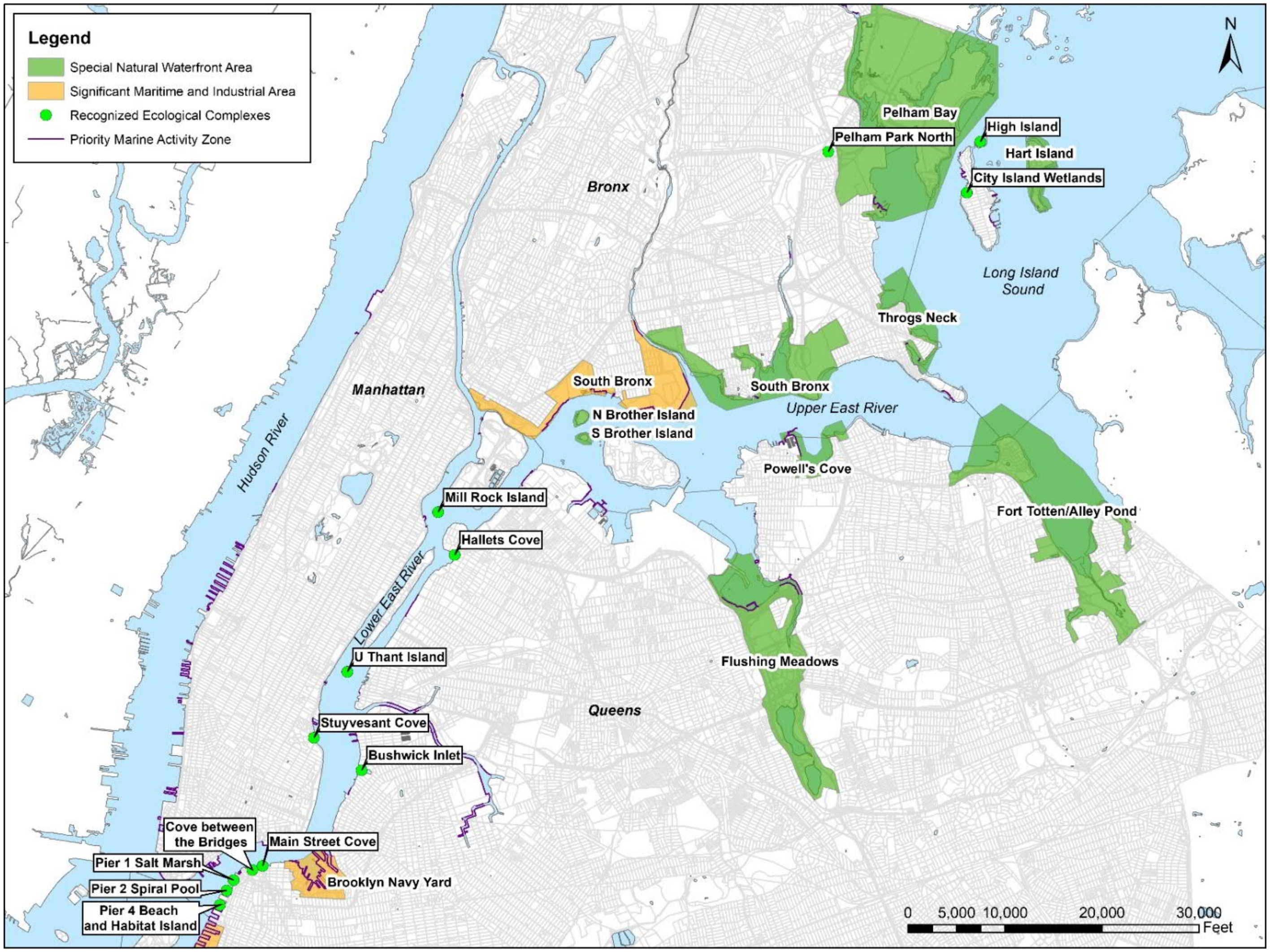


Figure 2.3-6. DCP's Waterfront Revitalization Plan Special Area Designations

- The *Hunts Point Special District* strengthens the expanding food industry sector and creates an area of high-performance industrial and commercial uses between the Hunts Point residential area and the heavy industrial areas. This district also has two sub-districts, the Residential Buffer Sub-district and the Food Industry Sub-district, that provide buffers by prohibiting most new heavy industrial uses.

- The *Little Italy District* was established to preserve and enhance the historic and commercial character of this traditional community. Regulations protect the retail area along Mulberry Street and encourage residential rehabilitation and new development consistent with the existing scale, and discourage the demolition of noteworthy buildings in the area.

- The *Long Island City Mixed-Use District* promotes the development and expansion of mixed uses within four sub-districts including Court Square, Queens Plaza, Hunters Point, and Dutch Kills.

- The *Lower Manhattan District* enhances the vitality of Lower Manhattan by allowing for the conversion of older commercial buildings to residential use and encouraging a dynamic mixed -use area while protecting its distinctive skyline and old street patterns. The pedestrian environment is enhanced by mandates for retail continuity, pedestrian circulation space, and subway improvements. This district includes the two sub-districts: the South Street Seaport Sub-district and the Historic and Commercial Core. The South Street Seaport Sub-district protects the scale and character of the 18^{th} and 19^{th} century mercantile buildings by allowing the transfer of development rights to designated receiving lots. The Historic and Commercial Core ensures that new development in the area will be compatible with existing buildings that line the streets.

- The *Midtown District* includes the sub-districts of Fifth Avenue, Grand Central, Penn Center, Preservation and Theater, and offers a floor area bonus for public plazas, subway station improvements, or theater rehabilitation in some of these sub-districts. The main goals of this special use district are growth, stabilization, and preservation of each area's character as a showcase tourist and shopping destination and transportation hub.

- The *Madison Avenue Preservation District* preserves and reinforces the unique retail and residential character of Madison Avenue between East 61^{st} Street and East 96^{th} Street.

- *Mixed-Use Districts 1, 2, 4, 7, 8, 9, and 17* (Port Morris, Lower Concourse, and Third Avenue/Tremont Avenue) were established to encourage investment in, and enhance the vitality of, existing neighborhoods with mixed residential and industrial uses in close proximity and create expanded opportunities for mixed-use communities.

- *Natural Area District 4* (Fort Totten) guides new development and site alterations in areas endowed with unique natural characteristics, including forests, rock outcrops, steep slopes, creeks, and a variety of botanic and aquatic environments. These natural features are protected by limiting modifications in topography and by encouraging clustered development.

- The *Planned Community Preservation District* protects the unique character of communities that have been planned and developed as a unit. Those communities characteristically have large landscaped open spaces and a superior relationship of buildings, open spaces, commercial uses, and pedestrian and vehicular circulation. No demolition, new development, enlargement or alteration of landscaping or topography is permitted within this district except by special permit.

- The *Park Improvement District* was created to preserve the residential character and architectural quality of Fifth and Park Avenues from East 59th Street to East 111th Street. It limits the height of of new buildings to 210 feet or 19 stories and mandates street wall continuity.

- The *Southern Hunters Point District* aims to transform an underutilized waterfront area into a higher-density mixed-use development with residential and retail uses, community facilities, a public park, and waterfront open space. Two sub-districts, the East River Sub-district and the Newtown Creek Sub-district, create a varied skyline, buildings with tapered tops, active, pedestrian-oriented ground floors and landscaped, publicly-accessible open space at key locations.

- The *Southern Roosevelt Island District* will facilitate a new Cornell NYCTech applied sciences and engineering campus to be built over 20 years. The campus will include a mix of residential, retail, and other commercial uses to support the academic, research, and development facilities. The district will allow flexible bulk zoning envelopes for the campus buildings that will assure access of light and air to the street and surrounding waterfront open areas along with a network of publicly-accessible open areas around the entire campus.

- The *Scenic View District* aims to prevent obstruction of outstanding scenic views as seen from a public park, esplanade, or mapped public place. No buildings or structures are allowed to penetrate a scenic view plane except by special permit. The Brooklyn Heights Scenic View District protects the views of the Lower Manhattan skyline, Governors Island, the Statue of Liberty, and the Brooklyn Bridge.

- The *Transit Land Use District* regulates development along Second Avenue in the vicinity of the new subway line. The district requires builders of developments adjoining planned subway stations to reserve space in their projects for public access to the subway.

- The *United Nations Development District* implements a development plan, consisting of a unified design plan, for the area adjacent to the United Nations consisting primarily of United Nations Plaza buildings.

- The *Union Square District* was established to revitalize the area around Union Square by encouraging mixed-use development with mandated ground floor retail uses, off-street relocation of subway stairs, and continuity of street walls. A floor bonus for subway improvements is also available.

Plans for significant development and redevelopment within the East River/Long Island Sound sewershed include the following:

- The *LaGuardia Airport Expansion,* over the next several years, will completely rebuild LaGuardia Airport to span 2.7 million square feet with six new concourses and 72 gates, as shown on Figure 2.3-7. The project will provide a Central Terminal with a “world-class” entrance, more mass transit connections, links to all terminals, a new roadway network, expanded aircraft taxiways, and a 3,000-car parking garage. The facility is projected to be completed by 2022.

- The *Staten Island/Bronx Special Districts Zoning Text Amendment* will create ecological areas across the special district based on proximity to the most sensitive natural resources. Regulations for development focus on lot coverage, impervious area and planting controls, which will vary depending on adjacency of sites to these natural areas.

- The *East Side Access Project* is one of the largest transportation infrastructure projects currently underway in the United States. The project involves a new LIRR terminal at Grand Central Terminal, more than eight miles of tunneling, 25,000 square feet of new retail space, and multiple work sites in Manhattan, Queens, and the Bronx. Revenue service is forecasted for December 2022.

- The *Penn Station Access Project* will connect Metro-North riders directly to Penn Station via an existing Amtrak line and the existing East River Tunnels. Four new ADA-accessible Metro-North stations will be constructed in the Eastern Bronx at Hunts Point, Parkchester/Van Nest, Morris Park, and Co-op City. Metro-North service to Penn Station will begin after the completion of the East River Tunnel rehabilitation and MTA's East Side Access Project which would create more availability at Penn Station for the Metro-North riders.

Figure 2.3-7. Proposed LaGuardia Airport Redevelopment

- The *Bronx Metro-North Station Area Study* will engage local communities to examine each of the new Metro-North stations areas to address existing obstacles, identify future opportunities, and ensure maximum benefits accrue to the borough and its residents.

- The *Second Avenue Subway Expansion*, when complete, will add 16 new stations and service to a new full-length subway line that extends 8.5 miles along Manhattan's East Side from 125th Street in Harlem to Hanover Square in Lower Manhattan. Phase 2 of the expansion project is currently underway.

- The *Resilient Neighborhood Studies* (Lower Manhattan, Edgewater Park, Harding Park) identify local planning strategies to increase the neighborhood's ability to withstand and recover from coastal storms and flooding, and seeks to improve access to the waterfront, as well as enhance public spaces in the community and maintain the neighborhood's character.

- The *Hunts Point Vision Plan* includes an ongoing task force formed in 2003 to provide a forum for addressing critical issues facing the Hunts Point Peninsula. The vision plan's goals focus on optimizing land use, implementing workforce solutions, creating open space, waterfront and pedestrian connections, and improving traffic safety and efficiency.

- NYCEDC is aiming to redevelop the *Hunts Point Peninsula* through its participation in the Hunts Point Vision Task Force and work in the Hunts Point Food Distribution Center.

- The *South Bronx Greenway* will vastly improve access to the waterfront, provide recreational opportunities, improve transportation safety, and enhance the network of bike and pedestrian paths on the South Bronx peninsula while providing opportunities for compatible economic growth. When completed, the Greenway will link existing and new parks through a network of waterfront and on-street routes, encompassing 1.5 miles of waterfront greenway, 8.5 miles of inland green streets, and nearly 12 acres of new waterfront open space throughout Hunts Point and Port Morris.

- The *Southern Boulevard Neighborhood Study* will be a comprehensive planning process that implements the land use vision and priorities of several other plans in the study area. The study will identify opportunities to protect and increase affordable housing, strengthen retail and local businesses, increase pedestrian safety and walkability, and improve community resources, supporting the long-term sustainability of the area.

- The *Greater East Midtown Zoning Text Amendment* would permit higher as-of-right densities for new state-of-the-art office buildings in order to ensure East Midtown remains a highly competitive business district.

- The *East Midtown Waterfront Project* will fill a major gap in the Manhattan Waterfront Greenway between East 38th Street and East 60th Street along the East River while providing much-desired waterfront access and public open space resources for the communities of East Midtown and the public at large.

- The *Vanderbilt Corridor* proposed zoning text amendment and map change would facilitate commercial development along Madison and Vanderbilt Avenues in Manhattan, improve pedestrian circulation within Grand Central Terminal and its vicinity, and allow opportunities for landmarks to transfer unused development rights.

- The *Long Island City Waterfront Design Guidelines* inform the establishment of a distinct waterfront district connecting Queensbridge Park to Anable Basin that reflects the industrial and creative character of Long Island City.

- The *Long Island City Core Neighborhood Planning Study* aims to promote affordable housing, economic opportunities for businesses and job growth, and supporting infrastructure and services.

- The expanded *NYC Ferry Service* incorporates the previous East River route and has added five new routes in the summers of 2017 and 2018. This project includes the construction of new ferry landings and renovation of existing landings. These routes provide affordable transit, support growing neighborhoods, and increase the resiliency and redundancy of the city's transportation network. A new 2018 Ferry Feasibility Study will also examine sites around the city that may be viable for future ferry service.

- The *North Brooklyn Industry and Innovation Plan* aims to increase space for jobs by updating zoning in industrial areas, reinforce the area for heavy industrial/manufacturing businesses, and increase job density in targeted areas near transit and residential areas.

- The *Seward Park Mixed-Use Development Project* will transform more than six acres of under-utilized land along Delancey Street and Essex Street by providing up to 1.65 million square feet of mixed-use development in the area. The project will include a dynamic streetscape, Essex Street Market, and a diverse range of retail and other commercial uses. The final buildings of the project are expected to be completed by 2024.

- The Department of City Planning's *Waterfront Revitalization Program* establishes policies for development and use of the waterfront. The goal of the program is to maximize benefits from economic development, environmental conservation, and public use of the waterfront, while minimizing any potential conflicts among these objectives.

- The Department of City Planning's *Vision 2020 Comprehensive Waterfront Plan* builds on NYC's success in opening up to the public miles of shoreline that had been inaccessible for decades and supporting expansion of the maritime industry (DEP, 2010c). Vision 2020 set the stage for expanded use of waterfront parks, use of waterways for transportation, housing and economic development, and recreation and natural habitats. The 10-year plan lays out a vision for the future with new citywide policies and site-specific recommendations. The East River spans Reaches 1, 7, 9, 11, 12, and 14N within the Vision 2020 plan and consists of 33 site-specific waterfront revitalization strategies (see Figure 2.3-8 through Figure 2.3-15).

Neighborhood Strategies

Reachwide
- Test feasibility of commuter ferry service on the East River connecting Brooklyn/Queens with Manhattan.

East River Greenway 1
- Form a long-term management strategy to design, fund, construct and maintain the entire East River Greenway.
- Explore alternative edge conditions and opportunities for in-water recreation, such as a boat launches, based on the criteria described in the Ctiywide Strategy.
- Provide concessions for boaters and other visitors.
- Study opportunities to improve upland connections, including providing ADA accessibility.

East River Greenway - E. 53rd to E. 59th St. 1.a
- Build esplanade on existing out board piles between E.53rd St. and E. 59th St.

East River Greenway - United Nations 1.b
- Study options for UN Consolidation building in exchange for funding of park improvements and waterfront esplanade.

East River Greenway - E. 38th to E. 41st St. 1.c
- Ensure that the former Con Edison waterfront pier at East 38th St. is improved for safe public access and for use as a park.
- Study pedestrian access options from upland areas to the waterfront pier.

East River Greenway - E. 23rd to E. 35th St. 1.d
- Explore long-term opportunities for maximizing water-dependent and water-enhancing uses along the waterfront.
- Explore inclusion of non-commercial recreational boating at marina.
- Upgrade esplanade to continuous, consistent design with amenities.
- Study opportunities for additional temporary uses of the 34th St. Heliport.
- Construct E. 35th Street ferry landing that provides sheltered waiting area, ticketing, and pedestrian amenities.

East River Greenway - E. 25th St. 1.e
- Improve signage at Waterside Plaza from southern esplanade entrance at E. 25th St.

East River Greenway - E. 13th to E. 15th St. 1.f
- Explore opportunities to improve bicycle and pedestrian connections in the area where the path narrows adjacent to the steam plant, including better lighting, screening, and signage to advise users of the limited right-of-way.

Stuyvesant Cove 2
- Support Solar 2 and expansion of environmental educational center.
- Explore opportunities for a recreational pier based on the criteria described in the Citywide Strategy.

East River Park 3
- Pursue funding for additional improvements to the Fireboat House facility, which supports both park maintenance and operations and an environmental education program.

Pier 42 4.a
- Study for use as a park with water-dependent community uses with connection to East River Esplanade South.

Pier 36 4.b
- Support plans to create public waterfront area as part of Basketball City development.

Pier 35 4.c
- Support plans to create public pier with an eco-park component.

Lower East Side 5
- Improve upland streetscape connections, along Montgomery St., Rutgers St., and Catherine St., as described in the East River Waterfront master plan.

REACH 1-*EAST RIVER SOUTH*

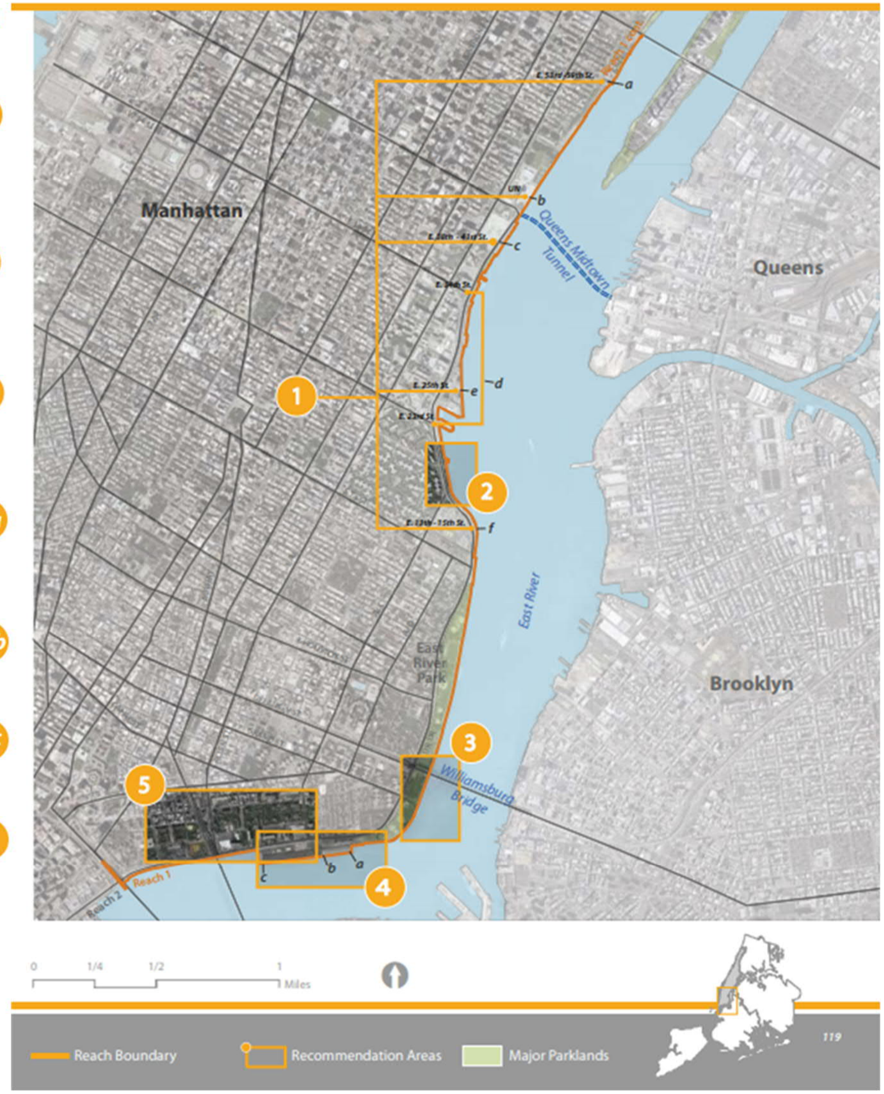


Figure 2.3-8. NYCDCP Vision 2020 Comprehensive Waterfront Plan – Reach 1 South

Neighborhood Strategies

East River Greenway (E. 59th St. to E.125th St.) 1

- Form a long-term management strategy to design, fund, construct and maintain the entire East River Greenway.
- Improve quality of existing esplanade (widen where possible, provide noise barriers, seating, lighting, dedicated paths, drainage, ADA access) and improve maintenance and current conditions of esplanade.
- Explore alternative edge conditions and opportunities for in-water recreation, such as a boat launches, based on the criteria described in the Citywide Strategy.
- Repair bulkhead prior to esplanade improvements.

East River Greenway- E. 111th St. 1.a

- Work with DDC to ensure that their planned reconstruction of the pedestrian bridge at E. 111th St. maximizes the Greenway and provides a more direct connection to the waterfront.

East 107th St. Pier 1.b

- Examine the feasibility of providing vessel tie-up.
- Improve pedestrian connection to E. 106th St.

East River Greenway- E. 96th St. 1.c

- Improve pedestrian connection across FDR Dr. to 96th St. pier to facilitate access to water. Accommodate pedestrians carrying boats by widening pedestrian bridge.
- Examine potential improvements for existing boat launch, consistent with the criteria described in the Citywide Strategy.

East River Greenway- E. 73rd to E. 75th St. 1.d

- Explore areas of the waterfront that can be made publicly accessible while maintaining the steam plant's facility needed for plant operation.

Queensboro Bridge Area 2

- Facilitate pedestrian upland access to the waterfront from E. 59th St. to E. 60th St., as recommended by Community Board 8's 197-a plan. Direct people to the waterfront through streetscape improvements, signage, landscaping, artistic or design elements which indicate proximity to the waterfront.
- Advance proposed Andrew Haskell Green Park.

Randall's and Ward's Island 3

- Explore opportunity for boat launch at the cove based on criteria described in the Citywide Strategy.
- Improve access via Ward St. bridge, including better maintenance and increased hours of operation.
- Support planned Renewable Energy Park and education center.
- Complete waterfront pathways, including Bronx Shore pathway, comfort stations, seawall repairs.
- Support Randall's Island Sports Foundation's plan to create a soft edge in areas where the bulkhead has deteriorated.
- Explore improvements to support habitat restoration and, where feasible, the navigability of the Bronx Kill for kayaks and canoes.
- Complete improvements at Ward's Island Waste Water Treatment Plant to reduce nitrogen discharge into the East River.
- Support salt marsh and wetlands restoration.

Roosevelt Island 4

- Support continued evaluation of effectiveness of tidal energy and strengths of river currents.
- Explore opportunity for boat launch based on criteria described in the Citywide Strategy.
- Explore opportunities in the east channel of the East River to reduce wave action to promote recreational boating and limit shoreline erosion.
- Ensure redevelopment of Goldwater Hospital maximizes open space and reflects proximity of the waterfront.

Roosevelt Island, Southern End 4.a

- Support an improved Southpoint Park with a waterfront esplanade and secure funding to build FDR Memorial.

REACH 1 -*EAST RIVER NORTH*

Figure 2.3-9. NYCDCP Vision 2020 Comprehensive Waterfront Plan – Reach 1 North

Neighborhood Strategies

Harlem River

- Explore opportunities to reduce wave action to promote recreational boating and limit shoreline erosion.

Lower Concourse / Harlem River WAP (1)

- Support the development of Lower Concourse Mixed Use Area and Special Waterfront District with required waterfront access, open space, and brownfield remediation.

Pier V (Former Velodrome Site) (1.a)

- Develop land for public use and open space.

144th St. (1.b)

- Fund acquisition and construction of proposed 2-acre park dependant on the redevelopment of the site north of the proposed park.

138th St. Bridge (Padded Wagon Site) (1.c)

- Plan for residential and commercial development of site (lease comes up in 2014).

Expansion of Harlem River WAP (2)

- Support waterfront redevelopment to increase public waterfront access and maximize economic development potential.
- Explore opportunity for public waterfront access and non-motorized boat launch at Park Ave. street end, based on the criteria described in the Citywide Strategy.

Bronx Kill (3)

- Explore improvements to support habitat restoration and, where feasible, the navigability of the Bronx Kill for kayaks and canoes.

North and South Brother Islands (4)

- Pursue additional funding for a comprehensive plan to integrate cultural, historical, and natural resource management on both islands.

Hunts Point / Port Morris (5)

- Complete improvements to the South Bronx Greenway.
- Identify opportunities to attract tall ships and other educational programming to the waterfront at Barretto Point Park and other recreational areas.
- Promote redevelopment of vacant land within the Significant Maritime and Industrial Area (SMIA) for industrial uses with preference for water-dependent maritime industries.
- Where feasible, preserve waterfront access to industrial properties and intermodal connections to facilitate waterborne movement of goods.
- Evaluate feasibility of developing a Hunts Point boat launch/docking facility that services recreational or freight vessels.
- Complete improvements at Hunts Point Waste Water Treatment Plant to reduce nitrogen discharge into the East River.

132nd St. / 134th St. (5.a)

- Study street ends for recreational or industrial purposes, including potential preservation of gantry cranes.

Hunts Point South (5.b)

- Study corrections site for potential redevelopment opportunities.

Farragut St. End & Marine Transfer Station (5.c)

- Support improvements at Farragut Street end.
- Balance needs of city's waste management with those of the community.
- Explore redevelopment of the Marine Transfer Station as a maritime use.

Hunts Point Market (5.d)

- Explore waterborne transportation modes for the movement of goods to and from the Food Distribution Center, as well as supporting infrastructure, such as a pier for fishing vessels and freight ferries.

Hunts Point-Riverside Park (6)

- Complete expansion of launch platform for canoes and small boats, consistent with the criteria described in the Citywide Strategy.

REACH 7-SOUTH BRONX

Figure 2.3-10. NYCDCP Vision 2020 Comprehensive Waterfront Plan – Reach 7

Neighborhood Strategies

Reachwide

- Explore opportunities for new capacity for dry bulk/ liquid operations in conjuction with ongoing wetland restoration work (may require dredging). Possible locations include Westchester Creek, Eastchester Bay, or Hutchinson River.

Soundview Park (1)

- Reconstruct playground, athletic courts and a new comfort station.
- Complete restoration of tidal wetlands including excavation work, sand replacement, and planting salt marsh grasses.

Loral site (1.a)

- Support brownfield clean-up and redevelopment of privately owned site.
- Seek to provide public waterfront access.

Clason Point/ Pugsley Creek (2)

- Explore opportunities for boat launch and fishing based on the criteria described in the Citywide Strategy.
- Complete restoration of tidal wetlands including excavation work, sand replacement, and planting salt marsh grasses.

Castle Ave. Park (2.a)

- Implement plans for improved waterfront public access.

Zerega Industrial Area (3)

- Study development of two-acre City-owned site north of Watson Ave. with water-dependent industrial uses and create street-end waterfront access at Watson Ave.

Ferry Point Park (4)

- Protect the shore of the park from erosion.
- Complete new 9.5-acre community park.

Throgs Neck (5)

- Pursue development as a "hub" for maritime support services in conjunction with educational and workforce development opportunities for citywide residents at SUNY Maritime College.
- Create opportunities for public view points at waterfront street ends.

Pelham Bay Park (6)

- Support citizen clean-up of the Hutchinson River from dumping and debris.
- Replenish Orchard Beach with clean sand, and expand the South Jetty to reduce further beach erosion.

Eastchester Brownfield Opportunity Area (6.a)

- Explore strategies for revitalizing shipping and barging industry as related to existing industrial and commercial businesses in the Eastchester area.
- Work with BOA to improve water quality of Hutchinson River and Eastchester Bay.
- Identify underutilized brownfield properties and identify strategies to remediate and revitalize them.
- Explore opportunities for public access and recreational use of the waterfront and waterway.
- Explore opportunities to collaborate with the City of Mount Vernon with regard to usage of the waterways and waterfront.

Eastchester (6.b)

- Explore access to waterfront at MTA bus yard.

Co-op City (6.c)

- Provide public access through point access at Bellamy Loop and at the city-owned site to the North with eventual connection from Pelham Bay Park to Co-Op City, possibly including a bike path.

City Island Gateway (7)

- Study reuse of city-owned land for improved public access and activation of waterfront.

Belden Point, City Island (8)

- Resolve maintenance issues to restore the shoreline and establish waterfront access.

REACH 9- EAST BRONX

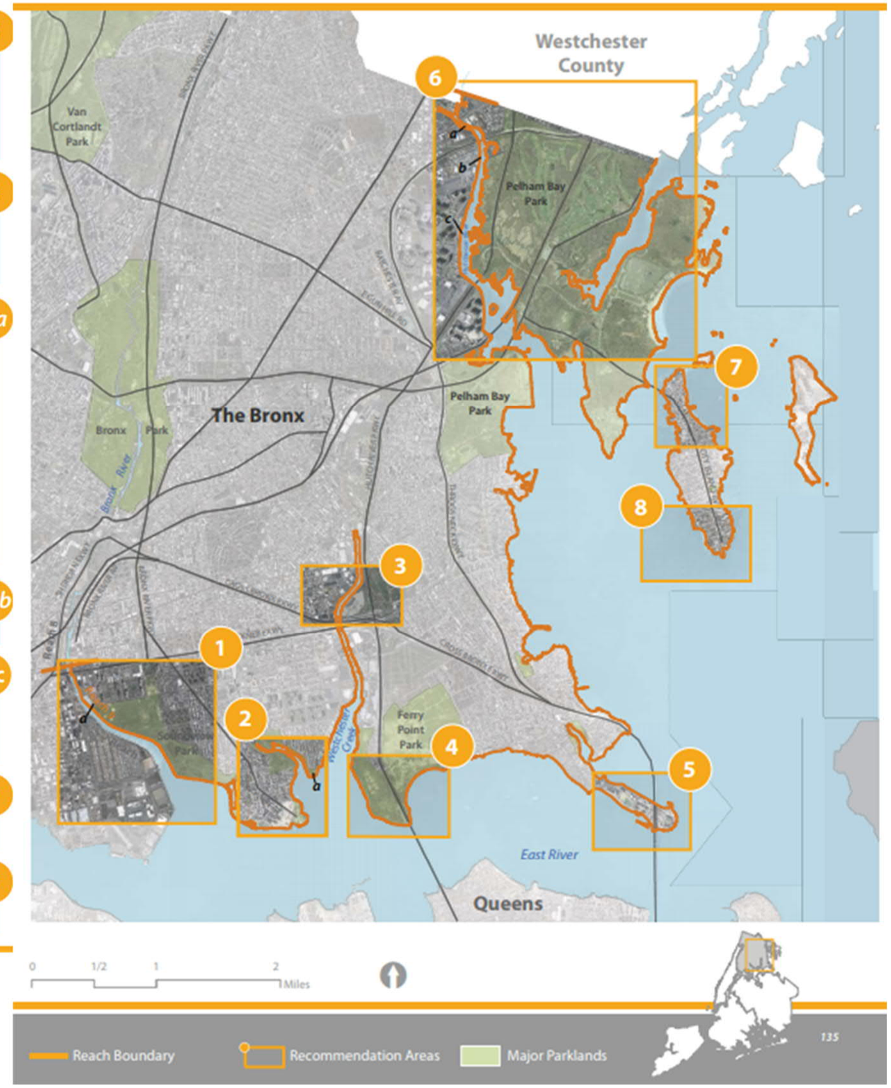


Figure 2.3-11. NYCDCP Vision 2020 Comprehensive Waterfront Plan – Reach 9

Neighborhood Strategies

Reachwide

- Explore possibility of providing signage and improving connections between upland neighborhoods and existing publicly accessible waterfront sites.

MacNeil Park 1

- Explore opportunities for human-powered boat launch and boathouse based on the criteria described in the Citywide Strategy.

Powell's Cove 2

- Explore street end public access to Powell's Cove from Powell's Cove Blvd.
- Complete improvements at Tallman Island Waste Water Treatment Plant to reduce nitrogen discharge into the East River.

Whitestone Pier 3.a

- Explore opportunities to lease and operate the dilapidated pier for recreation based on the criteria described in the Citywide Strategy.

Rock Crushing Site 3.b

- Support rezoning and lower density residential redevelopment that incorporates public waterfront access.

Alley Creek 4

- Complete new CSO storage facilities.

REACH 10 - ***QUEENS NORTH SHORE***

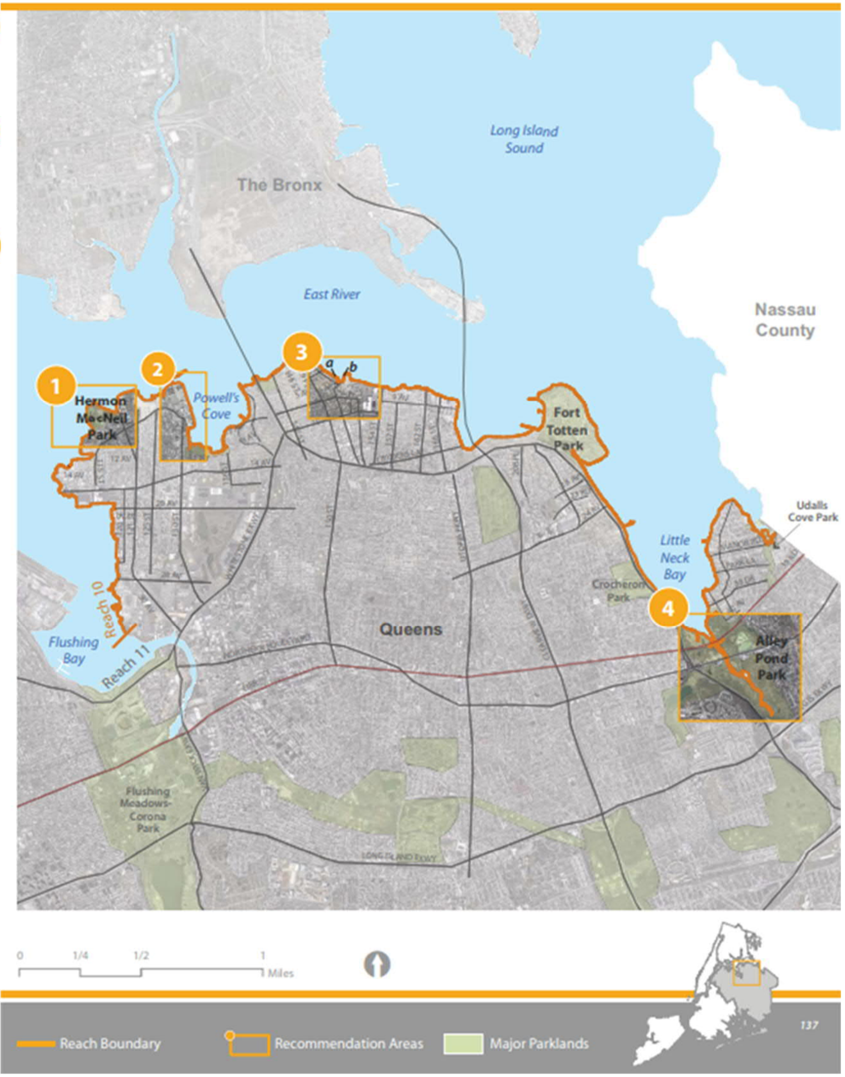


Figure 2.3-12. NYCDCP Vision 2020 Comprehensive Waterfront Plan – Reach 10

Neighborhood Strategies

Reachwide

- Continue to implement the Queens East River and North Shore Greenway Plan and explore additional locations to provide signage and improve connections between upland neighborhoods and existing publicly accessible waterfront sites with consideration for public safety and security.

Luyster Creek 1

- Explore street end public access to the creek from 19th Ave.

Bowery Bay 2

- Complete improvements at Bowery Bay Waste Water Treatment Plant to reduce nitrogen discharge into the East River.

REACH 11 -*QUEENS UPPER EAST RIVER*

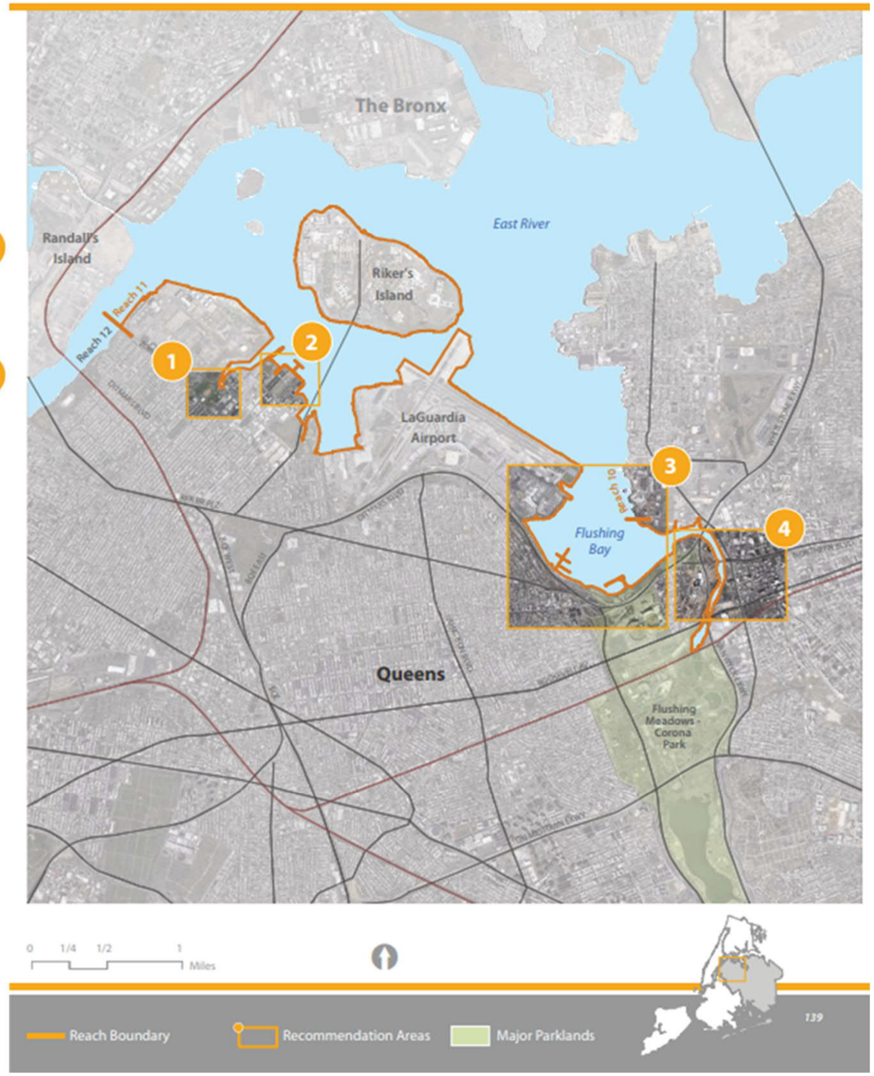


Figure 2.3-13. NYCDCP Vision 2020 Comprehensive Waterfront Plan – Reach 11

Neighborhood Strategies

Reachwide

- Continue to implement Queens East River and North Shore Greenway.
- Enhance wetland habitat at Pot Cove, Hallets Cove, in the vicinity of Socrates Sculpture Park, in the vicinity of the Queensboro Bridge, Anable Cove, and Hunter's Point South.
- Test feasibility of commuter ferry service on the East River connecting Brooklyn/Queens with Manhattan.

Hallets Point / Pot Cove 1

- Support rezoning and medium-density residential and mixed-use redevelopment with continuous waterfront access around peninsula.
- Improve pedestrian and vehicular connections through the peninsula by reconnecting Astoria Blvd., 8th St., and 26th Ave. street segments.
- Support repair and improve the maintenance of Hallets Cove Esplanade.
- Explore opportunities for additional access to in-water recreation in Pot and Hallet's Coves.

Broadway Waterfront Access 2

- Create pedestrian connection between Costco site walkway and Socrates Sculpture Park and improve nearby connection at Rainey Park as noted by the Queens East River and North Shore Greenway Plan.

Queens Plaza Bike and Pedestrian Improvement Project 3

- Support implementation of public waterfront access at DOT-owned parcel under Queensboro Bridge as part of Queens East River and North Shore Greenway.

Anable Basin 4

- Explore opportunities for boat launch based on the criteria described in the Citywide Strategy.
- Explore options for redevelopment that will complement the distinct contexts that frame the site, including the East River waterfront, the 100-foot wide basin and adjacent portions of the Hunter's Point neighborhood.

Anable Cove 4.a

- Explore options for public access as part of the Queens East River and North Shore Greenway with a natural edge and habitat area.

44th Drive Pier 4.b

- Complete design and reconstruction of the public access pier.

Hunter's Point South 5

- Continue to support residential redevelopment and enhance shoreline wetlands habitat as part of plans for public access.
- Complete construction of a new 5-acre waterfront park.

East River

- Explore opportunities to reduce wave action to promote recreational boating and limit shoreline erosion in the east channel of the East River.

REACH 12-*WEST QUEENS*

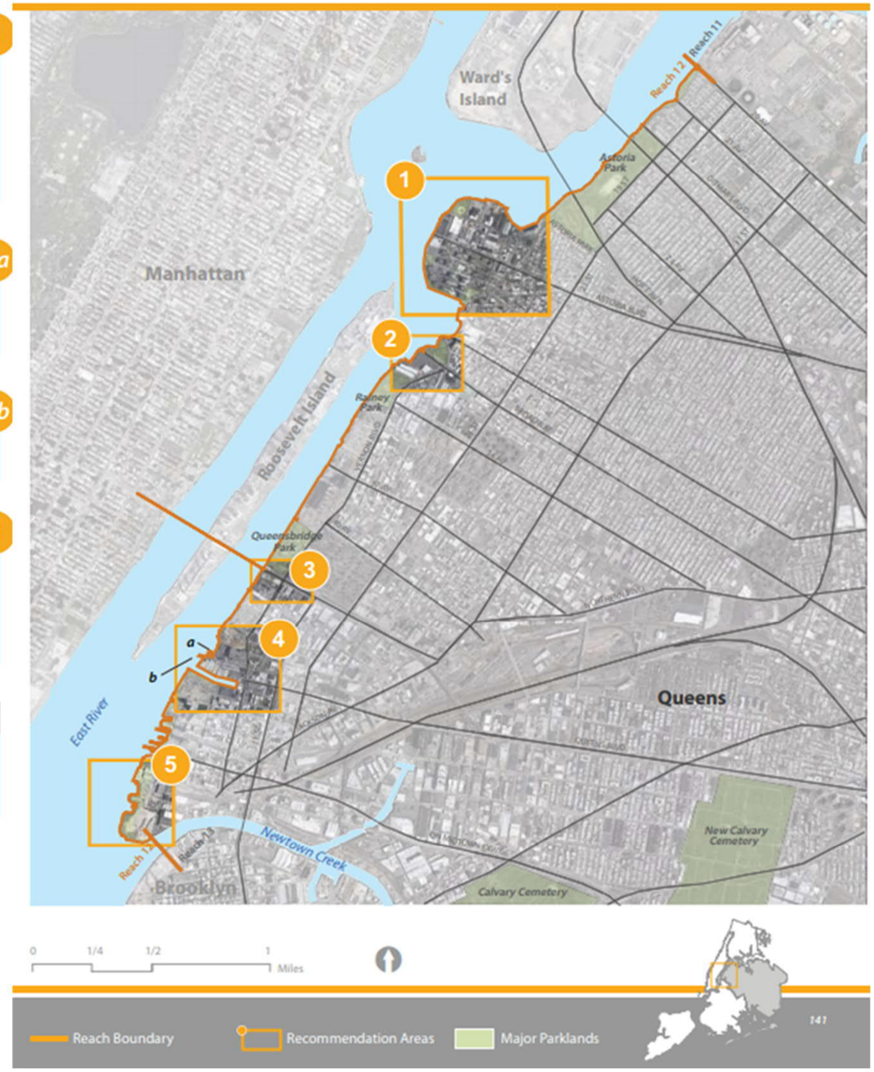


Figure 2.3-14. NYCDCP Vision 2020 Comprehensive Waterfront Plan – Reach 12

Neighborhood Strategies

Reachwide

- Facilitate open space improvements at street ends in coordination with approved plans and zoning regulations for adjacent sites.
- Release Brooklyn Waterfront Greenway Master Plan, guiding the creation of a 14-mile, multi-use, waterfront path between Newtown Creek and the Shore Parkway Greenway.
- Test feasibility of commuter ferry service on the East River connecting Brooklyn/Queens with Manhattan.

65 Commercial St. (1)

- Explore options for funding and relocation of MTA facility and construction of a public park.

Dupont St. Site (Greenpoint Lumber) (2)

- Support mixed use redevelopment of site to facilitate housing, expansion of Newtown Barge Park, and provision of public access.

India St. Pier (3.a)

- Support design of piers for water taxi services and explore opportunities for on-water recreation based on the criteria described in the Citywide Strategy.
- Ensure that any upland site development integrates pier into waterfront public access, consistent with the Greenpoint-Williamsburg Master Plan.

Java St. Pier (3.b)

- Explore opportunities for water-related educational programming and boat launch, based on the criteria described in the Citywide Strategy.

Transmitter Park (3.c)

- Complete construction of 1.5-acre park including a playground, small pier, benches, and trees.
- Pursue funding for refurbishment of transmitter building as park amenity.

Bushwick Inlet Park (4)

- Continue the phased acquisition, remediation and development of the new park.
- Provide access for variety of recreational boating uses along with related facilities such as boathouse or comfort station, consistent with criteria described in the Citywide Strategy.
- Explore opportunities for inclusion of a museum commemorating the USS Monitor.

Williamsburg Bridge Area (5)

- Explore potential for open space under bridge dependent on finding relocation sites for current DOT and DCAS facilities.
- Commence redevelopment of the Domino Sugar factory, including affordable housing, commercial, community facility and waterfront open space.

Brooklyn Navy Yard (6)

- Continue replacement of bulkhead and piers, and complete dredging to ensure long-term viability of maritime uses.
- Support continued economic development through industrial and commercial uses, including expansion of Steiner Studios, construction of Green Manufacturing Center, and redevelopment of DCAS Auction lot and Admirals Row site.
- Explore opportunities for controlled public access (including views of docks, planned point access, and paths) around and within Brooklyn Navy Yard where appropriate, building on existing regular public tours of the industrial park.
- Support preservation of historic structures.
- Complete redesign of Flushing Ave. between Williamsburg St. West and Navy St. as part of Brooklyn Waterfront Greenway.
- Open exhibition and visitors center.

ConEdison site at Division Ave. (7)

- Explore options for redevelopment for industrial and/or commercial uses with opportunities for public access if appropriate.

Brooklyn Bridge Park (8)

- Support continued development as envisioned in the General Project Plan including active, passive, and in-water recreational uses, habitat enhancement, and residential and hotel uses.
- Complete improvements, including Squibb Park pedestrian bridge, upland recreation areas between Piers 1-6, and active recreation on Pier 5.
- Explore improved connections with neighboring street network to provide a safe and cohesive access to the park (i.e. Old Fulton Street, Atlantic Avenue).
- Explore improvements to increase access to the park via mass transit.
- Finalize agreement for cultural use at Tobacco Warehouse.
- Develop Greenway linking the Columbia St. Greenway to DUMBO.
- Issue RFP for adaptive reuse of Empire Stores.
- Re-open Empire Fulton Ferry Park with "Jane's Carousel" installed in a new all-weather pavillion and other park landscape and amenity improvements.

REACH 14 N.-*BROOKLYN UPPER BAY NORTH*

Figure 2.3-15. NYCDCP Vision 2020 Comprehensive Waterfront Plan – Reach 14 North

Impervious Cover Analysis

The impervious cover analysis conducted for the East River/Long Island Sound sewershed is similar to the analysis described for the Harlem River (see Section 2.1.a.1).

Population Growth and Projected Flows

DEP routinely develops water consumption and dry-weather wastewater flow projections for planning purposes. In 2012, DEP projected an average per capita water demand of 75 gallons per day that was representative of future uses. The year 2040 was established as the planning horizon, and populations for that time were developed by the DCP and the New York Metropolitan Transportation Council.

The 2040 population projection figures were then used with the dry-weather per capita sewage flows to establish the dry-weather sewage flows in the IW models for the Hunts Point WRRF, Wards Island WRRF, Bowery Bay WRRF, Tallman Island WRRF, Newtown Creek WRRF, and Red Hook WRRF sewersheds. Average daily dry-weather sanitary sewage flows for the landside model subcatchments for each sewershed were established by distributing the total dry-weather flows at the respective WRRFs to the upstream subcatchments in proportion to the upstream subcatchment populations.

Updated Landside Modeling

The majority of the East River and Long Island Sound sewershed is included within the Hunts Point, Newtown Creek, and Bowery Bay WRRF collection system IW models. Smaller portions of the sewershed are represented by IW models for the Wards Island, Tallman Island, and Red Hook WRRF collection systems. In 2012, 13 of DEP's IW landside models underwent recalibration. This recalibration process is described in Section 2.1.a.1. As part of the Citywide/Open Waters LTCP, additional flow metering was conducted to check the 2012 calibration.

Additional model updates to the Wards Island model implemented as part of the Citywide/Open Waters LTCP development were described in Section 2.1.a.1. In the portion of the Wards Island model tributary to the East River, the Central Park Demand Management project was added to the baseline condition. This project involves the recirculation of water between the Harlem Meer, The Loch, the Pool, and the Jackie Onassis Reservoir and is expected to result in approximately a 4 MG CSO reduction at Outfalls WI-023 and WI-024 to the East River.

Additional model updates to the Newtown Creek model implemented as part of the Citywide/Open Waters LTCP development were described in Section 2.1.a.1.

Updates to the Hunt's Point IW model that were implemented as part of the Hutchinson River, Bronx River, and Westchester Creek LTCPs are summarized in Section 2 of each of those LTCPs. Updates to the Bowery Bay IW model that were implemented as part of the Flushing Bay LTCP, and updates to the Tallman Island IW model that were implemented as part of the Flushing Creek and Alley Creek LTCPs are summarized in Section 2 of those respective LTCPs. Additional model updates to the Hunts Point, Bowery Bay, Tallman Island and Red Hook system models implemented as part of the Citywide/Open Waters LTCP development are summarized as follows:

- Modifications to runoff coefficients, regulator configurations, and wastewater profiles associated with BMP metering and model calibration/validation (Hunts Point, Bowery Bay, Tallman Island, Red Hook)

- A simplified representation of retention-based GI at specified outfalls that results in the targeted CSO reductions (Hunts Point, Bowery Bay, Tallman Island, Red Hook)

- Updated representation of HP-020 (Regulator HP-02A) based on field investigation (Hunts Point)

Review and Confirm Adequacy of Design Rainfall Year

2008 rainfall from the JFK rain gage was determined to be the most representative of average annual rainfall conditions based on a review of rain gage data from 1969 to 2010 at four rainfall gauges (CPK, LGA, JFK, EWR). As a result, the landside modeling analyses, as part of the LTCP process, used the 2008 JFK precipitation as the typical rainfall year in NYC, together with the 2008 tide observations. The rainfall from the JFK gage for a 10-year period of 2002 to 2011 was also used to assess long-term performance of the LTCP Recommended Plan (see Sections 6 and 8). The period from 2002 through 2011 is the wettest continuous 10-year period over the past 50 years and provides a high level of conservatism to the LTCP analyses. Section 2.1.a.1 provides additional detail on selection of the typical year rainfall period.

2.3.a.2 Description of Sewer System

The East River and Long Island Sound watershed/sewershed is located within the Boroughs of Manhattan, the Bronx, Queens, and Brooklyn, and is served by six WRRFs. The northern shoreline is served by the Wards Island, Hunts Point, and Newtown Creek WRRFs and their collection systems. The southern shoreline is served by the Tallman Island, Bowery Bay, Newtown Creek, and Red Hook WRRFs and their collection systems. The Newtown Creek WRRF tributary area is the main contributor of CSO to the East River and covers the most acreage. Figure 2.3-4 and Table 2.3-1 show the different land uses within the sewersheds of the Wards Island, Hunts Point, Bowery Bay, Tallman Island, Newtown Creek, and Red Hook WRRFs that are tributary to the East River and Long Island Sound. The locations of these WRRFs and the respective boundaries are shown in Figure 2.3-1. Table 2.3-2 lists the CSO and stormwater outfalls that discharge to the East River and Long Island Sound by ownership as documented by the Shoreline Survey Unit of the DEP. The locations of these outfalls are shown in Figure 2.3-16.

In addition to the outfalls listed in Table 2.3-2, the outfalls for the Hunt’s Point, Wards Island, Tallman Island, Bowery Bay, Newtown Creek, and Red Hook WRRFs also discharge to the East River/Long Island Sound.

Table 2.3-2. Outfalls Discharging to East River and Long Island Sound

Identified Ownership of Outfalls	Number of Outfalls
DEP	DEP MS4 Permitted = 28
	DEP Non-MS4 Permitted = 32
	DEP CSO Permitted = 139
DEC	15
NYS Department of Transportation	231
Private	496
Unknown	123
Total	1,063

Based on data available on-line at the date of preparation of this LTCP, a total of 22 State-significant industrial SPDES permit holders are operating facilities located in the sewershed, as listed in Table 2.3-3.

Table 2.3-3. Industrial SPDES Permits within the East River and Long Island Sound Watershed

Permit Number	Owner	Location
NY0005118	Astoria Generating Company, L.P.	18-01 20th Ave., Astoria, NY
NY0005126	Consolidated Edison Company	801 E. 14th St., New York, NY
NY0005177	Consolidated Edison Company	506 E. 75th St., New York, NY
NY0005193	Helix Ravenswood, LLC	38-54 Vernon Blvd., Long Island City, NY
NY0007650	Buckeye Terminals, LLC	1040 E. 149th St., Bronx, NY
NY0006301	NYC Parks and Recreation	26 N. 12th St., Brooklyn, NY
NY0007668	Sprague Operating Resources, LLC	939 E. 138th St., Bronx, NY
NY0008133	Port Authority of New York and New Jersey	LaGuardia Airport, Flushing, NY
NY0072281	One New York Plaza Co. LLC	1 New York Plaza, New York, NY
NY0200778	Consolidated Edison Company	514 E. 60th St, New York, NY
NY0200824	J.B. Waste Oil Co. Inc.	18-18 41st St., Astoria, NY
NY0201120	United Nations Plaza	866 United Nations Plaza, New York, NY
NY0201154	Consolidated Edison Company	31-01 20th Ave., Astoria, NY
NY0201219	Consolidated Edison Company	20th Ave and Shore Blvd, Astoria, NY
NY0201227	Consolidated Edison Company	37th Ave and Vernon Blvd., Long Island City, NY
NY0201235	Astoria Gas Turbine Power, LLC	31-01 20th Ave. Astoria, NY
NY0201243	Consolidated Edison Company	31-01 20th Ave. Astoria, NY
NY0241577	Brooklyn Navy Yard Cogeneration Partners, L.P.	63 Flushing Ave., Brooklyn, NY
NY0267503	New York Power Authority	31-03 20th Ave., Astoria, NY
NY0267538	Astoria Energy	17-10 Steinway St., Astoria, NY
NY0267732	National Railroad Passenger Corporation	52-31 2nd St., Long Island City, NY
NY0276758	Cornell NYCTech Campus	1 Main St., New York, NY

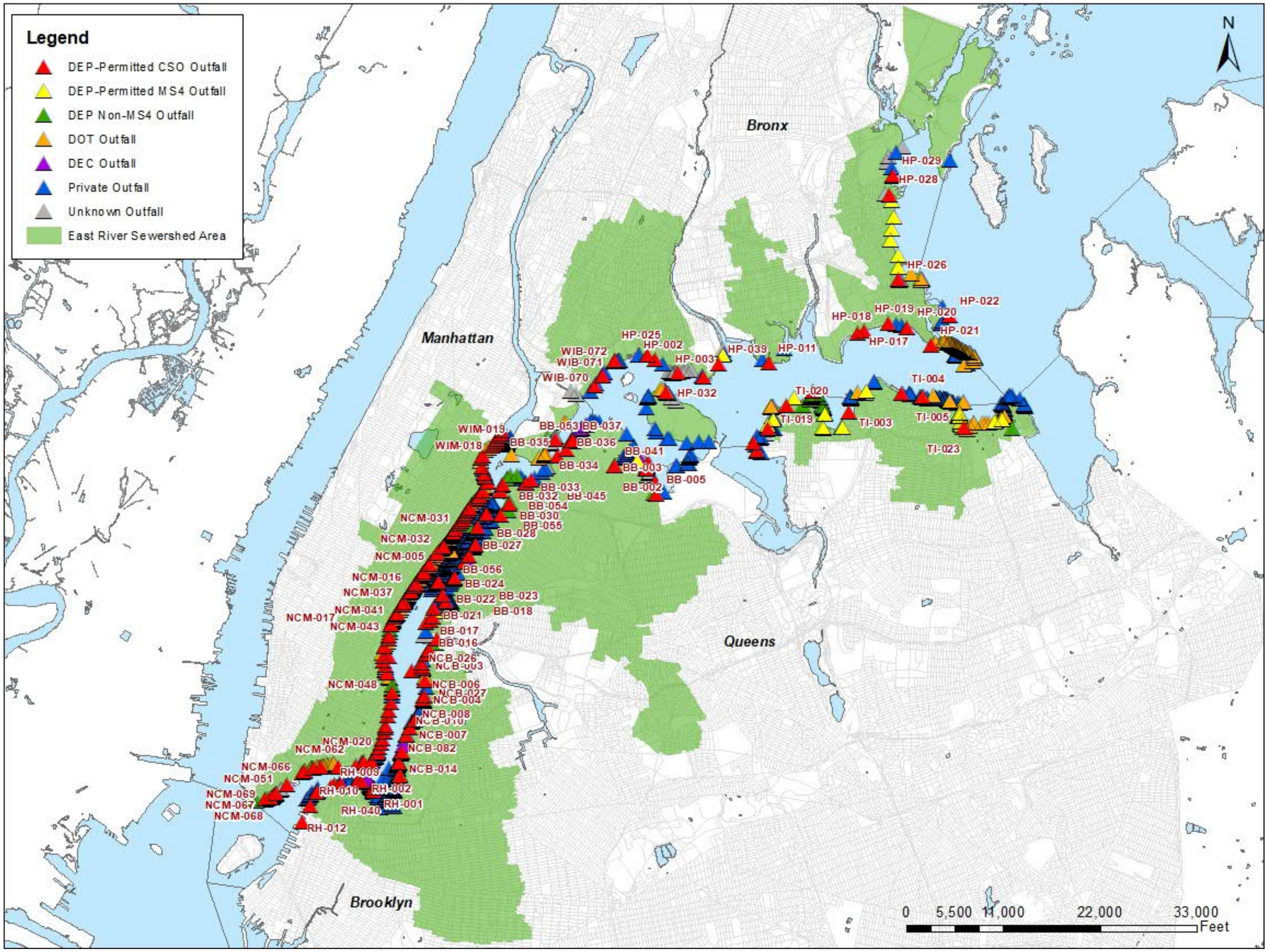


Figure 2.3-16. Outfalls Discharging to East River and Long Island Sound

Overview of Drainage Area and Sewer System

The following sections describe the major features of the Hunts Point, Wards Island, Tallman Island, Bowery Bay, Newtown Creek, and Red Hook WRRF sewersheds within the East River and Long Island Sound watershed. All WRRFs have been providing full secondary treatment since 1978, except for the Newtown Creek WRRF which was upgraded to provide full secondary service in 2012.

Table 2.3-4 shows the areas served by the various drainage system categories.

Table 2.3-4. WRRF Sewersheds Tributary to the East River and Long Island Sound: Acreage Per Sewer Category

WRRF	Combined	Separate (MS4 and non-MS4)(1)	Direct, Overland, Other(1)	Total Area (Acres)
Hunts Point	11,480	3,700	65	15,246
Wards Island	1,139	255	0	1,394
Tallman Island	8,369	6,073	1,115	15,557
Bowery Bay	6,115	1	1,581	7,698
Newtown Creek	7,416	117	291	7,824
Red Hook	1,501	96	306	1,903
Total	**36,021**	**10,242**	**3,358**	**49,621**

Note:
(1) Tributary drainage areas for direct drainage and other sources of stormwater have not been fully delineated by DEP or obtained from other agencies. These drainage areas were estimated based on GIS mapping, aerial photographs, land use maps, and topographic maps, rather than detailed topographic surveys and sewer maps.

Hunts Point WRRF Drainage Area and Sewer System

The Hunts Point WRRF is located at Ryawa Avenue and Halleck Street in the Hunts Point Section of the Bronx, on a 45-acre site on the Upper East River. The Hunts Point WRRF serves the east side of the Bronx, including the communities of City Island, Throgs Neck, Edgewater Park, Schuylerville, Country Club, Pelham Bay, Westchester Square, Clason Point, Castle Hill, Union Port, Soundview, Parkchester, Van Nest, Co-op City, Morris Park, Pelham Parkway, Pelham Gardens, Baychester, Olinville, Williamsbridge, Edenwald, Eastchester, Hunts Point, Woodlawn, Wakefield, East Tremont, West Farms, and Longwood. The total sewershed area tributary to the Hunts Point WRRF is 19,005 acres. Of that total area, 4,020 acres are directly tributary to outfalls that discharge to the East River/Long Island Sound.

The Hunts Point WRRF has a DDWF capacity of 200 MGD and is designed to receive a maximum flow of 400 MGD (2xDDWF) with 260 MGD (1.3xDDWF) receiving secondary treatment. Flows over 260 MGD receive primary treatment and disinfection.

A total of 12 CSO outfalls from the Hunts Point WRRF system are permitted to discharge to the East River/Long Island Sound during wet-weather. Figure 2.3-17 shows the main features of the Hunts Point WRRF collection system associated with the East River/Long Island Sound sewershed, along with the sewershed area tributary to the East River/Long Island Sound. Table 2.3-5 lists the CSO outfalls that are tributary to the East River and Long Island Sound from the Hunts Point WRRF sewershed, along with their associated regulators/relief structures.

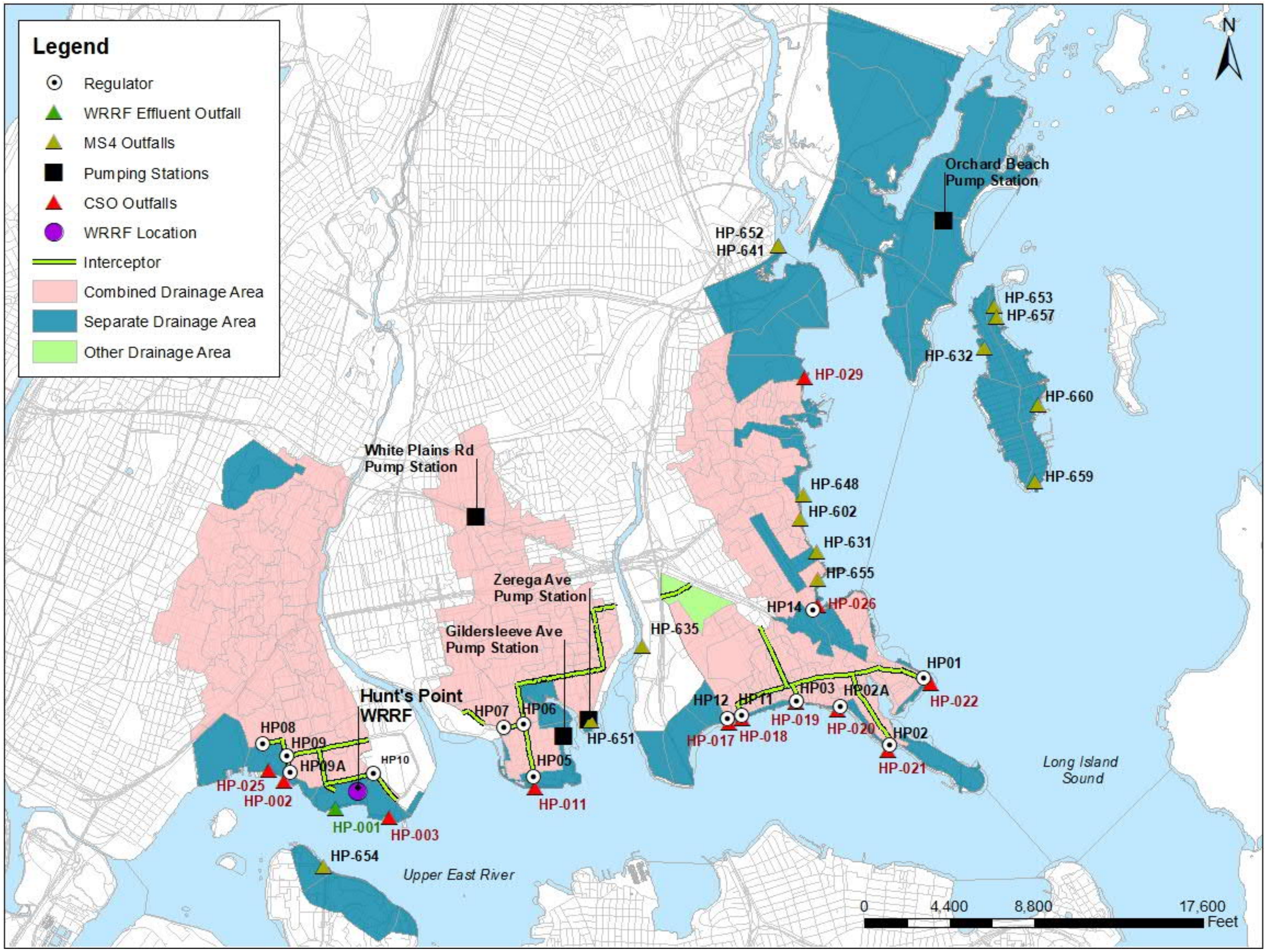


Figure 2.3-17. Hunts Point WRRF Collection System

Table 2.3-5. CSO Outfalls Tributary to the East River/Long Island Sound from the Hunts Point WRRF Service Area

Outfall	Regulator(s)
HP-002	Reg #9, 9A
HP-003	Reg #10
HP-011	Reg #5
HP-017	Reg #11
HP-018	Reg #12
HP-019	Reg #3
HP-020	Reg #2A
HP-021	Reg #2
HP-022	Reg #1
HP-025	Reg #8
HP-026	Reg #14
HP-029	CSO-21

<u>Wards Island WRRF Drainage Area and Sewer System</u>

The Wards Island WRRF sewershed and sewer system are described in Section 2.1.a.1. A total of 22 CSO outfalls from the Wards Island WRRF system are permitted to discharge to the East River/Long Island Sound during wet-weather.

Figure 2.3-18Figure 2.3-18 shows the main features of the Wards Island WRRF collection system associated with the East River and Long Island Sound sewershed, along with the sewershed area tributary to the East River/Long Island Sound. Table 2.3-6 lists the CSO outfalls that are tributary to the East River/Long Island Sound from the Wards Island WRRF sewershed, along with their associated regulators/relief structures.

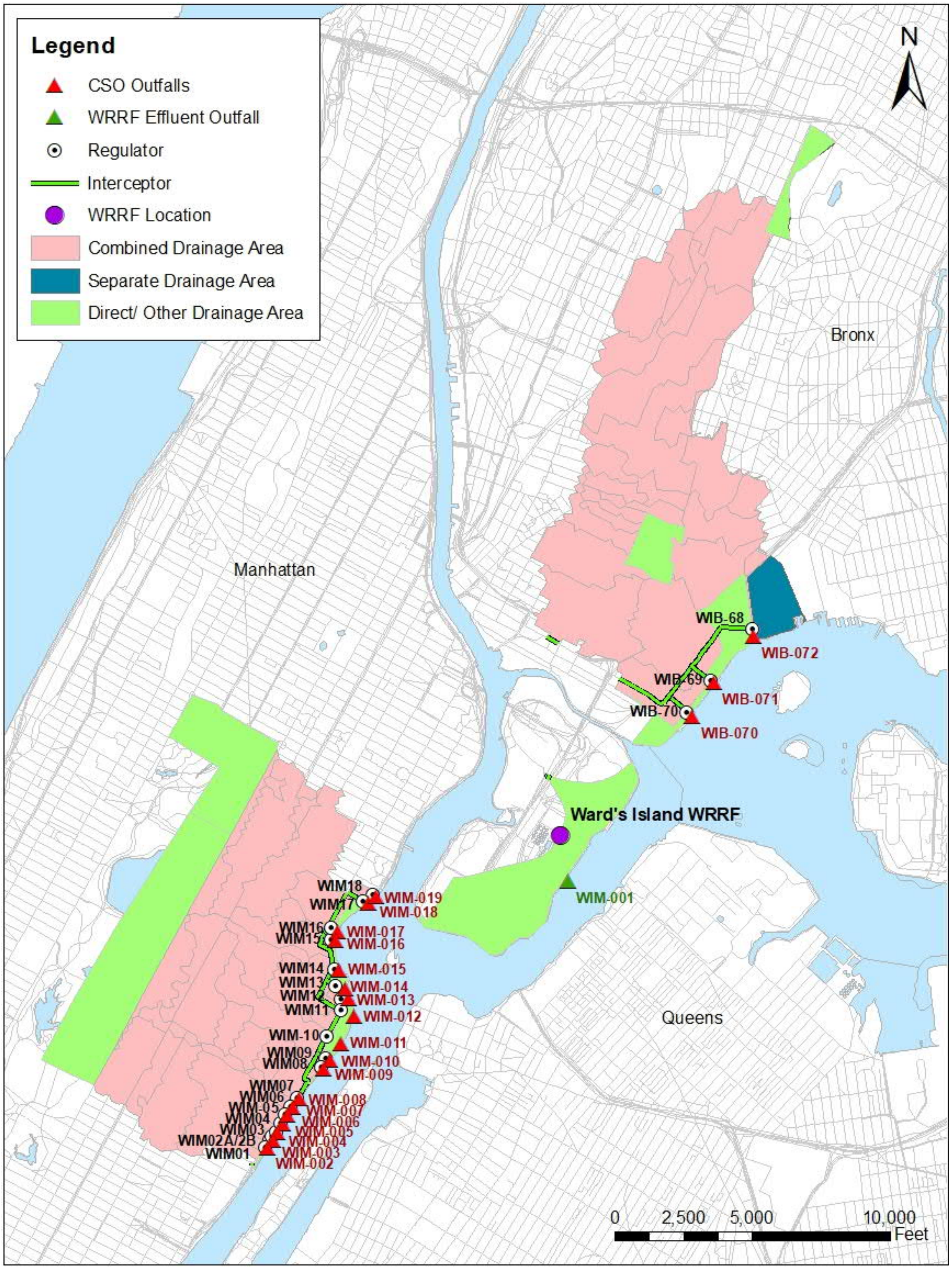


Figure 2.3-18. Wards Island WRRF Collection System

Table 2.3-6. CSO Outfalls Tributary to the East River/Long Island Sound from the Wards Island WRRF Service Area

Outfall	Regulator(s)
WIB-070	Reg #70
WIB-071	Reg #69
WIB-072	Reg #68
WIM-002	Reg #1
WIM-003	Reg #2A, 2B
WIM-004	Reg #3
WIM-005	Reg #4
WIM-006	Reg #5
WIM-007	Reg #6
WIM-008	Reg #7
WIM-009	Reg #8
WIM-010	Reg #9
WIM-011	Reg #10
WIM-012	Reg #11
WIM-013	Reg #12
WIM-014	Reg #13
WIM-015	Reg #14
WIM-016	Reg #15
WIM-017	Reg #16
WIM-018	Reg #17
WIM-019	Reg #18
WIM-043	Reg #19

Tallman Island WRRF Drainage Area and Sewer System

The northeastern portion of Queens within the East River/Long Island Sound watershed is served by the Tallman Island WRRF. The facility is located at 127-01 134th Street, in the College Point section of Queens, on a 31-acre site adjacent to Powells Cove. The Tallman Island WRRF serves the sewered area in the northeast section of Queens, including the communities of Little Neck, Douglaston, Oakland Gardens, Bayside, Auburndale, Bay Terrace, Murray Hill, Fresh Meadows, Hillcrest, Utopia, Pomonok, Downtown Flushing, Malba, Beechhurst, Whitestone, College Point, and Queensboro Hill. A total of 490 miles of sanitary, combined, and interceptor sewers feed into the Tallman Island WRRF.

The Tallman Island WRRF has provided full secondary treatment since 1978. Treatment processes include primary screening, raw sewage pumping, grit removal and primary settling, air-activated sludge capable of operating in the step aeration mode, final settling, and chlorine disinfection. The Tallman Island WRRF has a DDWF capacity of 80 MGD, and is designed to receive a maximum flow of 160 MGD (2XDDWF) with 120 MGD (1.5XDDWF) receiving secondary treatment. Flows over 120 MGD receive primary treatment and disinfection.

The Tallman Island WRRF system includes four principal interceptors: the Main Interceptor, the College Point Interceptor, the Flushing Interceptor, and the Whitestone Interceptor. The Whitestone Interceptor conveys flow from the area east of the facility along the East River and was extended and disconnected from the Flushing Interceptor. This sewershed also includes two CSO retention facilities that were developed from the East River Facility Planning and WWFP processes: the Flushing Bay CSO Retention Facility (43.4 MG storage capacity) and the Alley Creek Retention Tank (5 MG storage capacity).

A total of six CSO outfalls from the Tallman Island WRRF system are permitted to discharge to the East River/Long Island Sound during wet-weather. Figure 2.3-19 shows the main features of the Tallman Island WRRF collection system associated with the East River/Long Island Sound sewershed, along with the sewershed area tributary to the East River/Long Island Sound. Table 2.3-7 lists the CSO outfalls that are tributary to the East River and Long Island Sound from the Tallman Island WRRF sewershed, along with their associated regulators/relief structures.

Table 2.3-7. CSO Outfalls Tributary to the East River/Long Island Sound from the Tallman Island WRRF Service Area

Outfall	Regulator(s)
TI-003	Reg #10A, 10B
TI-004	Reg #11
TI-005	Reg #12
TI-019	Reg #2
TI-020	Reg #1
TI-023	Reg #13

Bowery Bay WRRF Drainage Area and Sewer System

The central portion of the East River's south shore watershed is served by the Bowery Bay WRRF. The Bowery Bay WRRF is located at 43-01 Berrian Boulevard in the Astoria section of Queens, on a 34.6 acre site adjacent to the Rikers Island Channel. The Bowery Bay WRRF serves an area in the northwest section of Queens, including the communities of Kew Garden Hills, Rego Park, Forest Hills, Forest Hills Gardens, North Corona, South Corona, Lefrak City, Elmhurst, Jackson Heights, Maspeth, Woodside, Sunnyside Gardens, Sunnyside, Hunters Point, Long Island City, Astoria, Astoria Heights, Steinway, Ravenswood, and Roosevelt Island.

The Bowery Bay WRRF has a DDWF capacity of 150 MGD, and is designed to receive a maximum flow of 300 MGD (2XDDWF). Wastewater flows to the Bowery Bay WRRF through two interceptors. The Low Level Interceptor flows east toward the facility and the High Level Interceptor flows west toward the facility. The elevation differential between the High Level and Low Level Interceptors at the Bowery Bay WRRF is 29 feet. The High Level Interceptor serves approximately 8,392 acres in the central and eastern part of the Bowery Bay WRRF sewershed, carrying flows from individual drainage basins extending from Steinway Creek, Bowery Bay, and Flushing Bay. The Low Level Interceptor serves approximately 3,502 acres in the western side of the Bowery Bay WRRF sewershed, carrying flow from individual drainage basins along the East River extending to Newtown Creek.

A total of 26 CSO outfalls from the Bowery Bay WRRF system permitted to discharge to the East River/Long Island Sound during wet-weather. Figure 2.3-20 shows the main components of the Bowery Bay WRRF collection system associated with the East River/Long Island Sound sewershed, along with the sewershed area tributary to the East River/Long Island Sound. Table 2.3-8 lists the CSO outfalls that are tributary to the East River/Long Island Sound from the Bowery Bay WRRF sewershed, along with their associated regulators/relief structures.

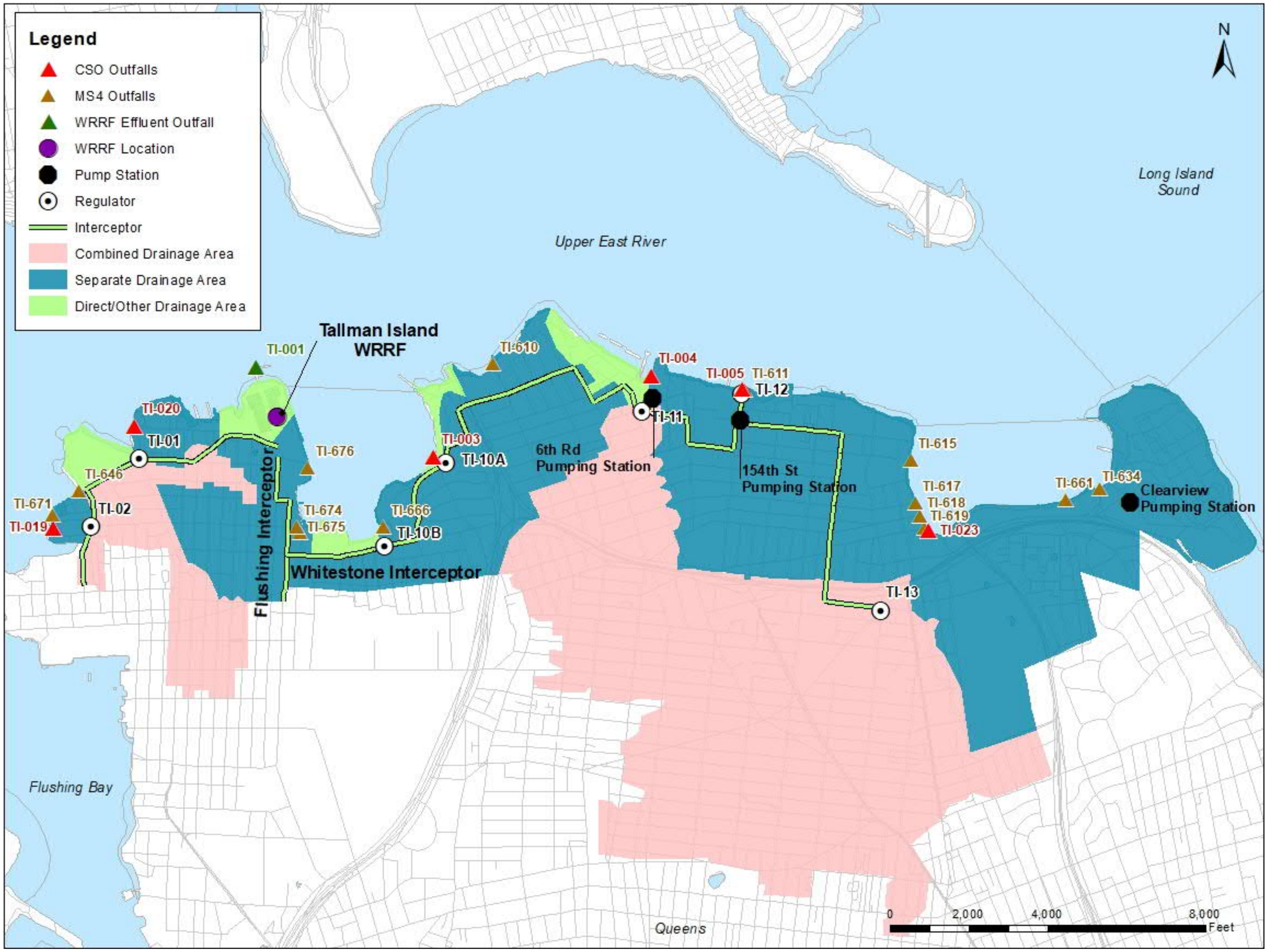


Figure 2.3-19. Tallman Island WRRF Collection System

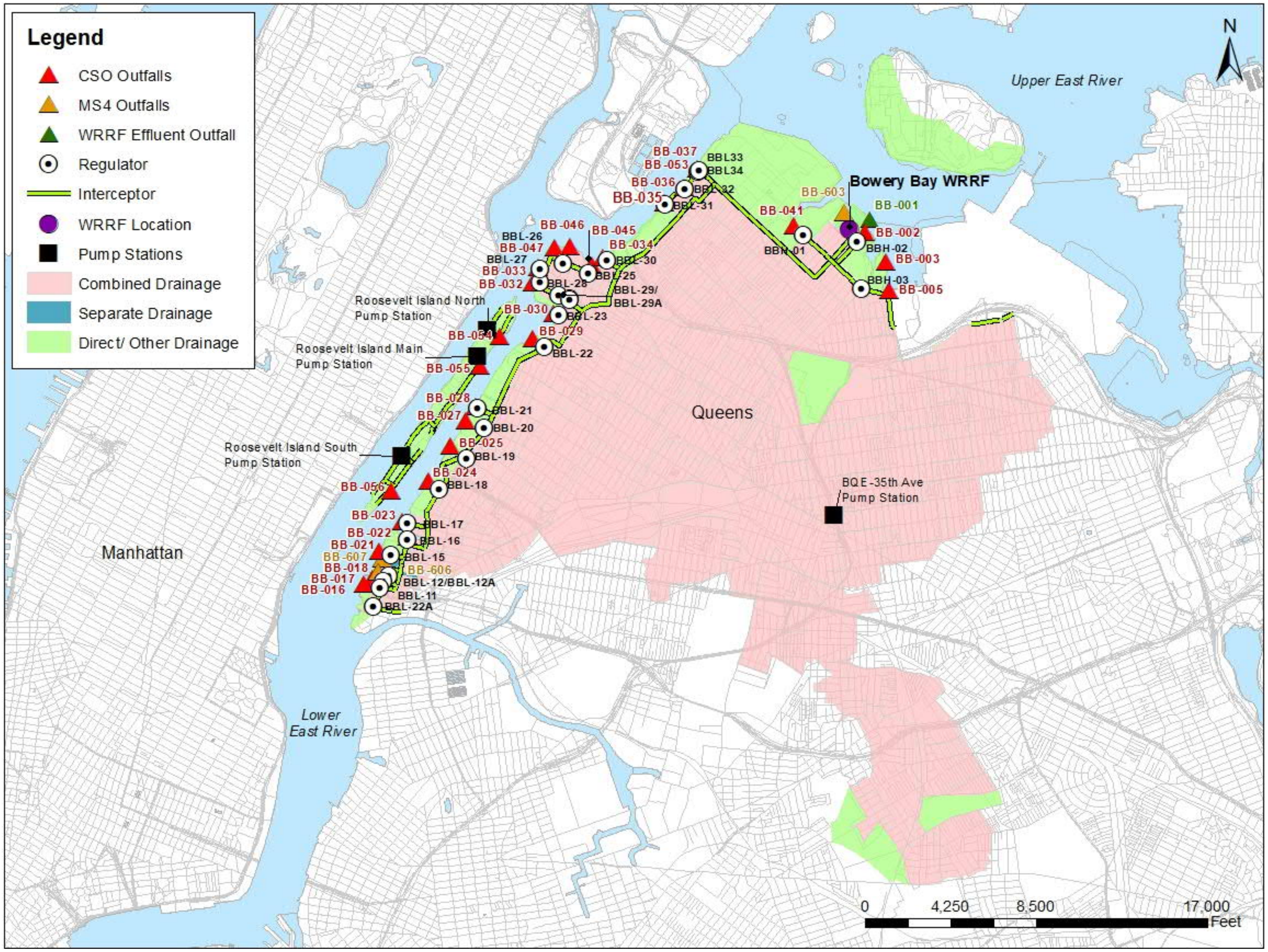


Figure 2.3-20. Bowery Bay WRRF Collection System

AECOM with Hazen

Table 2.3-8. CSO Outfalls Tributary to the East River/Long Island Sound from the Bowery Bay WRRF Service Area

Outfall	Regulator(s)	Outfall	Regulator(s)
BB-002	Reg #2	BB-029	Reg #L-22
BB-003	Reg #3	BB-030	Reg #L-23
BB-005	Reg #4	BB-031	Reg #H-03
BB-016	Reg #L-11	BB-032	Reg #L-29, L-29A
BB-017	Reg #L-12	BB-033	Reg #L-27
BB-018	Reg #L-12A	BB-034	Reg #L-30
BB-021	Reg #L-15	BB-035	Reg #L-31
BB-022	Reg #L-16	BB-036	Reg #L-32
BB-023	Reg #L-17	BB-037	Reg #L-33
BB-024	Reg #L-18	BB-041	Reg #1
BB-025	Reg #L-19	BB-045	Reg #L-25
BB-027	Reg #L-20	BB-046	Reg #L-26
BB-028	Reg #L-21	BB-047	Reg #L-28

Newtown Creek WRRF Drainage Area and Sewer System

The Newtown Creek WRRF sewershed and sewer system are described in Section 2.2.a.1. A total of 63 CSO outfalls from the Newtown Creek WRRF system are permitted to discharge to the East River/Long Island Sound during wet-weather. Figure 2.3-21 shows the main features of the Newtown Creek WRRF collection system associated with the East River and Long Island Sound sewershed along with the sewershed area tributary to the East River/Long Island Sound. Table 2.3-9 lists the CSO outfalls that are tributary to the East River/Long Island Sound from the Newtown Creek WRRF sewershed, along with their associated regulators/relief structures.

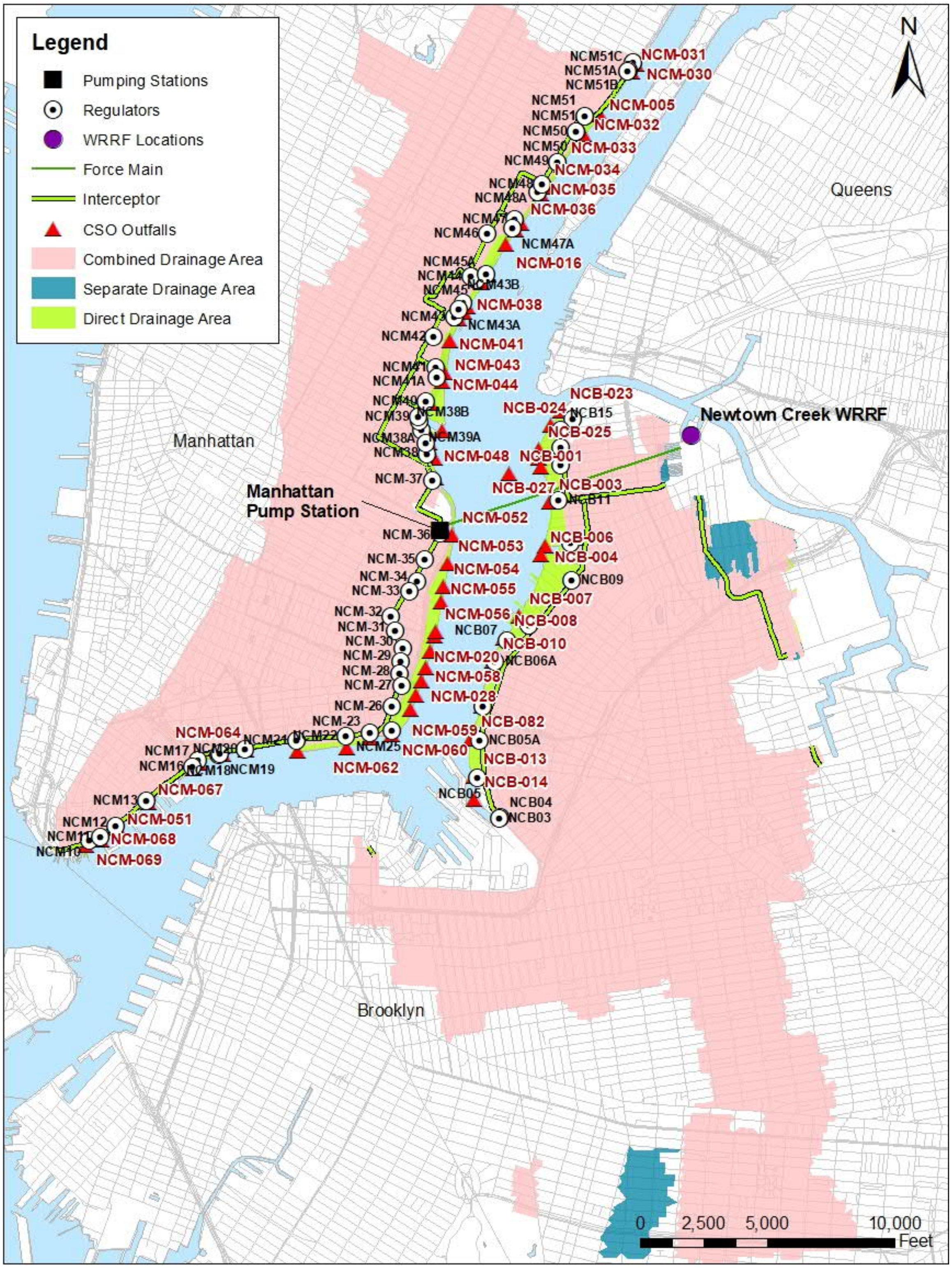


Figure 2.3-21. Newtown Creek WRRF Collection System

AECOM with Hazen

Table 2.3-9. CSO Outfalls Tributary to the East River/Long Island Sound from the Newtown Creek WRRF Service Area

Outfall	Regulator(s)	Outfall	Regulator(s)
NCB-003	Reg #B-11	NCM-042	Reg #M-27
NCB-004	Reg #B-10	NCM-043	Reg #M-41
NCM-005	Reg #M-51	NCM-044	Reg #M-41A
NCB-006	Reg #B-9	NCM-045	Reg #M-40
NCB-007	Reg #B-8	NCM-046	Reg #M-39, M-39A
NCB-008	Reg #B-7	NCM-047	Reg #M-38B
NCB-010	Reg #B-6A	NCM-048	Reg #M-38
NCM-011	Reg #M-47A	NCM-049	Reg #M-37
NCB-012	Reg #B-6	NCM-050	Reg #M-19
NCB-013	Reg #B-5	NCM-051	Reg #M-12
NCB-014	Reg #B-3, B-4	NCM-052	Reg #M-36
NCM-016	Reg #M-46	NCM-053	Reg #M-35
NCM-017	Reg #M-45A	NCM-054	Reg #M-34
NCM-018	Reg #M-45	NCM-055	Reg #M-33
NCM-020	Reg #M-31	NCM-056	Reg #M-32
NCB-024	Reg #B-15	NCM-057	Reg #M-30
NCB-025	Reg #B-14	NCM-058	Reg #M-29
NCB-026	Reg #B-13	NCM-059	Reg #M-26
NCB-027	Reg #B-12	NCM-060	Reg #M-25
NCM-028	Reg #M-28	NCM-061	Reg #M-23
NCM-030	Reg #M-51C	NCM-062	Reg #M-22
NCM-031	Reg #M-51A, M-15B	NCM-063	Reg #M-21
NCM-032	Reg #M-50	NCM-064	Reg #M-20
NCM-033	Reg #M-49	NCM-065	Reg #M-18
NCM-034	Reg #M-48	NCM-066	Reg #M-17
NCM-035	Reg #M-48A	NCM-067	Reg #M-13
NCM-036	Reg #M-47	NCM-068	Reg #M-11
NCM -037	Reg #M-44	NCM-069	Reg #M-10
NCM-038	Reg #M-43B	NCM-078	Reg #M-16
NCM-039	Reg #M-43A	NCB-082	Reg #B-5A
NCM-040	Reg #M-43	NCM-087	Reg #M-38A
NCM-041	Reg #M-42		

Red Hook WRRF Drainage Area and Sewer System

The portion of the East River sewershed draining to the Red Hook WRRF encompasses the northern portion of the Red Hook WRRF sewershed. The facility is located on a 53-acre site at 63 Flushing Avenue in Brooklyn, next to the Brooklyn Navy Yard. The Red Hook WRRF serves the sewered area in Red Hook, Carroll Gardens, Gowanus, Boerum Hill, Cobble Hill, Brooklyn Heights, and Vinegar Hill.

The Red Hook WRRF has a DDWF capacity of 60 MGD, and is designed to receive a maximum flow of 120 MGD (2xDDWF), with 90 MGD (1.5xDDWF) receiving secondary treatment. Flows over 90 MGD receive primary treatment and disinfection.

The Nevins Street and Gowanus Pumping Stations operate within the Red Hook portion of the East River sewershed. The Nevins Street Pumping Station serves an area of about 32 acres and has a capacity of 2.2 MGD. The pumping station conveys up to 2.2 MGD of the combined sewage via a force main to a trunk sewer feeding the Gowanus Pumping Station. The Gowanus Pumping Station, located on Douglass Street at the head of the Gowanus Canal, is designed to convey flow to the Columbia Street Interceptor via a force main in the Flushing Tunnel. It serves a sewershed of about 657 acres and has a capacity of 30 MGD. During wet-weather, the pumping station receives unregulated combined sewage flow from most of its drainage area, as well as regulated combined sewage flow from the Nevins Street Pumping Station.

A total of 10 CSO outfalls from the Red Hook WRRF system are permitted to discharge to the East River/Long Island Sound during wet-weather. Figure 2.3-22 shows the main features of the Red Hook WRRF collection system associated with the East River and Long Island Sound sewershed, along with the sewershed area tributary to the East River/Long Island Sound. Table 2.3-10 lists the CSO outfalls that are tributary to the East River/Long Island Sound from the Red Hook WRRF sewershed, along with their associated regulators/relief structures.

Table 2.3-10. CSO Outfalls Tributary to the East River/Long Island Sound from the Red Hook WRRF Service Area

Outfall	Regulator(s)
RH-002	R-21A
RH-003	R-21
RH-005	R-20A
RH-006	R-19A
RH-007	R-19
RH-008	R-18A
RH-009	R-18
RH-010	R-16
RH-011	R-15
RH-012	R-17
RH-013	R-14
RH-040	R-26

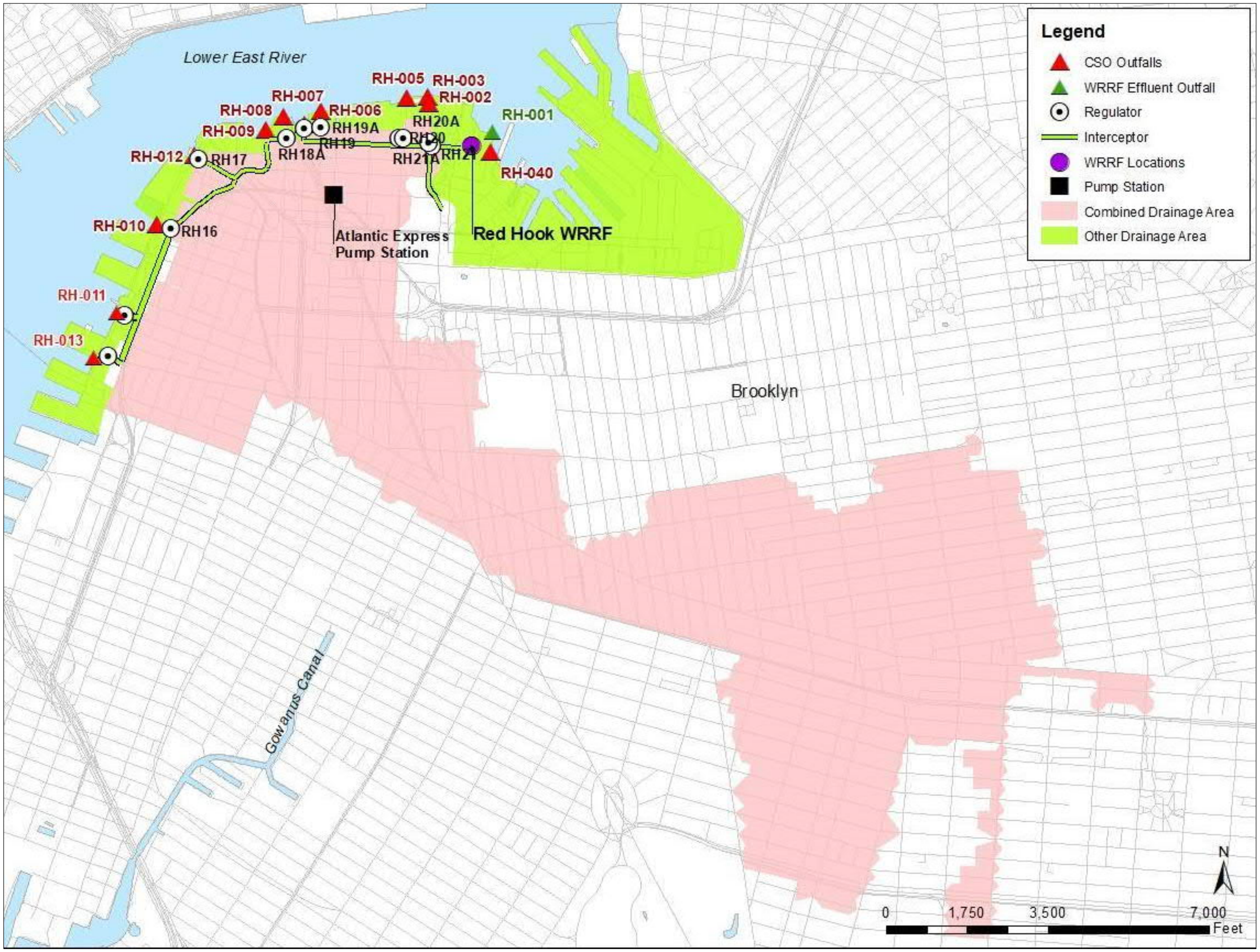


Figure 2.3-22. Red Hook WRRF Collection System

Stormwater and Wastewater Characteristics

Data collected from sampling events were used to estimate concentrations for fecal coliform bacteria and *Enterococci* bacteria to use in calculating loadings from various sources discharging into the East River/Long Island Sound. CSO concentrations were measured in 2017 to provide site-specific information for Outfalls HP-021, HP-011, HP-003, BB-005, BB-028, and NC-014. The CSO bacteria concentrations were characterized by direct measurements of two to four CSO events during various storms occurring during the months of March through December 2017. These concentrations are shown in the form of a cumulative frequency distribution in Figure 2.3-23 through Figure 2.3-28. Individual sample points are shown, as well as the trend line that best fits the data distribution. For all outfalls, measured fecal coliform and *Enterococci* concentrations were log-normally distributed. Table 2.3-11 provides the geometric means and ranges of the measured CSO fecal coliform and *Enterococci* concentrations for each outfall.

A flow monitoring and sampling program targeting CSO outfalls tributary to the East River/Long Island Sound was implemented as part of this LTCP. Flow monitoring data were collected for CSO Outfalls HP-021, HP-011, HP-003, BB-005, BB-028, and NC-014. Descriptions of the Hunts Point WRRF, Wards Island WRRF, Tallman Island WRRF, Bowery Bay WRRF, Newtown Creek WRRF, and Red Hook WRRF IW model updates and calibration processes based on the flow monitoring data gathered for the outfalls were provided earlier in Section 2.3.a.1.

Table 2.3-11. East River and Long Island Sound Measured CSO Bacteria Concentrations

Outfall	Fecal Coliform (cfu/100mL)		*Enterococci* (cfu/100mL)	
	Geometric Mean	Range	Geometric Mean	Range
HP-021	732,318	210,000 – 9,200,000	196,644	6,000 – 4,100,000
HP-011	466,635	110,000 – 2,100,000	239,248	28,000 – 1,200,000
HP-003	495,312	170,000 – 2,200,000	215,138	63,000 – 830,000
BB-005	629,364	3,600 – 2,300,000	311,782	800 – 2,800,000
BB-028(1)	681,064	140,000 – 4,200,000	202,460	42,000 – 1,200,000
NC-014(1)	670,257	370,000 – 1,700,000	312,021	170,000 – 1,600,000

Note:
(1) Outfalls BB-028 and NC-014 were sampled for two events.

Sampling, data analyses, and water quality modeling calibration resulted in the assignment of flows and loadings to these sources for inclusion in the calibration/validation of the water quality model. The CSO and stormwater concentrations used in the water quality evaluations in this LTCP are described in Section 6 of this LTCP.

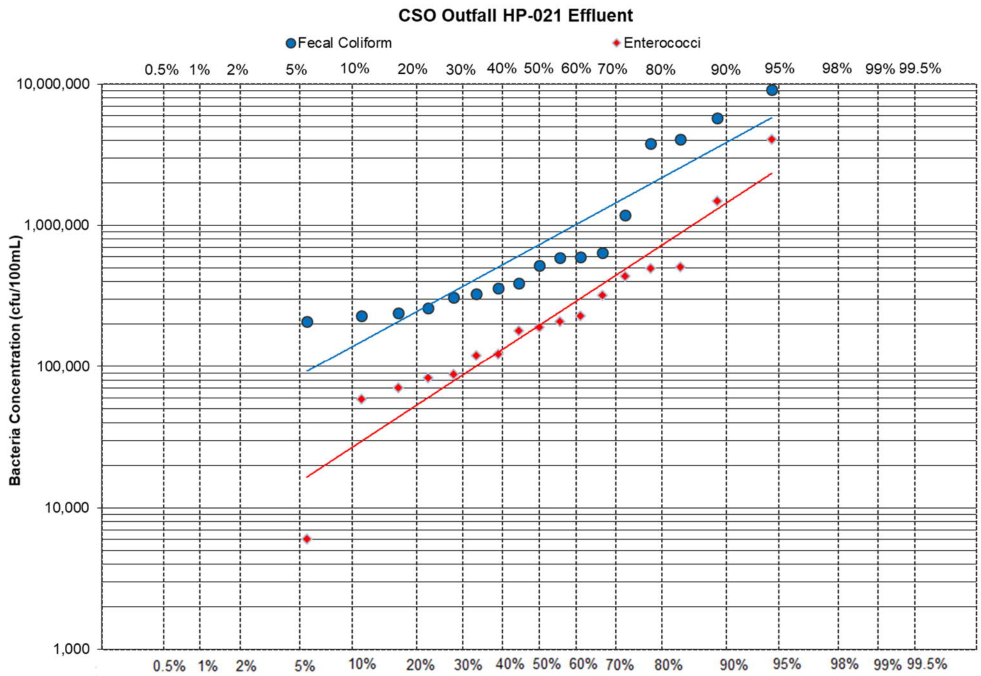


Figure 2.3-23. Outfall HP-021 Measured CSO Bacteria Concentrations

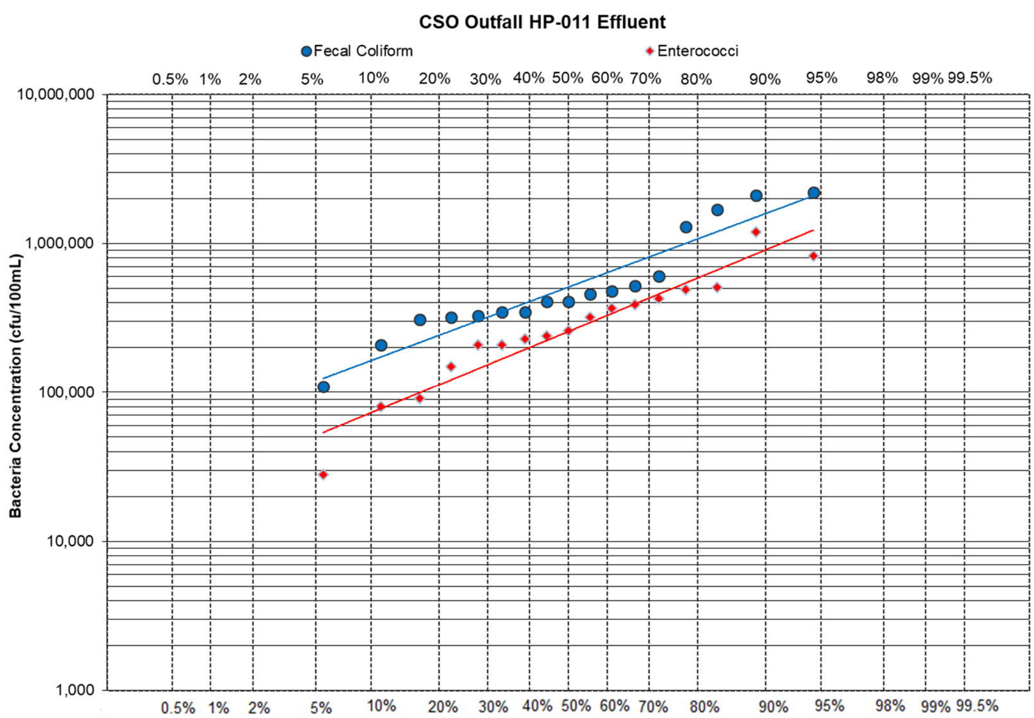


Figure 2.3-24. Outfall HP-011 Measured CSO Bacteria Concentrations

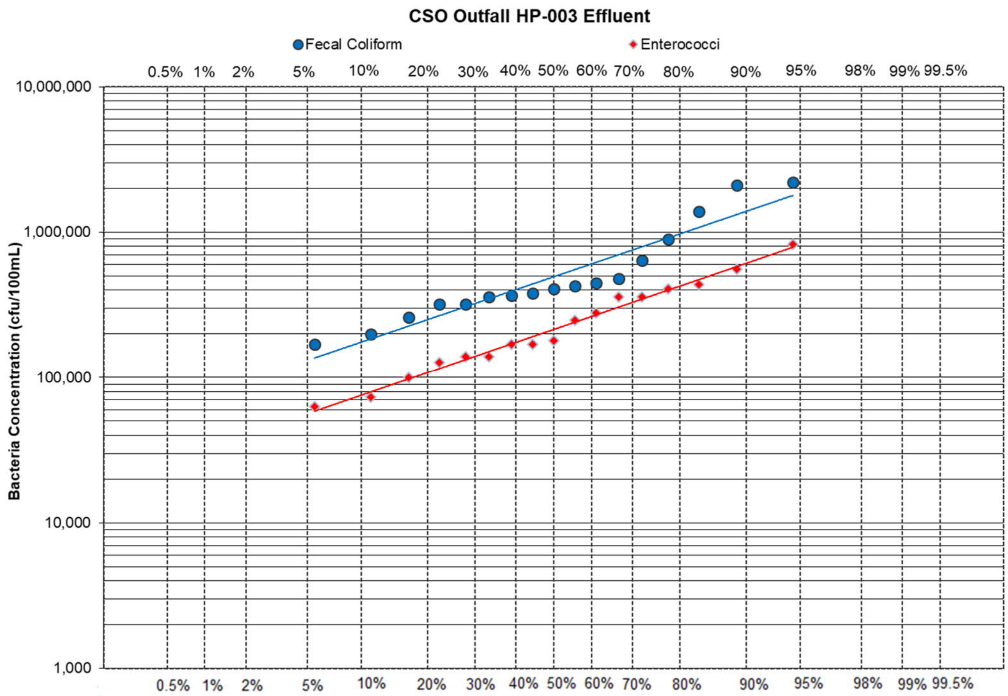


Figure 2.3-25. Outfall HP-003 Measured CSO Bacteria Concentrations

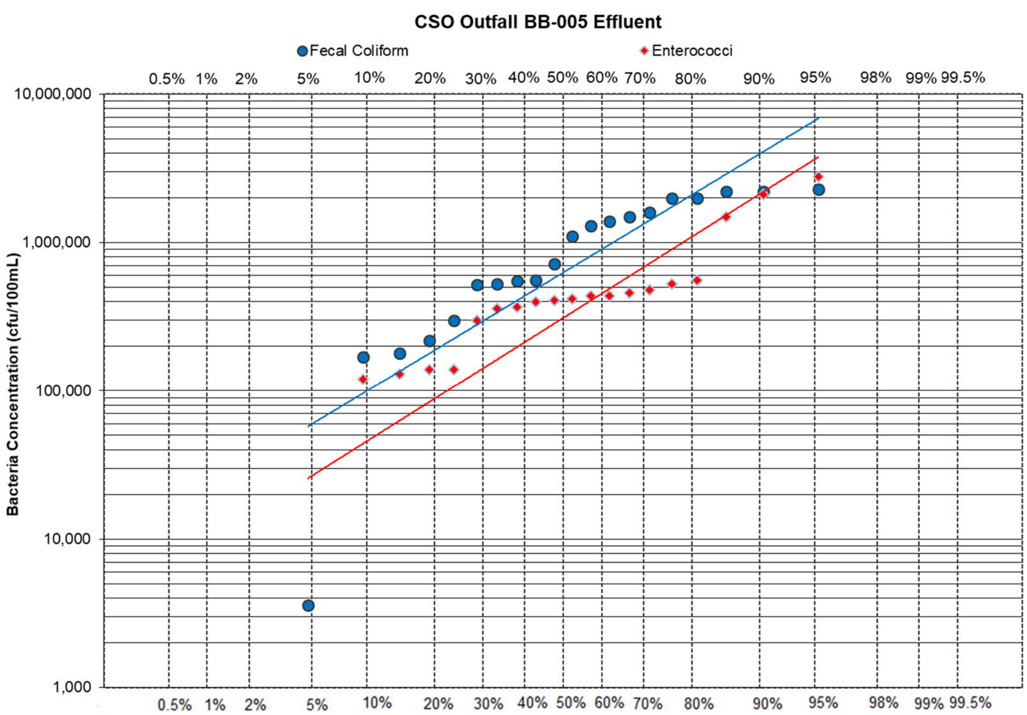


Figure 2.3-26. Outfall BB-005 Measured CSO Bacteria Concentrations

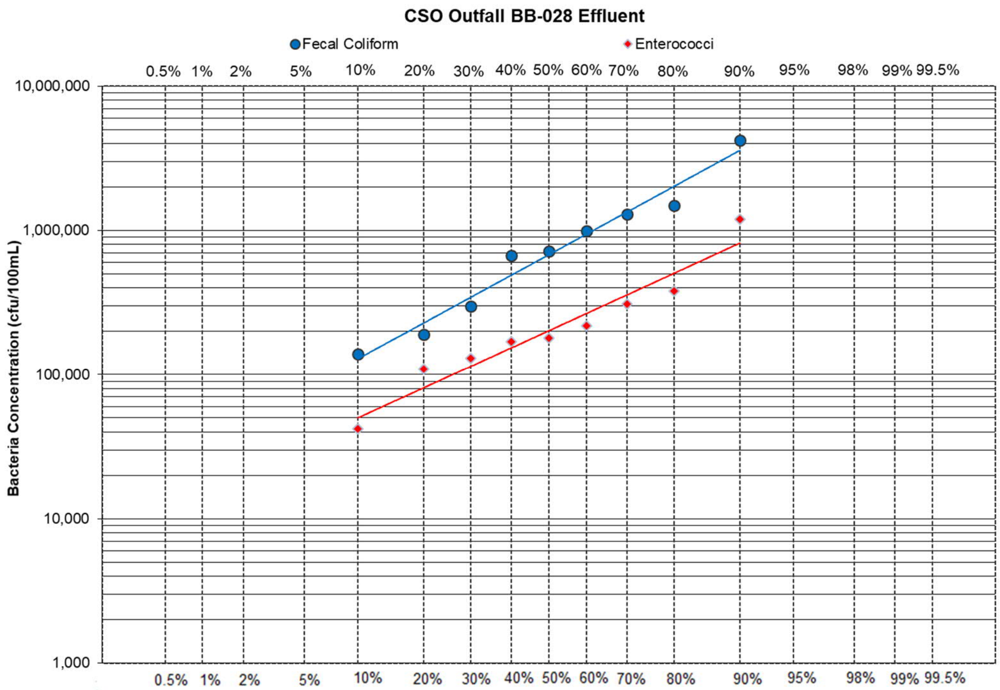


Figure 2.3-27. Outfall BB-028 Measured CSO Bacteria Concentrations

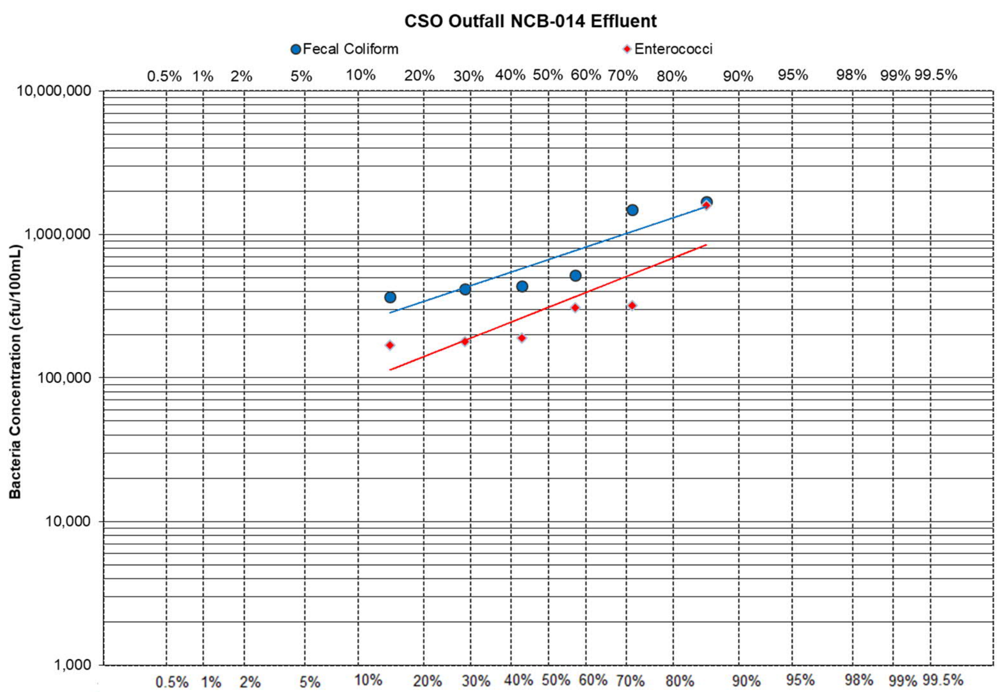


Figure 2.3-28. Outfall NC-014 Measured CSO Bacteria Concentrations

Hydraulic Analysis of Sewer System

A citywide hydraulic analysis was completed in December 2012 to provide further insight into the hydraulic capacities of key system components and system responses to various wet-weather conditions. The results of this analysis for the Wards Island and Newtown Creek WRRFs are described in Section 2.3.a.2. Following is a summary of the results for the Hunts Point, Tallman Island, Bowery Bay, and Red Hook WRRFs.

Hunts Point - Annual Hours at 2xDDWF for 2008 with Projected 2040 DWF

Model simulations were conducted to estimate the annual number of hours that the Hunts Point WRRF would be expected to treat 2xDDWF for the 2008 precipitation year. These simulations were conducted using projected 2040 DWF for two model input conditions – the recalibrated model conditions as described in the December 2012 IW Citywide Recalibration Report (DEP, 2012a), and the Cost-Effective Grey (CEG) alternative defined for the sewershed. The CEG elements represent the CSO controls that became part of the CSO Order. The CEG conditions applicable to the Hunts Point service area included weir modifications at two CSO regulators upstream of Westchester Creek, as well as a relief sewer in the Pugsley Creek area. For these simulations, the primary input conditions applied were as follows:

- Projected 2040 DWF conditions.
- 2008 tides and precipitation data.
- Hunts Point WRRF at 2xDDWF capacity of 400 MGD.
- No sediment in the combined sewers (i.e., clean conditions).
- Sediment in interceptors representing the post-interceptor sediment conditions after the inspection and cleaning program completed in 2011 and 2012.
- No green infrastructure.

Key observations/findings are summarized below:

- Simulation of the 2008 annual rainfall year resulted in a prediction that the Hunts Point WRRF would operate at its 2xDDWF capacity for 49 hours under the no-CEG condition. When the CEG conditions were applied in the model, the annual number of hours at 2xDDWF increased to 59 hours.

- The total volume (dry- and wet-weather combined) treated annually at the Hunts Point WRRF for the 2008 non-CEG condition was predicted to be about 49,787 MG, while the 2008 with-CEG condition resulted in a predicted 49,805 MG treated at the plant – an increase of 18 MG.

- The total annual CSO volume predicted for the outfalls in the Tallman Island WRRF sewershed were as follows:

    - 2008 non-CEG: 3,336 MG
    - 2008 with-CEG: 3,321 MG

The above results indicate a slight increase in the number of hours at the 2xDDWF operating capacity for Hunts Point WRRF, a slight increase in annual volume being delivered to the WRRF, and a slight decrease in CSO volume from the outfalls in the sewershed.

Tallman Island - Annual Hours at 2xDDWF for 2008 with Projected 2040 DWF

Model simulations were conducted to estimate the annual number of hours that the Tallman Island WRRF would be expected to treat 2xDDWF for the 2008 precipitation year. These simulations were conducted using projected 2040 DWF for two model input conditions – the recalibrated model conditions as described in the December 2012 IW Citywide Recalibration Report (DEP, 2012a), and the Cost-Effective Grey (CEG) alternative defined for the sewershed. The CEG elements represent the CSO controls that became part of the CSO Order. The CEG conditions applicable to the Tallman Island sewershed included the Alley Creek and Flushing Creek CSO retention facilities, and the parallel Main Interceptor and associated sewer/regulator improvements. Since the CSO retention facilities are end-of-pipe facilities that do not directly affect the conveyance of flow to the Tallman Island WRRF, the parallel Main Interceptor and associated sewer/regulator improvements are the primary differences between pre-CEG and CEG scenarios. For these simulations, the primary input conditions applied were as follows:

- Projected 2040 DWF conditions.
- 2008 tides and precipitation data.
- Tallman Island WRRF at 2xDDWF capacity of 160 MGD.
- No sediment in the combined sewers (i.e., clean conditions).
- Sediment in interceptors representing the post-interceptor sediment conditions after the inspection and cleaning program completed in 2011 and 2012.
- No green infrastructure.

Key observations/findings are summarized below:

- Simulation of the 2008 annual rainfall year resulted in a prediction that the Tallman Island WRRF would operate at its 2xDDWF capacity for 49 hours under the no-CEG condition. When the CEG conditions were applied in the model, the annual number of hours at 2xDDWF increased to 99 hours.

- The total volume (dry- and wet-weather combined) treated annually at the Tallman Island WRRF for the 2008 non-CEG condition was predicted to be about 24,038 MG, while the 2008 with-CEG condition resulted in a predicted 24,301 MG treated at the plant – an increase of 263 MG.

- The total annual CSO volume predicted for the outfalls in the Tallman Island WRRF sewershed were as follows:

    - 2008 non-CEG: 2,163 MG
    - 2008 with-CEG: 2,098 MG

The above results indicate an increase in the number of hours at the 2xDDWF operating capacity for Tallman Island WRRF, an increased annual volume being delivered to the WRRF, and a decrease in CSO volume from the outfalls in the sewershed.

Bowery Bay - Annual Hours at 2xDDWF for 2008 with Projected 2040 DWF

Model simulations were conducted to estimate the annual number of hours that the Bowery Bay WRRF would be expected to treat 2xDDWF for the 2008 precipitation year. These simulations were conducted using projected 2040 DWF for two model input conditions – the recalibrated model conditions as described in the December 2012 IW Citywide Recalibration Report (DEP, 2012a), and the CEG alternative defined for the sewershed. The CEG elements represent the CSO controls that became part of the 2012 CSO Order. The CEG conditions applicable to the Bowery Bay sewershed included raising weirs at Regulators BB-10, BB-09, BB-08, BB-07, BB-06, BB-07, and BB-02. Minor sewer reconstruction to divert flow from the High Level Interceptor to the Low Level Interceptor side as part of the weir raising at BB-02 was also included in the CEG scenario. For these simulations, the primary input conditions applied were as follows:

- Projected 2040 DWF conditions.
- 2008 tides and precipitation data.
- Bowery Bay WRRF at 2xDDWF capacity of 300 MGD.
- No sediment in the combined sewers (i.e., clean conditions).
- Sediment in interceptors representing the sediment conditions after the inspection and cleaning program completed in 2011 and 2012.
- No green infrastructure.

Key observations/findings are summarized below:

- Simulation of the 2008 annual rainfall year resulted in a prediction that the Bowery Bay WRRF would operate at its 2xDDWF capacity for 58 hours under the no-CEG condition. When the CEG conditions were applied in the model, the annual number of hours at 2xDDWF increased to 74 hours.

- The total volume (dry- and wet-weather combined) treated annually at the Bowery Bay plant for the 2008 non-CEG condition was predicted to be 47,289 MG, while the 2008 with-CEG condition resulted in a prediction that 47,471 MG would be treated at the plant – an increase of 182 MG.

- The total annual CSO volume predicted for the outfalls in the Bowery Bay sewershed were as follows:

  - 2008 non-CEG: 4,720 MG
  - 2008 with-CEG: 4,333 MG

The above results indicate an increase in the number of hours at the 2xDDWF operating capacity for Bowery Bay WWRF, an increased annual volume being delivered to the WWRF, and a decrease in CSO volume from the outfalls in the sewershed.

Red Hook - Annual Hours at 2xDDWF for 2008 with Projected 2040 DWF

Model simulations were conducted to estimate the annual number of hours that the Red Hook WRRF would be expected to treat 2xDDWF for the 2008 precipitation year. These simulations were conducted using projected 2040 DWF for two model input conditions – the recalibrated model conditions as described in the December 2012 IW Citywide Recalibration Report (DEP, 2012a), and the Cost-Effective Grey (CEG) alternative defined for the sewershed. The CEG elements represent the CSO controls that became part of the 2012 CSO Order. The CEG conditions applicable to the Red Hook sewershed included upgrading of Gowanus Pumping Station to 30 MGD capacity, and associated construction of a new force main to send flows directly to the interceptor. For these simulations, the primary input conditions applied were as follows:

- Projected 2040 DWF conditions.
- 2008 tides and precipitation data.
- Red Hook WRRF at 2xDDWF capacity of 120 MGD.
- No sediment in the combined sewers (i.e., clean conditions).
- Sediment in interceptors representing the sediment conditions after the inspection and cleaning program completed in 2011 and 2012.
- No green infrastructure in combined areas.

Key observations/findings are summarized below:

- Simulation of the 2008 annual rainfall year resulted in a prediction that the Red Hook WRRF would operate at its 2xDDWF capacity for 136 hours under the no-CEG condition. When the CEG conditions were applied in the model, the annual number of hours at 2xDDWF was higher, at 152 hours.
- The total volume (dry- and wet-weather combined) treated annually at the Red Hook WRRF for the 2008 non-CEG condition was predicted to be 12,976 MG, while the 2008 with-CEG condition resulted in a prediction that 13,096 MG would be treated at the plant – an increase of 120 MG.
- The total annual CSO volume predicted for the outfalls in the Red Hook WRRF sewershed were as follows:
  - 2008 non-CEG: 813 MG
  - 2008 with-CEG: 758 MG

The above results indicate an increase in the number of hours at the 2xDDWF operating capacity for the Red Hook WRRF, an increased annual volume being delivered to the WRRF, and a decrease in CSO volume from the outfalls in the sewershed as a result of the CEG projects.

Identification of Areas Prone to Flooding and History of Confirmed Sewer Backups

DEP maintains and operates the collection systems throughout the five boroughs. To do so, DEP employs a combination of reactive and proactive maintenance techniques. NYC's "311" system routes public complaints of sewer issues to DEP for response and resolution. Although not every call report of flooding or sewer backups corresponds to an actual issue with the municipal sewer system, each call to

311 is responded to. Sewer functionality impediments identified during a DEP response effort are corrected as necessary.

Findings from Interceptor Inspections

Figure 2.3-29 through Figure 2.3-32 illustrate the intercepting sewers that were inspected in the Boroughs of Manhattan, Bronx, Queens, and Brooklyn, respectively, encompassing the entire East River and Long Island Sound watershed. Throughout 2018, 13 cubic yards of sediment was removed from the Hunts Point WRRF intercepting sewers, 5,674 cubic yards of sediment was removed from Wards Island WRRF intercepting sewers; and 422 cubic yards of sediment was removed from Tallman Island WRRF intercepting sewers. No sediment was removed from the Bowery Bay, Newtown Creek or Red Hook WRRF intercepting sewers. Citywide, the inspection of 145,911 feet of intercepting sewers resulted in the removal of 6,112 cubic yards of sediment.

As described in Section 2.1.a.2, DEP's recent sediment accumulation analysis found that the aggregate mean sediment level for the entire NYC system was approximately 1.25 percent of sewer cross-sectional area, with a standard deviation of 2.02 percent.

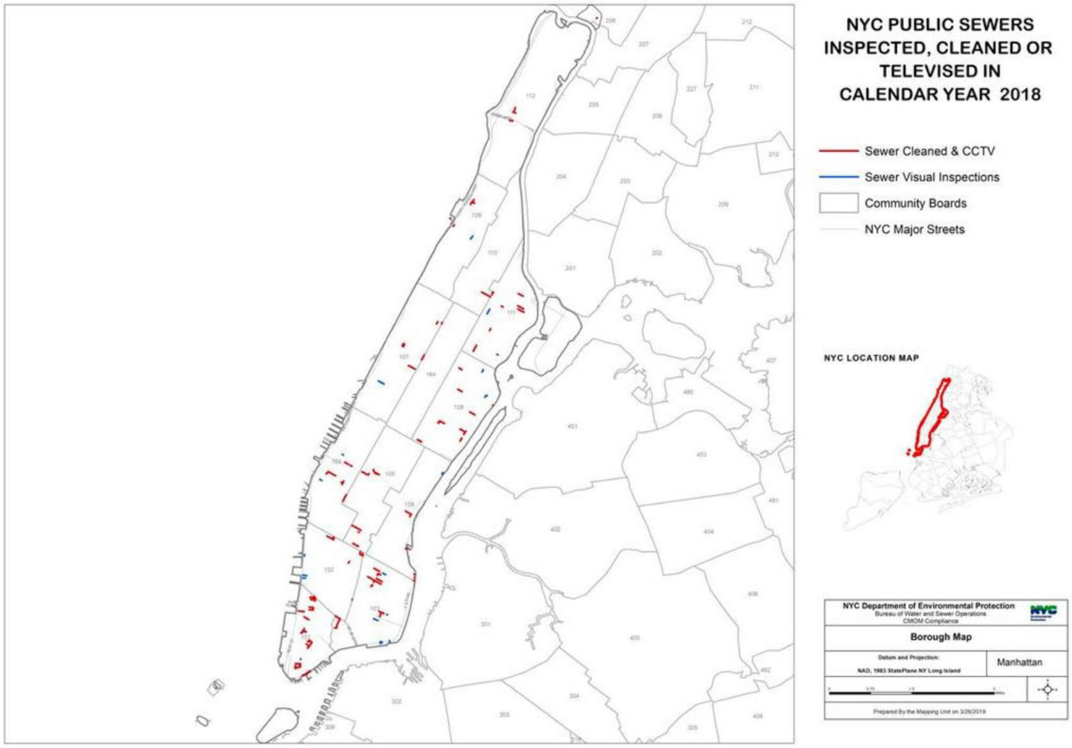


Figure 2.3-29. Sewers Inspected and Cleaned in Manhattan Throughout 2018

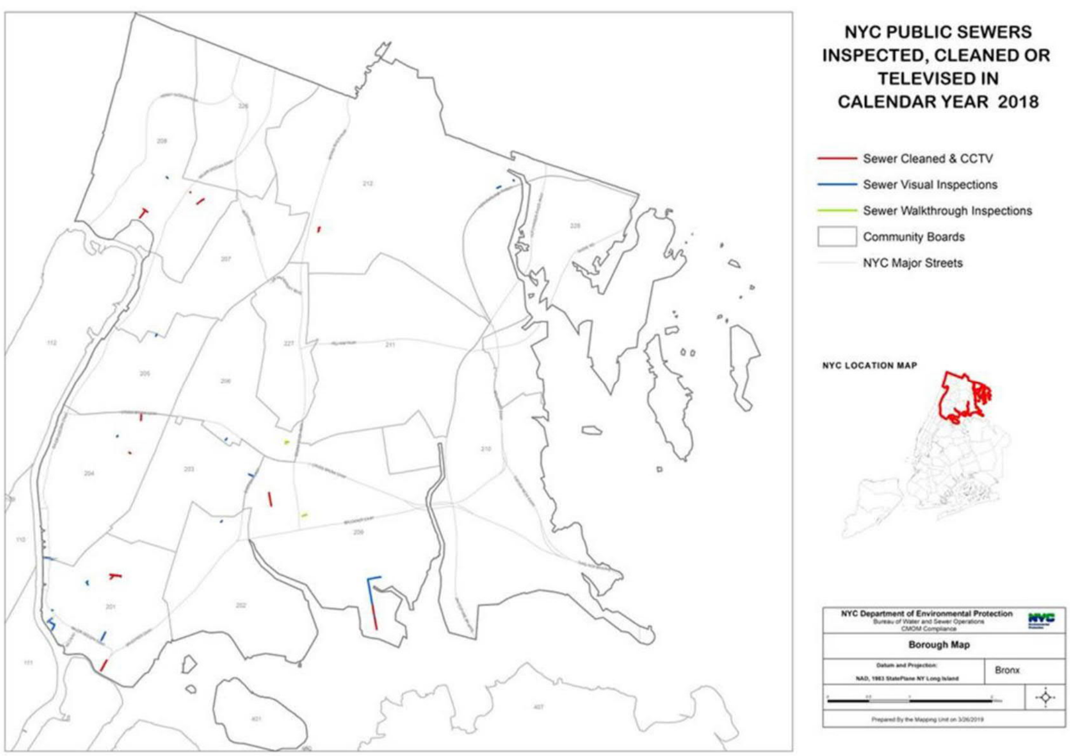


Figure 2.3-30. Sewers Inspected and Cleaned in Bronx Throughout 2018

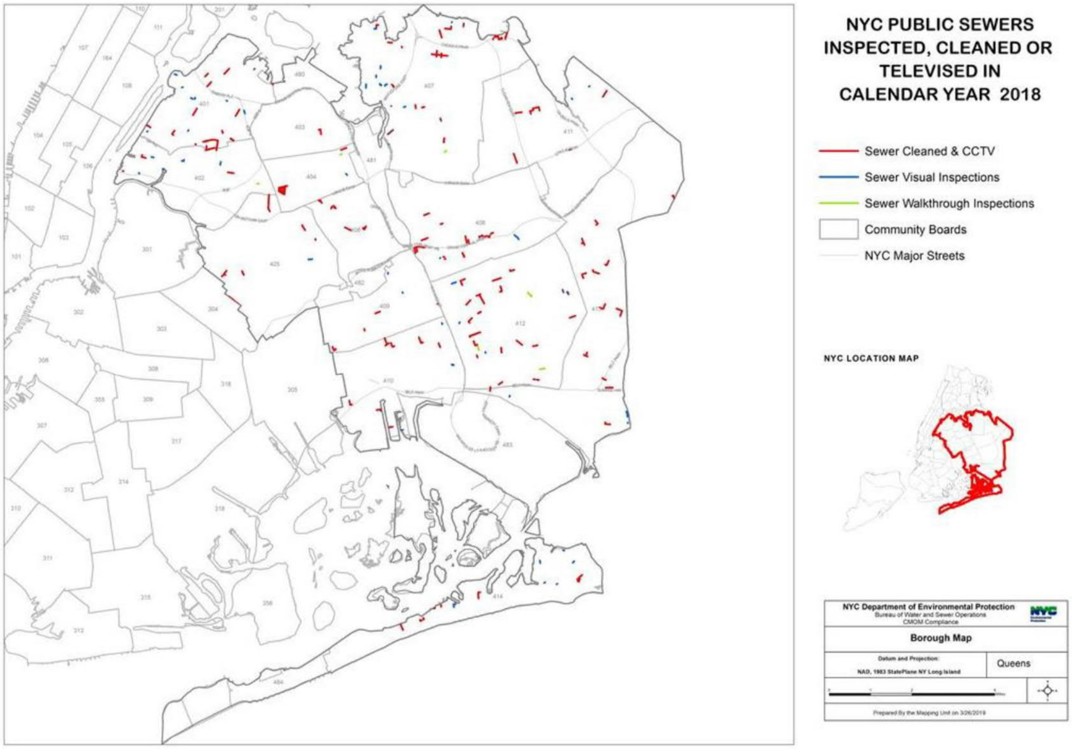


Figure 2.3-31. Sewers Inspected and Cleaned in Queens Throughout 2018

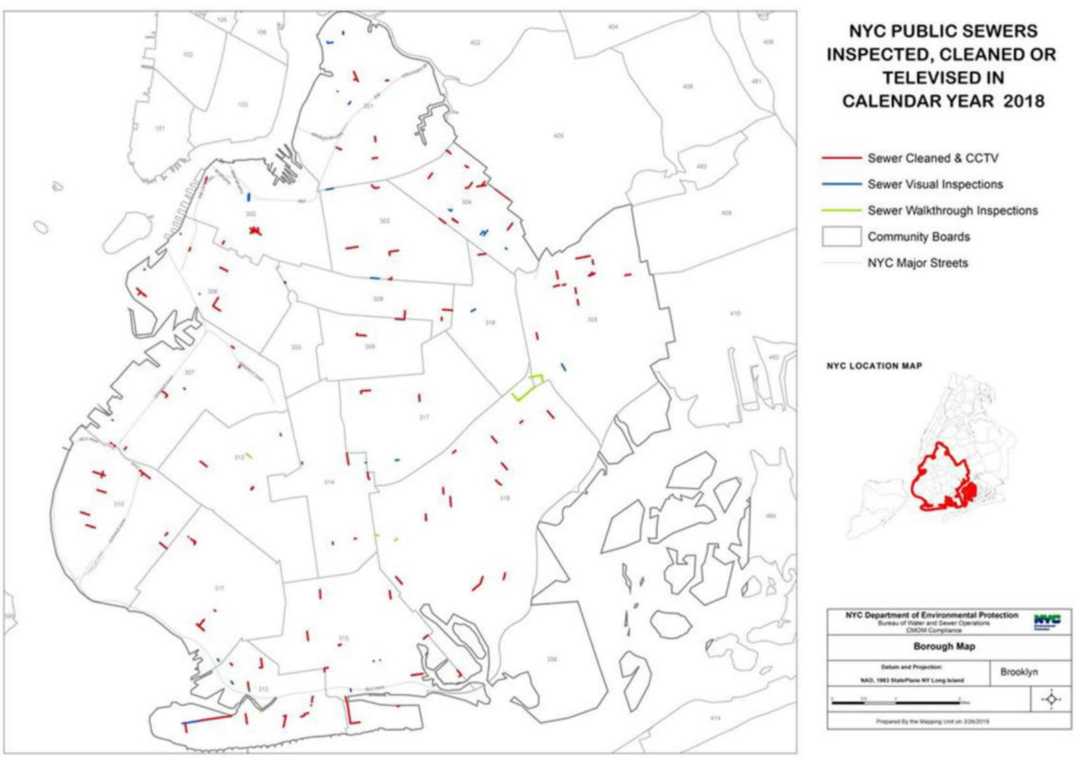


Figure 2.3-32. Sewers Inspected and Cleaned in Brooklyn Throughout 2018

2.3.b Waterbody Characteristics

This section describes the features and attributes of the East River and Long Island Sound.

2.3.b.1 Description of Waterbody

The East River is a navigable tidal strait which connects the Long Island Sound to the Upper New York Harbor and separates the boroughs of Queens and Brooklyn from Manhattan and the Bronx.

The Long Island Sound is a tidal estuary of the Atlantic Ocean located between the eastern shore of the Bronx, southern shore of Connecticut, and northern shore of Long Island. The portion of the Long Island Sound evaluated in this LTCP extends from City Island in the Bronx, to Kings Point, Queens and includes Eastchester Bay, a protected embayment between City Island and the Bronx mainland.

The East River and Long Island Sound are greatly influenced by tidal exchanges with their neighboring waterbodies. Water quality is influenced by CSO discharges, stormwater discharges, and tidal exchanges. The following section describes the current water quality characteristics of the East River and Long Island Sound, along with its uses.

2.3.b.2 Current Waterbody Classification(s) and Water Quality Standards

New York State Policies and Regulations

In accordance with the provisions of the CWA, the State of New York has established WQS for all navigable waters within its jurisdiction. DEC has classified the Long Island Sound east of the Throgs Neck Bridge as Coastal Primary Recreational Class SB. The portion of the Upper East River between the Whitestone Bridge and the Throgs Neck Bridge is Class SB (non-coastal tributary), while the remainder of the Upper East River and the Lower East River are designated Class I (Figure 2.3-33).

Numerical standards corresponding to these waterbody classifications are shown in Table 2.1-5 (Section 2.1.b.2), while narrative WQS criteria are presented in Table 2.1-6 (Section 2.1.b.2).

Interstate Environmental Commission

The States of New York, New Jersey, and Connecticut are signatories to the Tri-State Compact that designated the Interstate Environmental District and created the Interstate Environmental Commission (IEC). The IEC includes all saline waters of greater NYC. The East River and the Long Island Sound are interstate waters and are regulated by IEC as Class A (East River west of the Whitestone Bridge) and Class B-1(East River east of Whitestone Bridge and Long Island Sound) waters. Numerical and narrative standards for IEC-regulated waterbodies are shown in Table 2.1-7 (Section 2.1.b.2) and Table 2.1-8 (Section 2.1.b.2).

EPA Policies and Regulations

For designated bathing beach areas, the EPA has established an *Enterococci* reference level of 104 cfu/100mL to be used by agencies for announcing bathing advisories or beach closings in response to pollution events. All bathing beaches that are installed, operated, or constructed in NYC require a Permit to Operate a Bathing Beach issued by the New York City Department of Health and Mental Hygiene (DOHMH). DOHMH uses a 30-day moving GM of 35 cfu/100mL to trigger bathing beach closures. If the GM exceeds that value, the beach is closed pending additional analysis. An *Enterococci*

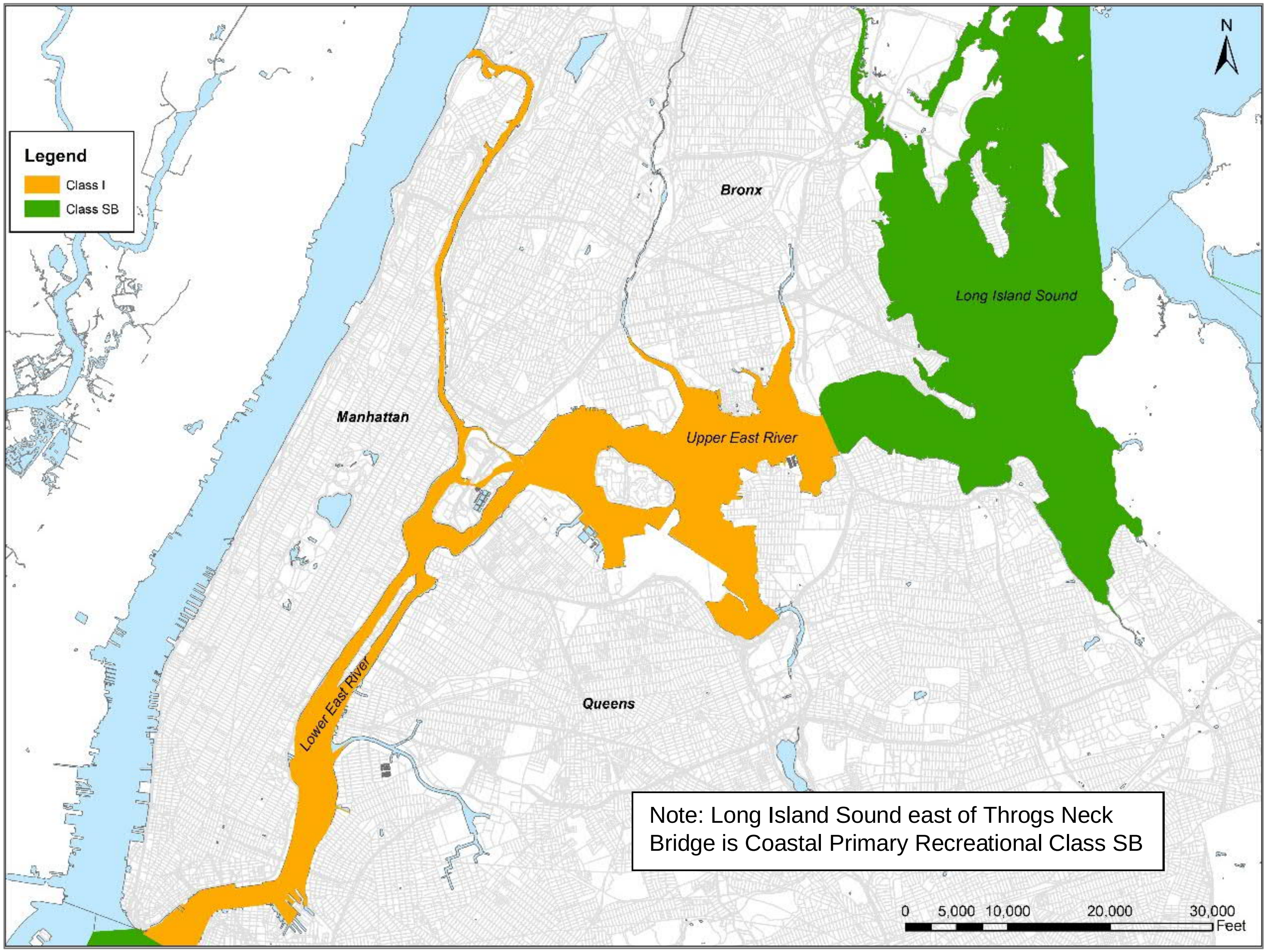


Figure 2.3-33. Waterbody Classifications for the East River and Long Island Sound

level of 104 cfu/100mL is an advisory upper limit used by DOHMH. If beach *Enterococci* data are greater than 104 cfu/100mL, a pollution advisory is posted on the DOHMH website and additional sampling is initiated. The advisory is removed when water quality is acceptable for primary contact recreation. Advisories are posted at the beach and on the agency website. Permitted bathing beaches are located along the Long Island Sound and in the Class SB reach of the Upper East River, but none are located in the Class I section of the East River.

For non-designated beach areas of primary contact recreation which are only used infrequently for primary contact, the EPA has established an *Enterococci* reference level of 501 cfu/100mL as indicative of pollution events.

According to EPA documents, these reference levels are not binding regulatory criteria; rather, they are to be used by the State agencies in making decisions related to recreational uses and pollution control needs. For bathing beaches, these reference levels are to be used for announcing beach advisories or beach closings in response to pollution events.

EPA's 2012 RWQC recommendations are designed to protect human health in coastal and non-coastal waters designated for primary recreational use. These recommendations were based on a comprehensive review of research and science that evaluated the link between illness and fecal contamination in recreational waters. The recommendations are intended as guidance to States, territories, and authorized tribes in developing or updating WQS to protect swimmers from exposure to pathogens found in water with fecal contamination.

The 2012 RWQC recommends two sets of numeric concentration thresholds, as listed in Table 2.3-12, and includes limits for both the GM (30-day) and a statistical threshold value (STV) based on exceeding a 90^{th} percentile value associated with the GM. The STV is a new limit, and is intended to be a value that should not be exceeded by more than 10 percent of the samples taken.

Table 2.3-12. 2012 RWQC Recommendations

Criteria Elements	Recommendation 1 (Estimated Illness Rate 36/1,000)		Recommendation 2 (Estimated Illness Rate 32/1,000)	
Indicator	**GM (cfu/100mL)**	**STV (cfu/100mL)**	**GM (cfu/100mL)**	**STV (cfu/100mL)**
Enterococci (Marine and Fresh)	35	130	30	110
E. coli (Fresh)	126	410	100	320

The *Enterococci* criteria for coastal primary recreational waters listed above in Table 2.3-5 are consistent with the "Recommendation 2" levels in Table 2.3-12**.** As noted above, these criteria apply to the Coastal Primary Recreational Class SB waters of Long Island Sound east of the Throgs Neck Bridge, but do not apply to the Class SB and Class I, non-coastal reaches of the East River west of Throgs Neck Bridge.

2.3.b.3 Physical Waterbody Characteristics

The western portion of Long Island Sound covers approximately 5,828 acres, including Eastchester Bay, and is generally wide and shallow with depths of about 15 feet. Figure 2.3-34 shows the location of the boundary between Long Island Sound and the East River, as defined in Table I of 6 NYCRR 935.6. As indicated in Figure 2.3-34, that boundary coincides with the location of the Throgs Neck Bridge. Figure

2.3-34 also shows the East River divided into lower and upper reaches (per 6 NYCRR 935.6 and 6 NYCRR 890.6). The Upper East River, extending from the Throgs Neck Bridge to Hell Gate, is generally wide and shallow with many embayments, and covers approximately 8,317 acres. The Lower East River begins at Hell Gate and extends to the Battery. This reach is generally narrow and deep, covering approximately 4,434 acres. Hell Gate is a natural rock sill that connects the Harlem River to the East River. Narrow and deep, this area experiences tidal and current influences from the East River and Harlem River, resulting in very high water current velocities and extreme turbulence during all tide phases.

Both segments of the East River change direction of flow frequently and are subject to strong fluctuations in current due to the two major tide boundaries with Long Island Sound and the Atlantic Ocean. The Lower East River, in particular, experiences dramatic changes in current, which are accentuated by its narrowness and variation in depth. Roosevelt Island further divides the Lower East River into two channels, with the western channel being deeper and more significant for tidal flow.

The Harlem River flows into the East River at Hell Gate and via the Bronx Strait. Other major tributaries to the East River/Long Island Sound include:

- The Hutchinson River, which drains to Long Island Sound at the north end of Eastchester Bay.
- Little Neck Bay, which opens into the southwestern end of Long Island Sound just east of the Throgs Neck Bridge.
- Westchester Creek and the Bronx River, which drain into the Upper East River in South Bronx.
- Flushing Creek, which empties into the Upper East River via Flushing Bay.
- Newtown Creek, which drains into the Lower East River.

Water quality in the East River/Long Island Sound is influenced by CSO discharges, stormwater discharges, and tidal exchanges with these waterbodies.

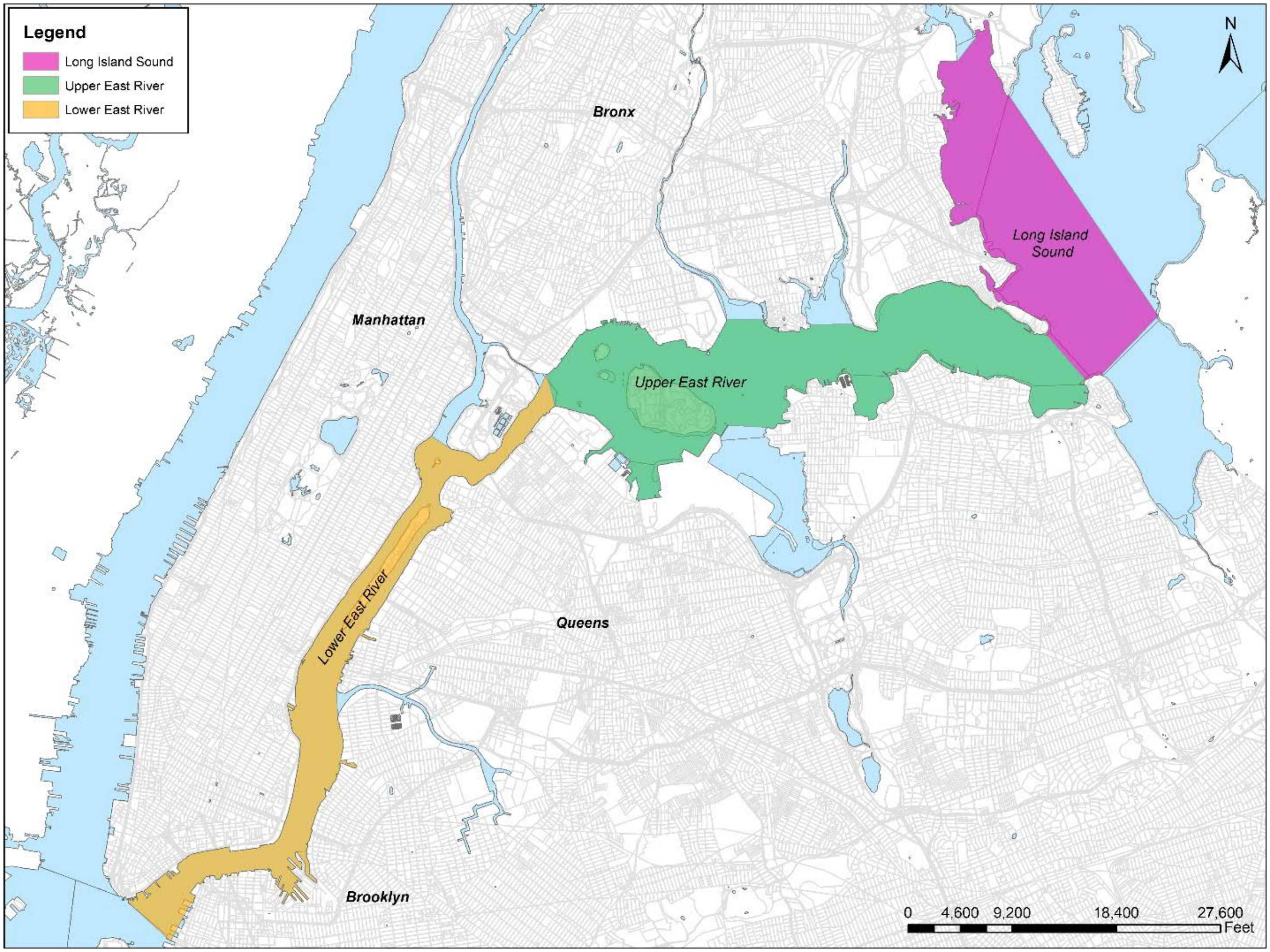


Figure 2.3-34. Waterbody Reach Distinction

Shoreline Physical Characterization

The shorelines of the East River and Long Island Sound have been dramatically altered from their historic conditions and now vary between natural and constructed, hardened shorelines. Natural shorelines are predominantly located in the Long Island Sound area, with several beaches located on the eastern Bronx shore in the Eastchester Bay. This area also features some stretches of riprap, marinas, and piers, as shown in Figure 2.3-35.

Along the southern Bronx shore of the Upper East River, a mixture of natural and riprap with piers and marinas is observed between Throgs Neck and Westchester Creek. Moving west towards Wards Island and along the northern Queens coast, the shoreline is predominately riprap with a mixture of bulkheads and natural shores. Piers line the shorelines in the Lower East River at the Battery, with the remaining shoreline in this area predominately bulkheaded with areas of riprap.

Figure 2.3-36 shows an example of natural shorelines along Orchard Beach in Long Island Sound, and Figure 2.3-37 shows a typical bulkheaded shoreline along the East River.

Shoreline Slope

Shorelines throughout the city have been greatly influenced by residential, commercial, and industrial development, landfilling with waste materials, and dredging operations. Since 1897, marshlands and streams along the Upper East River and LIS/Eastchester Bay have been filled significantly. Orchard Beach in Pelham Bay was also created by filling a portion of Eastchester Bay with landfill and sand and later extended with more fill (DEP, 2007). In many of these areas and those with natural shoreline types, the shoreline slope ranges from very flat to gentle sloping.

Other areas of the watershed have experienced significant and routine dredging activities to deepen the channels as needed for the extensive commercial and barge traffic. Coupled with the urbanization and hardening of the shorelines with bulkheads and riprap, the majority of the East River shoreline has little to no intertidal zone or natural slope.

Waterbody Sediment Surficial Geology/Substrata

Anthropogenic forces have influenced the surface soils that are now found in the East River and Long Island Sound watershed. Many of the soils found along the shoreline have been greatly influenced by residential, commercial, and industrial development, landfilling with waste materials, and dredging operations, and are generally disturbed in some form even if they consist of local material (DEP, 2007). The bottom of the East River and Long Island Sound is predominantly composed of mud/silt/clay with a relatively small proportion of sand, according to data from previous studies. Sampling conducted by HydroQual in 2003 indicated an 81 percent silt-sand bottom with little to no gravel. The composition of the mud/silt/clay-designated areas ranged from 40 percent to 98 percent mud/silt/clay, 2 to 60 percent sand, and 0 to 1 percent gravel. Additionally, NOAA surficial sediment classifications recorded mostly mud and some sand and gravel/rock along the bottom of the East River and Long Island Sound.

Tidal/Estuarine Systems Biological Systems

Tidal/Estuarine Wetlands

The U.S. Fish and Wildlife Service (USFWS) National Wetlands Inventory (NWI) maps show limited tidal/estuarine wetlands in the watershed, only in the Upper East River and on the Bronx's eastern shoreline in Long Island Sound, as shown in Figure 2.3-38. The estuarine wetlands areas are described in Table 2.3-13.

Table 2.3-13. NWI Classification Codes

NWI Classification	Description
E2AB1N	Estuarine, Intertidal, Aquatic Bed, Algal, Regularly Flooded
E2EM1N	Estuarine, Intertidal, Emergent, Persistent, Regularly Flooded
E2EM1P	Estuarine, Intertidal, Emergent, Persistent, Irregularly Flooded
E2RSN	Estuarine, Intertidal, Rocky Shore, Regularly Flooded
E2RSP	Estuarine, Intertidal, Rocky Shore, Irregularly Flooded
E2SS1P	Estuarine, Intertidal, Scrub-Shrub, Broad-leaved Deciduous, Irregularly Flooded
E2US2M	Estuarine, Intertidal, Unconsolidated Shore, Sand, Irregularly Exposed
E2US2N	Estuarine, Intertidal, Unconsolidated Shore, Sand, Regularly Flooded
E2US2P	Estuarine, Intertidal, Unconsolidated Shore, Sand, Irregularly Flooded
E2USN	Estuarine, Intertidal, Unconsolidated Shore, Regularly Flooded
E2USP	Estuarine, Intertidal, Unconsolidated Shore, Irregularly Flooded

Aquatic and Terrestrial Communities

The DCP Plan for the Manhattan and Bronx Waterfronts (DCP, 1993) reports a diverse range of species supported by the habitat in the East River and Long Island Sound area. The DCP Vision 2020 New York City Comprehensive Waterfront Plan (DCP, 2011) provides an update on progress towards preserving habitat along the shorelines of the East River.

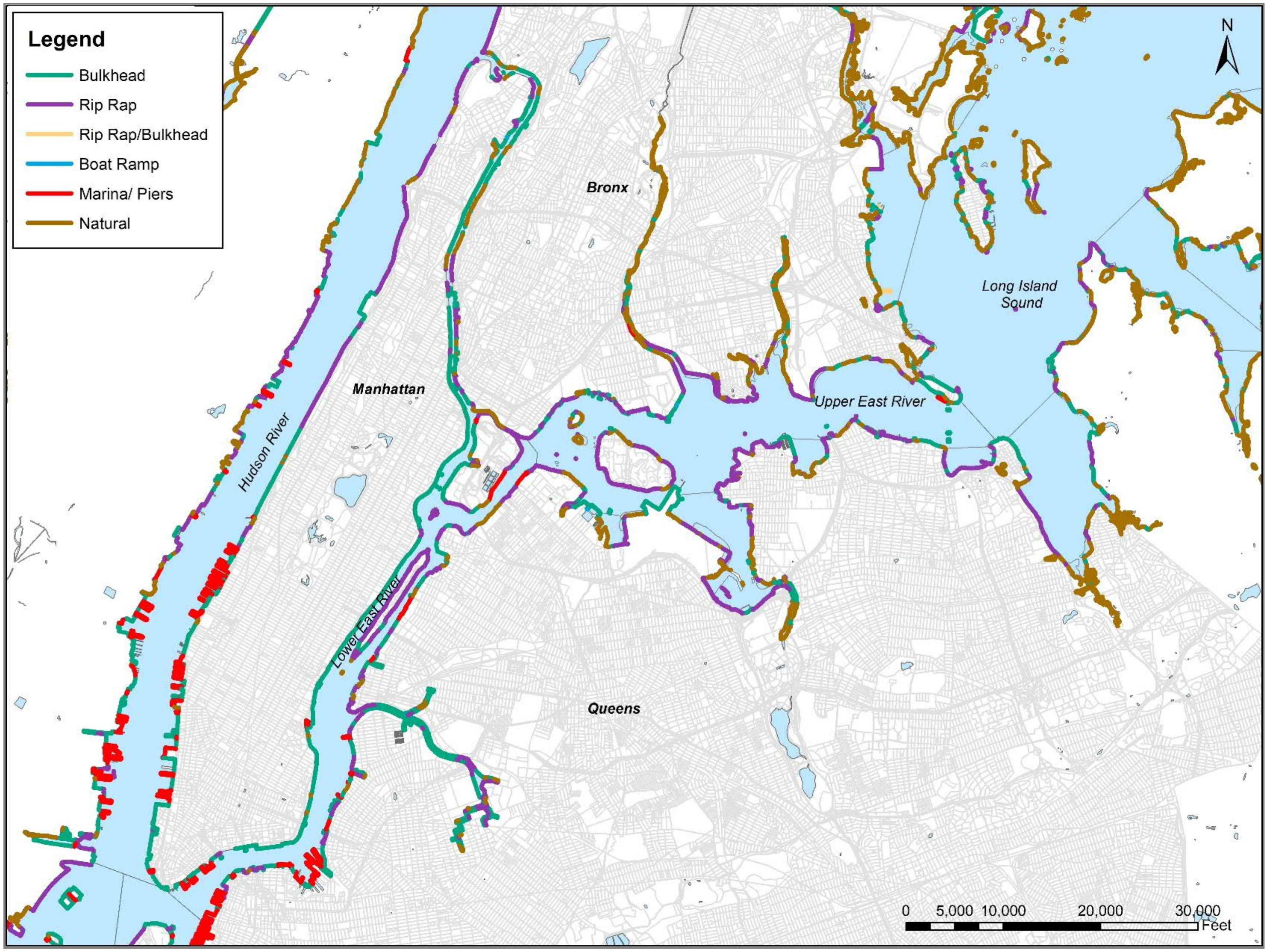


Figure 2.3-35. East River and Long Island Sound Shoreline Characteristics

Figure 2.3-36. Natural Shoreline View of Pelham Bay Park in Long Island Sound

Figure 2.3-37. Bulkheaded Shoreline of the East River

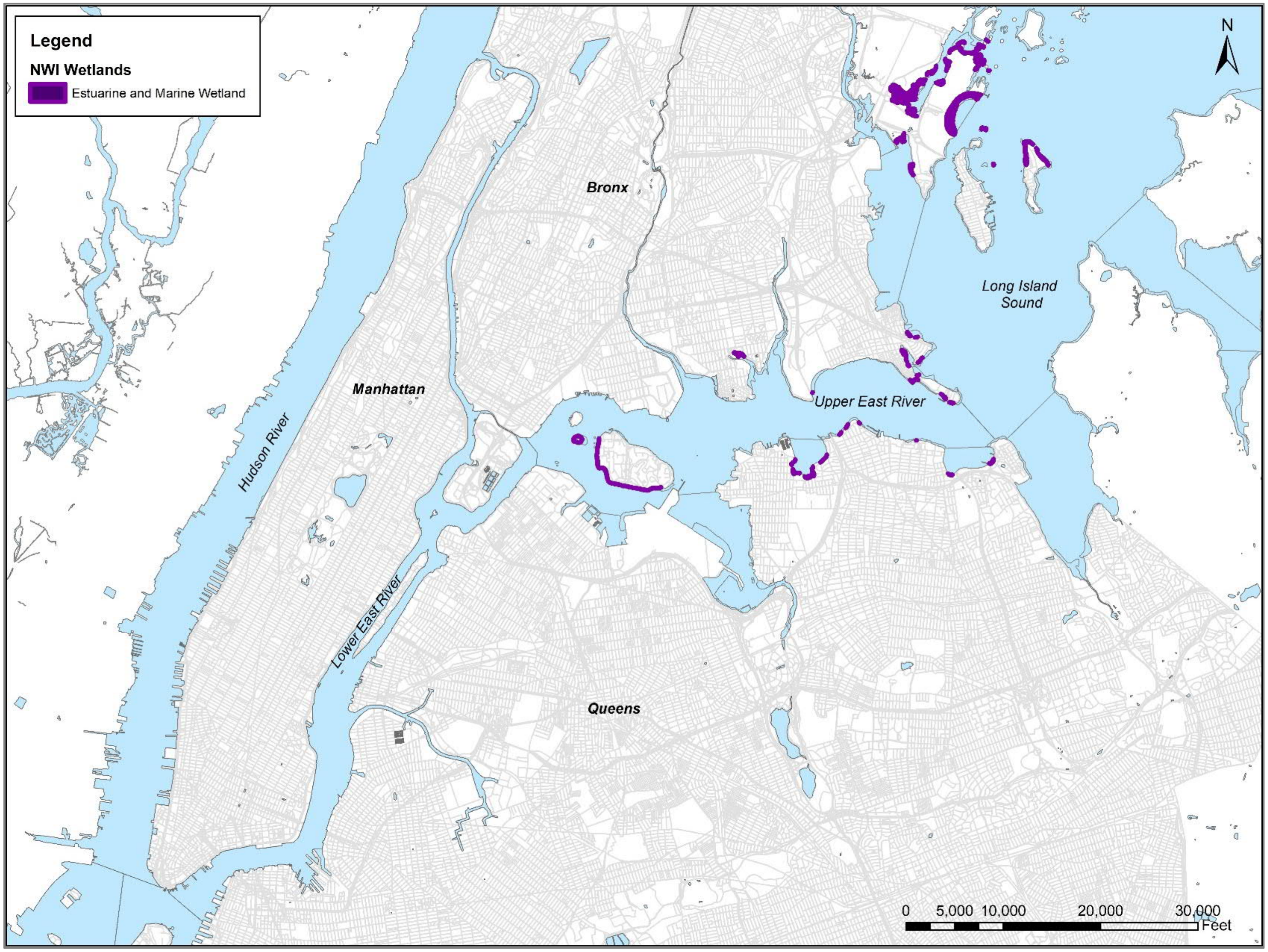


Figure 2.3-38. National Wetlands Inventory Source: NYS GIS Clearinghouse- 2014

Biological Systems

According to DEC's Freshwater Wetlands Maps, one NYS-Regulated freshwater wetland is located within the East River and Long Island Sound watershed at Fort Totten Park in Queens. This wetland is approximately 11.2 acres plus the regulated 100-foot wetland checkzone.

2.3.b.4 Current Public Access and Uses

The Long Island Sound and the portion of the Upper East River east of the Whitestone Bridge are classified as suitable for primary and secondary contact recreation and fishing. In the remainder of the East River, swimming (primary contact recreation use) is not the best use, as defined by New York State Codes, Rules and Regulations for Class I waterbodies. Secondary contact recreation opportunities are facilitated by access points along the East River and Long Island Sound as shown in Figure 2.3-39. Figure 2.3-40 presents an example of a public boat/kayak launch at the Brooklyn Bridge Park.

2.3.b.5 Identification of Sensitive Areas

Federal CSO Policy requires that the LTCP give the highest priority to controlling overflows to sensitive areas. The Policy defines sensitive areas as:

- Waters designated as Outstanding National Resource Waters (ONRW);
- National Marine Sanctuaries;
- Public drinking water intakes;
- Waters designated as protected areas for public water supply intakes;
- Shellfish beds;
- Water with primary contact recreation;
- Waters with threatened or endangered species and their habitat; and
- Additional areas determined by the Permitting Authority (i.e., DEC).

The presence/status of sensitive areas in the East River and Long Island Sound as defined by the Federal CSO Policy is summarized in Table 2.3-14. Sources of information supporting the status are included in the footnotes to the table.

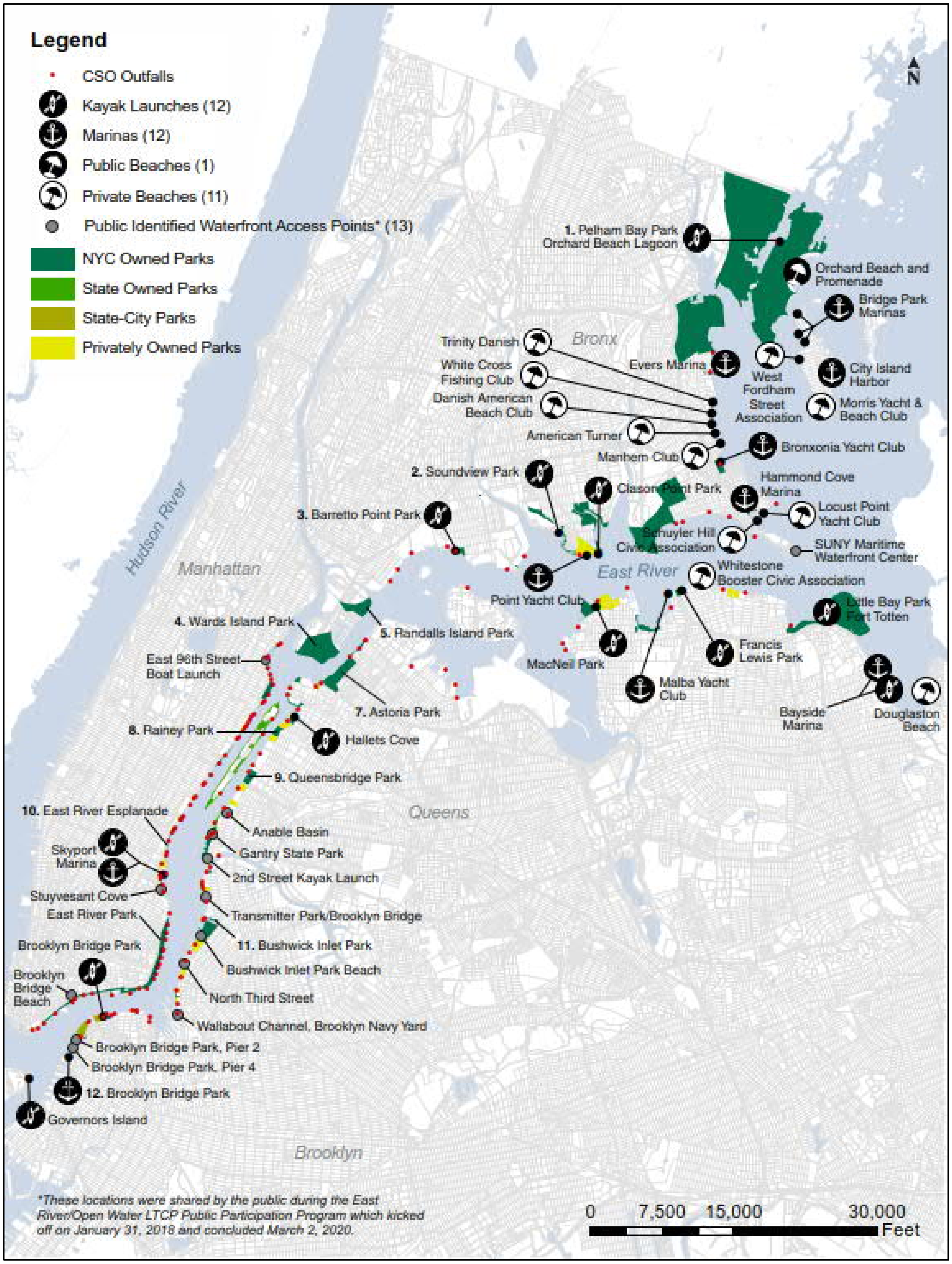


Figure 2.3-39. Waterfront Access Points to the East River and Long Island Sound

Figure 2.3-40. Boat/Kayak Launch at Brooklyn Bridge Park (Source: Brooklyn Bridge Park)

Table 2.3-14. Sensitive Areas Assessment

CSO Discharge Receiving Water Segments	Presence/Status of Sensitive Areas Classifications or Designations(1)						
	Outstanding National Resource Water	National Marine Sanctuaries	Threatened or Endangered Species and their Habitat	Best Use - Primary Contact Recreation	Public Water Supply Intake	Public Water Supply Protected Area	Shellfish Bed
Long Island Sound/ East River East of Whitestone Bridge	No(2)	No(3)	Yes(4)	Yes(5)	No(7)	No(7)	No(8)
East River from Whitestone Bridge to Battery	No(2)	No(3)	Yes(4)	No(6)	No(7)	No(7)	No(8)

Notes:
(1) Classifications or Designations per CSO Policy.
(2) EPA; DEC Protection of Waters Program and Environmental Resource Mapper.
(3) NOAA.
(4) USFWS; NOAA; DEC NYNHP.
(5) Waterbody is Class SB; swimming beaches are located along the shoreline of the waterbody.
(6) Waterbody is Class I; existing uses include secondary contact recreation and fishing.
(7) The East River and Long Island Sound are saline waterbodies.
(8) 6CRR-NY part 41.

As indicated in Table 2.3-14, the East River and Long Island Sound waterbody falls under the category of "Best Use – Primary Contact Recreation", by virtue of its Class SB water quality classification in the waters east of the Whitestone Bridge. The locations of beaches along the East River and Long Island Sound are shown in Figure 2.3-39. The East River and Long Island Sound also fall into the category of "Waters with Threatened or Endangered Species and their Habitat". Based on the lists produced by NOAA and the New York Natural Heritage Program, threatened and endangered species with the potential to occur in the East River and Long Island Sound include the following:

- Atlantic Sturgeon (*Acipenser oxyrhynchus oxyrhynchus*)
- Shortnose Sturgeon (*Acipenser brevirostrum*)
- Peregrine Falcon (*Falco peregrinus*)
- Fringed Boneset *(Eupatorium torryanum)*
- Slender Spike Rush (*Eleocharis tenuis var. pseudoptera)*
- Northern Gamma Grass (*Tripsacum dactyloides var. dactyloides)*
- Slender Blue Flag (*Iris prismatica)*
- Dwarf Glasswort (*Salicornia bigelovii)* [historical record only]

The US Fish and Wildlife Service lists the following with the potential to occur in the Citywide/Open Waters project area:

- Piping Plover (*Charadrius melodus)*
- Red Knot (*Calidris canutus rufa*)
- Roseate Tern (*Sterna dougallii dougallii*)
- Bog Turtle (*Clemmys muhlenbergii*)Indiana Bat (*Myotis sodalist*)
- Northern Long-eared Bat (*Myotis septentrionalis*)
- Sandplain Gerardia (*Agalinis acuta*)
- Seabeach Amaranth (*Amarnthus pumilus*)

Of the species listed above, only the Atlantic Sturgeon (*Acipenser oxyrhynchus oxyrhynchus*) was identified as having critical habitat present in the project area.

2.3.b.6 Compilation and Analysis of Existing Water Quality Data

East River and Long Island Sound water quality data are available from sampling conducted by DEP's HSM program from 2008 to 2018, and from intensive sampling conducted to support the Citywide/Open Waters LTCP. The majority of LTCP sampling locations (ER-1 through ER-12) were sampled from April through June 2017 while Stations ER-13 through ER-15 were sampled during October through December 2017. The East River and Long Island Sound has eight HSM stations, designated as E2, E4, E6, E7, E8, E12, E13, and E14. In addition to the HSM program, DEP also operates a Sentinel Monitoring (SM) Program, targeted at identifying illicit discharges to the waterbodies through changes to baseline sampling concentrations. The SM program collects quarterly dry-weather fecal coliform data from 12 stations in the East River and Long Island Sound (S3, S4, S8-S11, S16, S17, S58, S63, S65, and S67). LTCP sampling was conducted at 15 stations along the East River and Long Island Sound (Stations ER1 to ER12). The sampling stations of both programs are shown in Figure 2.3-41. Figure 2.3-42 and Figure 2.3-43 show the GM, minimum, maximum, 25th percentile, and 75th percentile) values for fecal coliform and *Enterococci*, respectively, for the LTCP sampling data. Figure 2.3-44 and Figure 2.3-45 show similar data for the HSM sampling program for the periods of 2015 to 2017.

The fecal coliform levels measured throughout the LTCP sampling program in wet-weather were generally higher than the levels measured during dry-weather, indicative of the impacts of wet-weather pollution sources on the East River/Long Island Sound. As indicated in Figure 2.3-42, the dry-weather geometric means at each of the East River/Long Island Sound LTCP sampling stations were all below 200 cfu/100mL, as were the wet-weather geometric means at Stations ER-1 to ER-5. The wet-weather geometric means at East River Stations ER-6 through ER-12 were all above 200 cfu/100mL, indicating that the wet-weather impacts were relatively limited. The LTCP *Enterococci* data generally followed a similar trend as the fecal coliform data: all of the wet-weather geometric means were higher than dry-weather geometric means; all of the dry-weather geometric means and the wet-weather geometric means at Stations ER-1 to ER-5 were below 30 cfu/100mL, and the wet-weather geometric means at Stations ER-6 through ER-12 were all above 30 cfu/100mL (Figure 2.3-43).

The HSM data were also generally consistent with the LTCP data. The fecal coliform geometric means were higher during wet-weather than during dry-weather, and the dry-weather geometric means were all below 200 cfu/100mL during 2015 through 2017 at all stations. For the HSM data, the wet-weather geometric means were also all below 200 cfu/100mL during this period (Figure 2.3-44). HSM *Enterococci* data showed a similar pattern (Figure 2.3-45) with geometric means below 30 cfu/100mL during 2015 through 2017 at all stations in both dry- and wet-weather conditions.

Figure 2.3-46 shows the arithmetic mean, minimum, maximum, 25th percentile, and 75th percentile values for DO from the LTCP dataset measured during 2017. The average DO concentrations at all stations were above 6.0 mg/L, while the minimum DO concentrations at Lower East River Stations ER-13 to ER-15 dropped below 4.0 mg/L. The HSM DO dataset from 2015 to 2017 showed generally similar values, with averages above 6.0 mg/L at all stations. Minimum values at the HSM stations were observed below 4.0 mg/L, and in some cases were below 3.0 mg/L (Figure 2.3-47).

Data collected by the Citizens Testing Group is also made available to the public by the Riverkeeper Group. This dataset is limited to *Enterococci* bacteria concentrations at several stations along the shorelines of the East River, as shown on Figure 2.3-41. These data are available at the Riverkeeper Group's website http://www.riverkeeper.org/ and, consistent with the LTCP and HSM data, showed a relationship between wet-weather conditions and higher *Enterococci* concentrations throughout the years 2015, 2016, and 2017.

A sampling program coordinated by the Passaic Valley Sewerage Commission (PVSC) in New Jersey, generated water quality data for stations in the Hudson River for the period of April to November 2016. Where the PVSC sampling stations were in the general vicinity of LTCP and/or HSM sampling stations, the data were compared, and were found to be generally consistent.

2.3.b.7 Water Quality Modeling

In addition to the collection, compilation, and analysis of measurements described in Section 2.3.b.6, water quality modeling was also used to characterize and assess the East River and Long Island Sound water quality. The LTCP Regional Model (LTCPRM) was used for water quality modeling for the Citywide/Open Waters LTCP. This model evolved from the System-Wide Eutrophication Model (SWEM) that underwent peer review by model evaluation groups (MEGs) in 1994, 1997, and 1999. The model computational grid associated with the LTCPRM, as well as further details on this model, are presented in Section 6 of this LTCP.

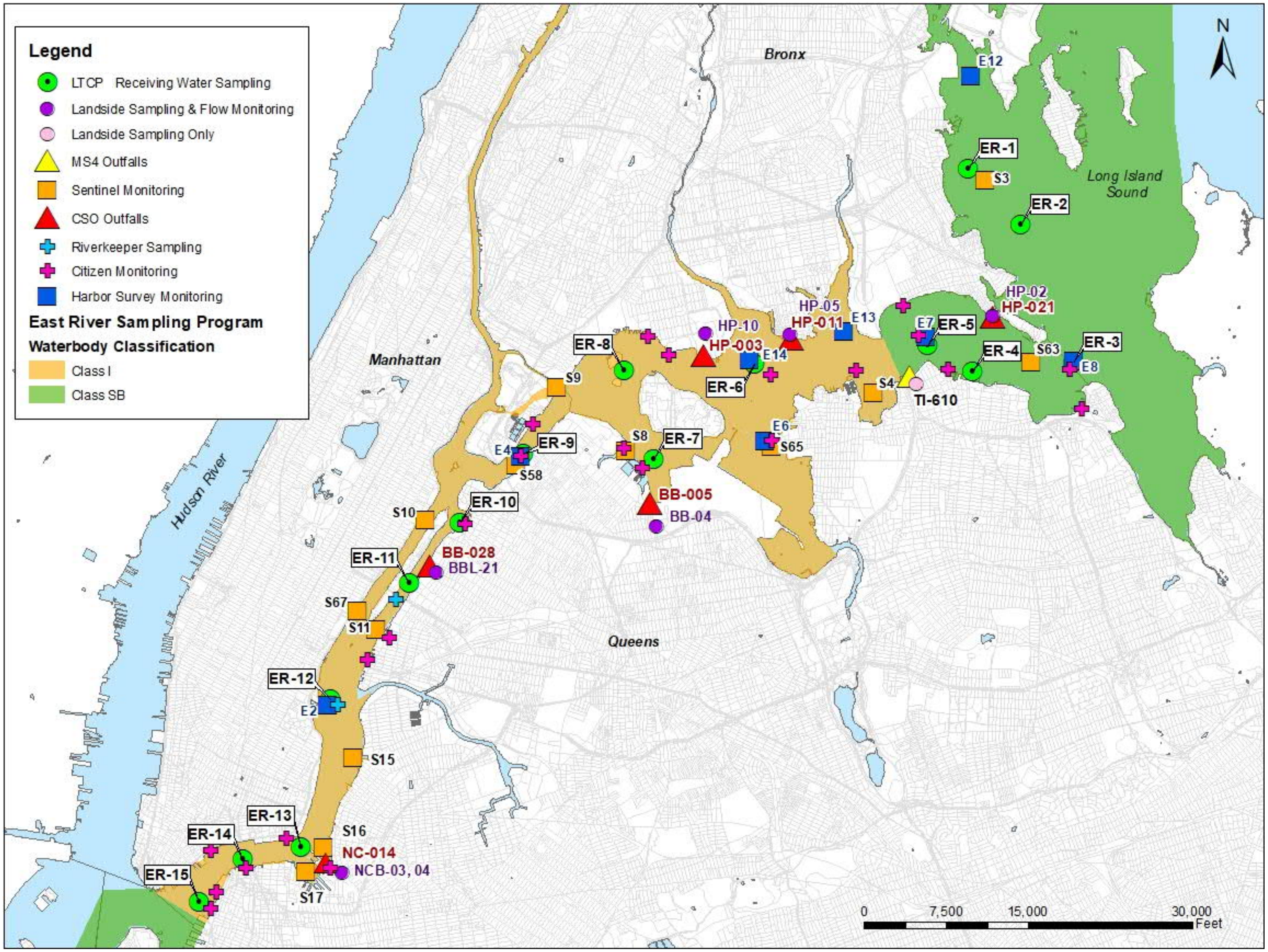


Figure 2.3-41. Water Quality Monitoring Sampling Locations within the East River and Long Island Sound

AECOM with Hazen

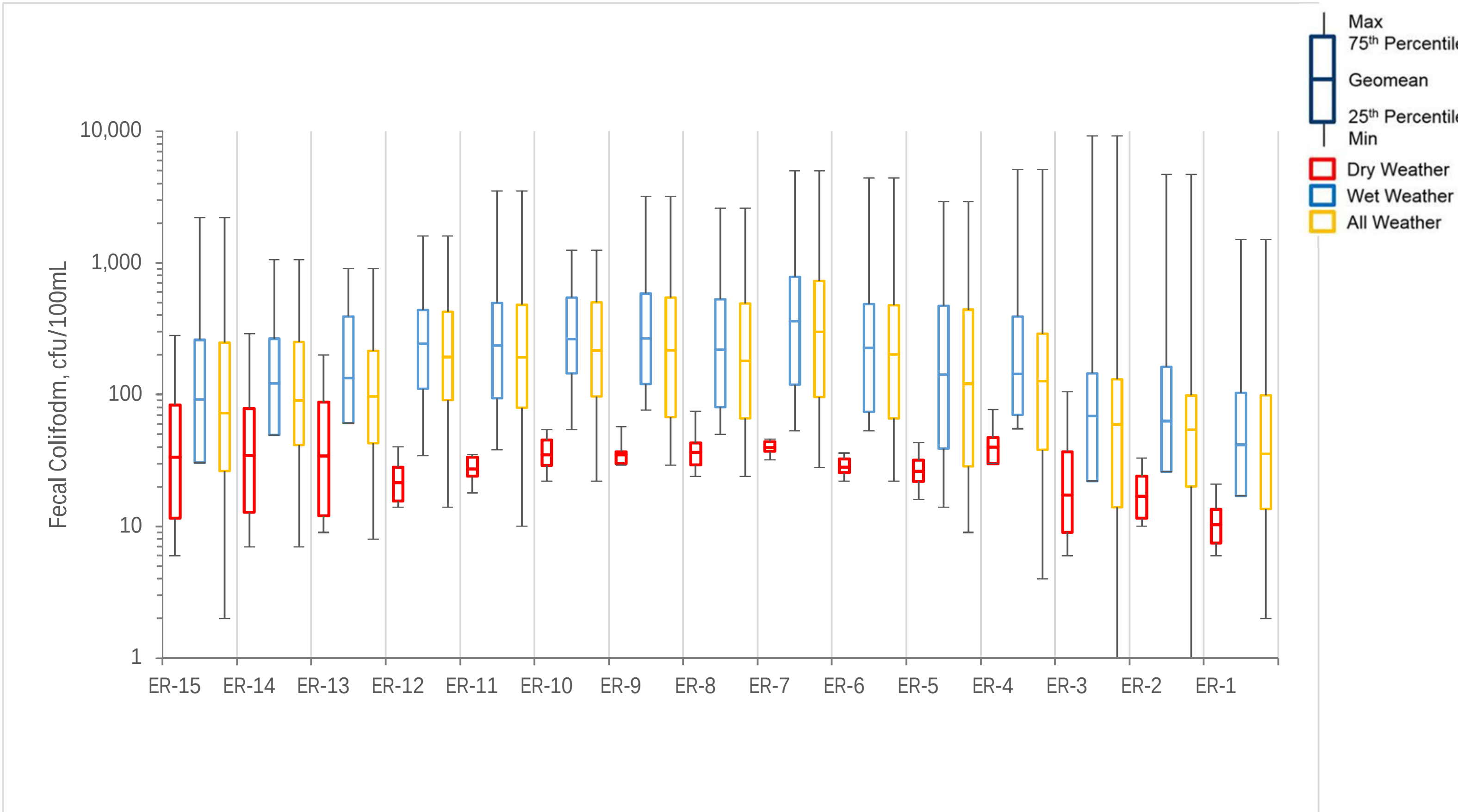


Figure 2.3-42. Fecal Coliform Concentrations at LTCP Sampling Stations in East River and Long Island Sound April - June 2017 and October - December 2017

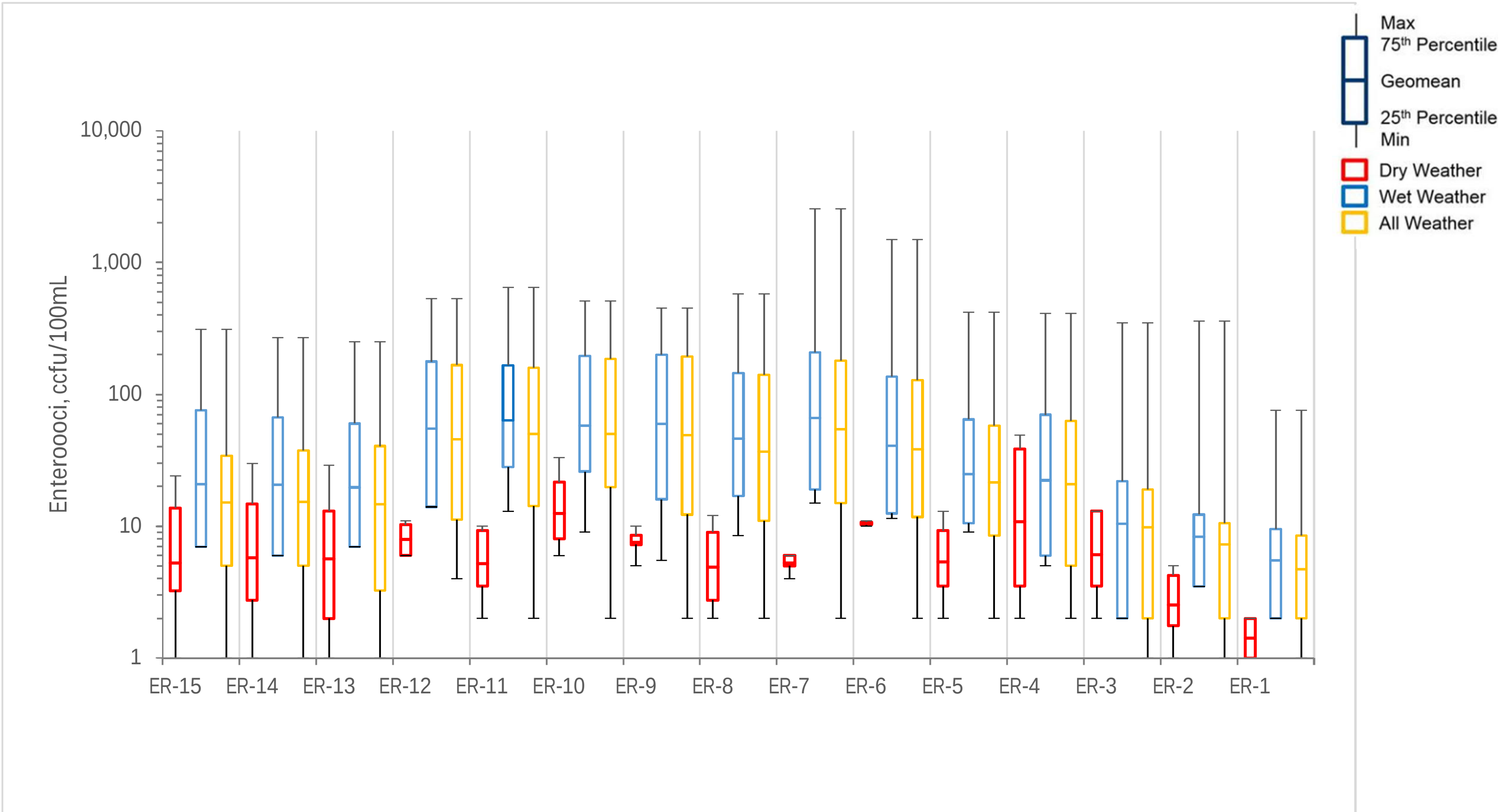


Figure 2.3-43. *Enterococci* Concentrations at LTCP Sampling Stations in East River and Long Island Sound April - June 2017 and October - December 2017*

*Note: *Enterococci* WQ Criteria apply only to the stations in Long Island Sound, east of Throgs Neck Bridge. *Enterococci* data for East River stations west of Throgs Neck Bridge are presented for informational purposes.

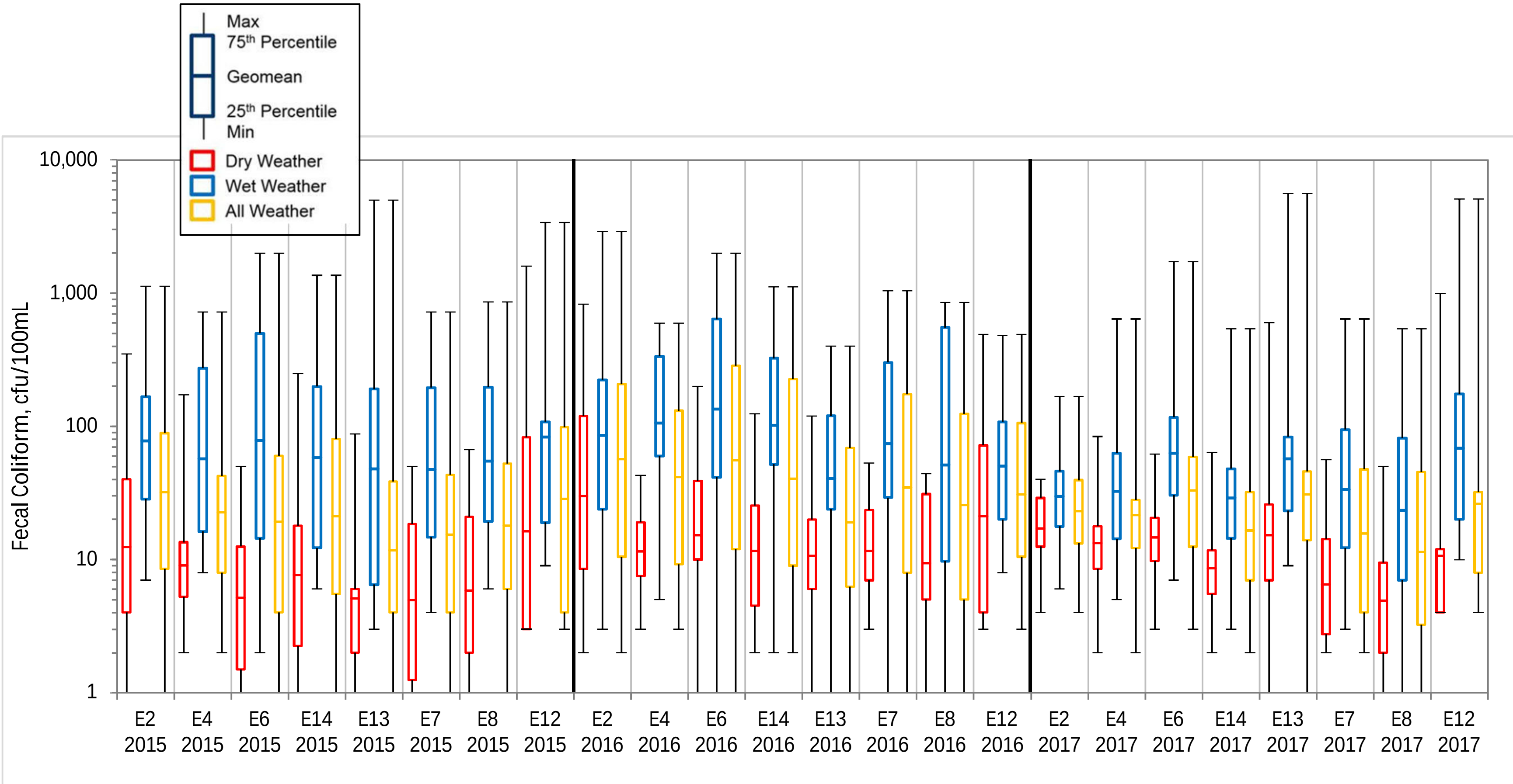


Figure 2.3-44. Fecal Coliform Concentrations at HSM Sampling Stations in the East River and Long Island Sound

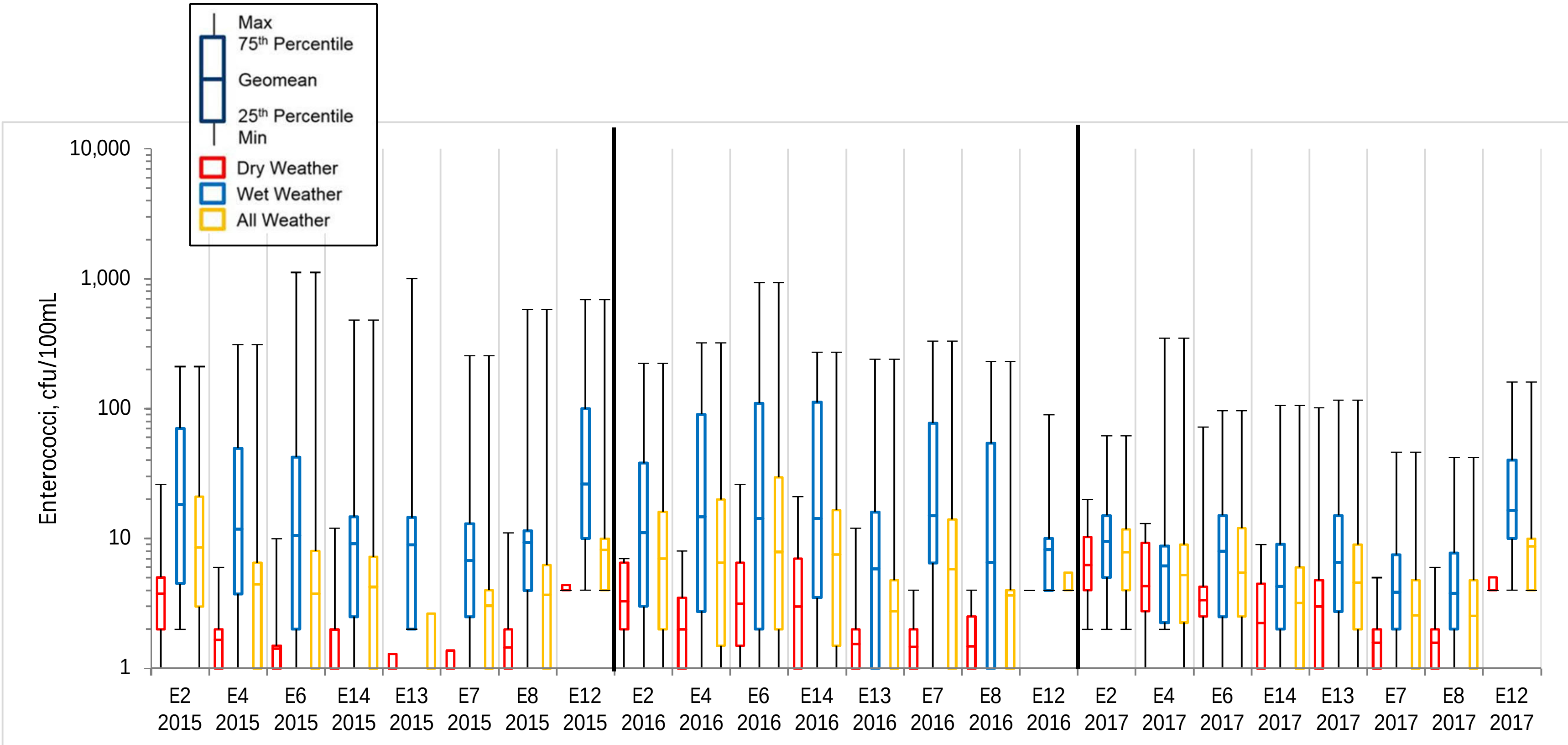


Figure 2.3-45. *Enterococci* Concentrations at HSM Sampling Station in the East River and Long Island Sound*

*Note: *Enterococci* WQ Criteria apply only to the stations in Long Island Sound, east of Throgs Neck Bridge. *Enterococci* data for East River stations west of Throgs Neck Bridge are presented for informational purposes.

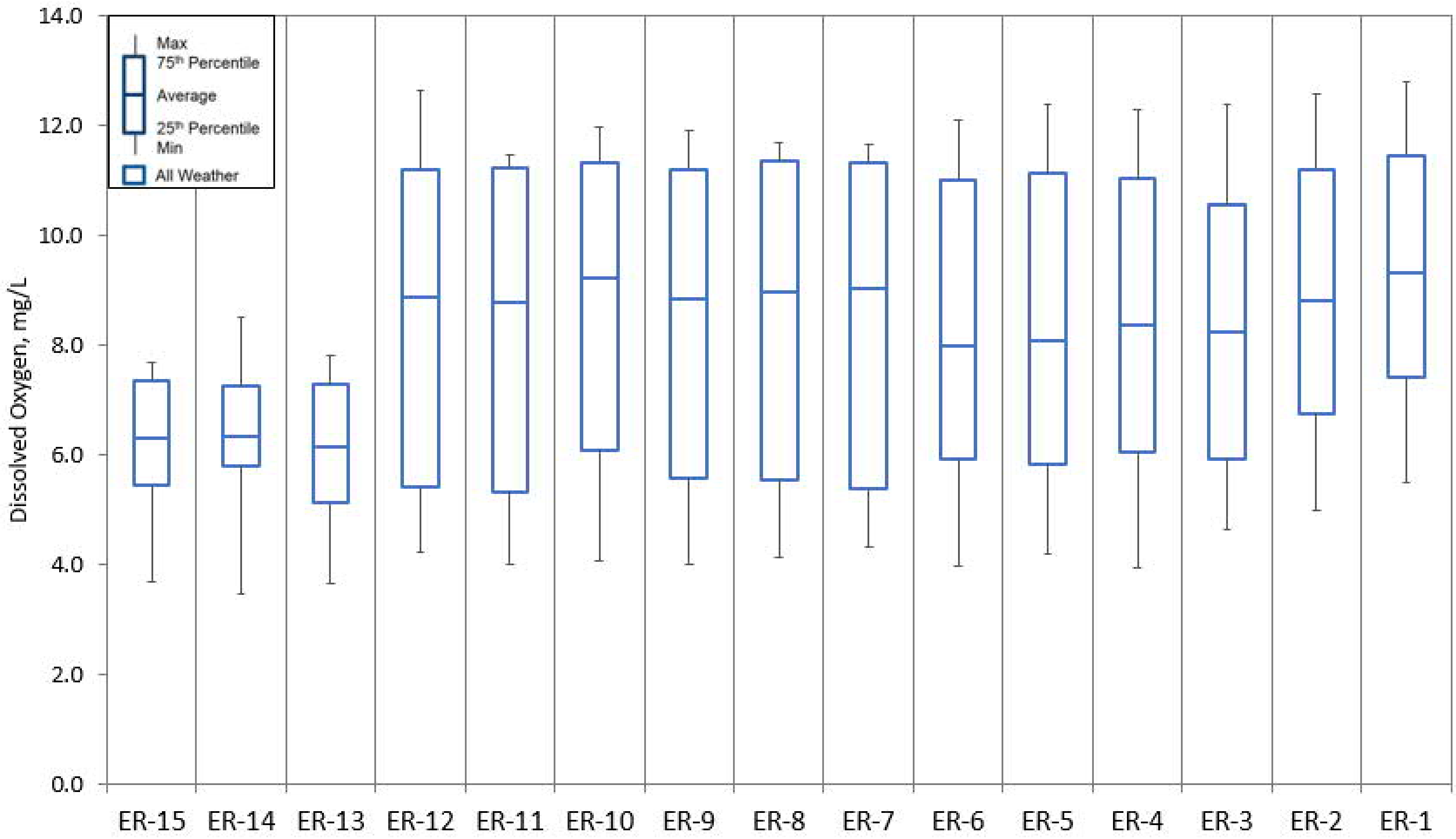


Figure 2.3-46. Dissolved Oxygen Concentrations at LTCP Sampling Stations in the East River and Long Island Sound

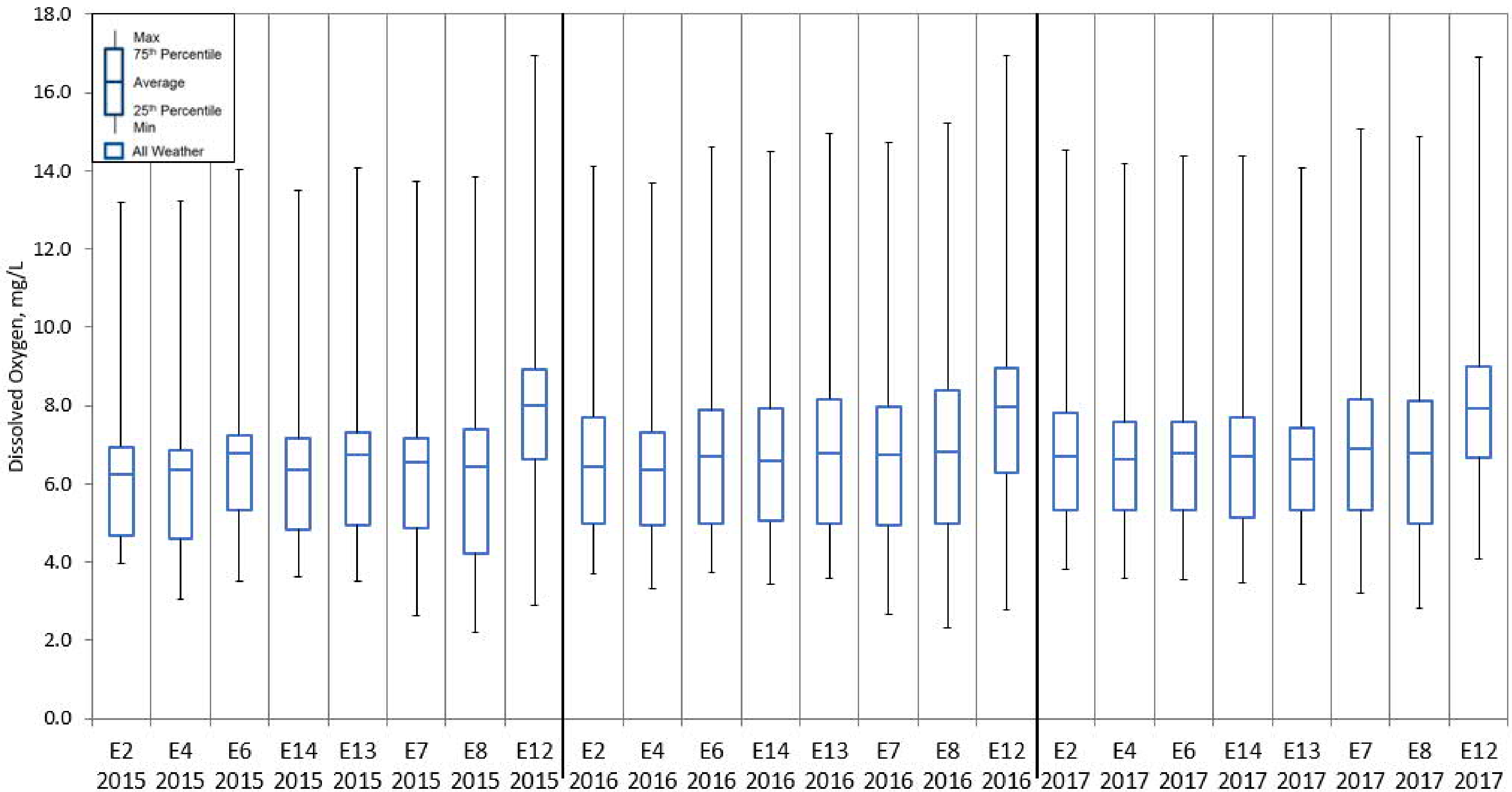


Figure 2.3-47. Dissolved Oxygen Concentrations at HSM Sampling Stations in the East River and Long Island Sound

2.4 Upper/ Lower New York Bay

This section summarizes the major characteristics of the New York Bay watershed and waterbody, building upon earlier documents that characterize the area. Section 2.2.a addresses watershed characteristics and Section 2.2.b addresses waterbody characteristics.

2.4.a Watershed Characteristics

The New York Bay watershed is highly urbanized and is primarily composed of residential areas with some commercial, transportation/utility, institutional and open space/outdoor recreation areas within the Boroughs of Manhattan, Brooklyn, and Staten Island, NY. Notable outdoor recreation areas in New York City within this watershed include Ellis Island, Governors Island, Liberty Island, and Great Kills Park in Staten Island.

This subsection presents a summary of the watershed characteristics as they relate to the land use, zoning, permitted discharges and their characteristics, sewer system configuration, performance, and impacts to the adjacent waterbodies, as well as the modeled representation of the collection system used to analyze system performance and CSO control alternatives.

2.4.a.1 Description of Watershed/Sewershed

The New York Bay watershed encompasses portions of the Boroughs of Manhattan, Brooklyn, and Staten Island in New York and a portion of Hudson County in New Jersey. The Upper Bay is fed by the waters of the Hudson River and the East River. The boundary between the Upper and Lower Bay is approximately at the Verrazano Narrows Bridge. South of the bridge, the Lower Bay opens directly into the Atlantic Ocean between Rockaway, Queens, and Sandy Hook, New Jersey.

The land area within NYC that is directly tributary to the Upper and Lower New York Bay as a result of the combined and separate storm sewer systems (the sewershed) is approximately 30,000 acres. Since the sewershed defines the limits of the combined sewer tributary area, this LTCP focuses on the sewershed of New York Bay, shown in Figure 2.4-1.

The growth and development of the areas surrounding the New York Bay have led to changes in landforms as marshes, creeks, and lowlands were filled. Staten Island has several significant filled areas including the Great Kills Park-Oakwood area and an area inland from South Beach-Midland Beach, both along the northeastern shore of Staten Island and the Lower Bay. Governor's Island is another area of notable fill, as is the New Jersey shoreline along the Upper New York Bay.

The urbanization of NYC and the New York Bay watershed has led to the creation of a large combined sewer systems, as well as areas of separate and direct drainage, primarily in areas adjacent to New York Bay. Four WRRFs are located within the New York Bay sewershed: Red Hook (60 MGD DDWF), Owls Head (120 MGD DDWF), Port Richmond (60 MGD DDWF) and Oakwood Beach (39.9 MGD DDWF). These WRRFs are permitted pursuant to DEC-issued SPDES permits. The Oakwood Beach WRRF serves a separate sanitary sewer system, and no CSO outfalls are associated with the Oakwood Beach WRRF. During dry-weather, the combined and sanitary sewer systems convey sewage to the WRRFs for treatment. During wet-weather, combined storm and sanitary flow is conveyed by the sewer system to the WRRFs. If the sewer system or WRRF is at full capacity, a diluted mixture of combined storm and sanitary flow may discharge through one or more of the 39 SPDES permitted CSO outfalls to New York

Bay (except as noted for Oakwood Beach). CSO outfalls from the Red Hook, Owls Head, and Port Richmond WRRFs primarily discharge into the Upper Bay, while CSO outfalls from the Port Richmond WRRF discharge into the Narrows and Lower Bay. These features are shown in Figure 2.4-2.

New York Bay is traversed by the Staten Island Ferry, which runs between the southernmost tip of Manhattan and Staten Island. In addition, NY Waterway operates ferry routes across the Bay and through the Narrows. The major transportation corridor that crosses the watershed to provide access between Brooklyn and Staten Island is the Verrazano Narrows Bridge (Interstate Highway 278). These transportation corridors limit access to some portions of the waterbody and are taken into consideration when developing CSO control solutions. These features are shown in Figure 2.4-3.

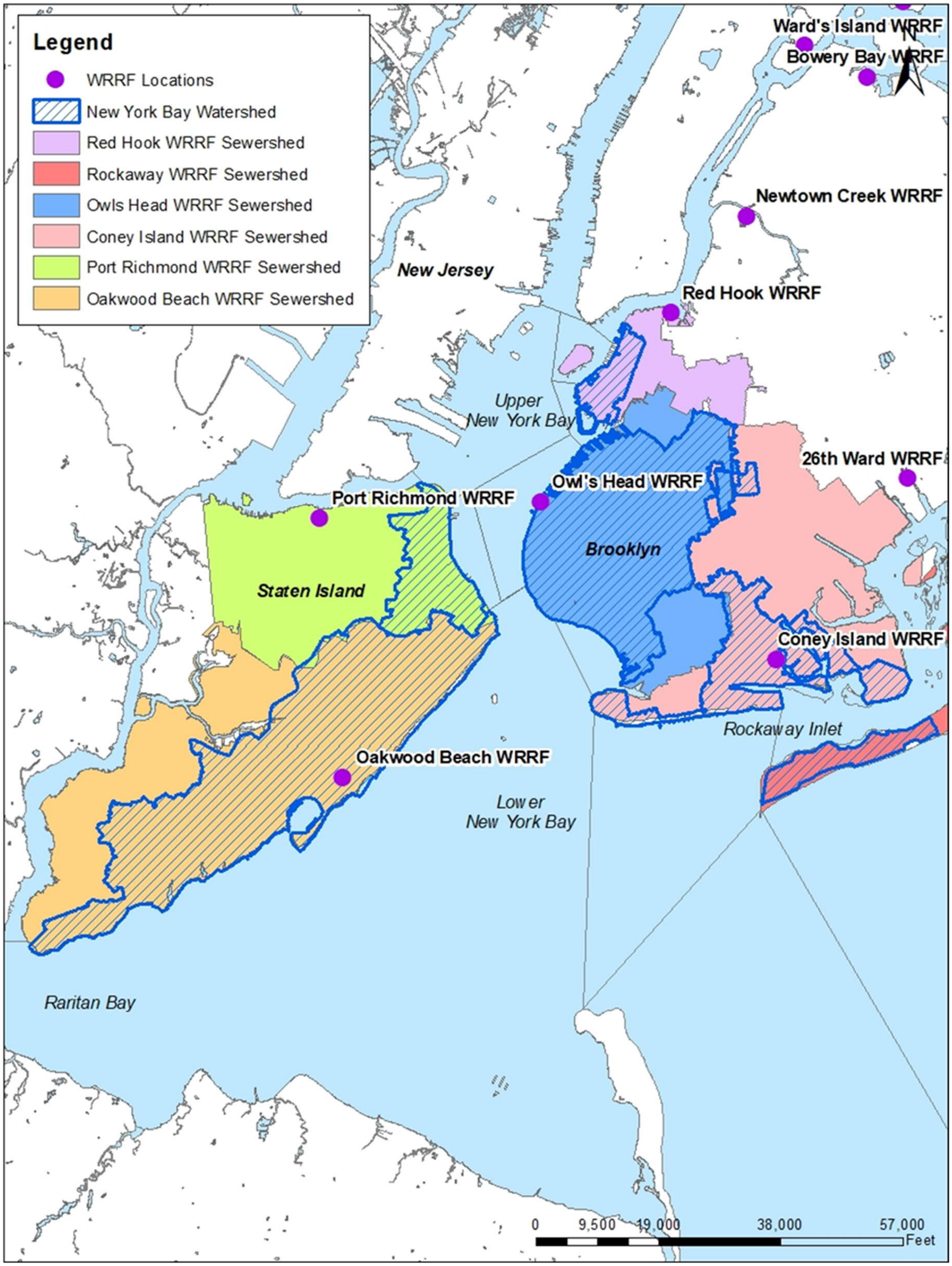


Figure 2.4-1. New York Bay Sewershed

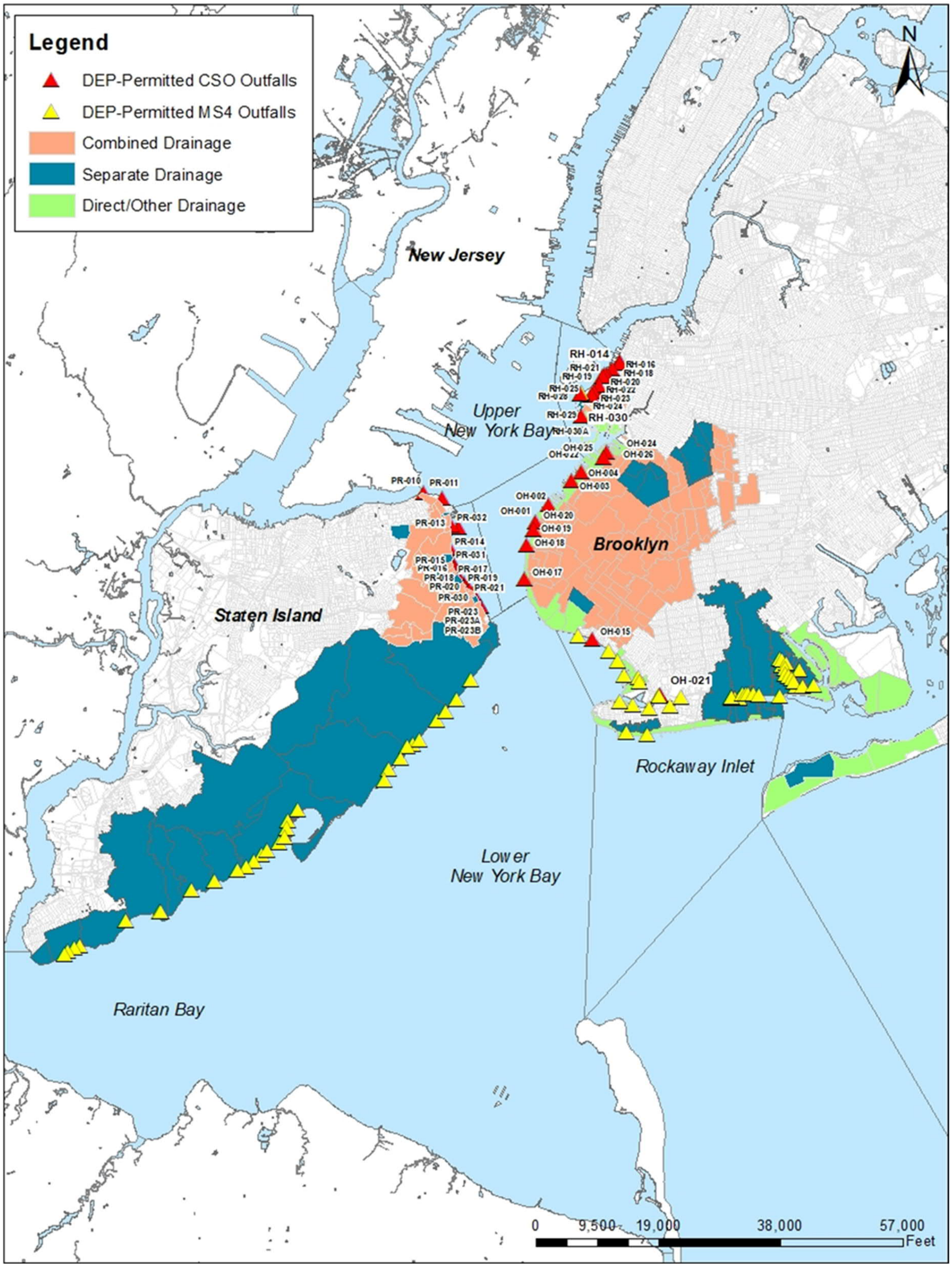


Figure 2.4-2. Components of the New York Bay Watershed

Figure 2.4-3. Major Transportation Features for the New York Bay

Existing and Future Land Use and Zoning

The current land use in the New York Bay sewershed is largely attributable to historical urbanization and development within the sewershed. Future use and development is controlled by zoning, land use proposals, and evolving land use policies. Figure 2.4-4 shows the distribution of the existing land uses within the overall New York Bay sewershed. Table 2.4-1 summarizes the land use characteristics of the overall New York Bay sewershed area, and the portions of the sewershed within a quarter-mile radius of the shoreline.

Table 2.4-1. Existing Land Use within the New York Bay Sewershed Area

Land Use Category	Percent of Area	
	Within Sewershed	Within 1/4-mile of Shoreline
Residential	47.8	21.5
Mixed Residential and Commercial	2.3	1.3
Commercial and Office	2.8	2.8
Industrial and Manufacturing	1.9	5.5
Transportation and Utility	3.5	10.2
Public Facilities and Institutions	6.6	6.1
Open Space and Outdoor Recreation	25.9	40.7
Parking Facilities	0.9	1.4
Vacant Land	7.8	9.4
Unknown	0.7	1.2

As indicated in Table 2.4-1, the predominant land use in the New York Bay sewershed is residential that is comprised mainly of single-family homes and 1-2 family walkups (48 percent). Open space also makes up a significant percentage of the sewershed (26 percent) due to the presence of federal, state, city, and local park properties and facilities. The sewershed contains several beaches along Staten Island and Coney Island, and the historic and recreational islands of Ellis Island, Governors Island, and the Statue of Liberty. The remaining 25 percent of the sewershed is relatively evenly distributed among the other uses listed in Table 2.4-1.

Within the quarter-mile area immediately surrounding the Bay, open space and recreation is the predominant use with 41 percent of the land cover, while residential uses cover 22 percent. Transportation and utility (10 percent), and industrial and manufacturing (6 percent) uses are common near the shorelines of Red Hook and Brooklyn, and several vacant plots (9 percent) are located along the Staten Island shoreline.

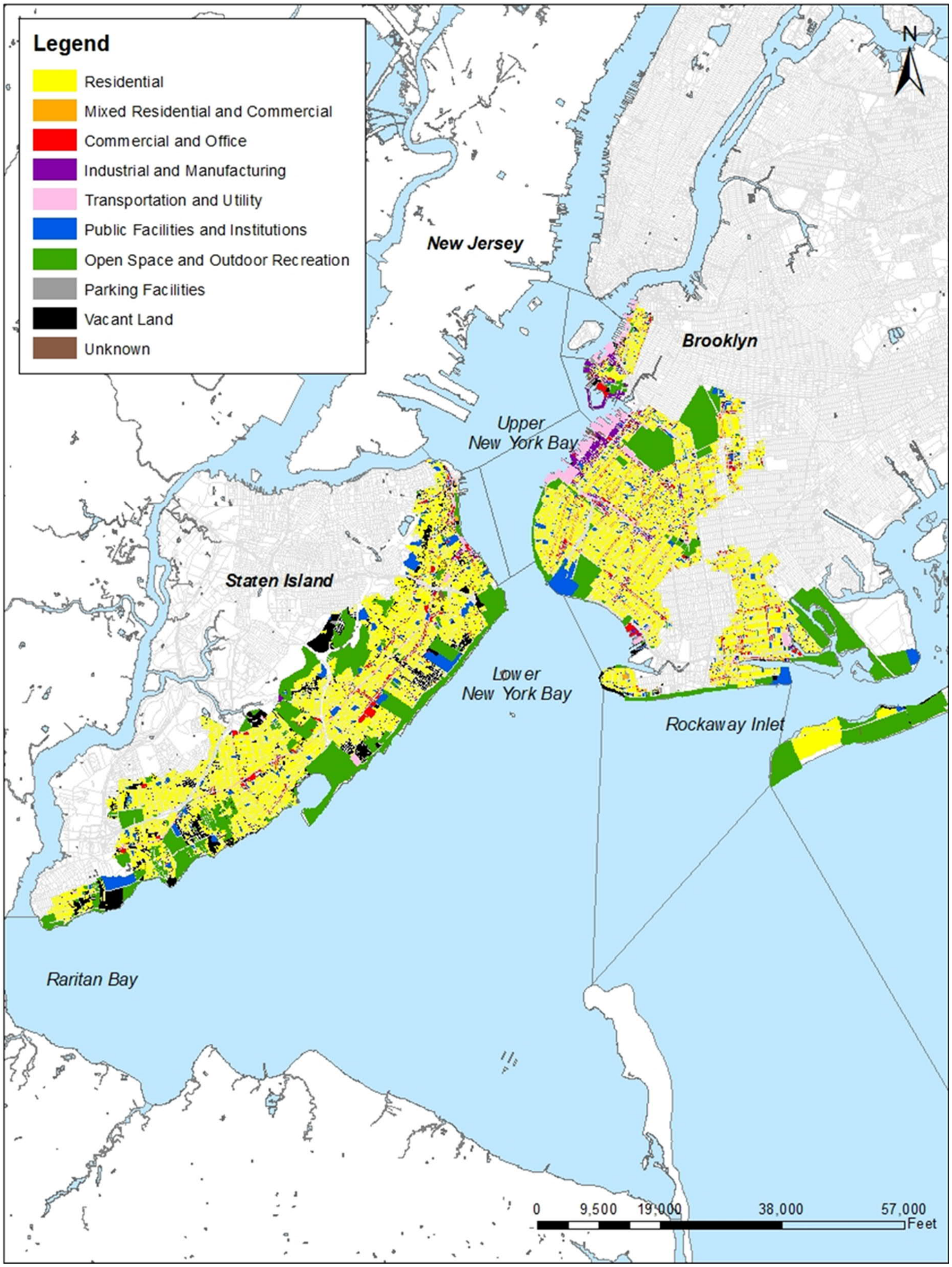


Figure 2.4-4. Land Use in the New York Bay Sewershed

Figure 2.4-5 identifies the zoning classifications within a quarter mile of the shoreline of the New York Bay. Residential properties are the predominant zoning classification making up to 42 percent of the quarter-mile buffer, with low-density residential districts making up to 50 percent of that area. Manufacturing zones cover approximately 27 percent of the area within a quarter mile of shoreline while park properties cover 16 percent and commercial zones cover approximately 13 percent of the area.

New York Bay is located within the Coastal Zone Boundary as designated by DCP. DCP has also designated New York Bay as a Significant Natural Waterfront Area (SNWA). As defined by DCP, SNWA is a large area of concentrated natural resources, such as wetlands and natural habitats, which possesses a combination of important coastal ecosystem features. One of the Priority Policies of the DCP Waterfront Revitalization Program is to protect and restore the ecological quality and component habitats and resources within the SNWA.

In addition to the standard zoning classifications, 24 "Special Use Districts" are located within the New York Bay sewershed. Special use districts are defined within the Zoning Resolution as areas designated "to achieve the specific planning and urban design objectives in areas with unique characteristics". The following Special Use Districts are located withing the New York Bay sewershed:

- The *Special Bay Ridge District* maintains the neighborhood's scale enacting regulations that preserve the low-rise character of one- to three-family homes on the midblocks and encourage five- to eight-story apartment houses with ground floor stores along the avenues.
- The *Special Coney Island District* was created as part of a comprehensive long term plan to reestablish Coney Island as a year-round, open entertainment and amusement area. The district also fosters neighborhood amenities and offers new affordable housing opportunities. Coney North and West provide for mixed residential and retail uses including entertainment along the revitalized Boardwalk and Surf Avenue.
- The *Special Coastal Risk District* has the goal of limiting density in highly vulnerable areas, protecting sensitive natural areas, and ensuring that new development is consistent with open space and infrastructure plans.
- *Special Enhanced Commercial District 1* (Fourth Ave, Park Slope and South Park Slope) promotes and maintains a lively, engaging, and varied pedestrian experience along specific commercial avenues.
- The *Special Hillsides Preservation District* guides development in the steep sloped areas of Staten Island's Serpentine Ridge, an area of approximately 1,900 acres in the northeastern park of the borough. The district regulates development and preserves the area's hilly terrain, trees, and vegetation in order to reduce hillside erosion, landslides, and excessive stormwater runoff.
- *Special Mixed Use Districts 2 and 5* (DUMBO and Red Hook) were established to encourage investment in, and enhance the vitality of, existing neighborhoods with mixed residential and industrial uses in close proximity and create expanded opportunities for mixed use communities.

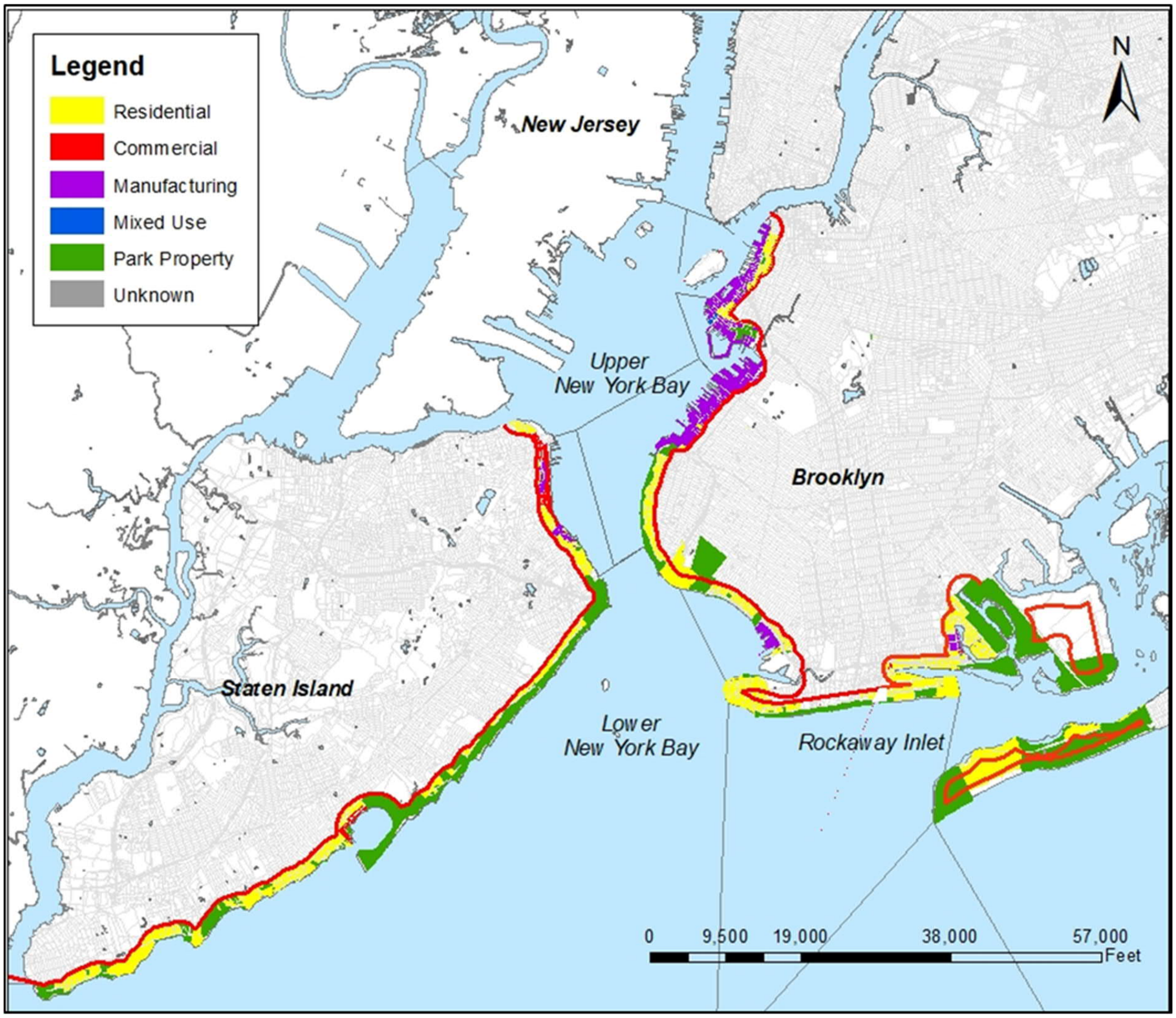


Figure 2.4-5. Zoning within 1/4 Mile of Shoreline

- *Special Natural Area Districts 1 and 3* (Emerson Hill, Lighthouse Hill and the central wetlands, and the Shore Acres Area) guide new development and site alterations in areas endowed with unique natural characteristics, including forests, rock outcrops, steep slopes, creeks, and a variety of botanic and aquatic environments. These natural features are protected by limiting modifications in topography and by encouraging clustered development.

- The *Special Ocean Parkway District* enhances the landscape along Ocean Parkway, spanning the blocks east and west of the parkway between Prospect Park and Brighton Beach, as a designated scenic landmark. This district also preserves the character of the large, detached one- and two-family homes in the areas east and west of the parkway.

- The *Special St. George District* supports a pedestrian-friendly business and residence district within a waterfront community that serves as a commercial, transit, and civic center. Special rules in this district enhance designated commercial streets, preserve waterfront and upland views, and enhance the pedestrian experience.

- The *Special South Richmond Development District* was established in 1975 to regulate the development of the southern end of Staten Island and preserve the natural spaces and outdoor recreation that defines the community.

- The *Special Scenic View District* aims to prevent obstruction of outstanding scenic views as seen from a public park, esplanade, or mapped public place. No buildings or structures are allowed to penetrate a scenic view plane except by special permit. The Brooklyn Heights Scenic View District protects the views of the Lower Manhattan skyline, Governors Island, the Statue of Liberty, and the Brooklyn Bridge.

- The *Special Stapleton Waterfront District* is part of a comprehensive plan to develop the former U.S. Navy homeport into a 12-acre waterfront esplanade with a mixed extension to the Stapleton town center. Regulation and design controls on commercial and mixed uses provide pedestrian connections to the waterfront esplanade and unobstructed visual corridors.

Plans for significant development and redevelopment within the New York Bay sewershed include the following:

- The *Gowanus Neighborhood Planning Study* will promote a thriving and inclusive neighborhood that balances a mix of goals and priorities including affordable housing, economic development, resiliency and sustainability, and infrastructure improvements.

- The *Red Hook Transportation Study* identifies incremental improvements that can be made by MTA to improve transportation for all modes and users in the community of Red Hook.

- The *Staten Island/Bronx Special Districts Zoning Text Amendment* will create ecological areas across the special district based on proximity to the most sensitive natural resources. Regulations for development focus on lot coverage, impervious area, and planting controls, which will vary depending on adjacency of sites to these natural areas.

- The *Resilient Neighborhood Studies* (Staten Island Eastern Shore) identify local planning strategies to increase the neighborhood's ability to withstand and recover from coastal storms and flooding and seeks to improve access to the waterfront, as well as enhance public spaces in the community and maintain the neighborhood's character.

- The *East Shore Buyout Areas Special Coastal Risk District Text Amendment and Rezoning* will modify the zoning rules in the New York State Buyout Areas of Oakwood Beach, Graham Beach, and Ocean Breeze. Figure 2.4-6 shows the location of the buyout areas on Staten Island's eastern shore.
- The Department of City Planning's *Waterfront Revitalization Program* establishes policies for development and use of the waterfront. The goal of the program is to maximize benefits from economic development, environmental conservation, and public use of the waterfront, while minimizing any potential conflicts among these objectives.
- The Department of City Planning's *Vision 2020 Comprehensive Waterfront Plan* builds on NYC's success in opening up to the public miles of shoreline that had been inaccessible for decades, and supporting expansion of the maritime industry (DEP, 2010c). Vision 2020 sets the stage for expanded use of waterfront parks, use of waterways for transportation, housing and economic development, and recreation and natural habitats. The 10-year plan lays out a vision for the future with new citywide policies and site-specific recommendations. New York Bay spans Reaches 14S, 15, 18, and 19 within the Vision 2020 plan and consists of several site-specific waterfront revitalization strategies (see Figure 2.4-7 through Figure 2.4-10).

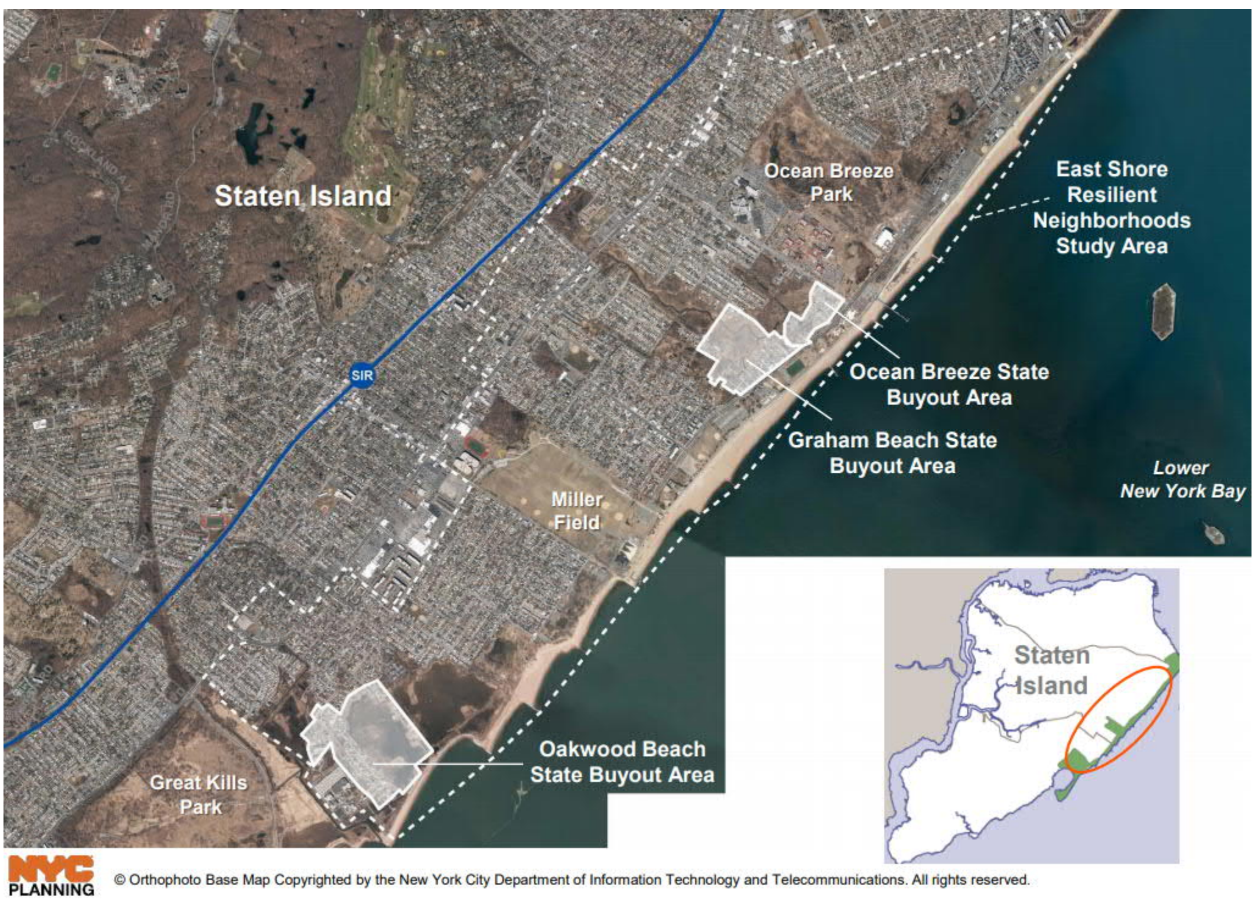


Figure 2.4-6. Staten Island Eastern Shore Buyout Areas – Special Coastal Risk District

REACH 14 S. -*BROOKLYN UPPER BAY SOUTH*

Location: Buttermilk Channel and New York Upper Bay from Atlantic Ave. to Owls Head

Upland Neighborhoods: Cobble Hill, Red Hook, Gowanus, Sunset Park, Carroll Gardens, Columbia Street Waterfront, Park Slope, Boerum Hill

Neighborhood Strategies

Reachwide

- Facilitate open space improvements at streetends in coordination with approved plans and zoning regulations for adjacent sites.
- Release Brooklyn Waterfront Greenway Master Plan, guiding the creation of a 14-mile waterfront path between Newtown Creek and the Shore Parkway Greenway.

Piers 7-12 1

- Support continuation of industrial uses.
- Build a multi-use path to connect Atlantic Basin to the Brooklyn waterfront greenway.
- Explore preservation of historic properties and creation of waterfront interpretive center focused on history of working waterfront.
- Support use of green port technology, such as shore power, clean energy, and use of waterborne freight transport.
- Minimize traffic conflicts between trucks and pedestrians/bicyclists.
- Pursue development of a "hub" for maritime support services in Atlantic Basin.
- Support opportunities for active publicly accessible use of cruise terminal on days when ship is not in port.
- Study opportunities for active water-related public uses in Atlantic Basin, such as recreation and educational programming.
- Market the Container Terminal as a distribution hub for containerized cargo destined for East of Hudson businesses.
- Provide additional berthing locations to commercial vessels along the north side of Atlantic Basin.

Valentino Pier 2

- Explore creation of boathouse and other amenities.

280 Richards St. 3

- Support development compatible with adjacent water-dependent industry and explore public access opportunities.

Gowanus Canal 4

- Complete pump station, force main and flushing tunnel upgrade to improve water quality.
- Participate in ongoing reviews of remedial investigation results and feasibility study for EPA's clean up.
- Design and begin construction of the first phase of high-level storm sewers within to reduce CSOs in the canal as well as street flooding and sewer backups in adjacent neighborhoods.
- Support rezoning in underutilized areas, continuous public waterfront access, and cleanup of contaminated sites consistent with city, state, and federal standards.
- Explore opportunities for safe indirect-contact in-water recreation, in consultation with State and Federal regulators.
- Support continued industrial activities and preservation of historic properties.
- Support plans to use street-end parks and pervious surfaces to capture stormwater and provide education to the public.

3rd Ave./3rd St. Site 5

- Continue ongoing remediation efforts.
- Explore options for reuse along with providing public and visual access to waterfront.

Public Place Site 6

- Support site remediation in cooperation with responsible parties and State and Federal regulators, and pursue planned housing development with public waterfront open space.

Hamilton Avenue Marine Transfer Station 7

- Support development of planned marine waste transfer station.

Sunset Park 8

- Support appropriate alignment of Brooklyn Waterfront Greenway, with point access to the waterfront where feasible and a safe, defined corridor to the new park that minimizes conflicts with uses in the Industrial Business Zone.
- Support recommendations of EDC's Sunset Park Vision Plan for future infrastructure improvements to maximize efficient movement of goods, including Brooklyn Waterfront Rail Improvement project, reactivation of the South Brooklyn Marine Terminal, and activation of rail yard and marine transload facility at the 65th and 51st street rail yards.
- Relocate NYPD tow-pound at South Brooklyn Marine Terminal.
- Explore rehabilitation of Pier 6 for possible dry bulk/liquid operations, and maritime support operations.
- Explore locations for a maritime support services "hub," where workboats can receive services such as provisioning, crew changes, wastewater removal, and fuel.
- Actively market marine transport as a option for local distribution and manufacturing businesses to reduce overall truck vehicle miles travelled (create a "Freight Village" around green transportation).
- Improve cross-harbor freight transportation, including reactivation of 65th Street float bridges and expanded use of rail freight via the "Southern Corridor" to the national rail freight network.
- Explore long-term opportunities for a deepwater container port in coordination with key stakeholders.
- Commence first phase of Brooklyn Army Terminal commercial life sciences and technology center, and support workforce development and training programs.
- Issue RFP for the lease and development of an approximately 130,000-square-foot property at the Bush Terminal Complex.

Bush Terminal Piers Park 9

- Advance plans for park including remediation, and explore opportunities for enhanced upland connections.
- Explore opportunities for boat launch based on the criteria described in the Citywide Strategy.
- Explore funding for planned environmental education center.
- Design park access to minimize pedestrian and industrial business conflicts.
- Explore options for preservation of deteriorating piers.

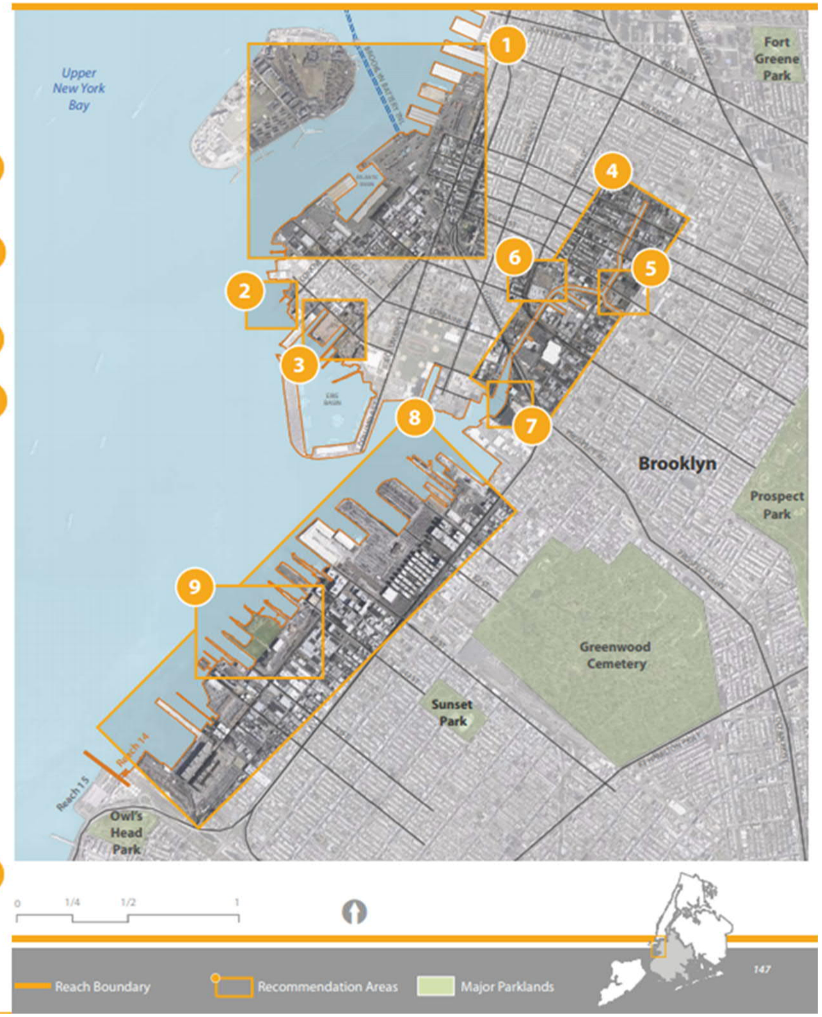


Figure 2.4-7. NYCDCP Vision 2020 Comprehensive Waterfront Plan – Reach 14S

Location: Owls Head to Sea Gate

Upland Neighborhoods: Bay Ridge, Bensonhurst, Bath Beach, Gravesend

Neighborhood Strategies

69th Street Ferry (1)

- Support planned eco-dock for kayakers and boaters, consistent with the criteria described in the Citywide Strategy.

Verrazano Bridge to Bay Parkway (2)

- Support extension and explore widening of bike path.
- Support repairs and reconstruction of exising path and sea wall.

Denyse Wharf (2.a)

- Explore opportunities for activation of site for public use.

Gravesend Bay (3)

- Support Southwest Brooklyn Marine Transfer Station.
- Support provision of public waterfront access at redevelopment sites.

Westshore Ave. Site (3.a)

- Support remediation as condition of possible development.

Calvert Vaux Park (3.b)

- Support improvements including the construction of new sports fields, lighting, and pedestrian paths.

REACH 15-*SOUTHWEST BROOKLYN*

Figure 2.4-8. NYCDCP Vision 2020 Comprehensive Waterfront Plan – Reach 15

Location: North Shore of Staten Island from Bard Ave. to Fort Wadsworth along the Kill Van Kull and Upper New York Bay

Upland Neighborhoods: New Brighton, St. George, Tompkinsville, Stapleton, Clifton, Rosebank, Fort Wadsworth, Shore Acres

Neighborhood Strategies

Reachwide

- Explore means to provide public views of waterfront activity along with interpretive signage.
- Provide easy and inviting connections between Staten Island Ferry and North Shore destinations.
- Continue the implementation of the North Shore Esplanade recommendations from Snug Harbor to the Verrazano Bridge as public and private projects are proposed along its route providing a continuous bicycle and pedestrian pathway, along the waterfront where feasible.

Snug Harbor 1

- Improve public access from the Staten Island Ferry Terminal along the waterfront and Richmond Terrace.
- Evaluate reconstruction of dock for potential future use.
- Improve pedestrian crossing to waterfront.
- Support designation of Snug Harbor wetlands in the Bluebelt program.
- Investigate relocating former rail right of way at Snug Harbor and take steps to protect against erosion.
- Improve bicycle connections and facilities.

New Brighton Waterfront 2

- Work with maritime businesses to build maritime infrastructure and recruit new maritime use.
- Encourage development of maritime hub with cultural and commercial uses; recruit light industrial users to complete new "Gateway to Working Waterfront."
- Evaluate retaining wall on North Shore esplanade to identify long-term maintenance needs.
- Investigate relocating rail right-of-way to facilitate maritime expansion.
- Provide wider sidewalks, bike lanes, and turn lanes on Richmond Terrace and reduce truck queuing on Richmond Terrace.

St. George 3

- Improve pedestrian connections between ferry terminal, waterfront and civic center.
- Activate public spaces with cultural uses.
- Explore how any future development at parking lots could improve waterfront access.
- Study feasibility and necessary infrastructure investments for development of baseball and ferry parking lots.

St. George - Ferry Terminal 3.b

- Provide better outreach and information to tourists to promote St. George as tourist destination.
- Improve bicycle connections and facilities.
- Ensure bus ramp redevelopment improves pedestrian connections.

North Shore Esplanade 4

- Support improvement of connections along waterfront from St. George to Stapleton, including such areas as Bay Street Landing Promenade.

Former Coast Guard Site 4.a

- Execute development agreement for residential, retail and open space components; consider feasible plans to create a cultural component that pays tribute to the site's history.

Merchant Marine Memorial Plaza 4.b

- Repair and maintain public waterfront plaza and pier.

Victory Blvd. 4.c

- Extend North Shore Promenade.
- Explore opportunities for kayak launch based on the criteria described in the Citywide Strategy.

Cromwell Center 4.d

- Evaluate Cromwell Center facility.

New Stapleton Waterfront 5

- Commence construction of 6-acre waterfront esplanade.
- Restore natural waterfront with limited on-water recreation in the cove.
- Support extension of the North Shore Promenade.
- Support master-planned development on the waterfront, along with necessary infrastructure improvements.

Edgewater/Rosebank 6

- Support continued water-dependent maritime uses.
- Support creation of public access to extend the North Shore Promenade as redevelopment occurs.
- Consider rezoning for residential development incorporated with public access.

Fort Wadsworth 7

- Support National Park Service's General Management Plan process for Gateway National Recreation Area to provide additional opportunities for waterfront access, recreational use and cultural exploration.

REACH 18 - *STATEN ISLAND NORTH SHORE*

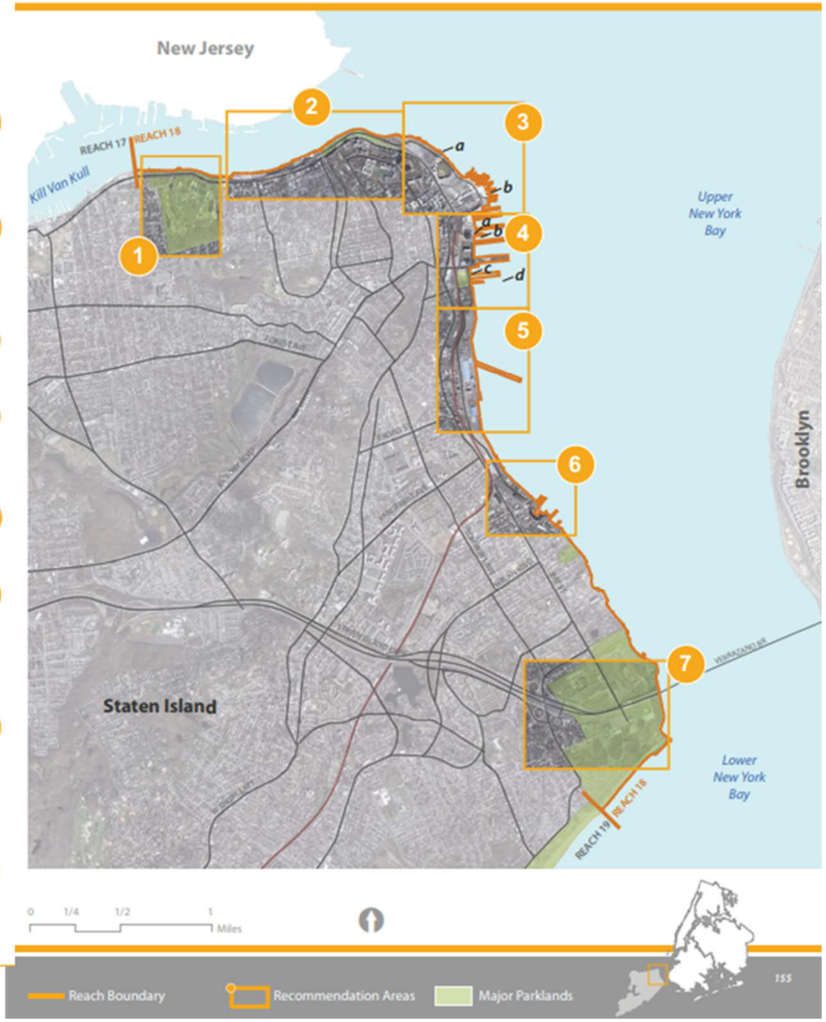


Figure 2.4-9. NYCDCP Vision 2020 Comprehensive Waterfront Plan – Reach 18

Location: Lower New York Bay and Raritan Bay from Verrazano Bridge to Conference House Park

Upland Neighborhoods: Midland Beach, South Beach, New Dorp Beach, Oakwood Beach, Great Kills Harbor, Eltingville Beach, Southeast Annadale, Prince's Bay, Tottenville

Neighborhood Strategies

Reachwide

- Study methods to limit coastal erosion on public and private land, including consideration of using suitable dredge material to replenish beaches.
- Explore creation of continuous bicycle and pedestrian pathway, along the waterfront where feasible.

Midland to Great Kills 1

- Support National Park Service's General Management Plan process for Gateway National Recreation Area to provide additional opportunities for waterfront access and to maximize public use and activation of Miller Field.
- Support completion of Midland Beach Children's Park and public amenities on the boardwalk.

Ocean Breeze Park 2

- Complete improvements to park including new regional athletic facility and indoor horseback-riding arena.

Oakwood Beach/Cedar Grove Park 3

- Restore and improve public access to the public park and beach.

Great Kills to Tottenville 4

- Work with DOT and DPR on evaluating the feasibility of widening street ends and posting signage to provide public waterfront viewing and seating areas.
- Identify and remove private obstructions and barriers placed on required public waterfront access sites.
- Consider providing public access along the mapped but unimproved section of Johnston Terrace to Sharrots Rd.

Lemon Creek 5

- Explore options for maintaining the navigability of the entrance channel to the Lemon Creek Marina.

REACH 19 - *STATEN ISLAND SOUTH SHORE*

Figure 2.4-10. NYCDCP Vision 2020 Comprehensive Waterfront Plan – Reach 19

Impervious Cover Analysis

The impervious cover analysis conducted for the New York Bay sewershed is similar to the analyses described for the Harlem River (see Section 2.1.a.1).

Population Growth and Projected Flows

DEP routinely develops water consumption and dry-weather wastewater flow projections for planning purposes. In 2012, DEP projected an average per capita water demand of 75 gallons per day that was representative of future uses. The year 2040 was established as the planning horizon, and populations for that time were developed by the DCP and the New York Metropolitan Transportation Council.

The 2040 population projection figures were then used with the dry-weather per capita sewage flows to establish the dry-weather sewage flows in the IW models for the Owls Head, Red Hook, Coney Island, Port Richmond, and Oakwood Beach WRRF sewersheds. Average daily dry-weather sanitary sewage flows for the landside model subcatchments for each sewershed were established by distributing the total dry-weather flows at the respective WRRFs to the upstream subcatchments in proportion to the upstream subcatchment populations.

Updated Landside Modeling

The Upper New York Bay sewershed is included within the Port Richmond, Red Hook, and Owls Head WRRF collection system IW models, while the only CSO outfall that discharges to the Lower Bay is from the Owl's Head WRRF system. An IW model of the Oakwood Beach separate stormwater areas has been developed to estimate the stormwater flows from this area, as the Oakwood Beach WRRF system is a separate sanitary system, with no CSO outfalls. In 2012, 13 of DEP's IW landside models underwent recalibration. This recalibration process is described in Section 2.1.a.1. As part of the Citywide/Open Waters LTCP, additional flow metering was conducted to check the 2012 calibration. Additional model updates to the Red Hook model implemented as part of the Citywide/Open Waters LTCP development were described in Section 2.1.a.1. Updates to the Owls Head IW model that were implemented as part of the Gowanus Canal LTCP are summarized in Section 2 of each of that LTCP. Additional model updates to the Owls Head and Port Richmond system models implemented as part of the Citywide/Open Waters LTCP development are summarized as follows:

<u>Owls Head IW Model</u>

- The Prospect Park Demand Management project was added to the Owl's Head baseline condition. This project involves the repair of a broken valve which was contributing about 1 MGD to the Prospect Park Lake producing a daily contribution to the combined sewer system. In order to include this project the model had to be updated to include a more detailed representation of the Prospect Park Lake and its overflow structure and connection to the combined sewer system. This project results in an approximately 8 MG CSO reduction at OH-015, which is tributary to Gravesend Bay, and additional smaller reductions at OH-002 and OH-003, which are tributary to Upper New York Bay.

- Modifications to runoff coefficients, regulator configurations, and wastewater profiles associated with BMP metering and model calibration/validation.

Port Richmond IW Model

- Modifications to runoff coefficients, regulator configurations, and wastewater profiles associated with BMP metering and model calibration/validation.

Review and Confirm Adequacy of Design Rainfall Year

2008 rainfall from the JFK rain gage was determined to be the most representative of average annual rainfall conditions based on a review of rain gage data from 1969 to 2010 at four rainfall gauges (CPK, LGA, JFK, EWR). As a result, the landside modeling analyses conducted as part of the LTCP process used the 2008 JFK precipitation as the typical rainfall year in NYC, together with the 2008 tide observations. The rainfall from the JFK gage for a 10-year period of 2002 to 2011 was also used to assess long term performance of the LTCP Recommended Plan (see Sections 6 and 8). The period from 2002 through 2011 was the wettest continuous 10-year period over the past 50 years and provided a high level of conservatism to the LTCP analyses. Section 2.1.a.1 provides additional detail on selection of the typical year rainfall period.

2.4.a.2 Description of Sewer System

The NYC portion of the New York Bay watershed/sewershed is located within the Boroughs of Manhattan, Brooklyn, and Staten Island, and is served by four WRRFs. The Upper New York Bay is served by the Red Hook, Owls Head, and Port Richmond WRRFs and their collection systems. The one CSO outfall in Lower New York Bay is in the Owl's Head WRRF system. Separate storm drains within the Oakwood Beach WRRF sewershed discharge to Lower New York Bay. Figure 2.4-4 and Table 2.4-1 show the different land uses within the sewersheds of the four WRRFs tributary to New York Bay. The locations of these WRRFs and the respective sewershed boundaries are shown in Figure 2.4-1. The CSO and stormwater outfalls associated with New York Bay are shown in Figure 2.4-11. In total, 476 discharge points have been documented to exist along the shoreline of New York Bay by the Shoreline Survey Unit of the DEP, as shown in Table 2.4-2. In addition to the outfalls listed in Table 2.4-2, the outfall for the Owls Head WRRF discharges to New York Bay, and the Oakwood Beach WRRF outfall discharges to Raritan Bay.

Table 2.4-2. Outfalls Discharging to the New York Bay

Identified Ownership of Outfalls	Number of Outfalls
DEP	DEP MS4 Permitted = 41
	DEP Non-MS4 Permitted = 20
	DEP CSO Permitted = 39
DEC	8
NYS Department of Transportation	123
Private	207
Unknown	38
Total	476

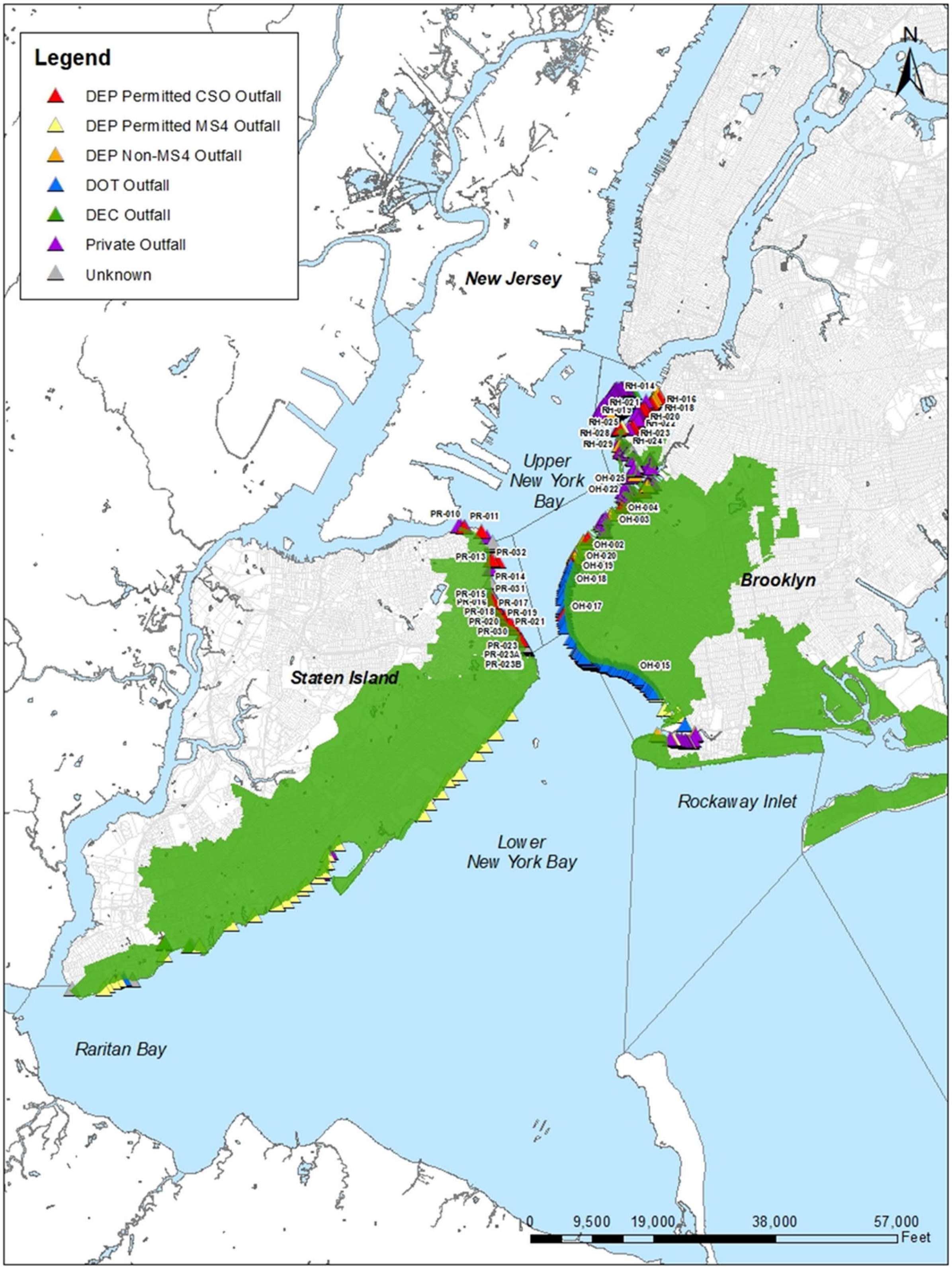


Figure 2.4-11. Outfalls Discharging to New York Bay

Overview of Drainage Area and Sewer System

The following sections describe the major features of the Red Hook, Owls Head, Port Richmond, and Oakwood Beach WRRF sewersheds within the New York Bay watershed. The total acreage of combined sewer, separate sewer, and direct drainage tributary area to New York Bay is presented in Table 2.4-3.

Table 2.4-3. WRRF Sewersheds Tributary to New York Bay: Acreage Per Sewer Category

WRRF	Combined	Separate (MS4 and non-MS4)(1)	Direct, Overland, Other(1)	Total Area
Red Hook	643	0	342	986
Owl's Head	7,461	2,930	2,599	12,989
Coney Island(2)	0	531	169	700
Port Richmond	2,414	58	64	2,535
Oakwood Beach(3)	0	13,170	0	13,170
Total	**10,518**	**16,689**	**3,174**	**30,380**

Notes:
(1) Tributary drainage areas for direct drainage and other sources of stormwater have not been fully delineated by DEP or obtained from other agencies. These drainage areas were estimated based on GIS mapping, aerial photographs, land use maps, and topographic maps, rather than detailed topographic surveys and sewer maps.
(2) Runoff from the south and southwestern shore of Coney Island can discharge to New York Bay via separate storm sewers and direct overland drainage. No CSO outfalls discharge to New York Bay from this system.
(3) The Oakwood Beach WRRF serves a separate sanitary system, with no CSO outfalls.

Red Hook WRRF Drainage Area and Sewer System

The Red Hook WRRF sewershed and sewer system are described in Section 2.3.a.2. A total of 14 CSO outfalls are permitted to discharge from the Red Hook WRRF system to the Upper Bay during wet-weather. Table 2.4-4 lists the CSO outfalls that are tributary to New York Bay from the Red Hook WRRF sewershed, along with their associated regulators/relief structures. Figure 2.4-12 shows the main features of the Red Hook WRRF collection system and the sewershed area tributary to the Bay.

Table 2.4-4. CSO Outfalls Tributary to the New York Bay from the Red Hook WRRF Service Area

Outfall	Regulator(s)
RH-014	R-13
RH-016	R-12
RH-018	R-11
RH-019	R-9
RH-020	R-10
RH-021	R-9A
RH-022	R-8
RH-023	R-7
RH-024	R-6
RH-025	R-5
RH-028	R-2
RH-029	R-1, VAN BLANT ST. PS

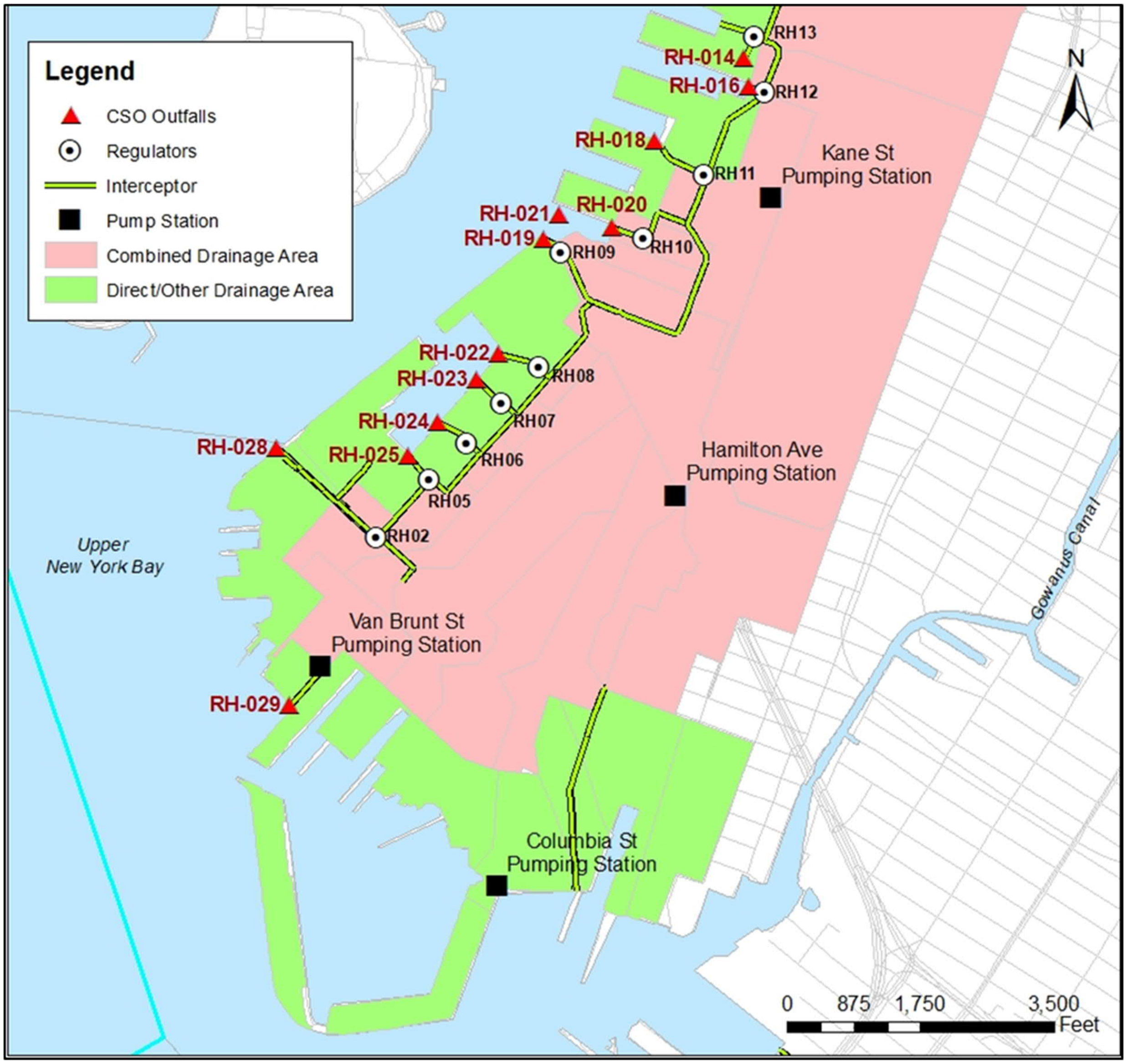


Figure 2.4-12. Red Hook WRRF Collection System

Owls Head WRRF Drainage Area and Sewer System

The Owls Head WRRF is located in the Bay Ridge section of Brooklyn, New York, on the southwestern tip of the Owls Head Park. The Owls Head WRRF serves the sewered area in the western portion of Brooklyn, including the communities of Bath Beach, Bensonhurst, Bay Ridge, Dyker Heights, Fort Hamilton, Borough Park, Ocean Parkway, Flatbush, Sunset Park, Windsor Terrace, Kensington, Prospect Park South, Gravesend, Prospect Lefferts Gardens, and Park Slope. The Owls Head WRRF has been providing full secondary treatment since 1995. Treatment processes include: primary screening; raw sewage pumping; grit removal and primary settling; air activated sludge capable of operating in the step aeration mode; final settling; and chlorine disinfection. The Owls Head WRRF has a design dry-weather flow capacity of 120 MGD, and is designed to receive a maximum wet-weather flow of 240 MGD (2xDDWF), with 180 MGD (1.5xDDWF) receiving secondary treatment. Flows over 180 MGD receive primary treatment and disinfection.

A total of 10 CSO outfalls from the Owls Head WRRF system are permitted to discharge to the Upper Bay and one CSO outfall from the Owls Head WRRF is permitted to discharge to the Lower Bay during wet-weather. Table 2.4-5 lists the CSO outfalls that are tributary to New York Bay from the Owls Head WRRF sewershed, along with their associated regulators/relief structures. Figure 2.4-13 shows the main features of the Owls Head WRRF collection system and the sewershed tributary to the Bay.

Table 2.4-5. CSO Outfalls Tributary to the New York Bay from the Owls Head WRRF Service Area

Outfall	Regulator(s)
OH-002	REG #6A, 6B, 6C
OH-003	REG #7A, 7B, 7C
OH-004	REG #7D, 19th St. PS
OH-015	REG #9A, 9B, 9C
OH-017	REG #1
OH-018	REG #2, 3
OH-019	REG #4
OH-020	REG #5
OH-022	2nd Ave Sewer Relief
OH-025	Bush Terminal PS

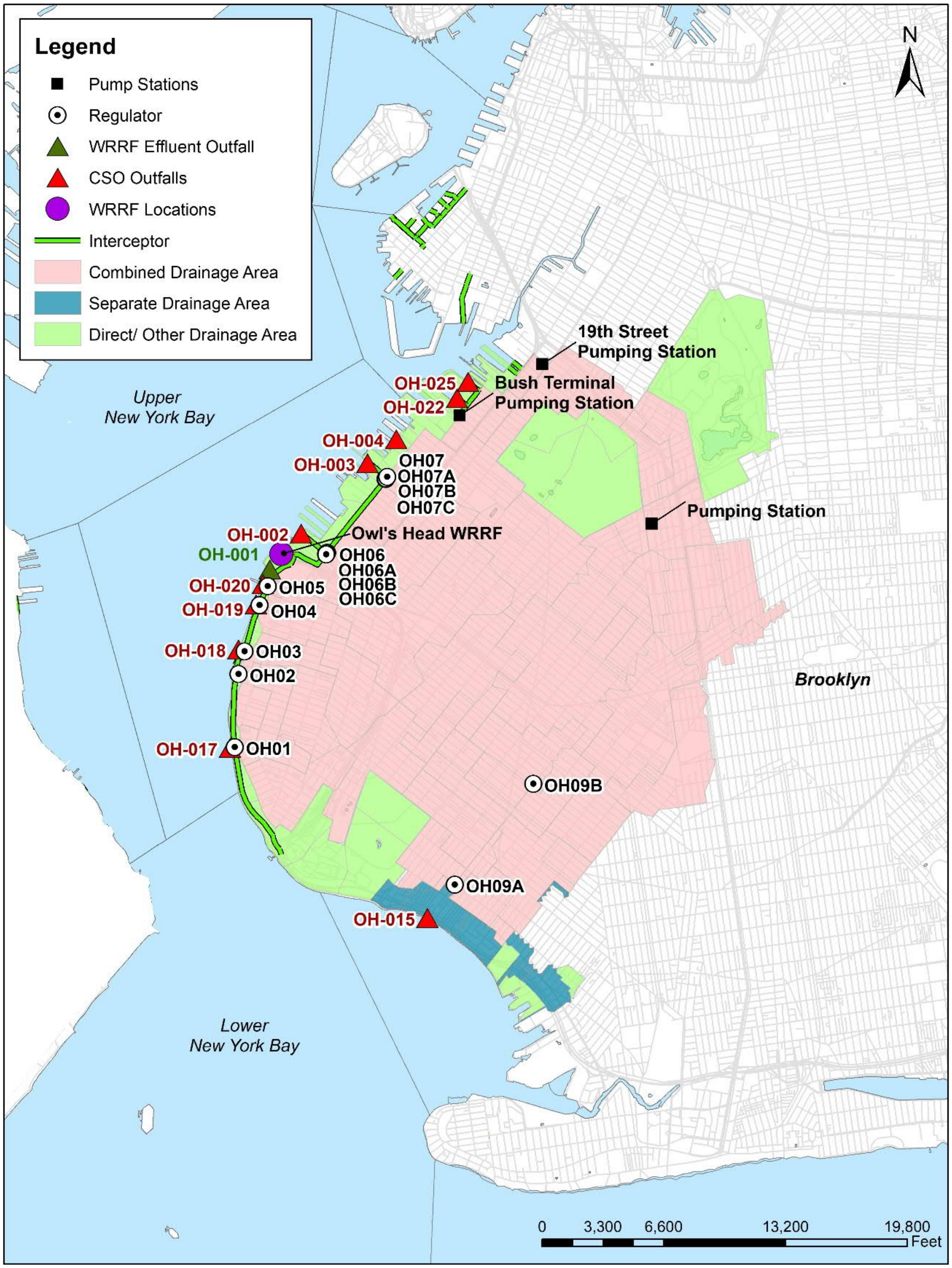


Figure 2.4-13. Owls Head WRRF Collection System

Port Richmond WRRF Drainage Area and Sewer System

The Port Richmond WRRF is located at 1801 Richmond Terrace in the Port Richmond section of Staten Island, New York. The Port Richmond WRRF serves the sewered area in the northeastern portion of Staten Island, including the communities of Howland Hock, Arlington, Old Place, Marnier's Harbor, Port Ivory, Graniteville, Port Richmond, Westerleigh, Livingston, Elm Park, West New Brighton, Silver Lake, St. George, Ward Hill, Stapleton, Grymes Hill, Clifton, Fox Hills, Rosebank, Shore Acres, Bloomfield, Chelsea, Travis, Bulls Head, Emerson Hill, Concord, Grasmere, and Arrochar. The Port Richmond WRRF has been providing full secondary treatment since 1979. Treatment processes include: primary screening; raw sewage pumping; grit removal and primary settling; air activated sludge capable of operating in the step aeration mode; final settling; and chlorine disinfection. The Port Richmond WRRF has a design dry-weather flow capacity of 60 MGD, and is designed to receive a maximum wet-weather flow of 120 MGD (2xDDWF), with 90 MGD (1.5xDDWF) receiving secondary treatment. Flows over 90 MGD receive primary treatment and disinfection.

A total of 15 CSO outfalls from the Port Richmond WRRF system are permitted to discharge to the Upper Bay and the Narrows during wet-weather. Table 2.4-6 lists the CSO outfalls that are tributary to New York Bay from the Port Richmond WRRF sewershed, along with their associated regulators/relief structures.

Figure 2.4-14 shows the main features of the Port Richmond WRRF collection system and sewershed tributary to the Bay.

Table 2.4-6. CSO Outfalls Tributary to the New York Bay from the Port Richmond WRRF Service Area

Outfall	Regulator(s)
PR-010	R-19
PR-011	R-18
PR-013	R-17
PR-014	R-15
PR-015	R-11
PR-016	R-10
PR-017	R-9
PR-018	R-8
PR-019	R-7
PR-020	R-5
PR-021	R-4
PR-023A	R-2
PR-030	R-6
PR-031	13
PR-032	16

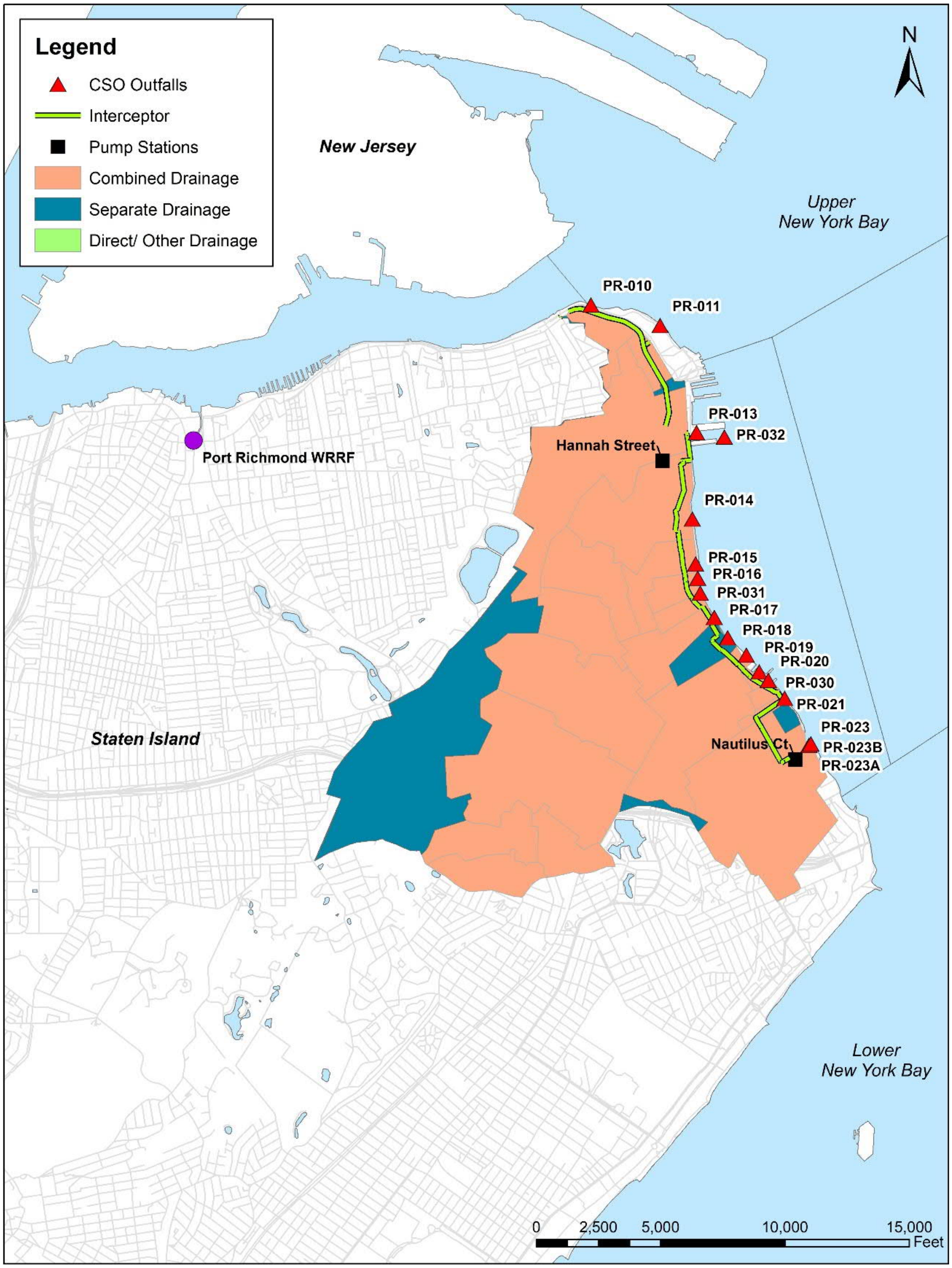


Figure 2.4-14. Port Richmond WRRF Collection System

Oakwood Beach WRRF Drainage Area and Sewer System

The Oakwood Beach WRRF is located at 683 Mill Road in the Oakwood section of Staten Island, New York, adjacent to Great Kills Park. The Oakwood Beach WRRF treats wastewater from a separate sanitary system, which serves a population of approximately 245,000. A separate storm sewer system drains stormwater flow from an area of almost 10,779 acres. The Oakwood Beach WRRF began operating in 1956. Treatment processes include: primary screening; raw sewage pumping; grit removal and primary settling; air activated sludge capable of operating in the step aeration mode; final settling; and chlorine disinfection. The Oakwood Beach WRRF has a design dry-weather flow capacity of 39.9 MGD, and is designed to receive a maximum wet--weather flow of 79.8 MGD (2xDDWF), with 59.9 MGD (1.5xDDWF) receiving secondary treatment. Flows over 59.9 MGD receive primary treatment and disinfection.

The Oakwood Beach WRRF collection system has no CSO outfalls.

Stormwater and Wastewater Characteristics

Data collected from sampling events were used to estimate concentrations for fecal coliform bacteria and *Enterococci* bacteria to use in calculating loadings from various sources discharging to New York Bay. CSO concentrations were measured in 2017 to provide site-specific information for Outfalls OH-003, OH-015, OH-017, and PR-031. The CSO bacteria concentrations were characterized by direct measurements of at least four CSO events during various storms occurring during the months of August through December 2017. These concentrations are shown in the form of a cumulative frequency distribution in Figure 2.4-15 through Figure 2.4-18. Individual sample points are shown, as well as the trend line that best fits the data distribution. For all outfalls, measured fecal coliform and *Enterococci* concentrations were log-normally distributed. Table 2.4-7 below provides the geometric mean and ranges of the measured CSO fecal coliform and *Enterococci* concentrations for each outfall.

Flow monitoring data were also collected for CSO Outfalls OH-003, OH-015, OH-017, and PR-031 to support the development of the Citywide/Open Waters LTCP. Descriptions of the Red Hook, Owls Head, Coney Island, Oakwood Beach, and Port Richmond WRRFs IW model updates and calibration processes based on the flow monitoring data gathered for these outfalls was provided earlier in Section 2.4.a.1.

Sampling, data analyses, and water quality modeling calibration resulted in the assignment of flows and loadings to these sources for inclusion in the calibration/validation of the water quality model. The CSO and stormwater concentrations used for the water quality evaluation in this LTCP are described in Section 6 of this LTCP.

Table 2.4-7. New York Bay Measured CSO Bacteria Concentrations

Outfall	Fecal Coliform (cfu/100mL)	*Enterococci* (cfu/100mL)
OH-003	380,000 – 5,800,000	27,000 – 2,200,000
OH-015	1,600,000 – 3,900,000	480,000 – 1,300,000
OH-017	1,700,000 – 25,000,000	320,000 – 2,700,000
PR-031	44,000 – 5,700,000	43,000 – 700,000

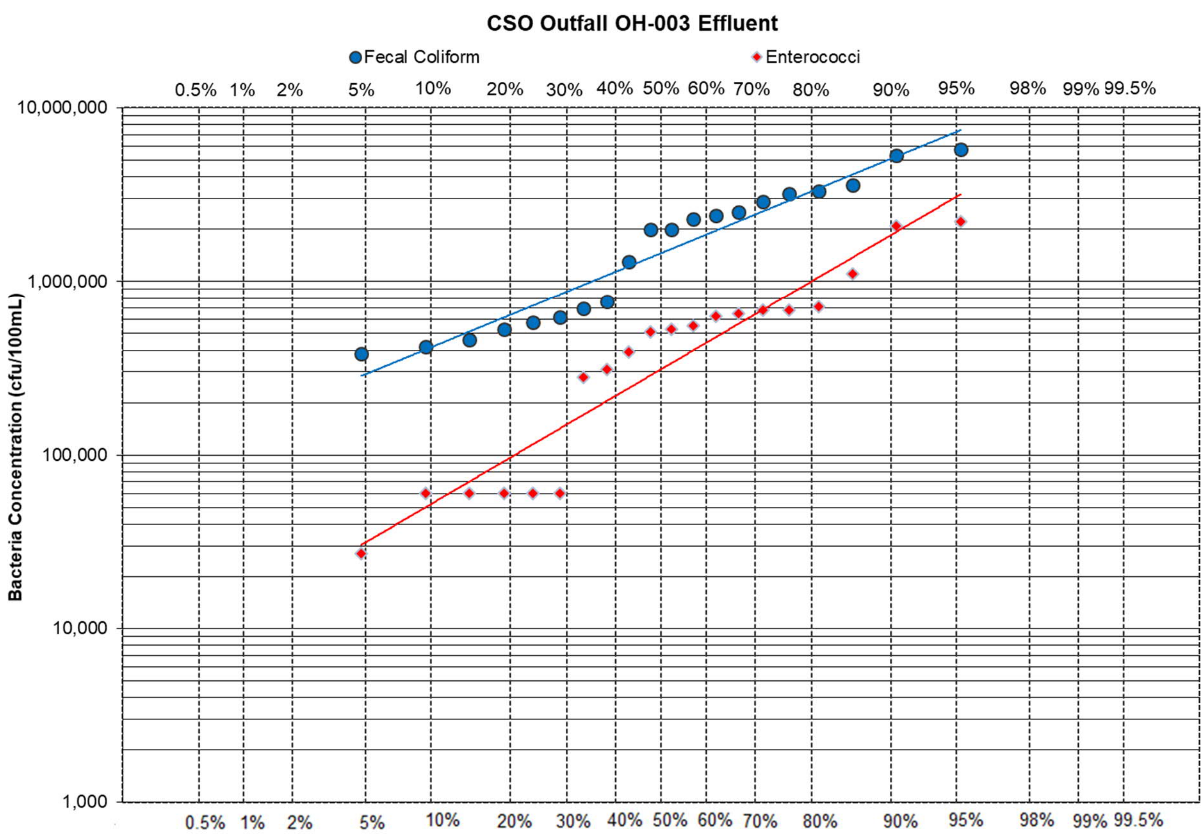


Figure 2.4-15. Outfall OH-003 Measured CSO Bacteria Concentrations

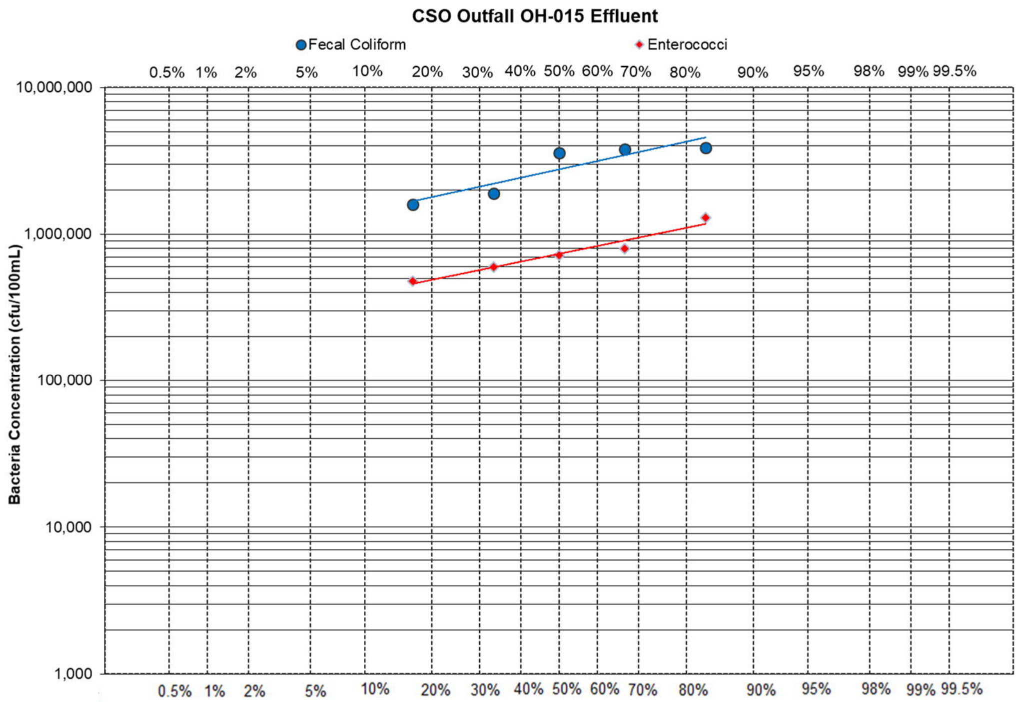


Figure 2.4-16. Outfall OH-015 Measured CSO Bacteria Concentrations

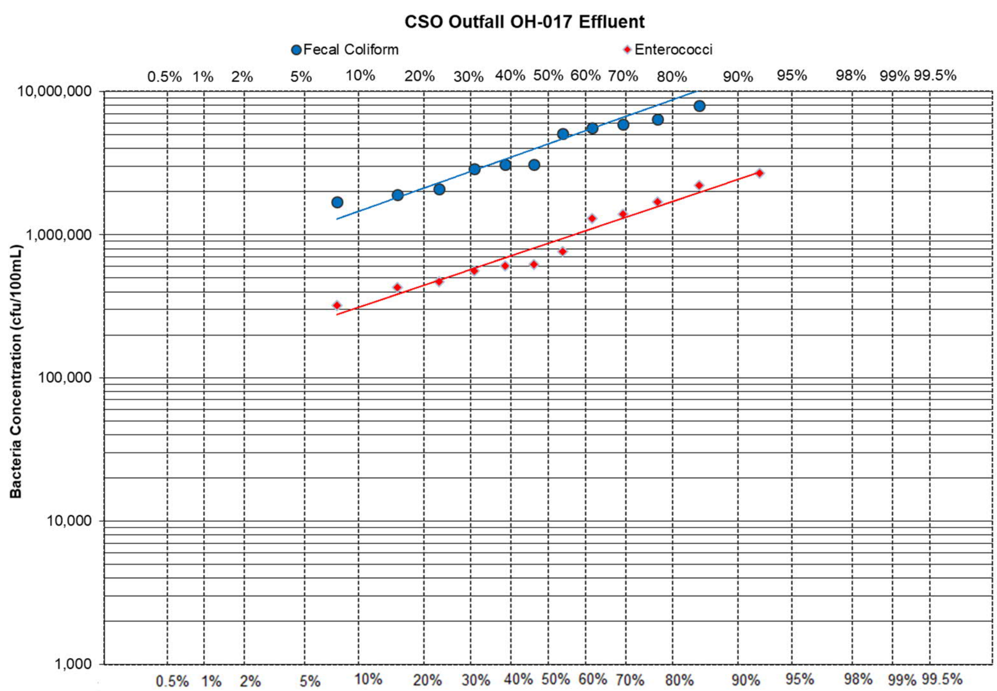


Figure 2.4-17. Outfall OH-017 Measured CSO Bacteria Concentrations

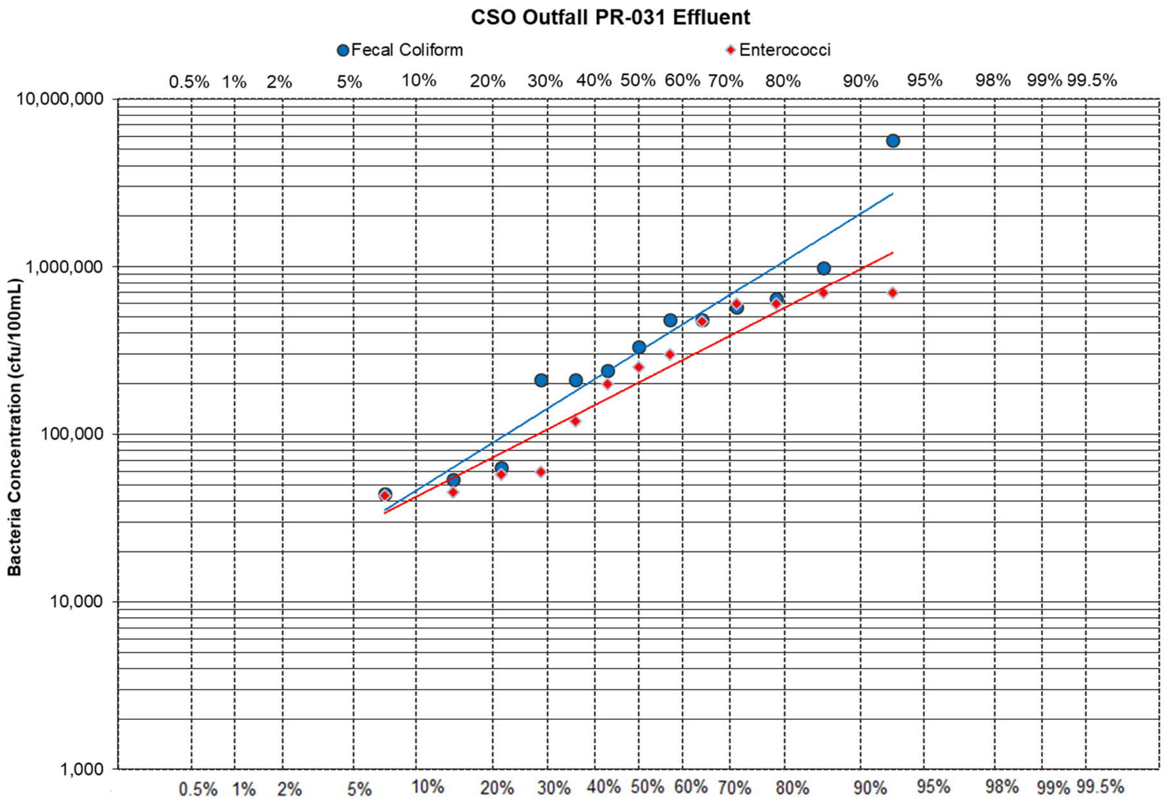


Figure 2.4-18. Outfall PR-031 Measured CSO Bacteria Concentrations

Hydraulic Analysis of Sewer System

A citywide hydraulic analysis was completed in December 2012 to provide further insight into the hydraulic capacities of key system components and system responses to various wet-weather conditions. The results of this analysis for the Red Hook WRRF are described in Section 2.3.b. An analysis was not completed for the Oakwood Beach WRRF, which is a separately sewered area. The following presents a summary of the results for the Owls Head and Port Richmond WRRFs.

Owls Head - Annual Hours at 2xDDWF for 2008 with Projected 2040 DWF

Model simulations were conducted to estimate the annual number of hours that the Owls Head WRRF would be expected to treat 2xDDWF for the 2008 precipitation year. These simulations were conducted using projected 2040 DWF for two model input conditions – the recalibrated model conditions as described in the December 2012 IW Citywide Recalibration Report (DEP, 2012a), and the Cost-Effective Grey (CEG) alternative defined for the sewershed. The CEG elements represent the CSO controls that became part of the CSO Order with DEC. The only CEG condition applicable to the Owls Head sewershed was the Avenue V Pumping Station upgrade. For these simulations, the primary input conditions applied were as follows:

- Projected 2040 DWF conditions.
- 2008 tides and precipitation data.
- Owls Head WRRF at 2xDDWF capacity of 240 MGD.
- No sediment in the combined sewers (i.e., clean conditions).
- Sediment in interceptors representing the sediment conditions after the inspection and cleaning program was completed in 2011 and 2012.
- No green infrastructure in combined areas.

Key observations/findings are summarized below:

- Simulation of the 2008 annual rainfall year resulted in a prediction that the Owls Head WRRF would operate at its 2xDDWF capacity for 105 hours under the no-CEG condition. When the CEG conditions were applied in the model, the annual number of hours at 2xDDWF were slightly less at 98 hours.
- The total volume (dry- and wet-weather combined) treated annually at the Owls Head WRRF for the 2008 non-CEG condition was predicted to be about 38,064 MG, while the 2008 with-CEG condition resulted in a predicted 38,074 MG treated at the plant – an increase of 10 MG.
- The total annual CSO volume predicted for the outfalls in the Owls Head sewershed were as follows:
    - 2008 non-CEG: 2,198 MG
    - 2008 with-CEG: 2,196 MG

The above results indicate a slight decrease in the number of hours at the 2xDDWF operating capacity for the Owls Head WRRF, a slight increase in annual volume being delivered to the WRRF, and a slight decrease in CSO volume from the outfalls in the sewershed.

Port Richmond - Annual Hours at 2xDDWF for 2008 with Projected 2040 DWF

Model simulations were conducted to estimate the annual number of hours that the Port Richmond WRRF would be expected to treat 2xDDWF for the 2008 precipitation year. These simulations were conducted using projected 2040 DWF for two model input conditions – the recalibrated model conditions as described in the December 2012 IW Citywide Recalibration Report (DEP, 2012a), and the Cost -Effective Grey (CEG) alternative defined for the sewershed. The CEG elements represent the CSO controls that became part of the CSO Order. No CEG alternatives were identified for this sewershed at that time, so the with-CEG model results would be identical to the without-CEG results. For these simulations, the primary input conditions applied were as follows:

- Projected 2040 DWF conditions.
- 2008 tides and precipitation data.
- Port Richmond WRRF at 2xDDWF capacity of 120 MGD.
- No sediment in the combined sewers (i.e., clean conditions).
- Sediment in interceptors representing the post-interceptor sediment conditions after the inspection and cleaning program completed in 2011 and 2012.
- No green infrastructure.

Key observations/findings are summarized below:

- Simulation of the 2008 annual rainfall year resulted in a prediction that the Port Richmond WRRF would operate at its 2xDDWF capacity for 27 hours under the no-CEG condition.
- The total volume (dry- and wet-weather combined) treated annually at the Port Richmond WRRF for the 2008 non-CEG condition was predicted to be about 11,784 MG.
- The total annual CSO volume predicted for the outfalls in the Port Richmond WRRF sewershed for the non-CEG condition was 772 MG.

Identification of Areas Prone to Flooding and History of Confirmed Sewer Backups

DEP maintains and operates the collection system throughout the five boroughs. To do so, DEP employs a combination of reactive and proactive maintenance techniques. NYC's "311" system routes public complaints of sewer issues to DEP for response and resolution. Although not every call that reports flooding or sewer backups corresponds to an actual issue with the municipal sewer system, each call to 311 is responded to. Sewer functionality impediments identified during a DEP response effort are corrected as necessary.

Findings from Interceptor Inspections

DEP has several programs with staff devoted to sewer maintenance, inspection, and analysis, and regularly inspects and cleans its sewers, as reported in the SPDES BMP Annual Reports. In the last decade, DEP has implemented advanced technologies and procedures to enhance its proactive sewer maintenance practices. GIS and Computerized Maintenance and Management Systems provide DEP with expanded data tracking and mapping capabilities, through which it can identify and respond to trends to better serve its customers. Both reactive and proactive system inspections result in maintenance, including cleaning and repairing, as necessary**.** Figure 2.4-19 and Figure 2.4-20 show the intercepting sewers that were inspected in the Boroughs of Brooklyn and Staten Island, respectively, encompassing the New York Bay sewershed. Throughout 2018, no sediment was removed from the Owls Head, Red Hook, Port Richmond, or Oakwood Beach WRRF intercepting sewers. Citywide, the inspection of 145,911 feet of intercepting sewers resulted in the removal of 6,112 cubic yards of sediment.

As described in Section 2.1.a.1 DEP's recent sediment accumulation analysis found that the aggregate mean sediment level for the entire NYC system was approximately 1.25 percent, with a standard deviation of 2.02 percent.

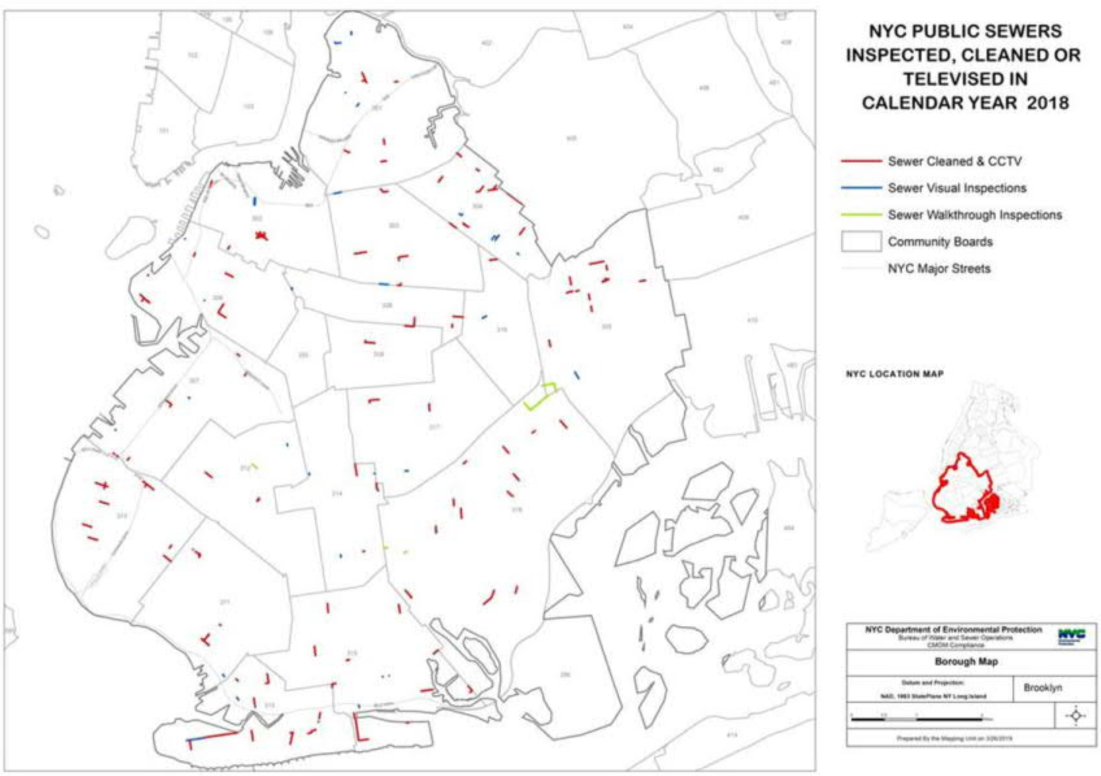


Figure 2.4-19. Sewers Inspected and Cleaned in Brooklyn Throughout 2018

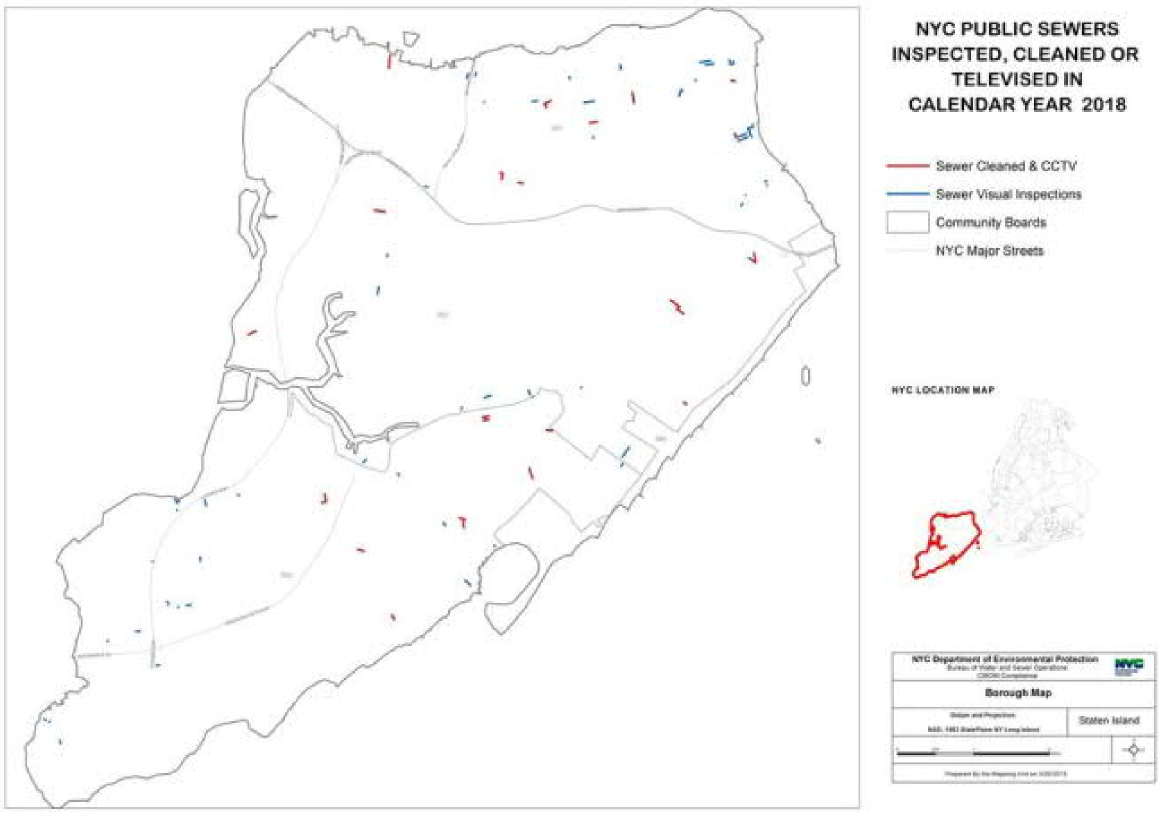


Figure 2.4-20. Sewers Inspected and Cleaned in Staten Island Throughout 2018

2.4.b Waterbody Characteristics

This section describes the features and attributes of New York Bay.

2.4.b.1 Description of Waterbody

New York Bay is a large natural harbor bordering on portions of the Boroughs of Manhattan, Brooklyn, and Staten Island in New York. The Upper Bay is fed by the waters of the Hudson River and East River, while the Lower Bay opens directly into the Atlantic Ocean. Water quality in New York Bay is influenced by CSO and stormwater discharges, as well as tidal exchanges with the Hudson River, East River, Kill Van Kull, Jamaica Bay, and the Atlantic Ocean. The following section describes the current water quality characteristics of New York Bay, along with its uses.

2.4.b.2 Current Waterbody Classification(s) and Water Quality Standards

New York State Policies and Regulations

In accordance with the provisions of the CWA, the State of New York has established WQS for all navigable waters within its jurisdiction. DEC has classified Upper and Lower New York Bay as a Class SB Coastal Primary Recreational waterbody (Figure 2.4-21).

Numerical standards corresponding to these waterbody classifications are shown in Table 2.1-5 (Section 2.1.b.2), while narrative WQS criteria are presented in Table 2.1-6 (Section 2.1.b.2).

Interstate Environmental Commission

The States of New York, New Jersey, and Connecticut are signatories to the Tri-State Compact that designated the Interstate Environmental District and created the Interstate Environmental Commission (IEC). The IEC includes all saline waters of greater NYC. New York Bay is an interstate water and is regulated by IEC as Class A and B-1 waters for the Lower Bay and Upper Bay, respectively. Numerical and narrative standards for IEC-regulated waterbodies are shown in Table 2.1-7 (Section 2.1.b.2) and Table 2.1-8 (Section 2.1.b.2).

EPA Policies and Regulations

EPA reference levels for designated bathing beach areas, non-designated beach areas of primary contact recreation, and 2012 RWQC recommendations are summarized in Section 2.3.b.2. In the context of the water quality criteria, New York Bay is classified as a coastal primary recreational waterbody, so the *Enterococci* criteria shown in Table 2.3-9 (Section 2.3.b.2) that are consistent with the 2012 RWQC would apply to these waters during the recreational season (May 1st through October 31st).

2.4.b.3 Physical Waterbody Characteristics

New York Bay encompasses approximately 146,000 acres and is approximately 25 miles long from the Battery to the south end of the NY Bight/Atlantic Ocean. The Upper Bay ranges in width from one to four miles, with the most narrow point located in the area between the Upper and Lower Bay called the Narrows. The Lower Bay is significantly wider with widths up to 22 miles across from Arthur Kill to the Rockaway Inlet.

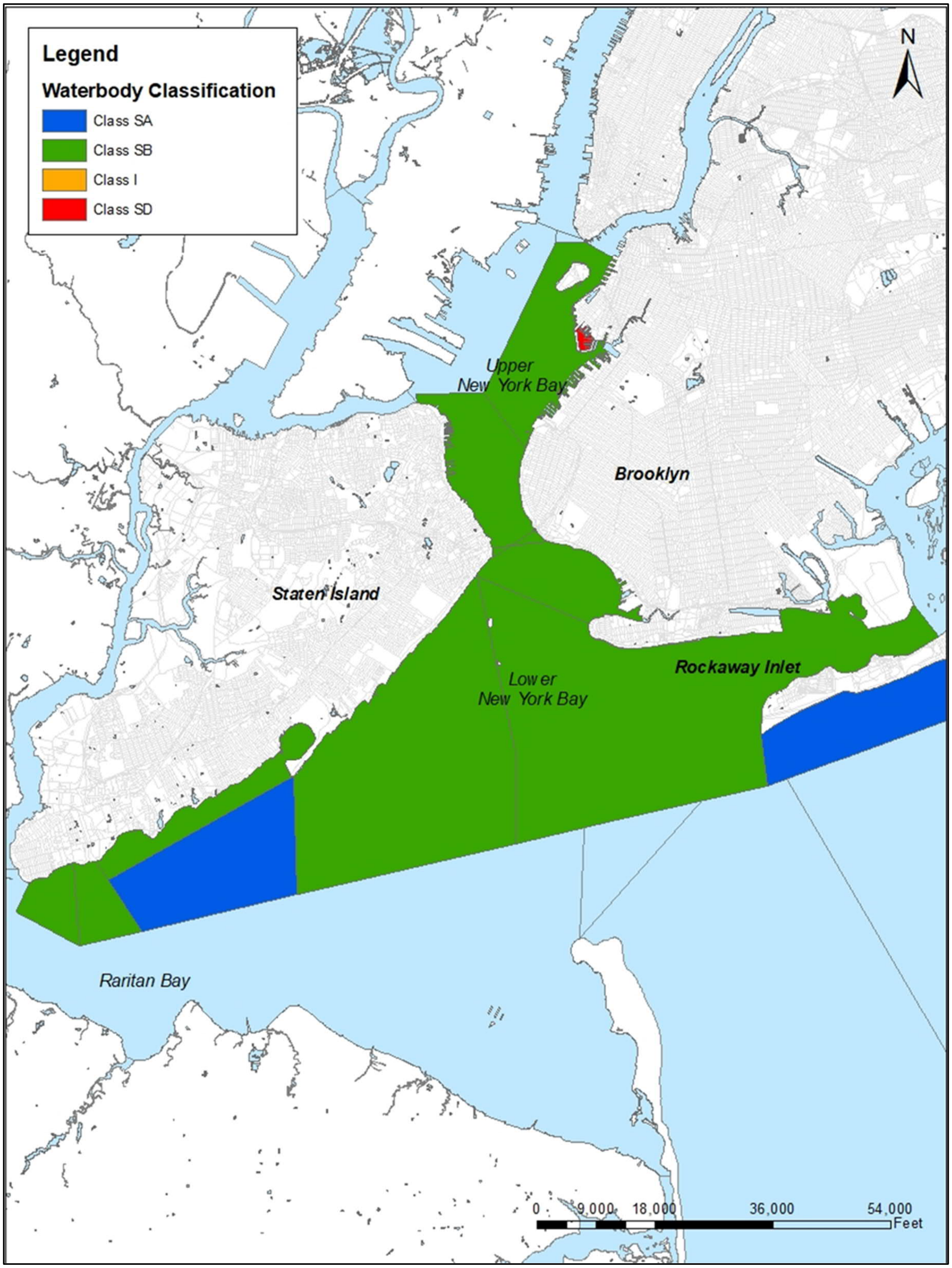


Figure 2.4-21. Waterbody Classifications for the New York Bay

Shoreline Physical Characterization

The shorelines of the Upper Bay are generally more developed than those of the Lower Bay. The Upper Bay shorelines are primarily composed of piers from the East River to the Narrows on the Brooklyn shores, and are a mix of piers, bulkhead, and riprap on the Staten Island shores. Moving into the Lower Bay, the Brooklyn shores are bulkheaded through the Narrows. The shoreline changes to riprap from the Narrows to the piers near Shore Parkway Park, before becoming natural shoreline through the Coney Island area. Natural shorelines occur from the Narrows through Wolfs Pond Park in southern Staten Island. Along the Lower Bay, groins and other reinforced structures have been installed to protect the beaches and waterfront communities. presents the distribution of shoreline characteristics within the New York Bay sewershed. Figure 2.4-23 shows an example of piers within the Upper Bay while Figure 2.4-24 shows an example of natural shorelines at Midland Beach in the Lower Bay.

Shoreline Slope

The natural or vegetated shorelines of the Lower Bay along the Coney Island peninsula, and the east and southern shores of Staten Island, are characterized by gentle and intermediate slopes. Historically, the shorelines of the Upper Bay along Brooklyn and northern Staten Island rose quickly to higher elevations. Significant extension and development of the coastlines and filling of the former marshland has altered the natural shorelines resulting in artificial shorelines or flat/gentle slopes.

Waterbody Sediment Surficial Geology/Substrata

Anthropogenic forces have influenced the surface soils that are now found in the New York Bay watershed. Many of the soils found along the shoreline have been greatly influenced by residential, commercial, and industrial development, landfilling with waste materials, and dredging operations, and are generally disturbed in some form even if they consist of local material (DEP, 2007). The bottom of New York Bay is predominantly composed of mud/silt/clay with a relatively small proportion of sand, according to data from previous studies. Sampling conducted by HydroQual in 2003 indicated an 81 percent silt-sand bottom with little to no gravel in the Upper Bay and 73 percent silt-sand bottom with little to no gravel in the Lower Bay. The composition of the mud/silt/clay designated areas ranged from 36 to 98 percent mud/silt/clay, 2 to 74 percent sand, and 0 to 1 percent gravel. Additionally, NOAA surficial sediment classifications recorded mostly mud, sand, and silty sand throughout the bottom of New York Bay.

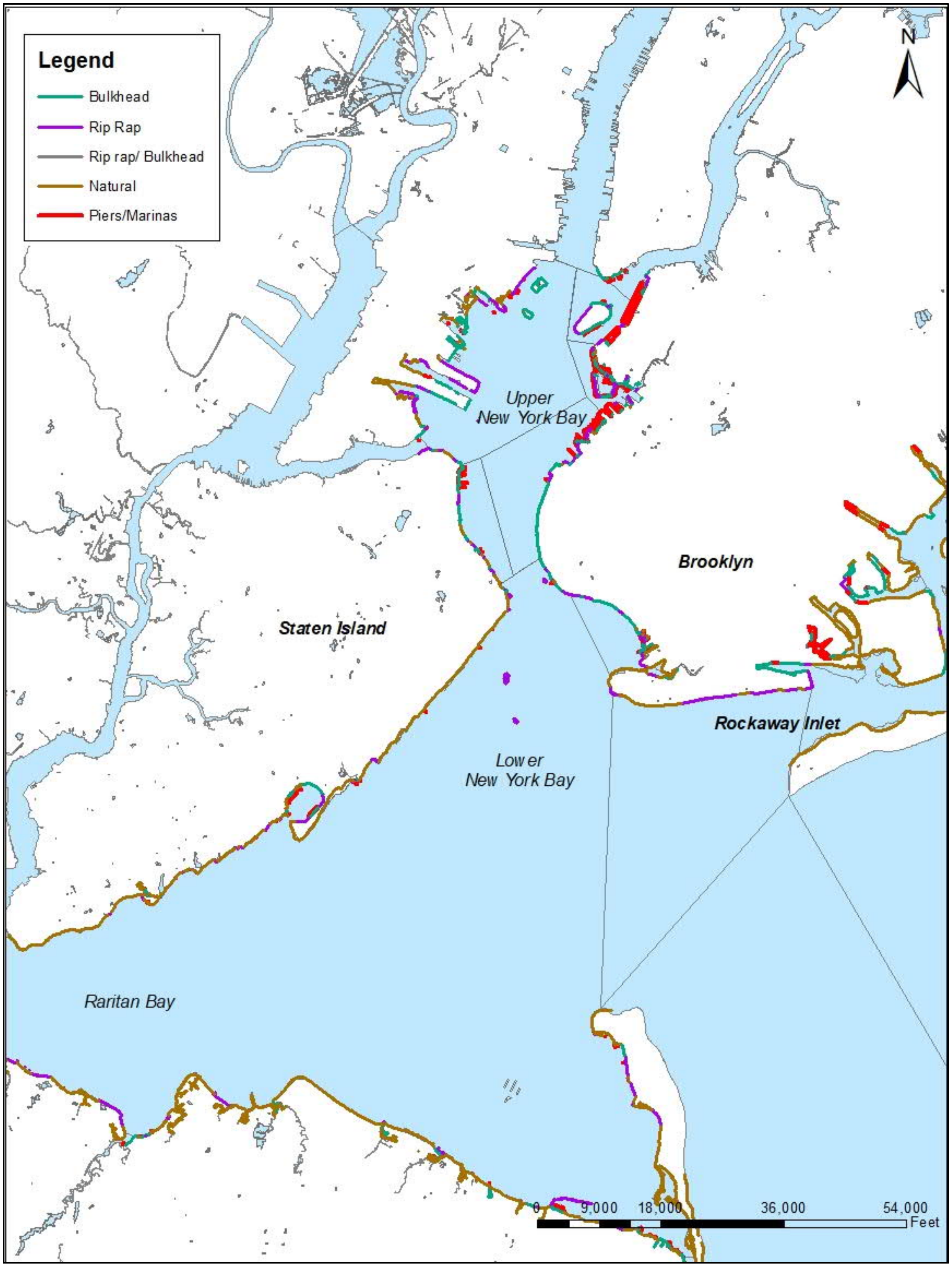


Figure 2.4-22. New York Bay Shoreline Characteristics

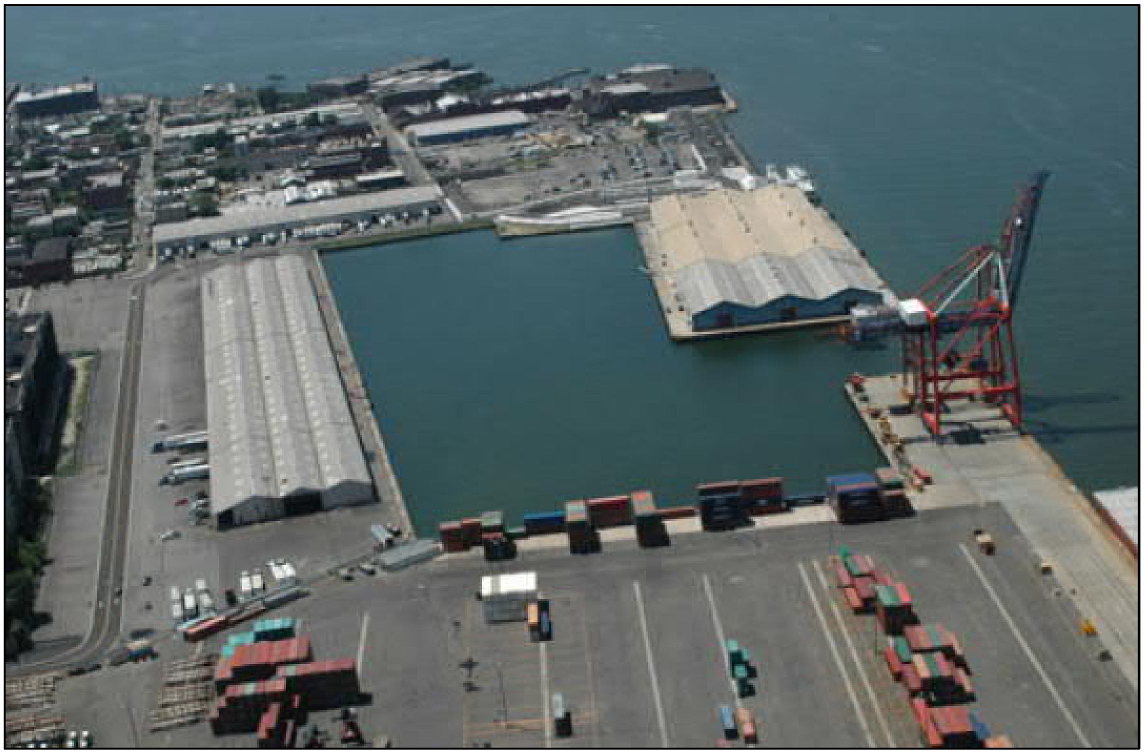


Figure 2.4-23. Piers in the Upper New York Bay

Figure 2.4-24. Natural Shoreline and Groin at Midland Beach in the Lower New York Bay

Tidal/Estuarine Systems Biological Systems

Tidal/Estuarine Wetlands

The growth and development of the area led to many changes in landforms and as a result, marshes, creeks, and lowland areas were filled. Historically the New York Bay area was home to many marshes but by 1850, marshes from Brooklyn Bridge to Bay Ridge were filled and developed.

The U.S. Fish and Wildlife Service (USFWS) National Wetlands Inventory (NWI) maps show extensive tidal/estuarine wetlands along the eastern shore of New Jersey in the Upper Bay, the majority of Staten Island's south and eastern shorelines, and Brooklyn's southeast shorelines including the tip of Coney Island, as shown in Figure 2.4-25.

Aquatic and Terrestrial Communities

The DCP Plan for the Brooklyn and Staten Island Waterfront (DCP, 1993) reports a diverse range of species supported by the habitat in the New York Bay area.

Figure 2.4-25. National Wetlands Inventory Source: NYS GIS Clearinghouse- 2014

Biological Systems

Several generalized freshwater wetlands areas are shown in DEC's Freshwater Wetlands Maps. Within the New York Bay watershed, these areas are mapped mostly on Staten Island. A DEC freshwater wetland is also identified in Brooklyn at the Dyker Beach Golf Course.

2.4.b.4 Current Public Access and Uses

In New York Bay, swimming (primary contact recreation use) is identified as a best use, as defined by New York State Codes, Rules and Regulations for Class SB waterbodies. Secondary contact recreation opportunities are also facilitated by access points along the shorelines. Figure 2.4-26 shows the public and private beaches and access locations along the shoreline of New York Bay. Figure 2.4-27 shows an example of a beach and pier at FDR Beach and Boardwalk, located on the eastern shore of Staten Island.

2.4.b.5 Identification of Sensitive Areas

Federal CSO Policy requires that the LTCP give the highest priority to controlling overflows to sensitive areas. The Policy defines sensitive areas as:

- Waters designated as Outstanding National Resource Waters (ONRW);
- National Marine Sanctuaries;
- Public drinking water intakes;
- Waters designated as protected areas for public water supply intakes;
- Shellfish beds;
- Water with primary contact recreation;
- Waters with threatened or endangered species and their habitat; and
- Additional areas determined by the Permitting Authority (i.e., DEC).

The presence/status of sensitive areas in New York Bay as defined by the Federal CSO Policy is summarized in Table 2.4-8. Sources of information supporting the status are included in the footnotes to the table.

Figure 2.4-26. Waterfront Access Points to New York Bay

AECOM with Hazen

Figure 2.4-27. Beach/Pier at Franklin D. Roosevelt Boardwalk and Beach (Source: nycgovparks.org)

Table 2.4-8. Sensitive Areas Assessment

CSO Discharge Receiving Water Segments	Presence/Status of Sensitive Areas Classifications or Designations(1)						
	Outstanding National Resource Water	National Marine Sanctuaries	Threatened or Endangered Species and their Habitat	Best Use - Primary Contact Recreation	Public Water Supply Intake	Public Water Supply Protected Area	Shellfish Bed
New York Bay	No(2)	No(3)	Yes(4)	Yes(5)	No (6)	No (6)	Yes(7)

Notes:

(1) Classifications or Designations per CSO Policy.
(2) EPA; DEC Protection of Waters Program and Environmental Resource Mapper.
(3) NOAA.
(4) USFWS; NOAA; DEC NYNHP.
(5) Waterbody is Class SB; swimming beaches are located along the shoreline of the waterbody..
(6) New York Bay is saline.
(7) 6 CRR-NY part 41. Shellfish beds off of Rockaway are outside the boundaries of New York Bay, but impacts to the shellfish beds will be assessed.

As indicated in Table 2.4-8, New York Bay falls under the category of "Best Use – Primary Contact Recreation", by virtue of its Class SB water quality classification. The locations of beaches along New York Bay are shown in Figure 2.4-26. The Upper and Lower New York Bay also fall into the category of "Waters with Threatened or Endangered Species and their Habitat". Based on the lists produced by NOAA and the New York Natural Heritage Program, threatened and endangered species with the potential to occur in the Upper and/or Lower New York Bay include the following:

- Leatherback Sea Turtle (*Dermochelys coriacea*)
- Loggerhead Sea Turtle (*Caretta caretta*)
- Kemp's Ridley Sea Turtle (*Lepidochelys kempii*)
- Green Sea Turtle (*Chelonia mydas*)
- Peregrine Falcon (*Falco peregrinus*)
- Common Tern (*Sterna hirundo*)
- Roseate Tern (*Sterna dougallii*)
- Least Tern (*Sternula antillarum*)
- Humpback Whale (*Megaptera novaeangliae*)
- Seabeach Amaranth *Amaranthus pumilus*
- Oakes' Evening Primrose *(Oenothera oakesiana)*
- Dune Sandspur *(Cenchrus tribuloides)*
- Fringed Boneset *(Eupatorium torryanum)*
- Great Plains Flat Sedge (*Cyperus lupulinus ssp. lupulinus)*
- Trinerved White Boneset *(Eupatorium subvenosum)*

The US Fish and Wildlife Service lists the following with the potential to occur in the Citywide/Open Waters project area:

- Piping Plover (*Charadrius melodus)*
- Red Knot (*Calidris canutus rufa*)

- Roseate Tern (*Sterna dougallii dougallii*)
- Bog Turtle (*Clemmys muhlenbergii*)Indiana Bat (*Myotis sodalist*)
- Northern Long-eared Bat (*Myotis septentrionalis*)
- Sandplain Gerardia (*Agalinis acuta*)
- Seabeach Amaranth (*Amarnthus pumilus*)

Of the species listed above, none was identified as having critical habitat present in the project area.

Although no certified shellfish beds as defined in 6 CRR-NY part 41 are located in New York Bay, the shellfish beds along the Atlantic coast of Rockaway are adjacent to New York Bay. Accordingly, the potential impacts of CSO discharges on those shellfish beds will be assessed.

2.4.b.6 Compilation and Analysis of Existing Water Quality Data

New York Bay water quality data are available from sampling conducted by DEP's HSM program from 2007 to 2018, and from intensive sampling conducted from October through December 2017 to support the Citywide/Open Waters LTCP. The sampling locations for both programs are shown in Figure 2.4-28. The DEP's HSM program focuses on the water quality parameters of fecal coliform and *Enterococci* bacteria, DO, chlorophyll 'a', and Secchi disk transparency. HSM data are organized into four geographic regions within the Harbor, and the Upper Bay is located within the Inner Harbor section while the Lower Bay/Raritan Bay is located in the Lower Bay section. Seven HSM stations are located within New York Bay, designated as N6, N7, N8, GB1, N9, K5, and K5A. In addition to the HSM program, DEP also operates a Sentinel Monitoring (SM) Program, targeted at identifying illicit discharges to the waterbodies through changes to baseline sampling concentrations. The SM program collects quarterly dry-weather fecal coliform data from nine stations in the Bay (S18, S19, S39 to S44, and S73). LTCP sampling was conducted at 13 stations within the Bay. The HSM, SM, and LTCP sampling locations are all shown in Figure 2.4-28. Figure 2.4-29 and Figure 2.4-30 show the GM, minimum, maximum, 25th percentile, and 75th percentile values for fecal coliform and *Enterococci*, respectively, for the LTCP sampling data. Figure 2.4-31 and Figure 2.4-32 show similar data for the HSM sampling program from 2014 through 2016.

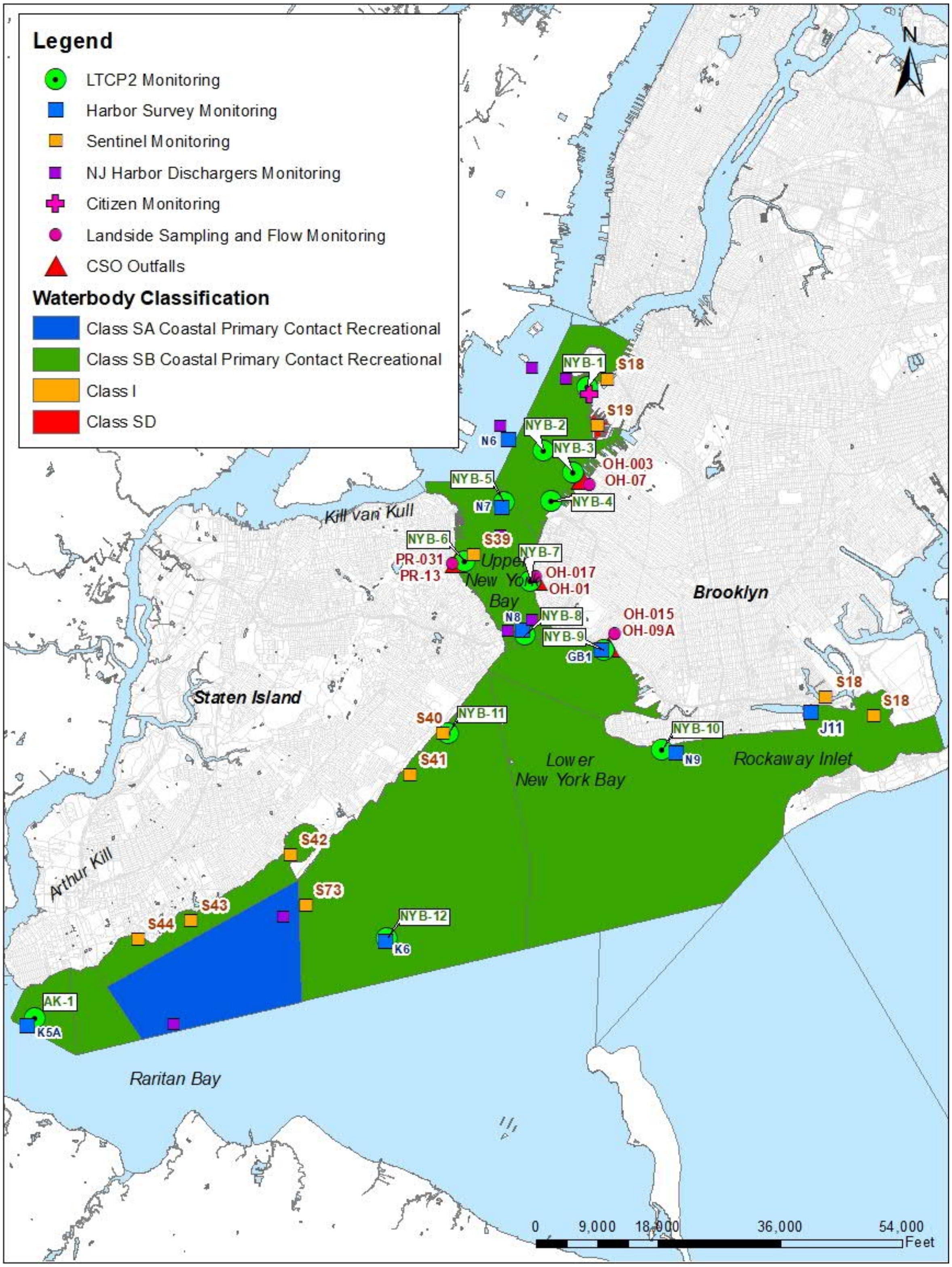


Figure 2.4-28. Water Quality Monitoring Sampling Locations within New York Bay

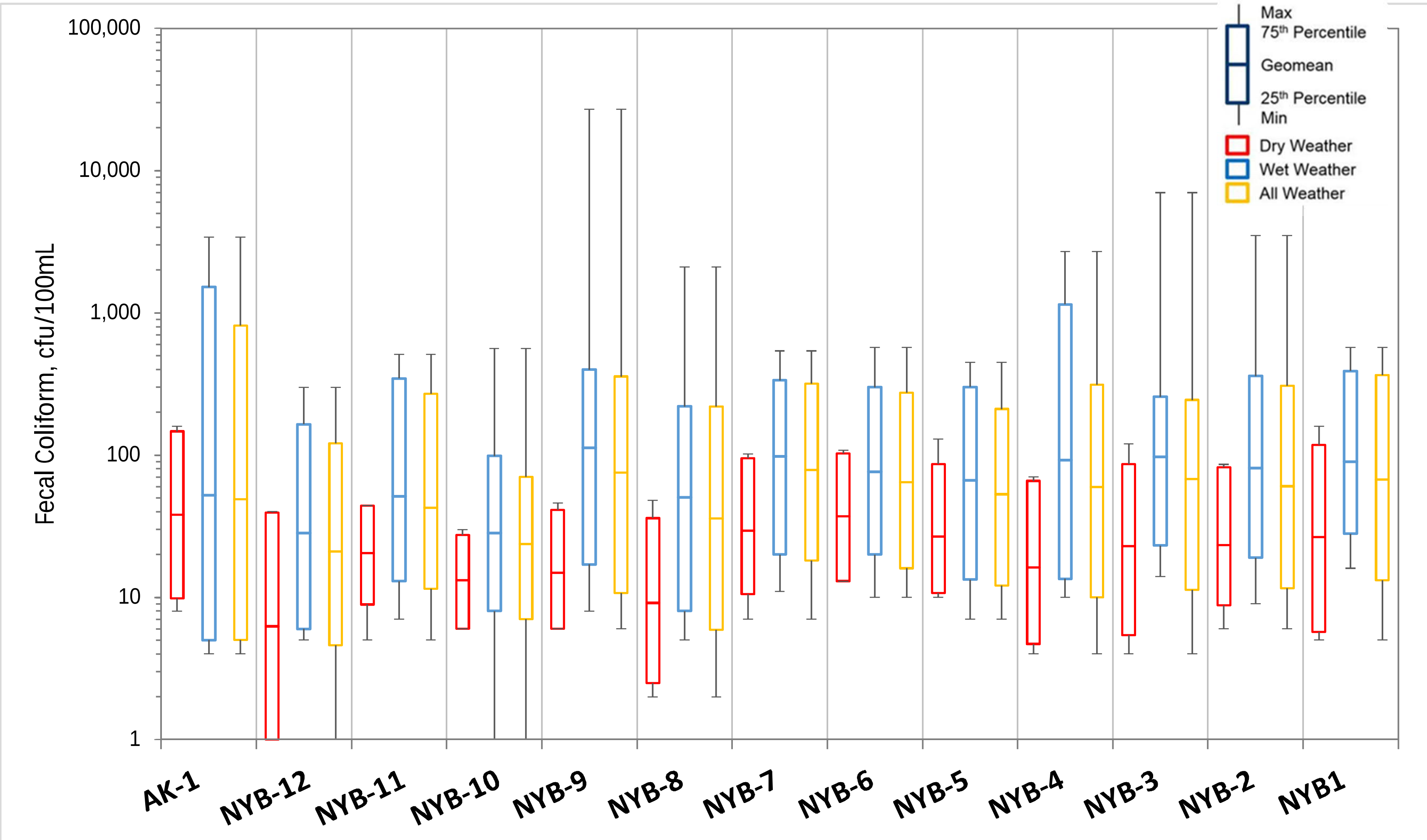


Figure 2.4-29. Fecal Coliform Concentrations at LTCP2 Sampling Stations in New York Bay

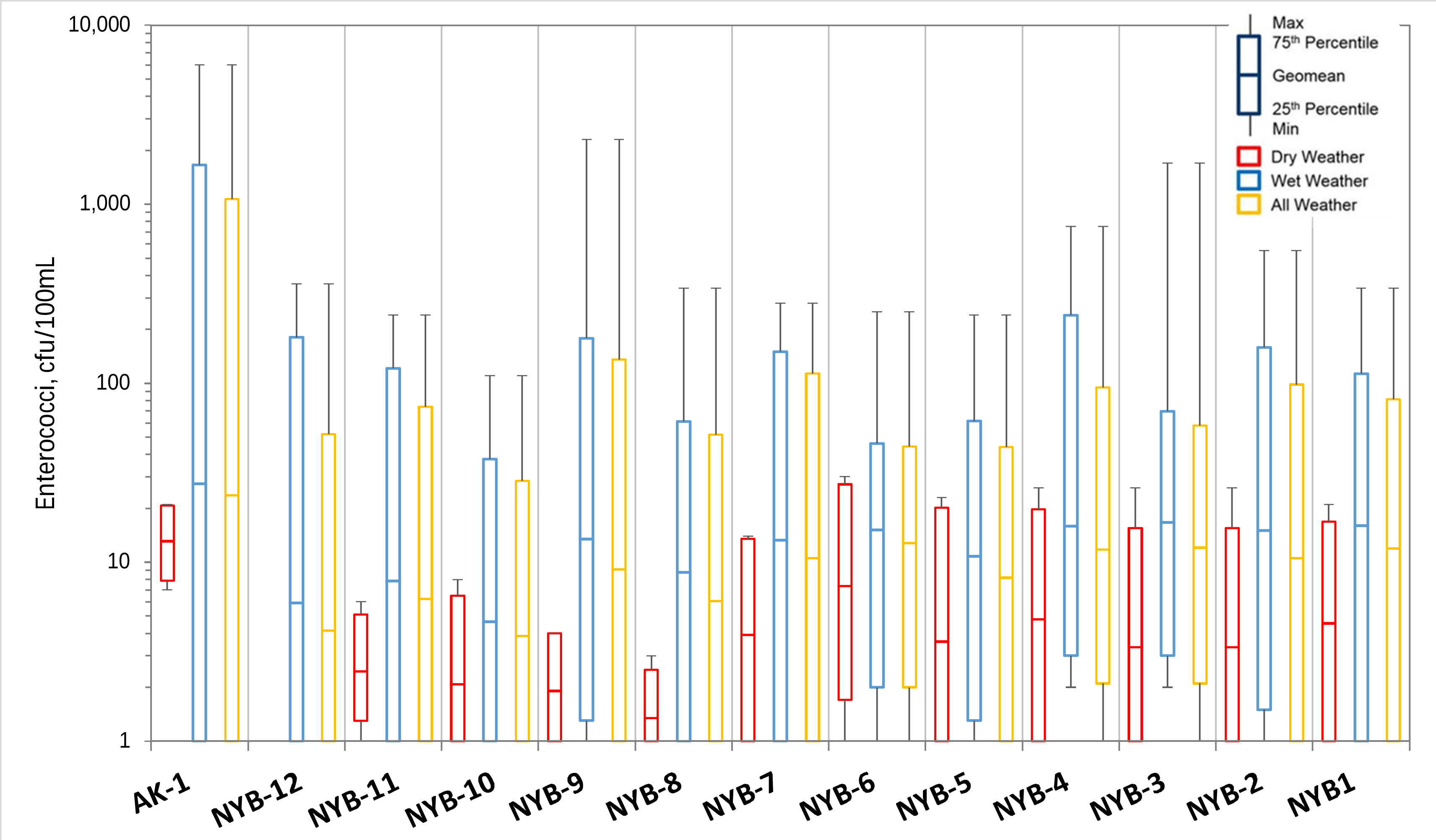


Figure 2.4-30. ***Enterococci*** **Concentrations at LTCP2 Sampling Stations in New York Bay**

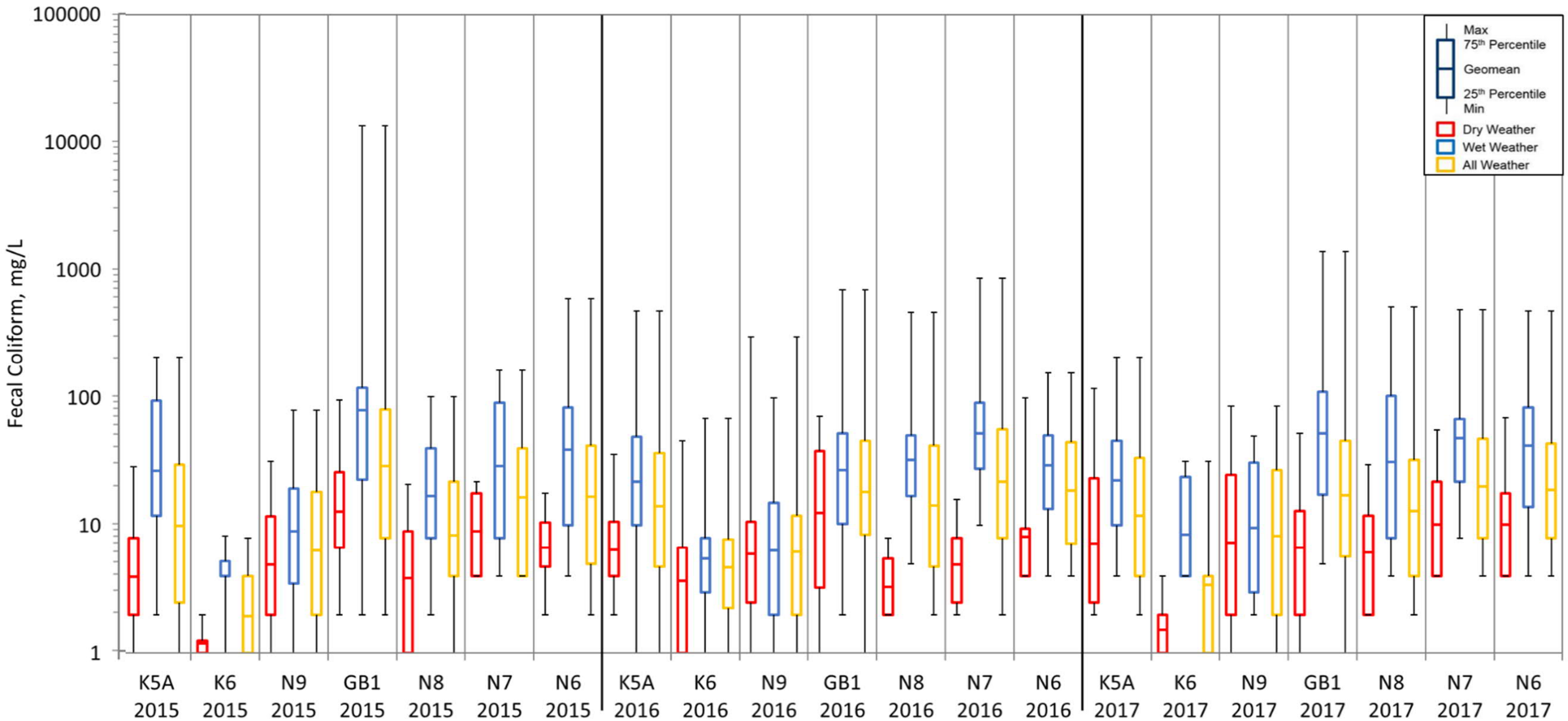


Figure 2.4-31. Fecal Coliform Concentrations at HSM Sampling Stations in New York Bay

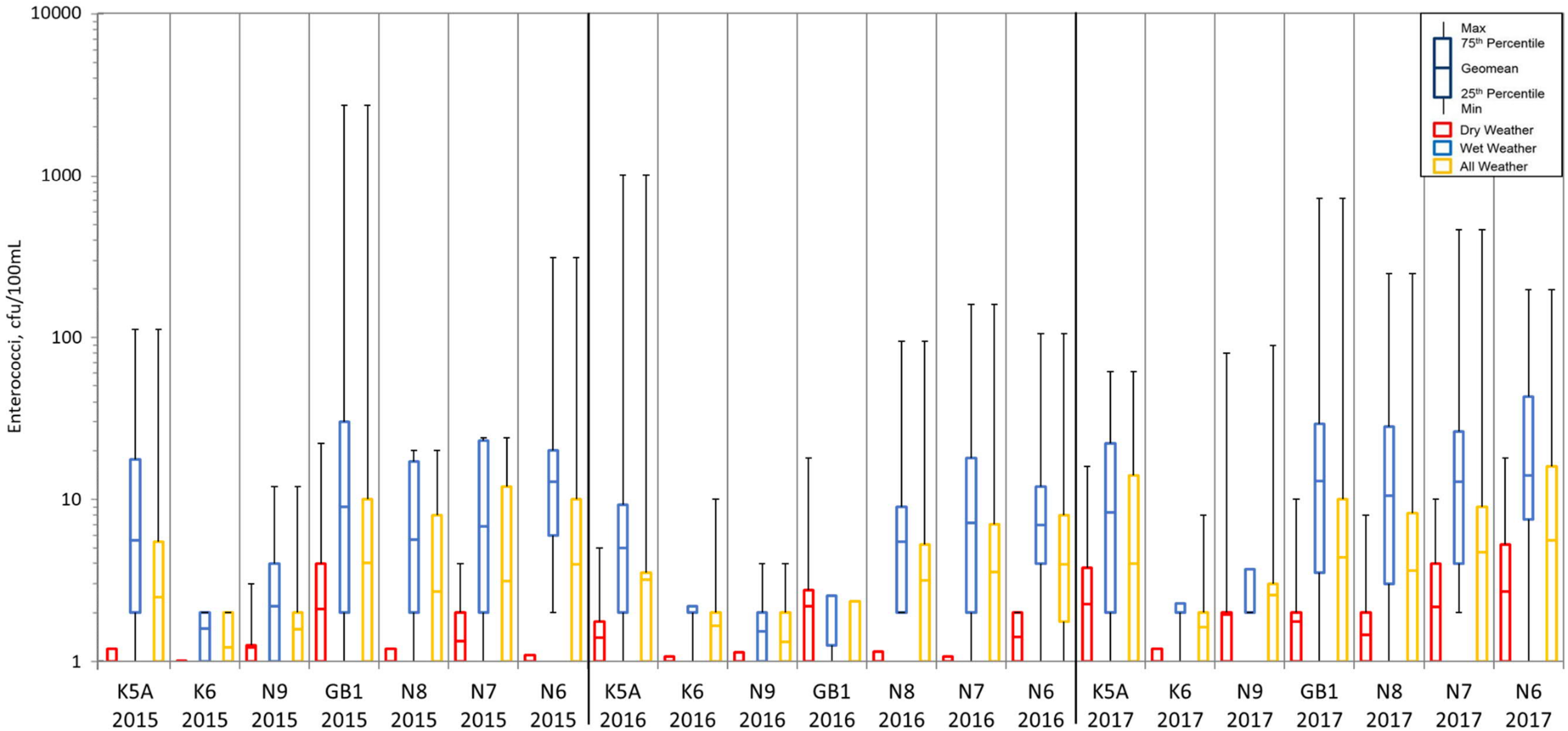


Figure 2.4-32. *Enterococci* Concentrations at HSM Sampling Stations in New York Bay

The fecal coliform levels measured throughout the LTCP sampling program in wet-weather were generally higher than the levels measured during dry-weather, indicative of the impacts of wet-weather pollution sources on New York Bay. However, as indicated in Figure 2.4-29, the wet-weather geometric means at each of the New York Bay LTCP sampling stations were all below 200 cfu/100mL, indicating that the wet-weather impacts were relatively limited. The LTCP *Enterococci* data generally followed a similar trend as the fecal coliform data, with wet-weather geometric means higher than dry-weather geometric means, but the wet-weather geometric means were all below 30 cfu/100mL (Figure 2.4-30).

The HSM fecal coliform data presented in Figure 2.4-31 are also consistent with the LTCP2 data. While a wet-weather impact is evident, the geometric means of the fecal coliform data were all below 200 cfu/100mL. HSM *Enterococci* data showed generally a similar pattern (Figure 2.4-32).

Data collected by the Passaic Valley Sewerage Commission (PVSC) NJ Harbors Monitoring was also consistent with the LTCP and HSM data. GMs for both fecal coliform and *Enterococci* were in the same general range as for the LTCP and HSM data at adjacent sampling stations for both dry- and wet-weather conditions.

Data collected by the Citizens Testing Group is also made available to the public by the Riverkeeper Group. This dataset is limited to *Enterococci* bacteria concentrations for one sampling station along Brooklyn's western shoreline, as shown in Figure 2.4-28. These data are available at the Riverkeeper Group's website http://www.riverkeeper.org/ and, consistent with the LTCP and HSM data, showed a relationship between wet-weather conditions and higher *Enterococci* concentrations throughout the years 2015, 2016, and 2017.

Figure 2.4-33 shows the arithmetic mean, minimum, maximum, 25^{th} percentile, and 75^{th} percentile values for DO from the LTCP October-December 2017 sampling program. As indicated in Figure 2.4-33, all of the average values were above 5.0 mg/L, and minimum values were above 4.0 mg/L except at Stations NYB-1 to NYB-5, where the minimum values were still above 3.0 mg/L. The HSM DO data from 2015 to 2017 are shown in Figure 2.4-34. These data indicate average values all above 6.0 mg/L, and all minimum values above 4.0 mg/L except at Station K5A.

2.4.b.7 Water Quality Modeling

In addition to the collection, compilation, and analysis of measurements described in Section 2.2.a.6, water quality modeling was also used to characterize and assess New York Bay water quality. The LTCP Regional Model (LTCPRM) was used for water quality modeling for the Citywide/Open Waters LTCP. This model evolved from the System-Wide Eutrophication Model (SWEM) that underwent peer review by model evaluation groups (MEGs) in 1994, 1997, and 1999. The model computational grid associated with the LTCPRM, as well as further details on this model, are presented are presented in Section 6 of this LTCP.

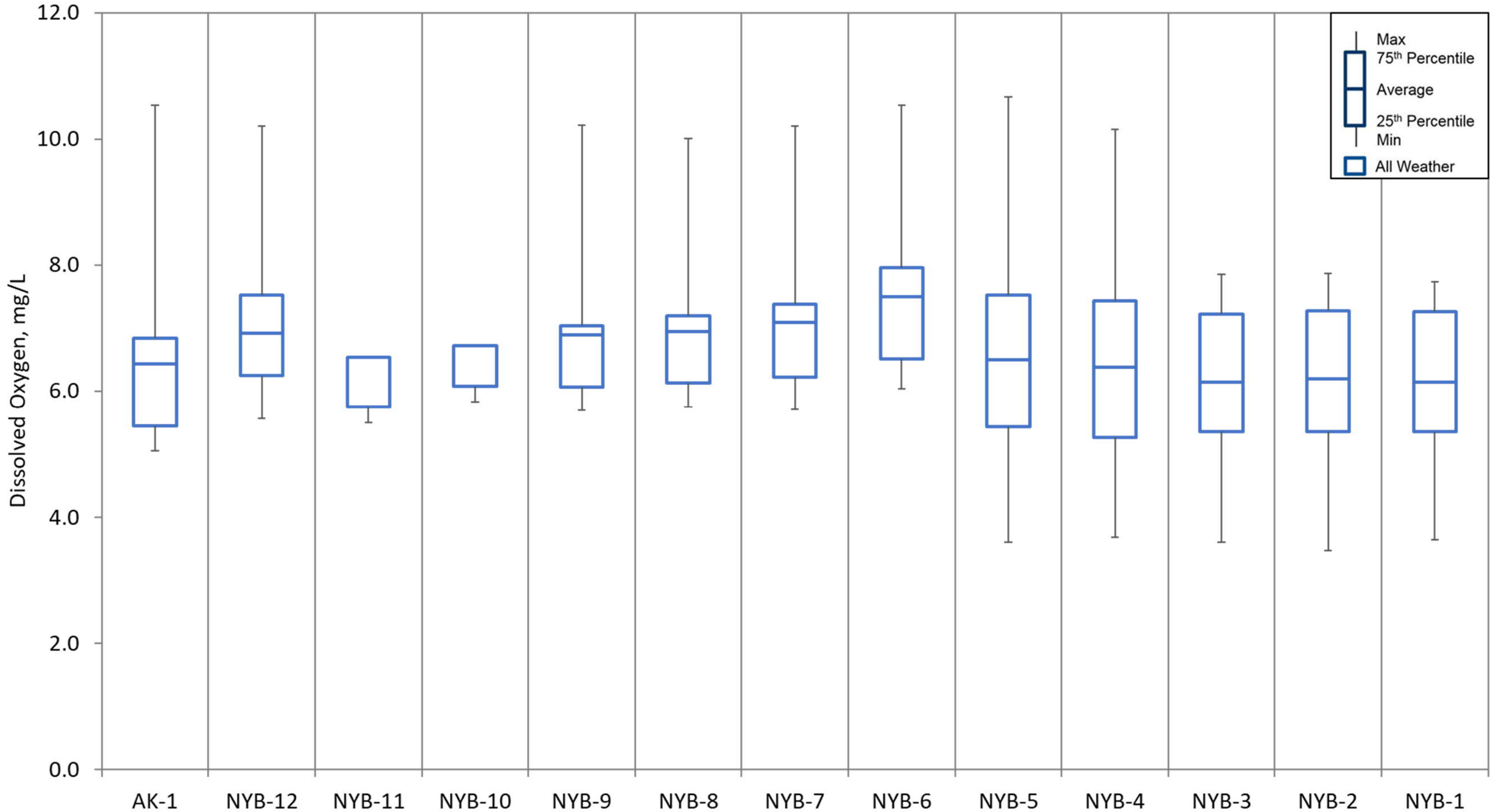


Figure 2.4-33. Dissolved Oxygen Concentrations at LTCP2 Sampling Stations in New York Bay

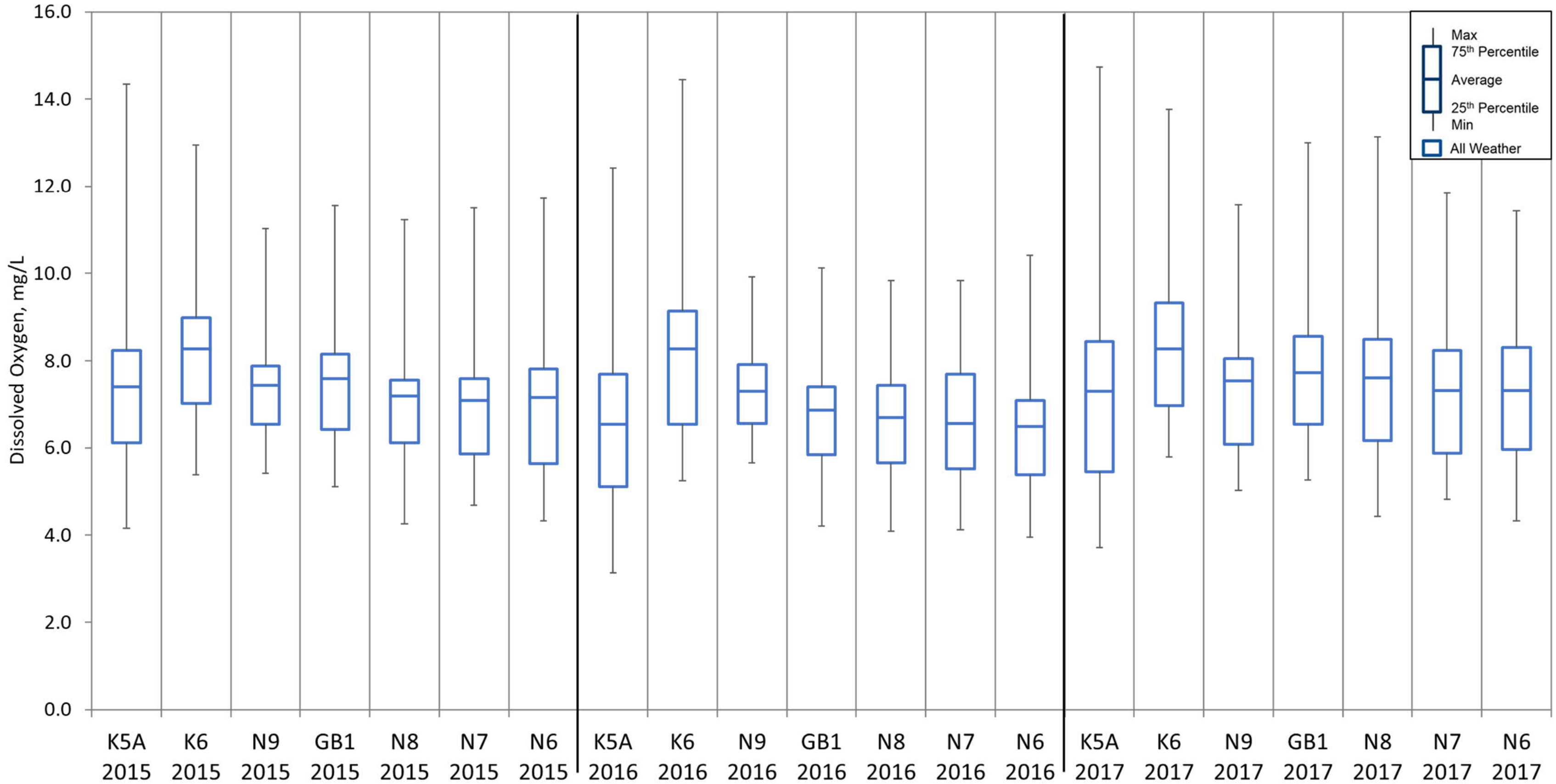


Figure 2.4-34. Dissolved Oxygen Concentrations at HSM Sampling Stations in New York Bay

2.5 Kill Van Kull/Arthur Kill

This section summarizes the major characteristics of the Kill Van Kull and Arthur Kill watershed and waterbody, building upon earlier documents that characterize the area. Section 2.5.a addresses watershed characteristics and Section 2.5.b addresses waterbody characteristics.

2.5.a Watershed Characteristics

The Kill Van Kull and Arthur Kill watershed is divided between the States of New York and New Jersey. It is highly urbanized and primarily composed of residential areas with some commercial, industrial, institutional, and open space/outdoor recreation areas. The northern shoreline along Kill Van Kull is the most urbanized part of Staten Island while the western shoreline is the least populated and most industrial. Along the Kill Van Kull, notable outdoor recreation areas include the Snug Harbor Botanical Garden and Alison Pond Park, in Staten Island, NY. Along Arthur Kill, notable outdoor recreation areas include the Freshkills Park, North Mount Lorretto State Forest, Clay Pit Pond State Park Preserve, and Long Pond Park, in Staten Island, NY. Several wetlands are also located within both channels along the New York and the New Jersey shorelines. This LTCP focuses on the New York portion of the Kill Van Kull and Arthur Kill watershed.

This subsection presents a summary of the watershed characteristics as they relate to the land use, zoning, permitted discharges and their characteristics, sewer system configuration, performance, and impacts to the adjacent waterbodies, as well as the modeled representation of the collection system used to analyze system performance and CSO control alternatives.

2.5.a.1 Description of Watershed/Sewershed

The Arthur Kill watershed encompasses portions of the Boroughs of Staten Island in New York and Union and Middlesex counties in northern New Jersey. Arthur Kill is a ten-mile long, navigable tidal channel which separates New York and New Jersey, and connects Newark Bay with Raritan Bay.

The Kill Van Kull watershed encompasses portions of the Boroughs of Staten Island in New York and Bayonne, New Jersey. Kill Van Kull is a four and a half-mile long, navigable tidal channel which separates New York and New Jersey, and connects Newark Bay with Upper New York Bay.

The land area within Staten Island that is directly tributary to the Kill Van Kull and Arthur Kill as a result of the combined and separate storm sewer systems (the sewershed) is approximately 20,000 acres. Figure 2.5-1 shows the Kill Van Kull and Arthur Kill sewershed.

Arthur Kill and Kill Van Kull have been modified over the last 150 years by dredging and filling activities that have altered islands and shorelines, bulkheading to stabilize and protect shorelines, dredging of channels and borrow areas that have altered bottom contours and flow patterns, and the filling of natural tributaries. These activities have eradicated natural habitats, negatively impacted water quality, and modified the rich ecosystem that characterized the waterbodies up until the mid-nineteenth century.

The urbanization of New York and New Jersey in the Arthur Kill and Kill Van Kull watersheds has led to the creation of a large combined sewer systems, as well as areas of separate and direct drainage, primarily in areas adjacent to the waterbodies. Two WRRFs are located within the sewershed: Port Richmond (60 MGD DDWF) and Oakwood Beach (39.9 MGD DDWF). These WRRFs are permitted pursuant to DEC issued SPDES permit. The Oakwood Beach WRRF serves a separate sanitary sewer system, and no CSO outfalls are associated with the Oakwood Beach WRRF. During dry-weather, the combined sewer system conveys flow to the Port Richmond WRRF and the sanitary sewer systems convey sewage to the Oakwood Beach WRRF for treatment. During wet-weather, combined storm and sanitary flow is conveyed by the sewer system to the Port Richmond WRRF. If the sewer system or WRRF is at full capacity, a diluted mixture of combined storm and sanitary flow may discharge through one or more of the 19 SPDES permitted CSO Outfalls to Kill Van Kull. No NYC CSO outfalls exist to discharge into Arthur Kill. These features are shown in Figure 2.5-2.

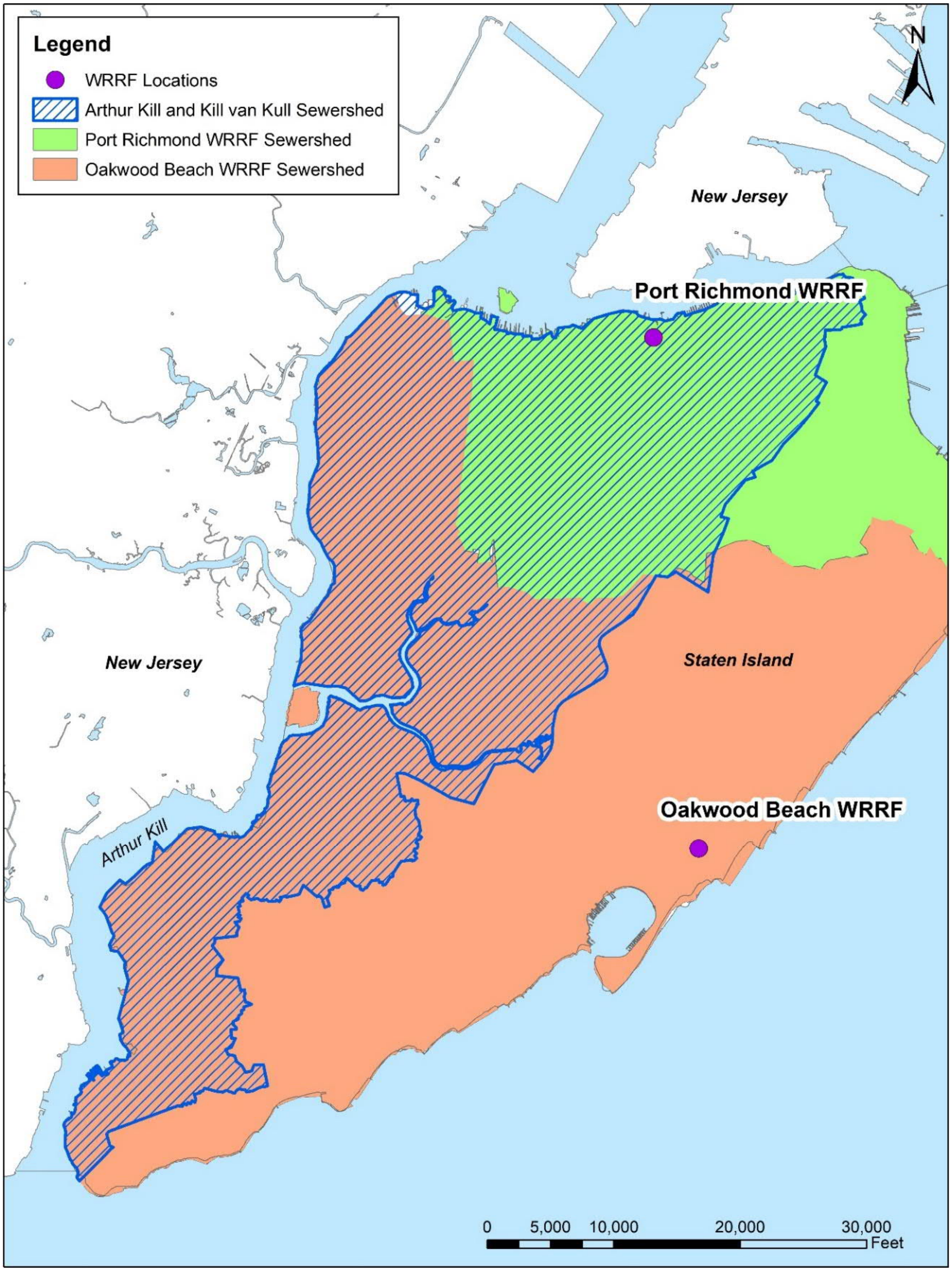


Figure 2.5-1. Arthur Kill and Kill Van Van Kull Sewershed

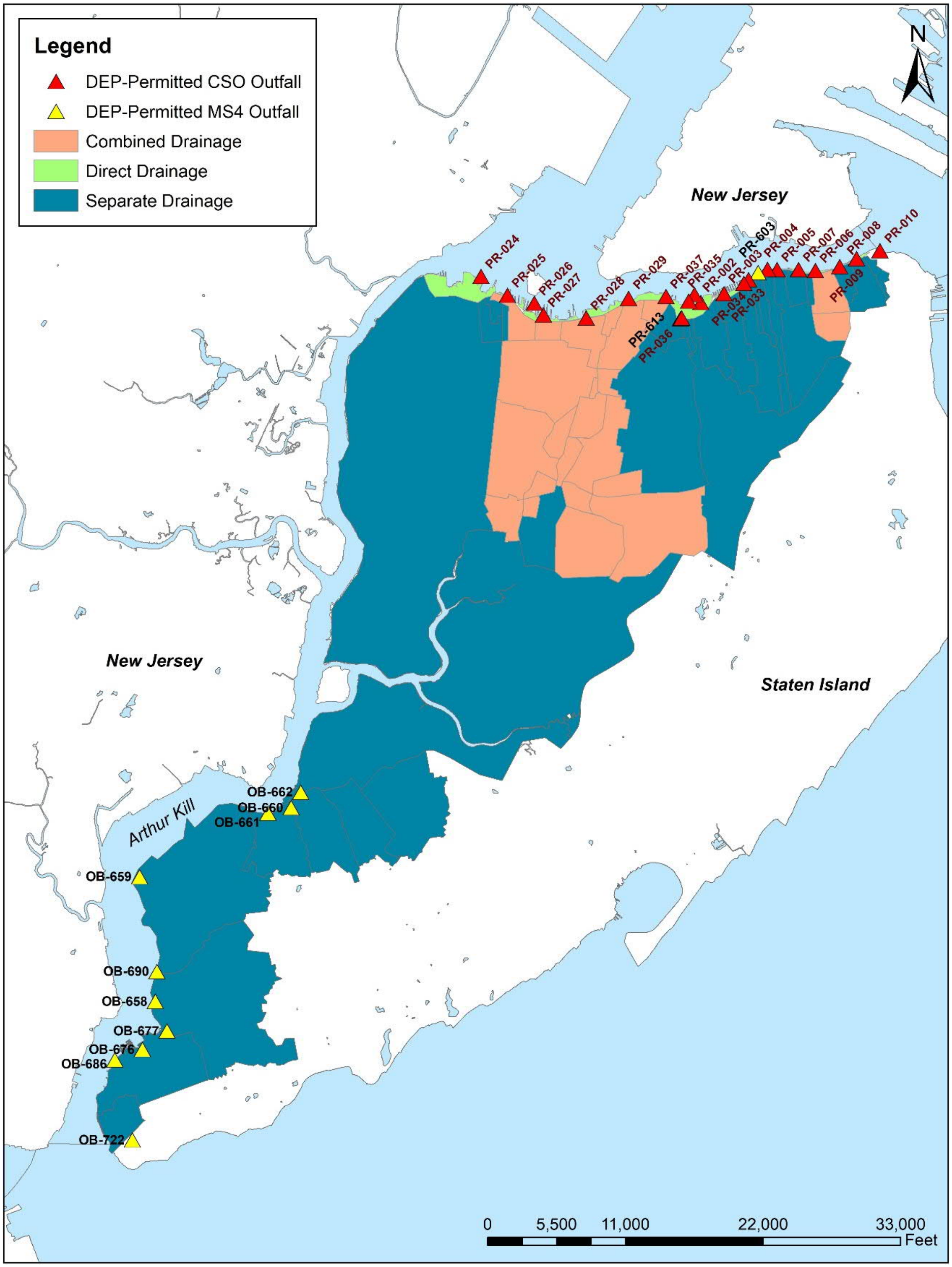


Figure 2.5-2. Components of the Arthur Kill and Kill Van Kull Watershed

The Arthur Kill sewershed has several large transportation corridors that cross the watershed to provide access between industrial, commercial, and residential areas. The major east/west transportation corridor is the U.S Interstate 278 (I-278) and New Jersey Route 440. The major north/south transportation corridor is the Interstate 95 (I-95). The Avenel Train Station of New Jersey Transit and NYC MTA Staten Island Railway also traverse the sewershed. The Goethals Bridge, the Outerbridge Crossing, and the Arthur Kill Vertical Lift Bridge cross over Arthur Kill.

Across the Kill Van Kull, the major east/west transportation corridor is the U.S Interstate 278 (I-278) and Interstate 78 (I-78). The major north/south transportation corridor is the New York State Route 440 Bayonne Bridge (Dr. Martin Luther King Jr. Expressway). The New Jersey Transit 8th Street Light Rail Station is also within the sewershed.

The transportation features for Arthur Kill and Kill Van Kull are shown in Figure 2.5-3.

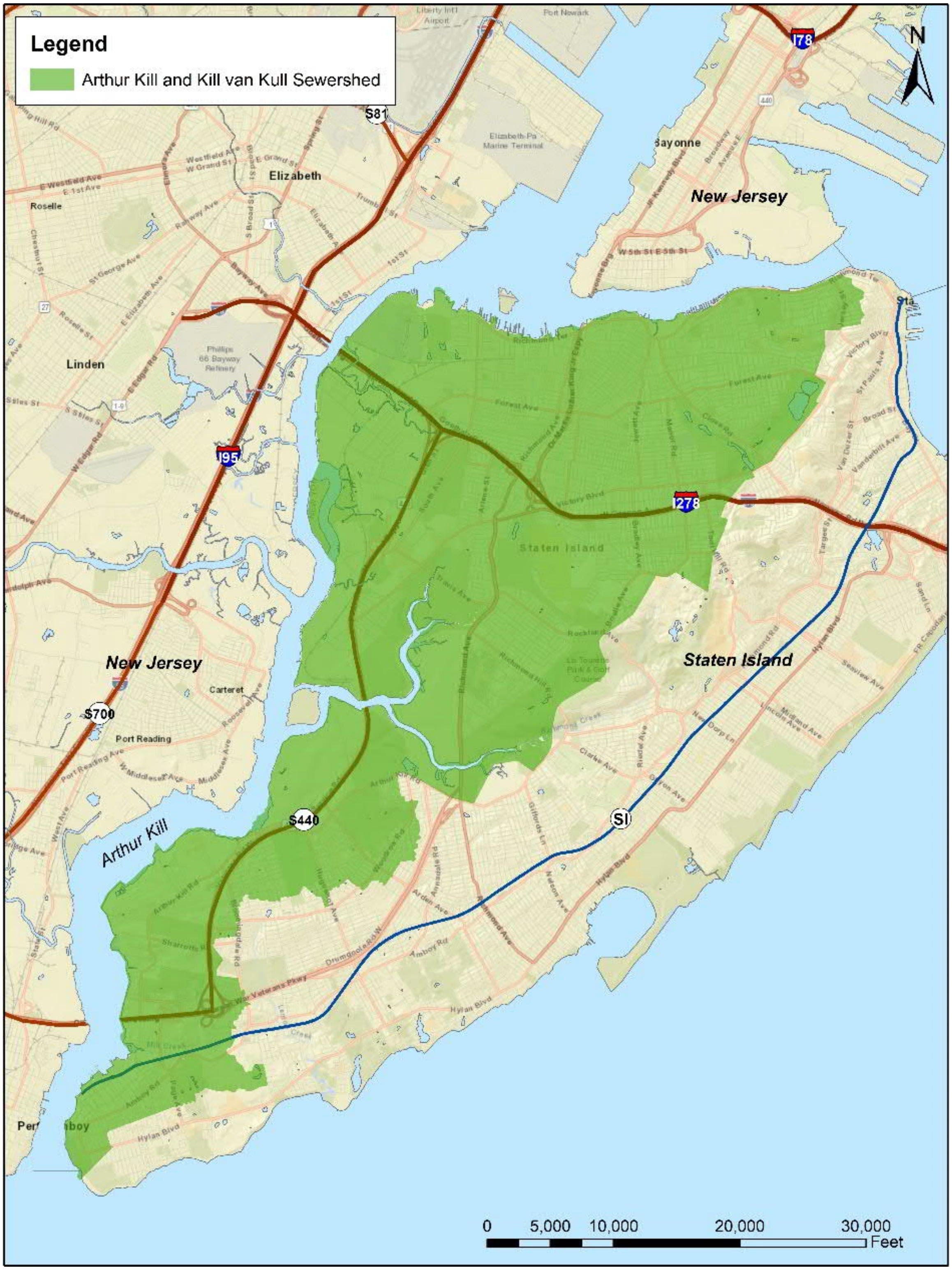


Figure 2.5-3: Arthur Kill and Kill Van Kull Sewershed Major Transportation Features

Existing and Future Land Use and Zoning

The current land use in the Kill Van Kull and Arthur Kill sewershed is largely attributable to historical urbanization and development within the sewershed. Future use and development is controlled by zoning, land use proposals, and evolving land use policies. Figure 2.5-4 shows the distribution of existing land uses within the overall Kill Van Kull/Arthur Kill sewershed. Table 2.5-1 summarizes the relative percentages of the various land use categories both for the overall sewershed, and for the portions of the sewershed within a quarter-mile of the shoreline.

Table 2.5-1. Existing Land Use within the Kill Van Kull Sewershed Area

Land Use Category	Percent of Area	
	Within Sewershed	Within 1/4-mile of Shoreline
Residential	29.7%	18.5%
Mixed Residential and Commercial	0.6%	0.7%
Commercial and Office	5.1%	5.3%
Industrial and Manufacturing	4.1%	13.2%
Transportation and Utility	13.0%	19.9%
Public Facilities and Institutions	6.6%	1.6%
Open Space and Outdoor Recreation	21.8%	10.3%
Parking Facilities	1.1%	3.6%
Vacant Land	17.2%	24.8%
Unknown	0.80%	2.1%

As indicated in Table 2.5-1, the predominant land use in the Kill Van Kull/Arthur Kill sewershed is residential (30 percent) which is comprised mainly of one- and two- family homes (nearly 90 percent). Open space and outdoor recreation also makes up a significant percentage of the sewershed (22 percent) due to the presence of several federal, state, and city park properties and facilities. Vacant land, transportation, and utilities comprise up to 30 percent of the sewershed while the remaining 18 percent is distributed among the other land uses listed in Table 2.5-1.

Within the quarter-mile area immediately surrounding the shorelines, vacant land covers the largest area (25 percent), due to the presence of salt marshes and several lots. Transportation and utility also cover a significant portion of the quarter-mile buffer (20 percent), followed by residential land uses (19 percent) which are primarily composed of one- and two- family homes (88 percent). Industrial and manufacturing uses are also common along the shorelines (13 percent) and open space and recreation make up 10 percent of the quarter-mile buffer. The remaining 13 percent is distributed amongst the other land uses listed in Table 2.5-1.

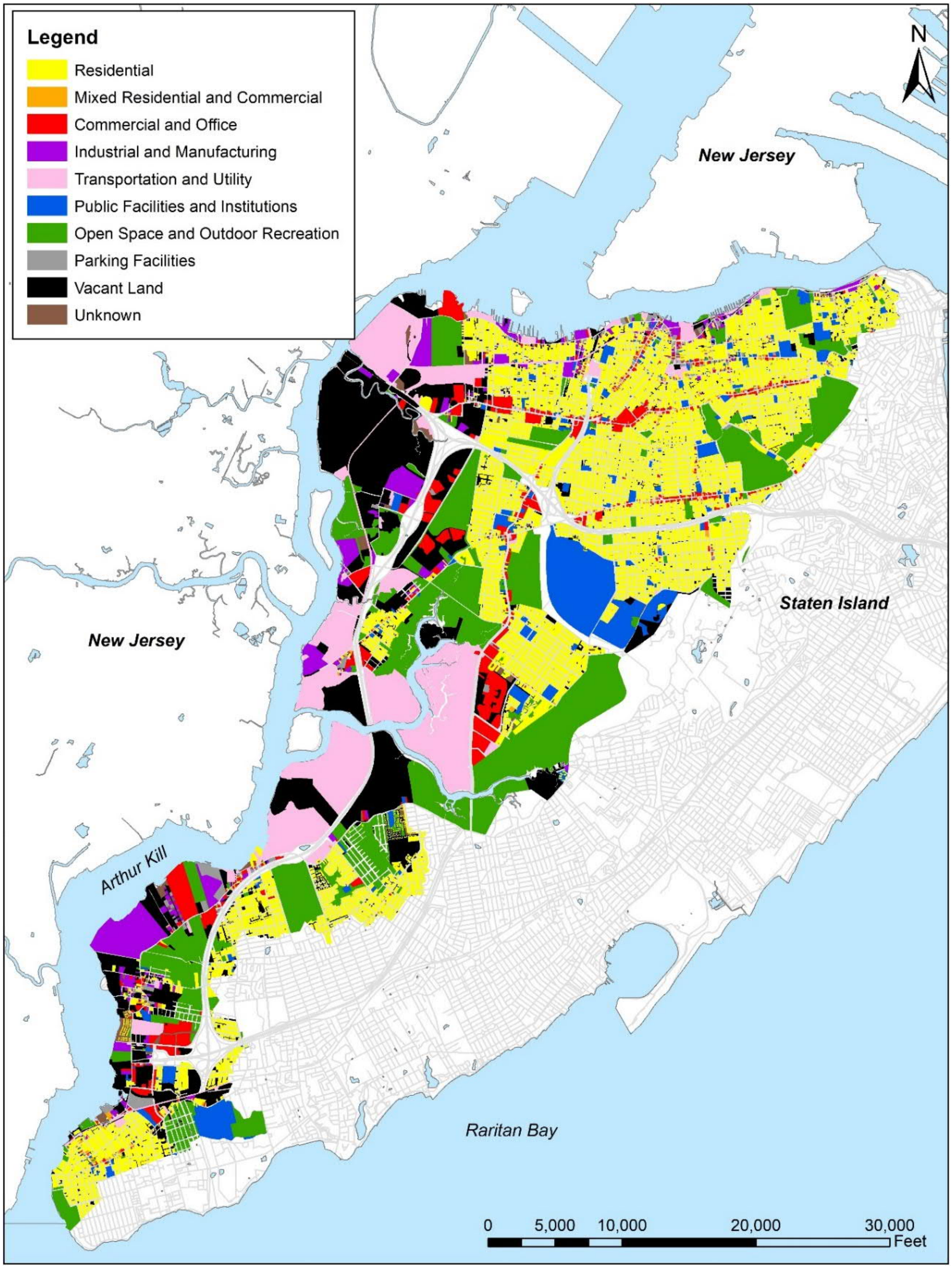


Figure 2.5-4. Land Use in the Arthur Kill and Kill Van Kull Sewershed

Figure 2.5-5 identifies the zoning classifications within a quarter-mile of the Kill Van Kull and Arthur Kill shorelines. Manufacturing zones are the most predominant zoning classification making up to 68 percent of the quarter-mile area. Residential zoning covers 22 percent, with low-density residential districts comprising nearly that entire area (97 percent). Park property is zoned at approximately 8 percent while commercial zoning is less than 2 percent of the quarter-mile buffer.

Both Kill Van Kull and Arthur Kill are located within the Coastal Zone Boundary as designated by DCP. DCP has also designated parts of Arthur Kill and Kill Van Kull as Significant Natural Waterfront Areas (SNWA). As defined by DCP, a SNWA is a large area of concentrated natural resources, such as wetlands and natural habitats, which possesses a combination of important coastal ecosystem features. One of the Priority Policies of the DCP Waterfront Revitalization Program is to protect and restore the ecological quality and component habitats and resources within the SNWA. The four SNWAs identified within the sewershed include West Shore/Fresh Kills, Shooter's Island, Prall's Island, and Arlington Marsh. DCP has also designated the northern and western shorelines of Staten Island as Significant Maritime and Industrial Areas (SMIA) and the northern portion of Arthur Kill as an Ecologically Sensitive Maritime and Industrial Area (ESMIA). Priority marine activity zones (PMAZs) are located along the shorelines of Staten Island as well as several Recognized Ecological Complexes (RECs)

In addition to the standard zoning classifications, four "Special Use Districts" are located within the Kill Van Kull/Arthur Kill sewershed. Special use districts are defined within the Zoning Resolution as areas designated "to achieve the specific planning and urban design objectives in areas with unique characteristics". The Special Use Districts that are located within the Kill Van Kull/Arthur Kill sewershed include:

- The *Special Hillsides Preservation District* guides development in the steep sloped areas of Staten Island's Serpentine Ridge, an area of approximately 1,900 acres in the northeastern park of the borough. The district regulates development and preserves the area's hilly terrain, trees, and vegetation in order to reduce hillside erosion, landslides, and excessive stormwater runoff.

- *Special Natural Area District 1* (Emerson Hill, Lighthouse Hill and the central wetlands, and the Shore Acres Area) guide new development and site alterations in areas endowed with unique natural characteristics, including forests, rock outcrops, steep slopes, creeks, and a variety of botanic and aquatic environments. These natural features are protected by limiting modifications in topography and by encouraging clustered development.

- The *Special St. George District* supports a pedestrian-friendly business and residence district within a waterfront community that serves as a commercial, transit, and civic center. Special rules in this district enhance designated commercial streets, preserve waterfront and upland views, and enhance the pedestrian experience.

- The *Special South Richmond Development District* was established in 1975 to regulate the development of the southern end of Staten Island and preserve the natural spaces and outdoor recreation that defines the community.

Several major, potential waterfront projects, along with several smaller projects, could potentially change the land use along the Kill Van Kull/Arthur Kill shoreline. Upland projects away from the waterfront are not included in this survey. The major projects are:

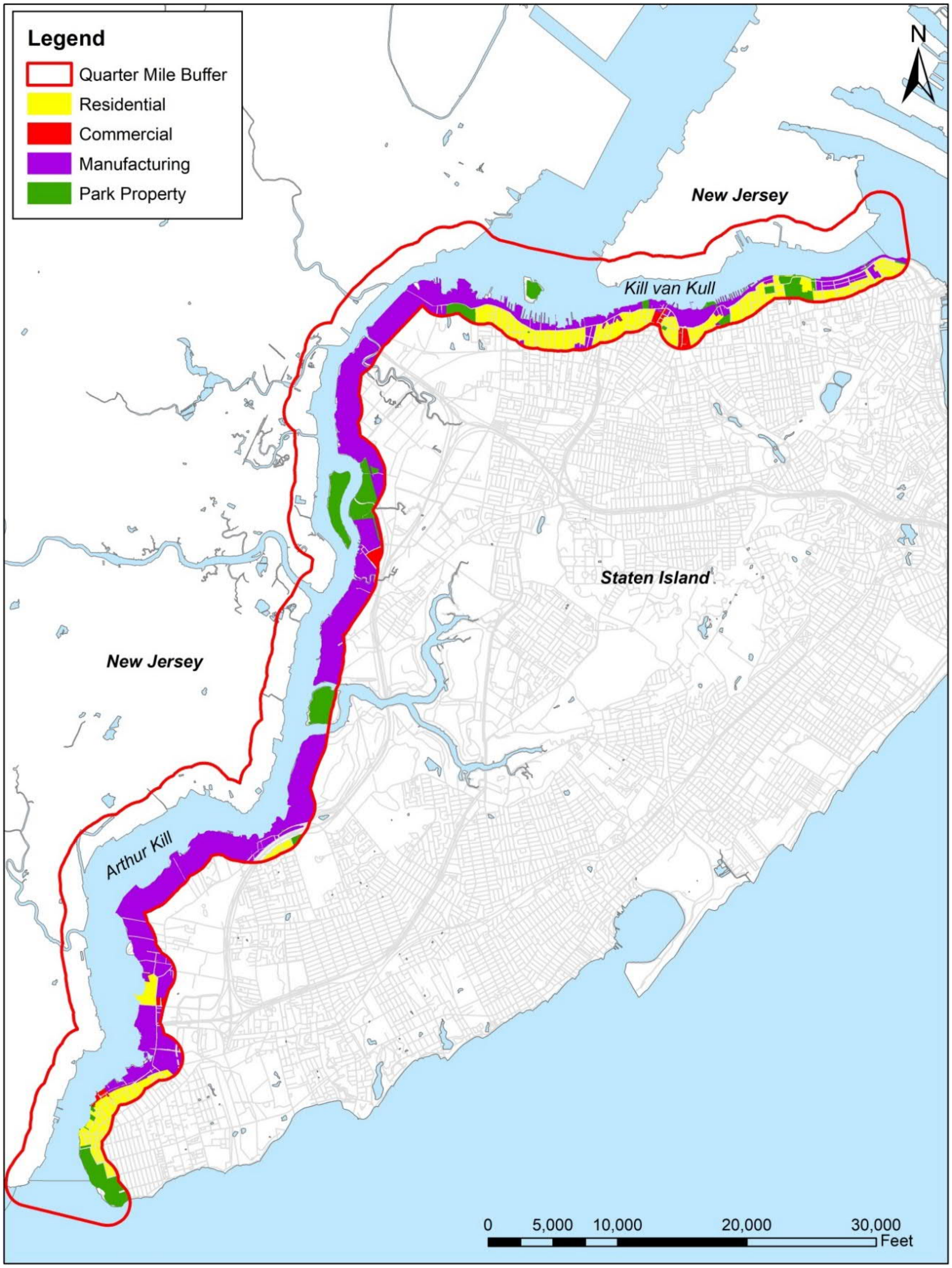


Figure 2.5-5. Zoning within 1/4 Mile of Arthur Kill and Kill Van Kull Shoreline

- The *Fresh Kills Lifescape Master Plan* will transform one of the world's largest landfills into 2,200 acres of public parkland to become NYC's second largest park. A Lifescape is an ecological process of environmental reclamation and renewal on a vast scale and aims to recover the health and biodiversity of ecosystems and the public's accessibility to open space. Construction begain in 2008 and will continue in phases for at least 30 years. Figure 2.5-6 shows an illustrative plan for the Fresh Kills Park.

- The *Port Richmond Brownfield Opportunity Area Strategic Plan* follows up on the North Shore 2030 Report recommendations and aims to support new retail services and jobs, strengthen the working waterfront, and provide needed amenities including open space and waterfront access.

- The *Working West Shore 2030 Report* lays out the framework for future investment and land use decisions on the West Shore of Staten Island and identifies strategies that will help create jobs, upgrade infrastructure, preserve open space, and manage growth over the next twenty years.

- The *West Brighton Brownfield Opportunity Area Strategic Plan* is under development for the West Brighton area with the intent to improve public access to waterfront and upland open space, support new and existing maritime industrial uses, expand retail and community services and provide a safe, multi modal transportation network along Richmond Terrace.

- The *Staten Island North Shore – Land Use and Transportation Study* identifies opportunities for creating jobs, increasing public waterfront access, improving transportation connections, strengthening neighborhood centers and addressing environmental challenges.

- The *St. George Waterfront Redevelopment* intends to transform the St. George Waterfont into a dynamic, mixed-use destination. The transformation will include construction of the largest observation wheel in the Western Hemisphere along with new 340,000 sqare-foot retail complex with 100 designer outlet stores and a 190-room hotel.

- *Saw Mill Creek Wetland Mitigation Bank Credits* are now available for impact offsetting in portions of NYC's five boroughs. The bank credits will facilitate the improvement and protection of critical coastal resources, and the establishment of a predictable, efficiant, and environmentally responsible process to serve the wetland mitigation needs in New York City.

- The *Department of City Planning's Waterfront Revitalization Program* establishes policies for development and use of the waterfront. The goal of the program is to maximize benefits from economic development, environmental conservation, and public use of the waterfront, while minimizing any potential conflicts among these objectives.

- The *Department of City Planning's Vision 2020 Comprehensive Waterfront Plan* builds on NYC's success in opening up to the public miles of shoreline that had been inaccessible for decades, and supporting expansion of the maritime industry (DEP, 2010c). Vision 2020 sets the stage for expanded use of waterfront parks, use of waterways for transportation, housing and economic development, and recreation and natural habitats. The 10-year plan lays out a vision for the future with new citywide policies and site-specific recommendations. Kill Van Kull and Arthur Kill span Reaches 20, 21, and 22 within the Vision 2020 plan, which include several site-specific waterfront revitalization strategies (see Figure 2.5-7 through Figure 2.5-9).

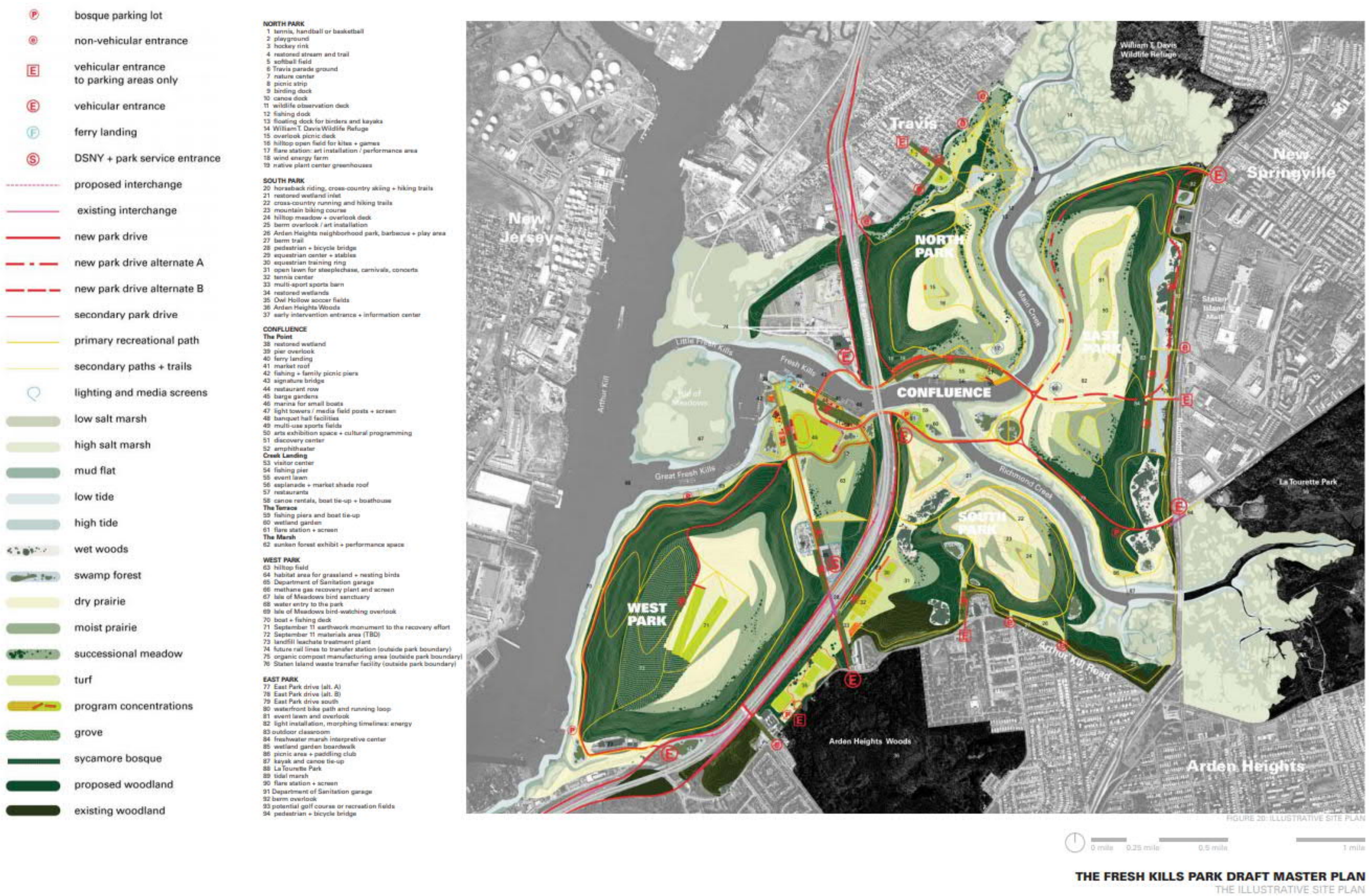


Figure 2.5-6. The Fresh Kills Lifescape Master Plan

REACH 20 - *ARTHUR KILL SOUTH*

Location: Arthur Kill from southern end of FreshKills Park to northern boundary of Conference House Park

Upland Neighborhoods: Rossville, Charleston, Kreischerville, Tottenville

Neighborhood Strategies

Reachwide

- Explore creation of continuous bicycle and pedestrian pathway with connections to waterfront where feasible.
- Explore possible extension or creation of Significant Maritime and Industrial Area (SMIA).
- Support the widening of Arthur Kill Rd.

Rossville Waterfront 1

- Explore feasibility of improving municipal pier and recruiting maritime user.
- Support redevelopment that includes a mix of maritime, retail and commercial uses.
- Improve public waterfront access, incorporating Blazing Star Cemetery with an eventual link to FreshKills Park.

Charleston/Kreischerville 2

- Provide continuous esplanade along waterfront from Clay Pit Ponds Park to Tottenville with consideration of public safety and security of the Outerbride Crossing.
- Explore rezoning in Special Area M district to minimize land use conflicts.
- Explore mixed-use development with housing and commercial uses along the Charleston waterfront near transit.

Richmond Valley 3

- Support incorporating Mill Creek in the Bluebelt program and providing complementary public access.

Ellis St. Waterfront 4

- Explore mixed-use development while supporting continued operation of existing marinas.

Figure 2.5-7. NYCDCP Vision 2020 Comprehensive Waterfront Plan – Reach 20

REACH 21 - *ARTHUR KILL NORTH*

Location: Arthur Kill from New Jersey rail spur to the southern boundary of Freshkills Park.

Upland Neighborhoods: Bloomfield, Travis, Freshkills

Neighborhood Strategies

Reachwide

- Explore possible extension or creation of Significant Maritime and Industrial Area (SMIA).
- Create a master plan that integrates ecological complexes into a single, linked preserve. Include opportunities and constraints analysis for acquisition, restoration, brownfield remediation, public access, and stormwater management.

Bloomfield Waterfront 1

- Reutilize industrial sites with modern distribution, maritime and commercial facilities that utilize the waterfront for goods movement, with sensitivity to existing wetlands.
- Explore financing mechanisms for essential infrastructure.
- Explore opportunities for public point access to waterfront.

Goethals Bridge 1.a

- Support designated site of new bridge and advocate for construction.
- Support expansion of maritime industry around new Goethals Bridge.
- Support provision of bike, pedestrian, and transit access on new bridge.

Freshkills Park 2

- Develop the first public access areas overlooking Main Creek.
- Construct portions of the new greenway construction.
- Explore opportunities for boat launch based on the criteria described in the Citywide Strategy.
- Protect and enhance natural habitats in appropriate areas within park.
- Support implementation of master plan for parkland.
- Map officially as parkland.
- Increase transportation to and through the park, with consideration for ferry, light rail and bus rapid transit.
- Explore potential sources of revenue such as park concessions.
- Promote as an eco-tourism destination.
- Retain barge tie-up fender systems and DSNY barge fleet during park construction.

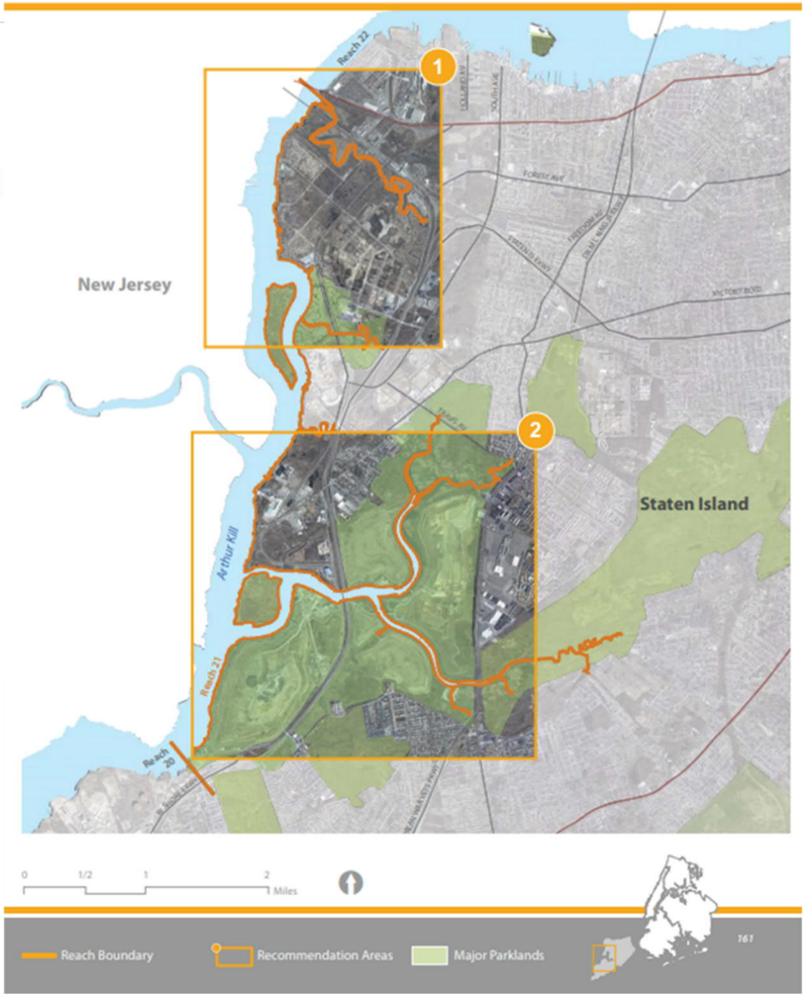


Figure 2.5-8. NYCDCP Vision 2020 Comprehensive Waterfront Plan – Reach 20

REACH 22 - *KILL VAN KULL*

Location: Kill Van Kull, from Old Place Creek to Bard Ave., including Shooter's Island

Upland Neighborhoods: Arlington, Old Place, Graniteville, Mariners' Harbor, Port Richmond, Livingston Manor, West New Brighton

Neighborhood Strategies

Reachwide

- Coordinate with Community Board 1's efforts to designate a North Shore multi-purpose pathway, along the waterfront where feasible, from Snug Harbor to the Goethals Bridge connecting points of historic, cultural, recreational and maritime interest.
- Strengthen east-west transportation connections by making targeted intersection improvements, utilizing bus priority service on key routes and creating safe pedestrian connections along Richmond Terrace and to the waterfront.
- In coordination with the MTA North Shore Alternatives Analysis, resolve the conflicts between the former rail line, businesses and public spaces by relocating parts of the ROW and identifying underutilized lots that could support future transit.
- Incorporate educational opportunities on the history of the North Shore in coordination with new public waterfront access.
- Investigate using street-ends as public overlooks of maritime activity.
- Encourage transparent fencing along Richmond Terrace to view working waterfront.
- Determine necessary maritime infrastructure repair and expansion throughout maritime industrial sites.
- Identify needed physical improvements to the deteriorating shoreline and connect property owners with new tools to remediate contaminated sites.
- Explore possible changes to existing Significant Maritime and Industrial Area (SMIA).

Howland Hook/Arlington Marsh 1

- Complete environmental review for expanding container handling capacity at New York Container Terminal.
- Identify funding for remediation and development of waterfront access and active/passive recreation at Arlington Marsh.
- Complete transfer of 70-acre Arlington Marsh property from the Department of Small Business Services to the Parks Department.
- Determine appropriate municipal use at Arlington Marsh site.

Mariners Harbor Waterfront 2

- Use publicly owned land at Van Pelt/Van Name Ave. to provide open space with views of Shooters Island.
- Facilitate maritime expansion on underutilized sites.
- Recruit industrial users and maritime training facility to historic industrial buildings.
- Permit and recruit commercial amenities along Richmond Terrace frontage and in reused historic buildings.
- Provide safe pedestrian crossings at future parks.

Bayonne Bridge 3

- Support raising the bridge's roadway to increase its clearance to accommodate larger ships (with consideration of sea level rise), retain bicycle and pedestrian access, and consider future transit access.

Port Richmond 4

- Help recruit appropriate industrial uses to North Shore Industrial Park.
- Preserve and expand bulkhead at the end of Port Richmond Ave. for maritime use and provide appropriate buffer.
- Investigate de-mapping a portion of Port Richmond Ave. to encourage mixed uses and public access on the waterfront.
- Include waterfront connections in new waterfront development.
- Provide public overlook of maritime activity on the waterfront.
- Consider expanded uses along the waterfront, compatible with active maritime support services.

West Brighton Waterfront 5

- Facilitate maritime expansion on underutilized sites.
- Coordinate with MTA to market vacant site and pursue development that creates jobs and improves waterfront access.
- Encourage transparent fencing along Richmond Terrace to view working waterfront.
- Investigate relocating rail right-of-way to facilitate maritime expansion.
- Secure funding for remediation, design, and maintenance of new North Shore waterfront park.
- Encourage industrial and commercial uses that compliment the future waterfront park.

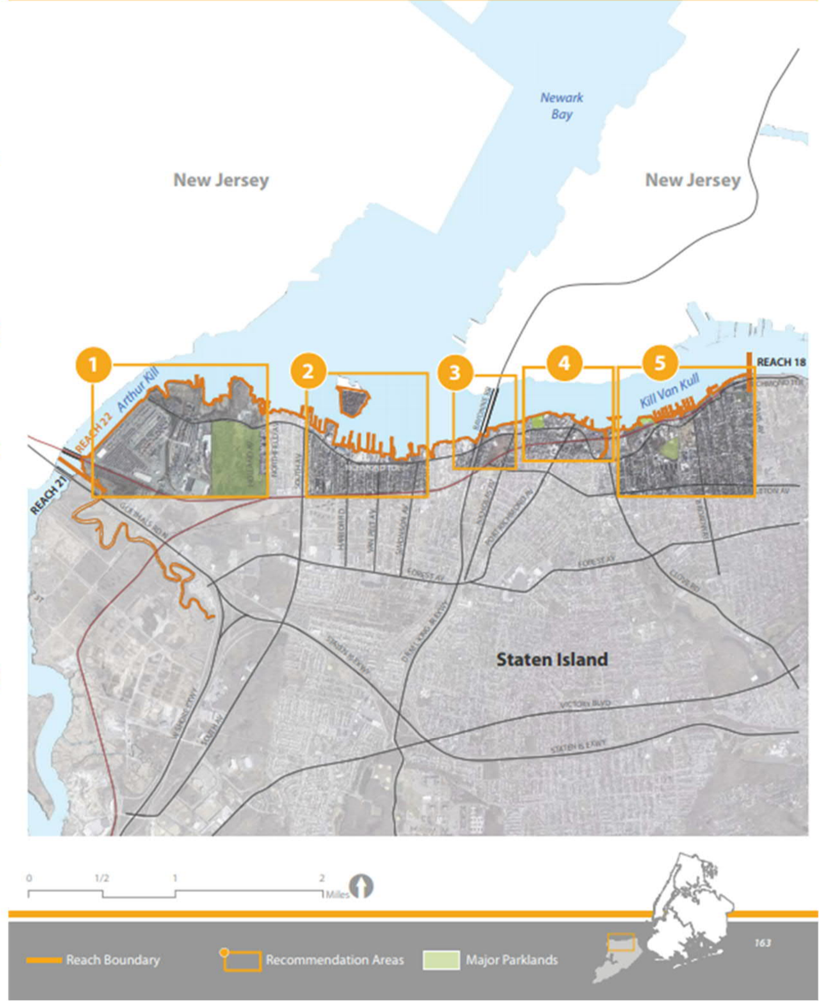


Figure 2.5-9. NYCDCP Vision 2020 Comprehensive Waterfront Plan – Reach 20

Impervious Cover Analysis

The impervious cover analysis conducted for the Kill Van Kull/Arthur Kill sewershed is similar to the analyses described for the Harlem River (see Section 2.1.a.1).

Population Growth and Projected Flows

DEP routinely develops water consumption and dry-weather wastewater flow projections for planning purposes. In 2012, DEP projected an average per capita water demand of 75 gallons per day that was representative of future uses. The year 2040 was established as the planning horizon, and populations for that time were developed by the DCP and the New York Metropolitan Transportation Council.

The 2040 population projection figures were then used with the dry-weather per capita sewage flows to establish the dry-weather sewage flows in the IW models for the Port Richmond and Oakwood Beach WRRF sewersheds. Average daily dry-weather sanitary sewage flows for the landside model subcatchments for each sewershed were established by distributing the total dry-weather flows at the respective WRRFs to the upstream subcatchments in proportion to the upstream subcatchment populations.

Updated Landside Modeling

The Kill Van Kull/Arthur Kill sewershed is included within the Port Richmond and Oakwood Beach WRRF collection system IW models. An IW model of the Oakwood Beach separate stormwater areas was developed to estimate the stormwater flows from this area, as the Oakwood Beach WRRF system is a separate sanitary system, with no CSO outfalls. In 2012, 13 of DEP's IW landside models underwent recalibration. This recalibration process is described in Section 2.1.a.1. As part of the Citywide/Open Waters LTCP, additional flow metering was conducted to check the 2012 calibration. The additional flow metering program and model verification activities are described in the 2020 Citywide/Open Waters Water Quality and Sewer System Modeling Report. Additional model updates to the Port Richmond model implemented as part of the Citywide/Open Waters LTCP development were described in Section 2.4.a.1.

Review and Confirm Adequacy of Design Rainfall Year

2008 rainfall from the JFK rain gage was determined to be the most representative of average annual rainfall conditions based on a review of rain gage data from 1969 to 2010 at four rainfall gauges (CPK, LGA, JFK, EWR). As a result, the landside modeling analyses conducted as part of the LTCP process used the 2008 JFK precipitation as the typical rainfall year in NYC, together with the 2008 tide observations. The rainfall from the JFK gage for a 10-year period of 2002 to 2011 was also used to assess long term performance of the LTCP Recommended Plan (see Sections 6 and 8). The period from 2002 through 2011 was the wettest continuous 10-year period over the past 50 years and provided a high level of conservatism to the LTCP analyses. Section 2.1.a.1 provides additional detail on selection of the typical year rainfall period.

2.5.a.2 Description of Sewer System

The NYC portion of the Kill Van Kull/Arthur Kill sewershed is located within the Borough of Staten Island (New York County, within NYC). The Kill Van Kull is served by the Port Richmond WRRF collection system while separate storm sewers within the Oakwood Beach WRRF sewershed discharge to the Arthur Kill. As mentioned in Section 2.5.a. and shown in Figure 2.5-10, no CSO outfalls discharge to Arthur Kill.

Figure 2.5-4 and Table 2.5-1 show the different land uses within the sewershed. The locations of the WRRFs and the respective sewershed boundaries are shown in Figure 2.5-1. The CSO and stormwater outfalls associated with Kill Van Kull and Arthur Kill are shown in Figure 2.5-2. In total, 71 discharge points have been documented to exist along the shorelines of Kill Van Kull and Arthur Kill, as shown in Table 2.5-2. In addition to the outfalls listed in Table 2.5-2, the outfall for the Port Richmond WRRF discharges to Kill Van Kull.

Table 2.5-2. Outfalls Discharging to Kill Van Kull and Arthur Kill

Identified Ownership of Outfalls	Number of Outfalls
DEP	DEP MS4 Permitted = 12
	DEP Non-MS4 Permitted = 1
	DEP CSO Permitted = 19
DEC	2
NYS Department of Transportation	0
Private	20
Unknown	17
Total	71

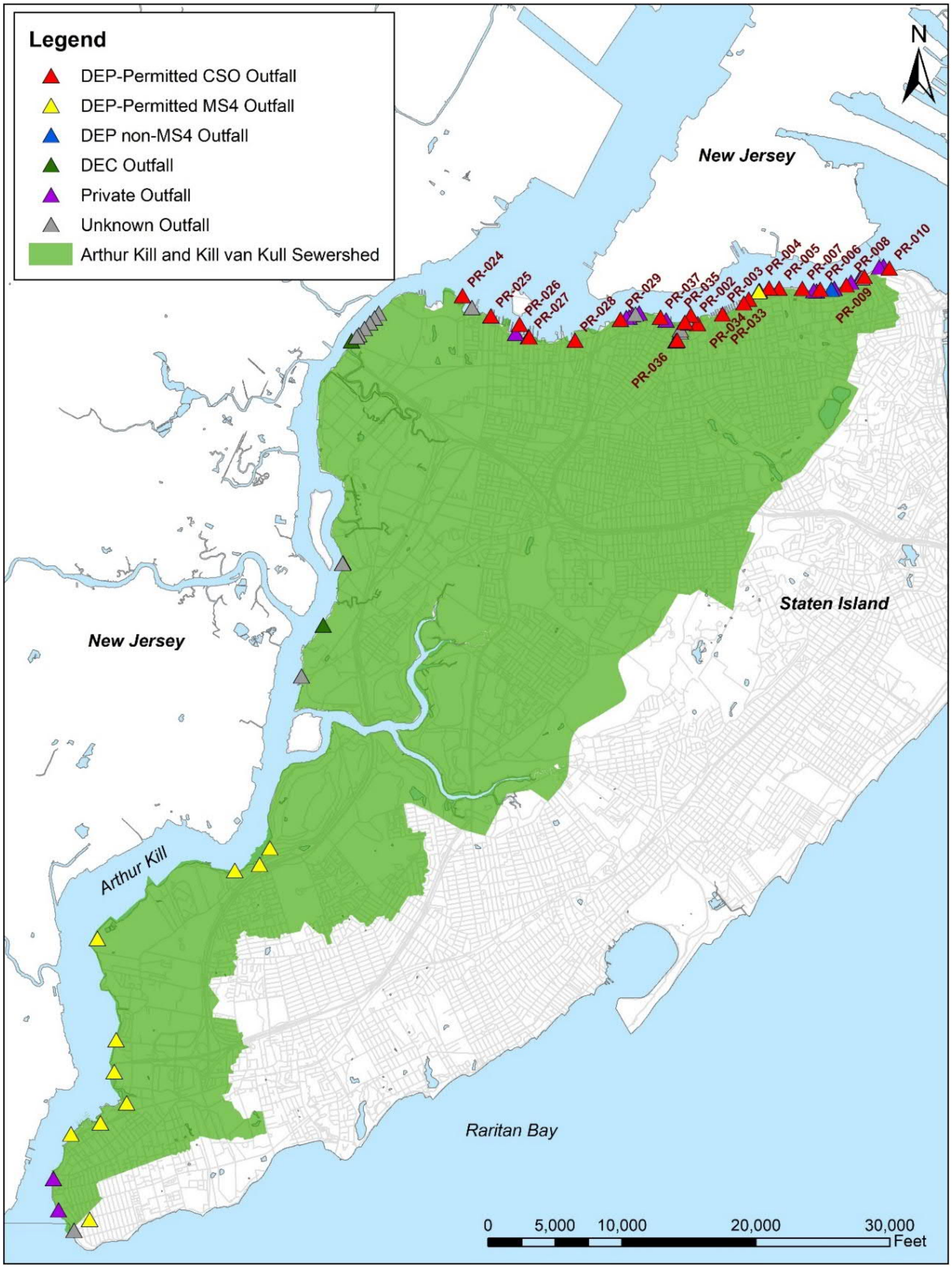


Figure 2.5-10. Arthur Kill and Kill Van Kull Outfalls

Overview of Drainage Area and Sewer System

The following sections describe the major features of the Port Richmond and Oakwood Beach WRRF sewersheds within the Kill Van Kull/Arthur Kill sewershed. The total acreage of combined sewer, separate sewer, and direct drainage tributary area to Kill Van Kull and Arthur Kill is presented in Table 2.5-3.

Table 2.5-3. WRRF Sewersheds Tributary to Kill Van Kull/Arthur Kill: Acreage Per Sewer Category

WRRF	Combined	Separate (MS4 and non-MS4)(1)	Direct, Overland, Other(1)	Total Area (acres)
Port Richmond	1,084(2)	5,523	0	6,607
Oakwood Beach	0	9,655	0	9,655
Total	**1,084**	**15,178**	**0**	**16,262**

Notes:
(1) Tributary drainage areas for direct drainage and other sources of stormwater have not been fully delineated by DEP or obtained from other agencies. These drainage areas were estimated based on GIS mapping, aerial photographs, land use maps, and topographic maps, rather than detailed topographic surveys and sewer maps.
(2) Port Richmond combined sewer area is tributary only to Kill Van Kull. No CSO area is tributary to Arthur Kill.

Kill Van Kull-Port Richmond WRRF Drainage Area and Sewer System

The Port Richmond WRRF sewershed area and sewer system are described in Section 2.4.a.1 and Section 2.4.a.2. A total of 19 CSO outfalls from the Port Richmond WRRF system are permitted to discharge into Kill Van Kull during wet-weather. No NYC CSO outfalls exist to discharge into Arthur Kill. Table 2.5-4 lists the CSO outfalls that are tributary to Kill Van Kull from the Port Richmond WRRF sewershed, along with their associated regulators/relief structures. Figure 2.5-11 shows main features of the Port Richmond WRRF collection system and the sewershed area tributary to Kill Van Kull.

Table 2.5-4. CSO Outfalls Tributary to Kill Van Kull from Port Richmond WRRF Service Area

Outfall	Regulator(s)
PR-002	R-34
PR-003	R-33
PR-004	R-29
PR-005	R-28
PR-006	R-23
PR-007	R-27
PR-008	R-21
PR-009	R-20
PR-024	R-1W

Table 2.5-4. CSO Outfalls Tributary to Kill Van Kull from Port Richmond WRRF Service Area

Outfall	Regulator(s)
PR-025	R-2W
PR-026	R-3W
PR-027	R-4W
PR-028	R-5W
PR-029	R-6W
PR-033	R-31
PR-034	R-32
PR-035	R-35
PR-036	R-36
PR-037	R-37

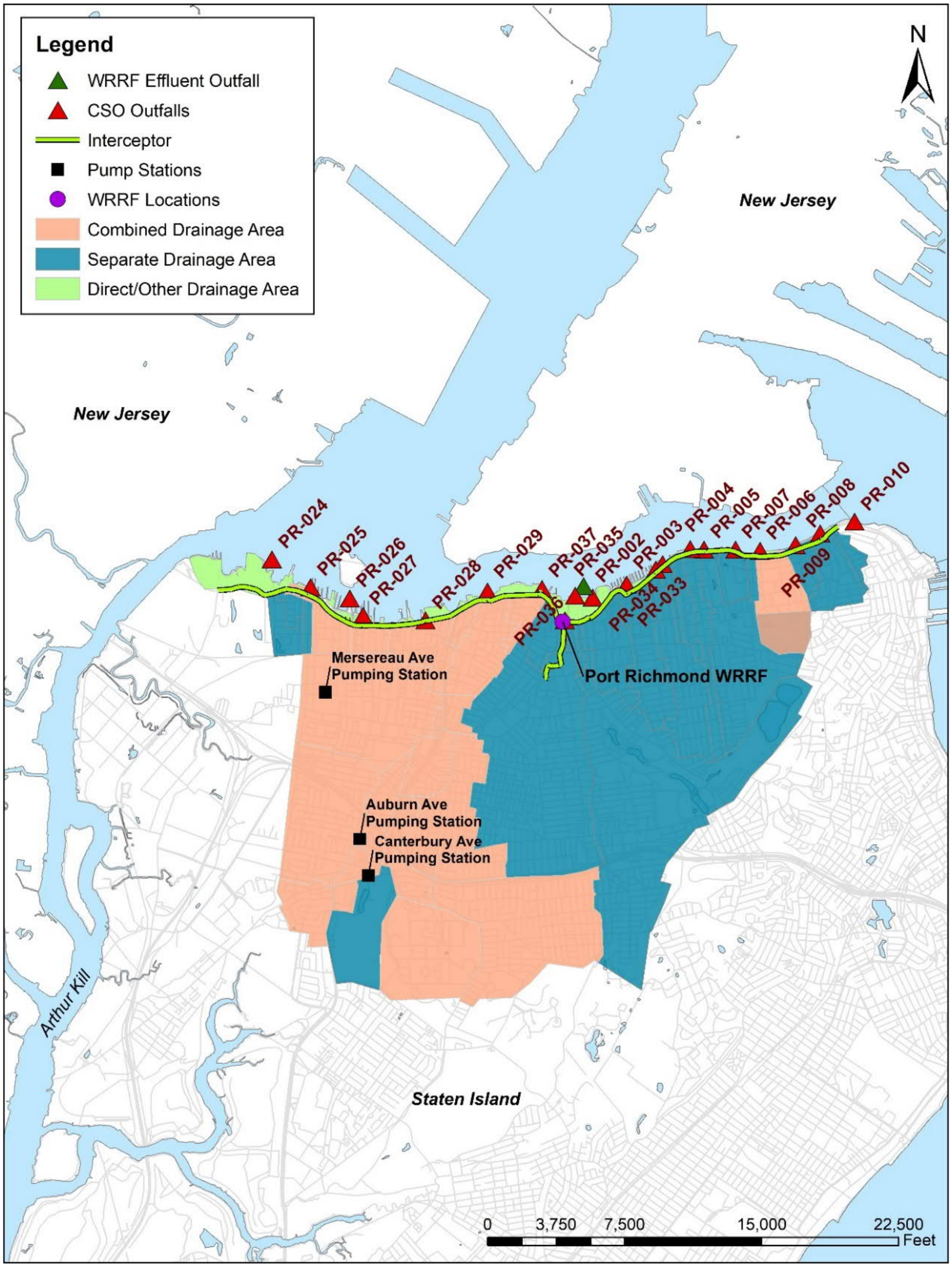


Figure 2.5-11. Port Richmond WRRF Collection System Tributary to Kill Van Kull

Oakwood Beach WRRF Drainage Area and Sewer System

The Oakwood Beach WRRF sewershed area and sewer system are described in Section 2.4.a.2. The Oakwood Beach WRRF collection system has no CSO outfalls.

Stormwater and Wastewater Characteristics

Data collected from sampling events were used to estimate concentrations for fecal coliform bacteria and *Enterococci* bacteria to use in calculating loadings from various sources discharging to Kill Van Kull and Arthur Kill. Although none of the CSO outfalls discharging to Arthur Kill were sampled as part of the LTCP program, CSO concentrations were measured in 2017 at Port Richmond Outfall PR-031, which discharges to New York Bay. The sampling data for Outfall PR-031 is summarized in Section 2.4.a.2.

Flow monitoring data were also collected for CSO Outfall PR-031 to support the development of the Citywide/Open Waters LTCP. Descriptions of the Oakwood Beach and Port Richmond WRRFs IW model updates and calibration processes based on the flow monitoring data gathered for these outfalls was provided earlier in Section 2.4.a.1.

Sampling, data analyses, and water quality modeling calibration resulted in the assignment of flows and loadings to these sources for inclusion in the calibration/validation of the water quality model. The CSO and stormwater concentrations used for the water quality evaluation in this LTCP are described in Section 6 of this LTCP.

Hydraulic Analysis of Sewer System

A citywide hydraulic analysis was completed in December 2012 to provide further insight into the hydraulic capacities of key system components and system responses to various wet-weather conditions. The results of this analysis for the Port Richmond WRRF are described in Section 2.4.b. An analysis was not completed for the Oakwood Beach WRRF, which is a separately sewered area.

Identification of Areas Prone to Flooding and History of Confirmed Sewer Backups

DEP maintains and operates the collection systems throughout the five boroughs. To do so, DEP employs a combination of reactive and proactive maintenance techniques. NYC's "311" system routes public complaints of sewer issues to DEP for response and resolution. Although not every call that reports flooding or sewer backups corresponds to an actual issue with the municipal sewer system, each call to 311 is responded to. Sewer functionality impediments identified during a DEP response effort are corrected as necessary.

Findings from Interceptor Inspections

DEP has several programs with staff devoted to sewer maintenance, inspection and analysis, and regularly inspects and cleans its sewers, as reported in the SPDES BMP Annual reports. In the last decade, DEP has implemented advanced technologies and procedures to enhance its proactive sewer maintenance practices. Section 2.4.a.2 provides the details from the interceptor inspections throughout Staten Island.

2.5.b Waterbody Characteristics

This section of the report describes the features and attributes of Arthur Kill and Kill Van Kull.

2.5.b.1 Description of Waterbody

Arthur Kill is a tidal strait located between the west coast of Staten Island, NY and Union and Middlesex Counties in New Jersey. Kill Van Kull is located between the north coast of Staten Island, NY and Bayonne County in New Jersey. Both channels define the state boundary between New York and New Jersey. Both Arthur Kill and Kill Van Kull are greatly influenced by neighboring waterbodies. Tidal oscillations cause dramatic fluctuations of its currents and may influence the spread of sediments, pollutants, and other particles throughout the connecting waterways. As no CSO outfalls from the NY side discharge to Arthur Kill, water quality in this channel is mostly affected by stormwater and tidal exchanges between the bays while Kill Van Kull water quality experiences more influence from CSO discharges.

The following sections describe the current water quality characteristics of Arthur Kill and Kill Van Kull.

2.5.b.2 Current Waterbody Classification(s) and Water Quality Standards

New York State Policies and Regulations

In accordance with the provisions of the CWA, the State of New York has established WQS for all navigable waters within its jurisdiction. DEC has classified Kill Van Kull and the upper reach of Arthur Kill north of the Outerbridge Crossing Bridge as Class SD waterbodies. The lower portion of Arthur Kill south of the Outerbridge Crossing Bridge is Class I, as shown in Figure 2.5-12. Numerical standards and narrative WQS criteria corresponding to the classification of these waterbodies are shown in Section 2.1.b.2.

Interstate Environmental Commission

The States of New York, New Jersey, and Connecticut are signatories to the Tri-State Compact that designated the Interstate Environmental District and created the Interstate Environmental Commission (IEC). The IEC includes all saline waters of greater NYC. Arthur Kill and Kill Van Kull are interstate waters and are regulated by IEC as Class B-2 waters. Numerical standards for IEC-regulated waterbodies are shown in Section 2.1.b.2, while narrative standards are shown in Table 2.1-7 (Section 2.1.b.2) and Table 2.1-8 (Section 2.1.b.2).

EPA Policies and Regulations

EPA reference levels for designated bathing beach areas, non-designated beach areas of primary contact recreation, and 2012 RWQC recommendations are summarized in Section 2.1.b.2. In the context of the water quality criteria, Arthur Kill and Kill Van Kull are classified as non-coastal tributary waterbodies, so the 2012 RWQC recommendations do not apply to Arthur Kill and Kill Van Kull.

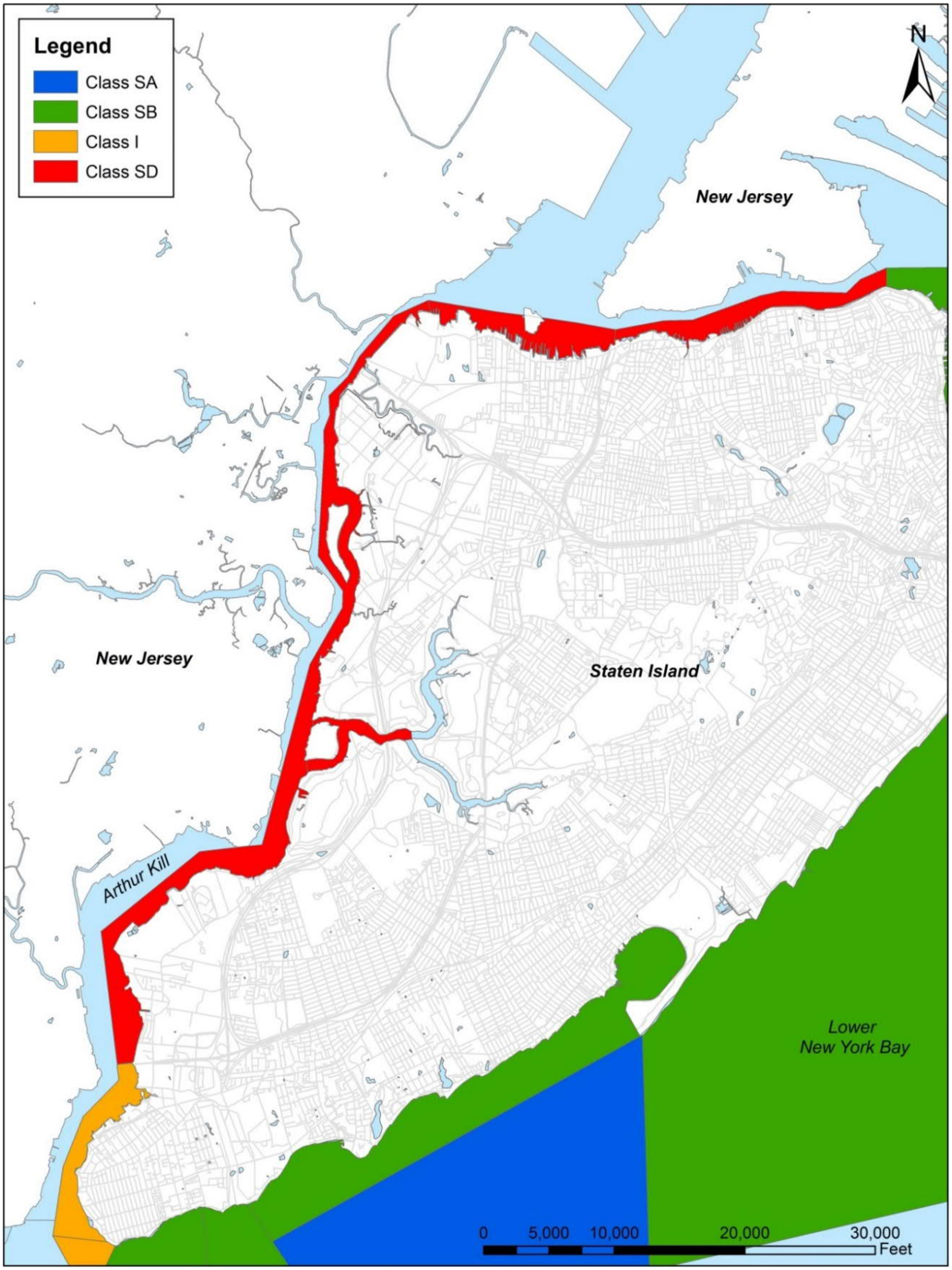


Figure 2.5-12. Waterbody Classifications for Arthur Kill and Kill Van Kull

2.5.b.3 Physical Waterbody Characteristics

Arthur Kill is a 10-mile long tidal strait that flows between Staten Island and Union and Middlesex counties of New Jersey. The Arthur Kill is approximately 600 feet wide and connects the Raritan Bay/Lower New York Bay on its south end to Newark Bay/Kill Van Kull on the north end.

Kill Van Kull is a three-mile long tidal straight that flows between the northern shore of Staten Island and Bayonne, New Jersey. The channel is approximately 1,000 feet wide and connects Newark Bay at its western end to Upper New York Bay at its eastern end.

Both Arthur Kill and Kill Van Kull are major navigational channels of the Port of New York and New Jersey, receiving heavy shipping traffic. Periodic dredging has been required to deepen and widen both channels to depths of 35 to 50 feet in order to accommodate large commercial ship traffic.

Shoreline Physical Characterization

The shorelines of Arthur Kill and Kill Van Kull are composed of a mix of natural areas, riprap, piers and bulkhead, as shown in Figure 2.5-13. Most of the shoreline in Arthur Kill is natural with a small extent of piers, bulkhead and riprap. In Kill Van Kull, the shoreline is more diverse and almost evenly distributed between riprap, piers and bulkhead.

Shoreline Slope

The natural or vegetated shorelines of Arthur Kill and Kill Van Kull are generally characterized by gentle and intermediate slopes.

Waterbody Sediment Surficial Geology/Substrata

A study of Newark Bay benthic fauna by Cerrato [1986] included sampling stations in Arthur Kill near Shooters Island. This study included channel and shoal stations and a variety of substrate types. The dominant benthic species were sedentary forms that were suspension or deposit feeders. Cerrato [1986] reported that the benthic fauna in the study area was more diverse and productive than in prior surveys. Similar benthic fauna would be expected in other areas of Arthur Kill and Kill Van Kull where similar substrates occur, and maintained channels and berthing areas are a dominant feature of the waterbodies as they are in Newark Bay. In Arthur Kill, a predominance of species favoring mud and sand substrates would be expected in the embayments, compared to Kill Van Kull where the channel is dredged to rock and swift currents minimize the build-up of soft substrates.

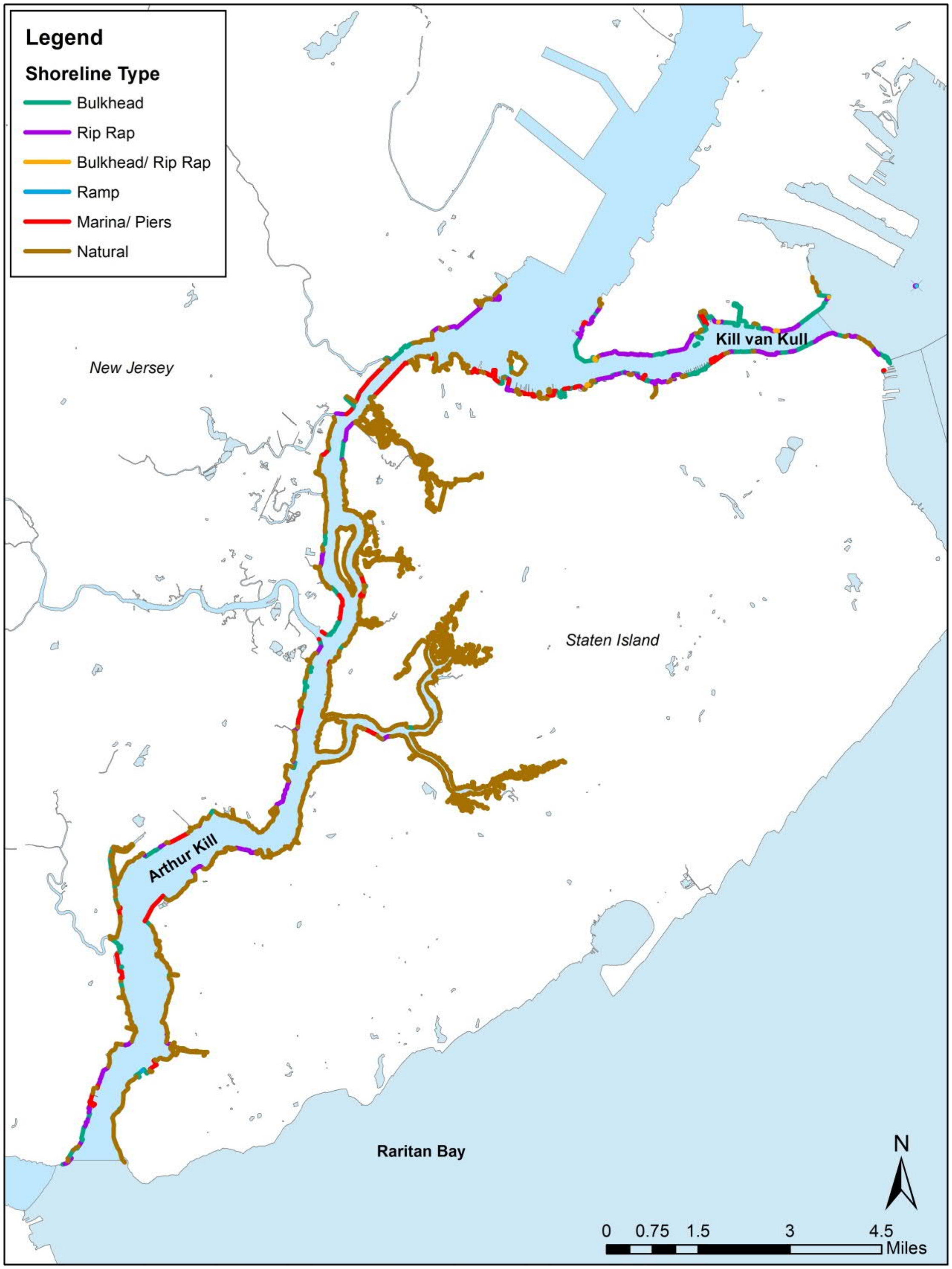


Figure 2.5-13. Arthur Kill and Kill Van Kull Shoreline Characteristics

Tidal/Estuarine Systems Biological Systems

Tidal/Estuarine Wetlands

Tidal/estuarine wetlands reported by the U.S. Fish and Wildlife Service (USFWS) National Wetlands Inventory (NWI) maps show tidal/estuarine wetlands throughout the Arthur Kill study area, as shown in Figure 2.5-14.

Aquatic and Terrestrial Communities

The DCP Plan for the Brooklyn and Staten Island Waterfront (DCP, 1993) reports a diverse range of species supported by the habitat in the Kill Van Kull and Arthur Kill area.

Biological Systems

DEC's Freshwater Wetlands Maps designate several freshwater wetlands within the Arthur Kill and Kill Van Kull watersheds. The main wetlands for Arthur Kill are located in Clay Pit Pond Park Reserve, Saw Mill Creek Marsh and the Bloomfield area. For Kill Van Kull, the only wetland is at the Snug Harbor Cultural Center & Botanical Garden.

2.5.b.4 Current Public Access and Uses

In Arthur Kill and Kill Van Kull, swimming (primary contact recreation use) is not identified as a best use, as defined by New York State Codes, Rules and Regulations for Class I and SD waterbodies. Limited public access locations for secondary contact recreation are located along the shoreline of Arthur Kill and Kill Van Kull, as shown in Figure 2.5-15.

2.5.b.5 Identification of Sensitive Areas

Federal CSO Policy requires that the LTCP give the highest priority to controlling overflows to sensitive areas. The Policy defines sensitive areas as:

- Waters designated as Outstanding National Resource Waters (ONRW);
- National Marine Sanctuaries;
- Public drinking water intakes;
- Waters designated as protected areas for public water supply intakes;
- Shellfish beds;
- Water with primary contact recreation;
- Waters with threatened or endangered species and their habitat; and
- Additional areas determined by the Permitting Authority (i.e., DEC).

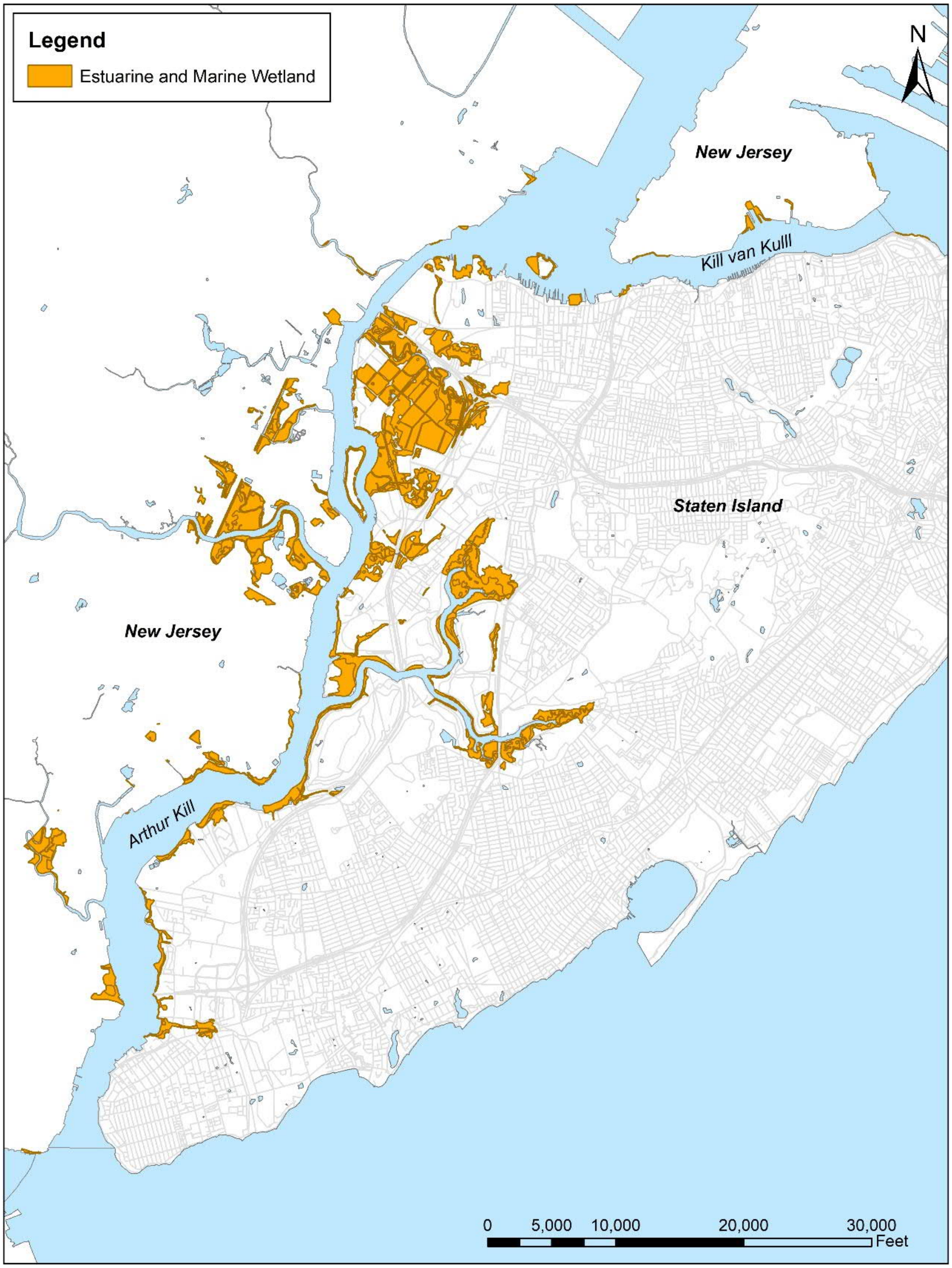


Figure 2.5-14. USWFS NWI Tidal/Wetland Estuaries of Arthur Kill and Kill Van Kull

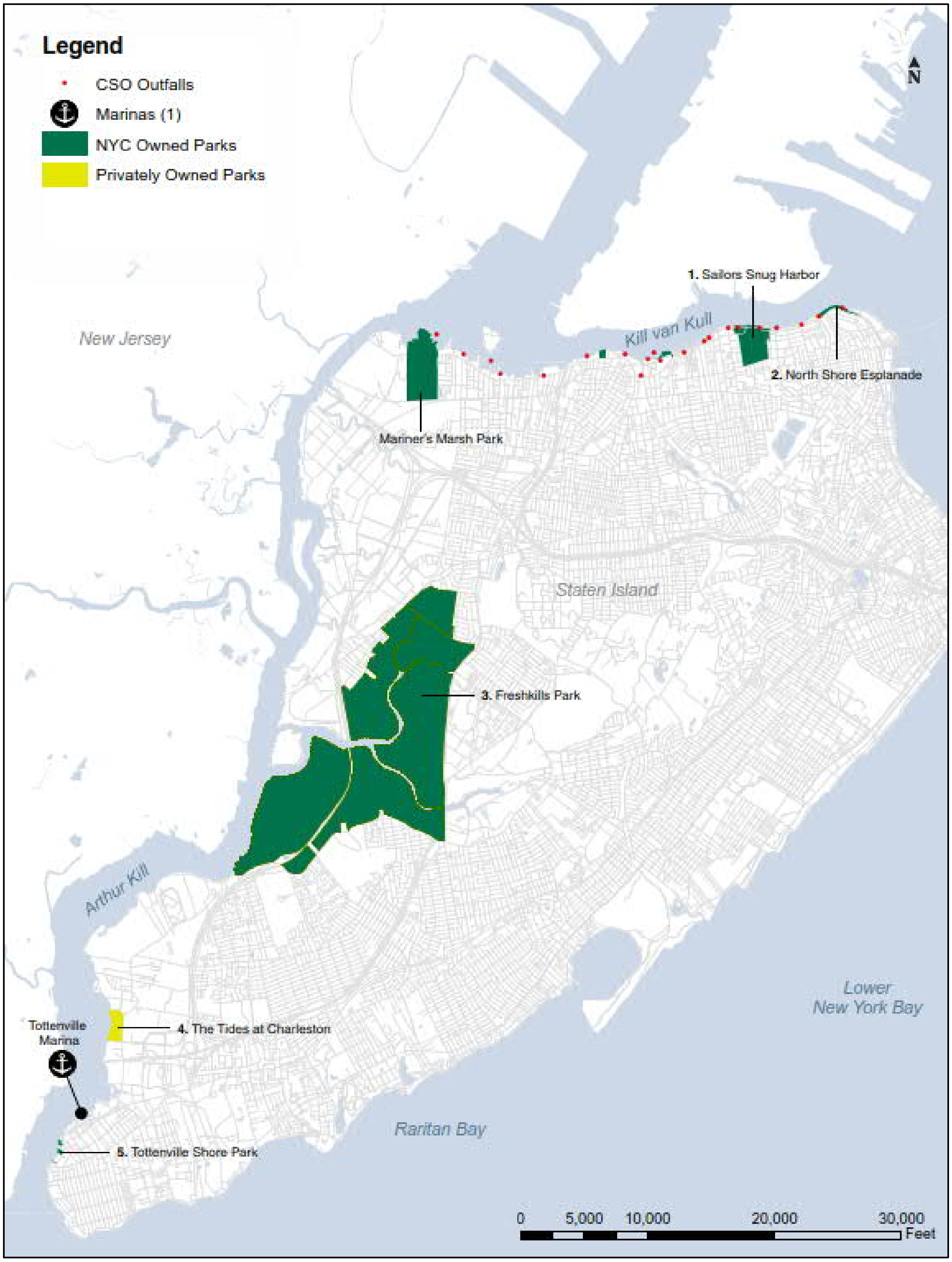


Figure 2.5-15. Access Points to Arthur Kill and Kill Van Kull

The presence/status of sensitive areas in Arthur Kill and Kill Van Kull, as defined by the Federal CSO Policy, is summarized in Table 2.5-5. Sources of information supporting the status are included in the footnotes to the table.

Table 2.5-5. Sensitive Areas Assessment

CSO Discharge Receiving Water Segments	Current Uses Classification of Waters Receiving CSO Discharges Compared to Sensitive Areas Classifications or Designations(1)						
	Outstanding National Resource Water (ONRW)	National Marine Sanctuaries	Threatened or Endangered Species and their Habitat	Best Use - Primary Contact Recreation	Public Water Supply Intake	Public Water Supply Protected Area	Shellfish Bed
Arthur Kill/ Kill Van Kull	No(2)	No(3)	Yes(4)	No(5)	No(6)	No(6)	

Notes:
(1) Classifications or Designations per CSO Policy.
(2) EPA; DEC Protection of Waters Program and Environmental Resource Mapper.
(3) National Oceanic and Atmospheric Administration (NOAA).
(4) United States Fish and Wildlife Service (USFWS); NOAA; DEC New York Natural Heritage Program (NYNHP).
(5) Primary Contact is not designated as a best use for Class I and SD waters.
(6) Arthur Kill and Kill Van Kull are saline.
(7) 6CRR-NY part 41.

As indicated in Table 2.5-5, Arthur Kill and Kill Van Kull fall into the category of "Waters with Threatened or Endangered Species and their Habitat". Based on the lists produced by NOAA and the New York Natural Heritage Program, threatened and endangered species with the potential to occur in Arthur Kill and/or Kill Van Kull include the following:

- Peregrine Falcon (*Falco peregrinus*)
- Bald Eagle (*Haliaeetus leucocephalus*)
- Least Bittern *(Ixobrychus exilis)*
- Pied-billed Grebe *(Podilymbus podiceps)*

The US Fish and Wildlife Service lists the following with the potential to occur in the Citywide/Open Waters project area:

- Piping Plover (*Charadrius melodus)*
- Red Knot (*Calidris canutus rufa*)
- Roseate Tern (*Sterna dougallii dougallii*)
- Bog Turtle (*Clemmys muhlenbergii*)Indiana Bat (*Myotis sodalist*)
- Northern Long-eared Bat (*Myotis septentrionalis*)
- Sandplain Gerardia (*Agalinis acuta*)
- Seabeach Amaranth (*Amarnthus pumilus*)

None of the species listed above was identified as having critical habitat present in the project area.

2.5.b.6 Compilation and Analysis of Existing Water Quality Data

Data collected within Kill Van Kull and Arthur Kill are available from sampling conducted by DEP's HSM program from 2007 to 2018, and additional data is available within Kill Van Kull from intensive sampling conducted from October through December 2017 to support the Citywide/Open Waters LTCP. The DEP's HSM program focuses on the water quality parameters of fecal coliform and *Enterococci* bacteria, DO, chlorophyll 'a', and Secchi disk transparency. HSM data are organized into four geographic regions within the Harbor, and both Kill Van Kull and the Arthur Kill are located within the "Inner Harbor" region. Two HSM stations are located in Kill Van Kull (K1 and K2) and three HSM stations are located in Arthur Kill (K3, K4, and K5). In addition to the HSM program, DEP also operates a Sentinel Monitoring (SM) Program, targeted at identifying illicit discharges to the waterbodies through changes to baseline sampling concentrations. The SM program collects quarterly dry-weather fecal coliform data from two stations in Kill Van Kull (S69, S70) and three stations in the Arthur Kill (S71, S72, and S45). LTCP sampling was conducted at three stations within the Kill Van Kull (KVK-1 through KVK-3). The HSM, SM, and LTCP sampling locations are all shown in Figure 2.5-16.

Figure 2.5-17 and Figure 2.5-18 show the GM, minimum, maximum, 25th percentile, and 75th percentile values for fecal coliform and *Enterococci*, respectively, for the LTCP sampling data in Kill Van Kill. Figure 2.5-19 and Figure 2.5-20 show similar data for the HSM sampling program in Kill Van Kull and Arthur Kill from 2015 through 2017.

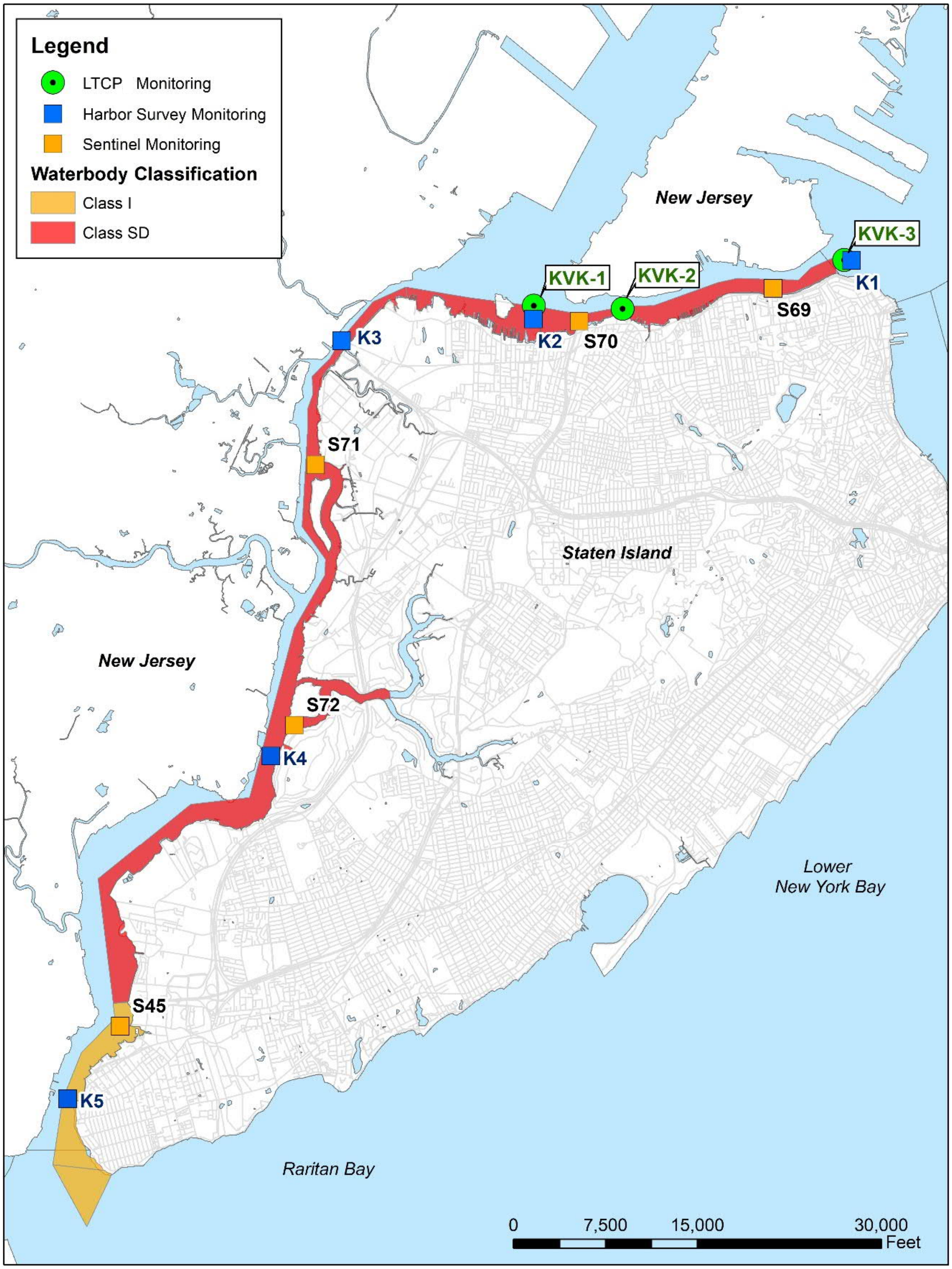


Figure 2.5-16. Water Quality Monitoring Sampling Locations within Arthur Kill and Kill Van Kull

AECOM with Hazen

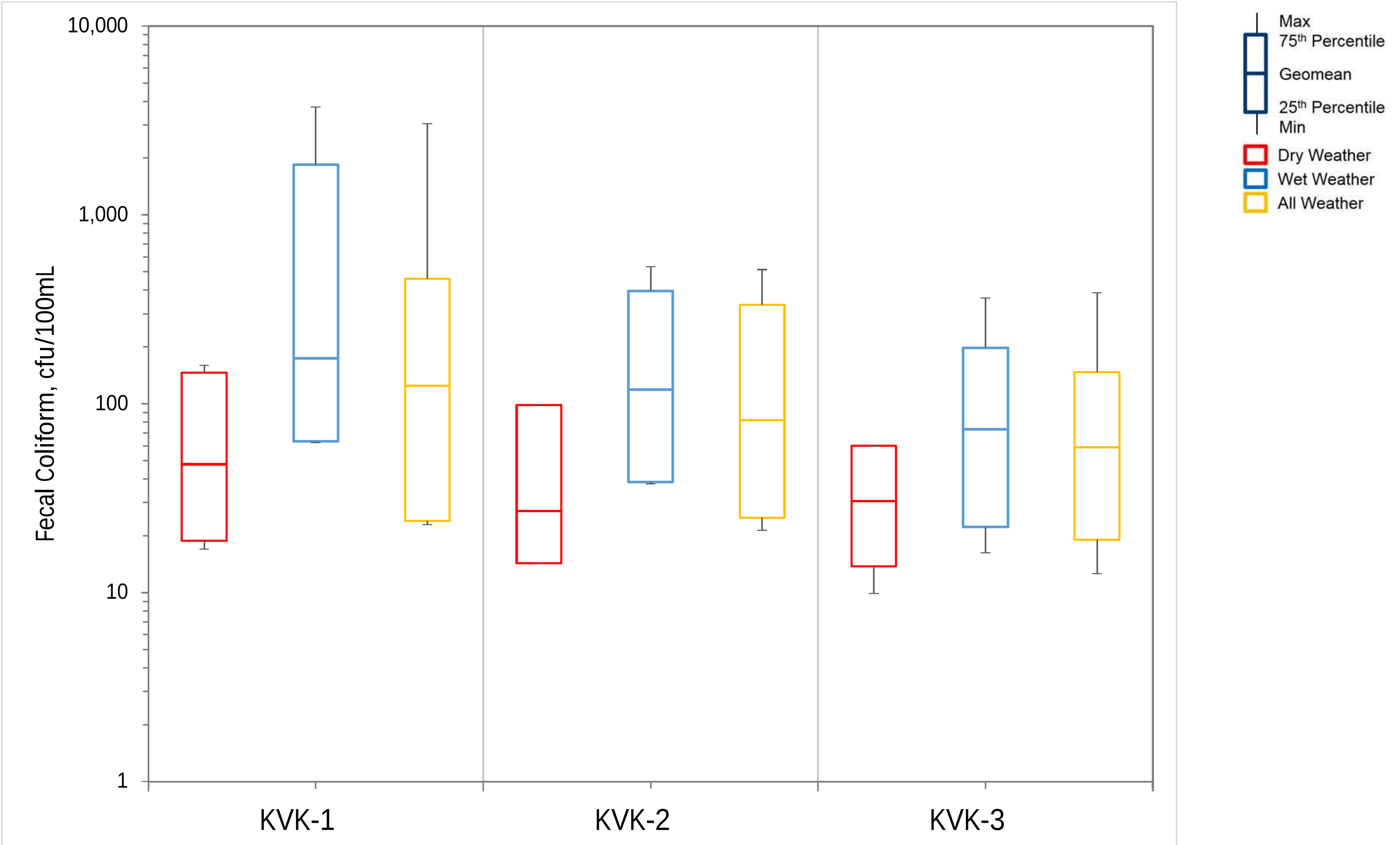


Figure 2.5-17. Fecal Coliform Concentrations at LTCP Sampling Stations in Kill Van Kull October - December 2017

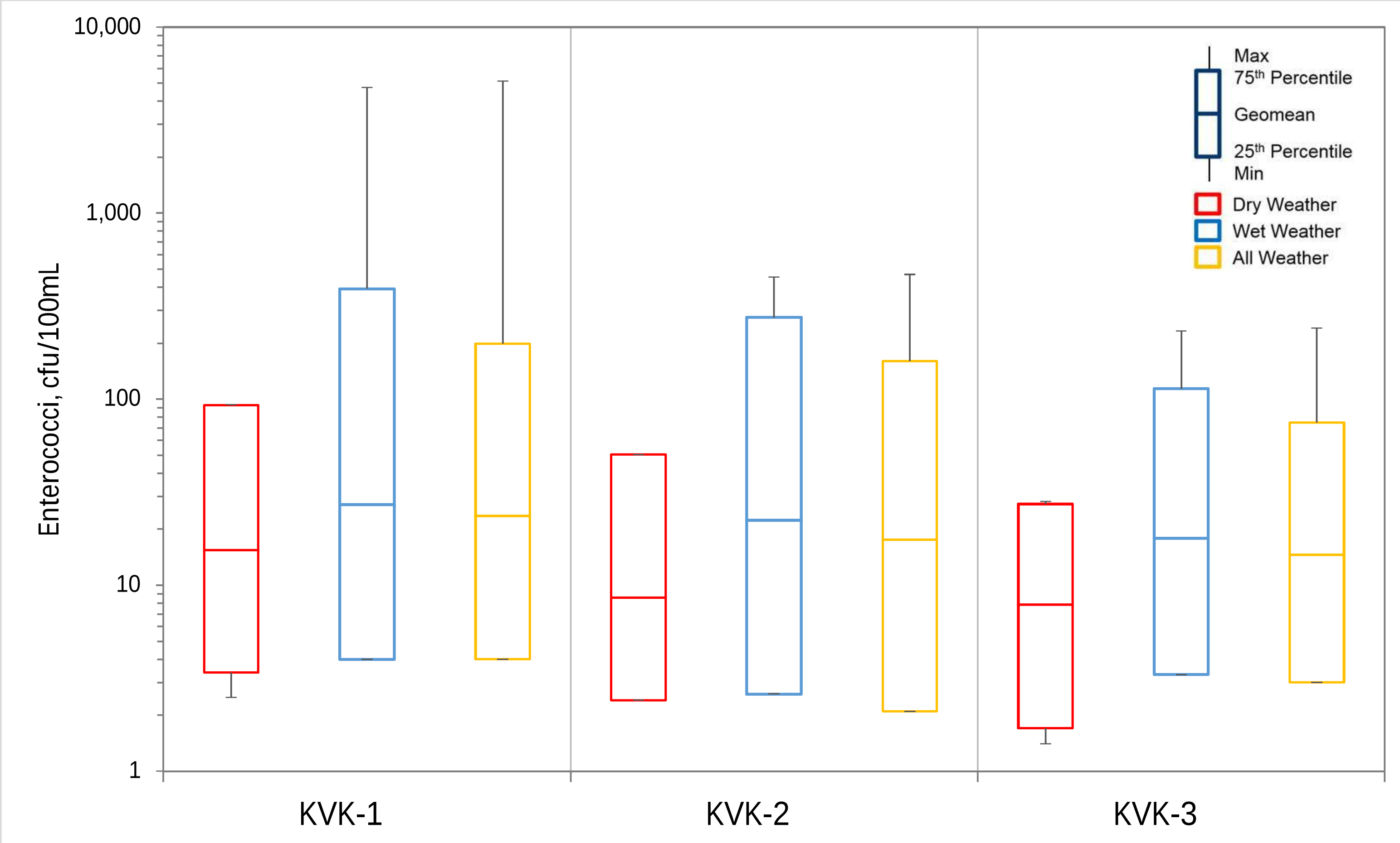


Figure 2.5-18. *Enterococci* Concentrations at LTCP Sampling Stations in Kill Van Kull October - December 2017*

*Note: Enterococci WQ Criteria do not apply to Kill Van Kull.
Enterococci data are presented for informational purposes.

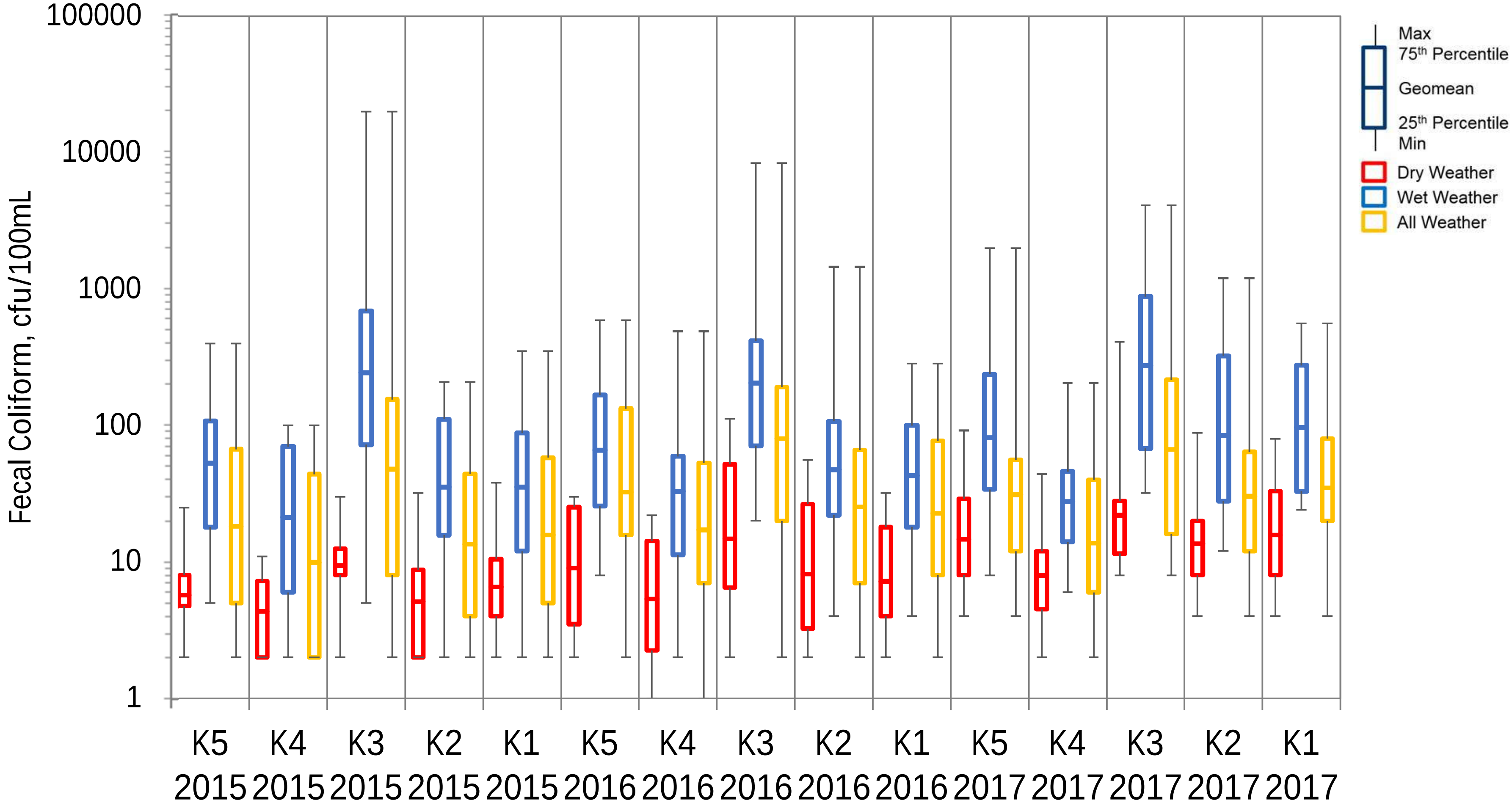


Figure 2.5-19. Fecal Coliform Concentrations at HSM Sampling Stations in Kill Van Kull

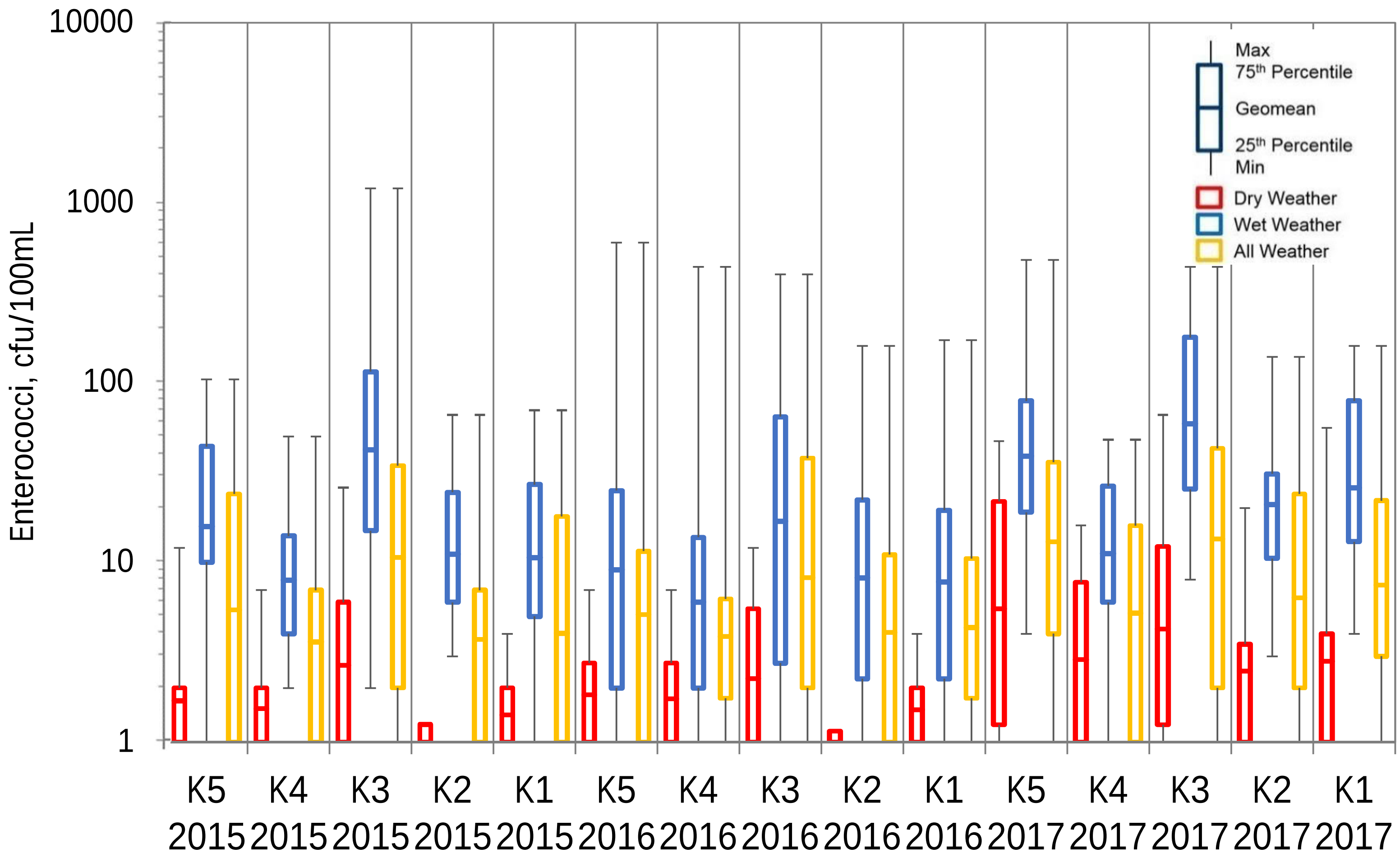


Figure 2.5-20. *Enterococci* Concentrations at HSM Sampling Stations in Kill Van Kull and Arthur Kill*

*Note: Enterococci WQ Criteria do not apply to Kill Van Kull or Arthur Kill.
Enterococci data are presented for informational purposes.

The fecal coliform levels measured throughout the LTCP sampling program in wet-weather were generally higher than the levels measured during dry-weather, indicative of the impacts of wet-weather pollution sources on Kill Van Kull. However, as indicated in Figure 2.5-17, geometric means were below 200 cfu/100mL at all stations during both dry- and wet-weather conditions, indicating that the wet-weather impacts were relatively limited. The LTCP *Enterococci* data shown in Figure 2.5-18 generally follow a similar trend as the fecal coliform data, with wet-weather geometric means higher than dry-weather geometric means and all geometric means were below 30 cfu/100mL.

The HSM fecal coliform data presented in Figure 2.5-19 are also consistent with the LTCP data. While a wet-weather impact is evident, the geometric means of the fecal coliform data were below 200 cfu/100mL at all stations except at Station K3, where wet-weather geometric means were above 200 cfu/100mL for all years. The HSM *Enterococci* data shown in Figure 2.5-20 generally follow a similar trend as the fecal coliform data, with wet-weather geometric means higher than dry-weather geometric means. HSM *Enterococci* geometric means were above 30 cfu/100mL at Station K3 during 2015 and 2017 and at Station K5 during 2017.

Figure 2.5-21 shows the arithmetic mean, minimum, maximum, 25th percentile, and 75th percentile values for DO from the LTCP October through December 2017 sampling program. The measured DO concentrations portray autumn/winter conditions and therefore may not capture the lower DO values expected to occur during the summer periods. As indicated in Figure 2.5-21, no DO values were observed below 3.0 mg/L. The HSM DO data from 2015 to 2017 are shown in Figure 2.5-22. Similar to the LTCP data, no DO values fell below 3.0 mg/L requirement for a Class SD waterbody. Additionally, the DO arithmetic mean at Station K5 was above the 4.0 mg/L Class I requirement during all years and all weather conditions.

2.5.b.7 Water Quality Modeling

In addition to the collection, compilation, and analysis of measurements described in Section 2.2.a.6, water quality modeling was also used to characterize and assess Arthur Kill and Kill Van Kull water quality. The LTCP Regional Model (LTCPRM) was used for water quality modeling for the Citywide/Open Waters LTCP. This model evolved from the System-Wide Eutrophication Model (SWEM) that underwent peer review by model evaluation groups (MEGs) in 1994, 1997, and 1999. The model computational grid associated with the LTCPRM, as well as further details on this model, are presented are presented in Section 6 of this LTCP.

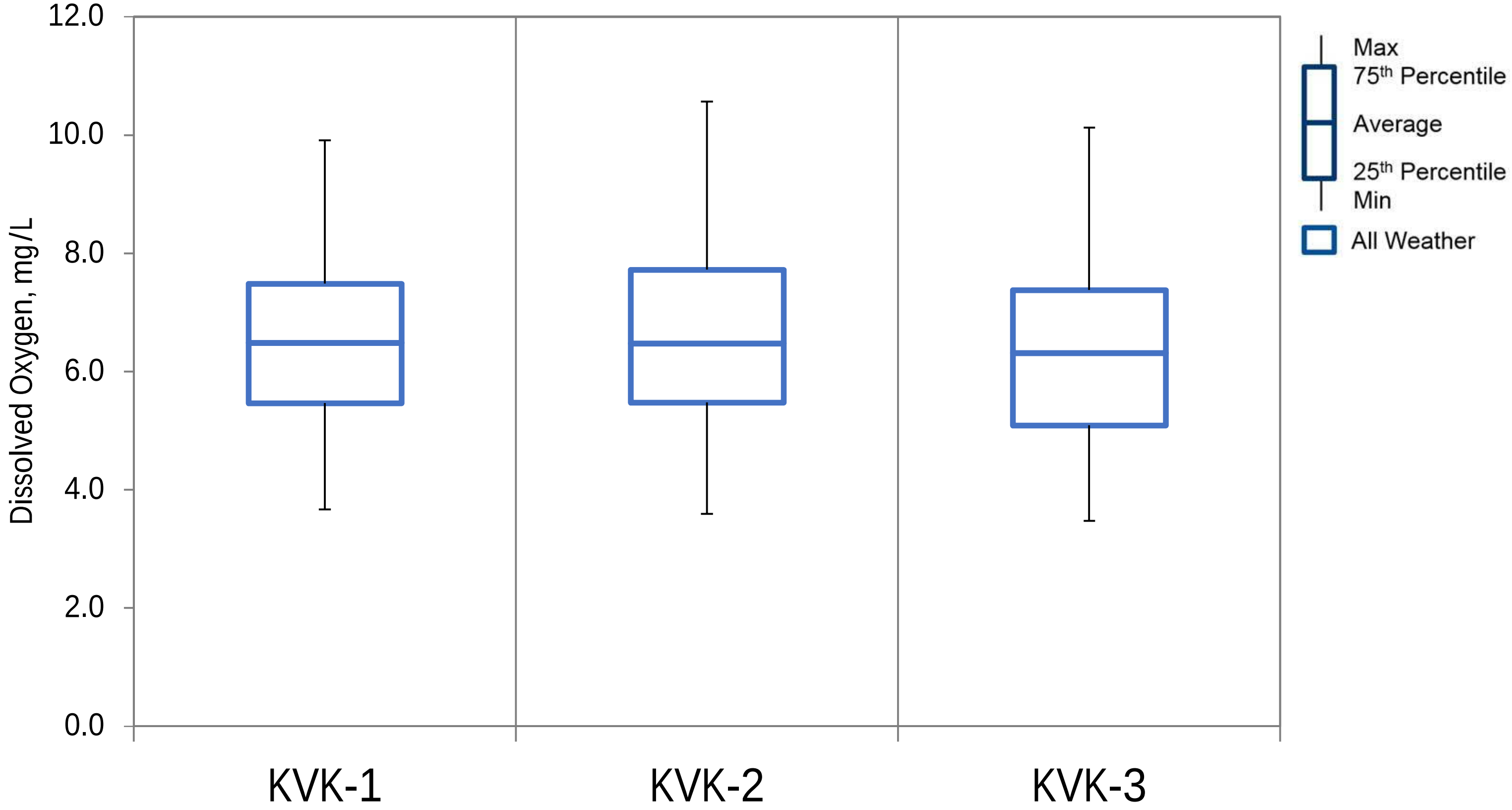


Figure 2.5-21. Dissolved Oxygen Concentrations at LTCP Sampling Stations in Kill Van Kull

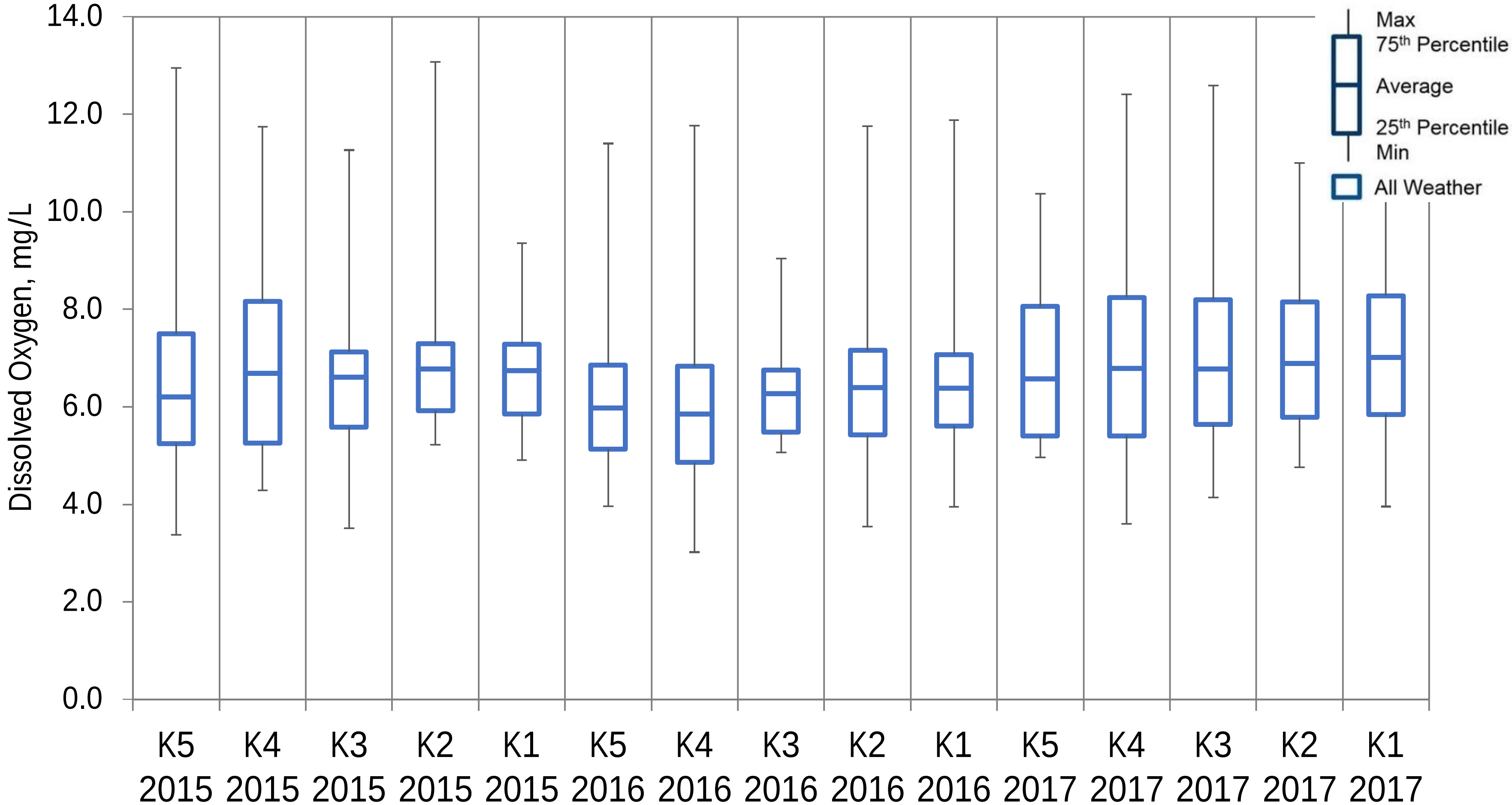


Figure 2.5-22. Dissolved Oxygen Concentrations at HSM Sampling Stations in Kill Van Kull

3.0 CSO BEST MANAGEMENT PRACTICES

CSO Best Management Practices (BMPs) address operation and maintenance procedures, maximizing use of existing systems and facilities, and related planning efforts to maximize capture of CSO and to reduce contaminants in the combined sewer system, thereby reducing water quality impacts. The SPDES permits for all 14 WRRFs in NYC require DEP to report annually on its progress in implementing the following 13 CSO BMPs:

1. CSO Maintenance and Inspection Program
2. Maximum Use of Collection System for Storage
3. Maximize Flow to Publicly Owned Treatment Works (POTW)
4. Wet Weather Operating Plan (WWOP)
5. Prohibition of Dry Weather Overflow
6. Industrial Pretreatment
7. Control of Floatable and Settleable Solids
8. Combined Sewer System Replacement
9. Combined Sewer Extension
10. Sewer Connection and Extension Prohibitions
11. Septage and Hauled Waste
12. Control of Runoff
13. Public Notification

These 13 BMPs listed above are equivalent to the Nine Minimum Controls (NMCs) required under the EPA CSO Control Policy. The NMCs were developed by the EPA to represent BMPs that would serve as technology-based CSO controls. The BMPs were intended to be "determined on a best professional judgment basis by the NPDES permitting authority" and to be the best available technology-based controls that permittees could implement within two years. EPA developed two guidance manuals that explained the underlying intent of the NMCs for permit writers and municipalities, offering suggested language for SPDES permits and programmatic controls that could accomplish the goals of the NMCs (EPA, 1995a, 1995b). A comparison of the EPA's NMCs to the 13 SPDES BMPs is shown in Table 3-1.

Table 3-1. Comparison of EPA NMCs with SPDES Permit BMPs

EPA Nine Minimum Controls	SPDES Permit Best Management Practices
NMC 1: Proper Operations and Regular Maintenance Programs for the Sewer System and the CSOs	BMP 1: CSO Maintenance and Inspection Program BMP 4: Wet Weather Operating Plan BMP 8: Combined Sewer Replacement BMP 9: Combined Sewer Extension BMP 10: Sewer Connection and Extension Prohibitions BMP 11: Septage and Hauled Waste
NMC 2: Maximum Use of the Collection System for Storage	BMP 2: Maximum Use of Collection System for Storage
NMC 3: Review and Modification of Pretreatment Requirements to Assure CSO Impacts are Minimized	BMP 6: Industrial Pretreatment
NMC 4: Maximization of Flow to the Publicly Owned Treatment Works for Treatment	BMP 3: Maximize Flow to POTW BMP 4: Wet Weather Operating Plan
NMC 5: Prohibition of CSOs During Dry Weather	BMP 5: Prohibition of Dry Weather Overflow
NMC 6: Control of Solid and Floatable Material in CSOs	BMP 7: Control of Floatable and Settleable Solids
NMC 7: Pollution Prevention	BMP 6: Industrial Pretreatment BMP 7: Control of Floatable and Settleable Solids BMP 12: Control of Runoff
NMC 8: Public Notification to Ensure that the Public Receives Adequate Notification of CSO Occurrences and CSO Impacts	BMP 13: Public Notification
NMC 9: Monitoring to Effectively Characterize CSO Impacts and the Efficacy of CSO Controls	BMP 1: CSO Maintenance and Inspection Program BMP 5: Prohibition of Dry Weather Overflow BMP 6: Industrial Pretreatment BMP 7: Control of Floatable and Settleable Solids

On May 8, 2014 DEP and DEC entered into the 2014 CSO BMP Order on Consent[1] (2014 CSO BMP Order). The 2014 CSO BMP Order identified certain deliverables and procedures in Appendices A and B that were added to DEP's SPDES permit in October 2015 as "Additional CSO BMP Special Conditions." The SPDES Additional CSO BMP Special Conditions are in addition to the 13 CSO BMPs referenced above and consist of the following:

Additional CSO BMP Special Conditions – Appendix A

- Interceptor Cleaning;
- Management of Interceptor Sewer Physical Assets;
- Interceptor Re-inspection and Cleaning; and
- Data Submission.

Additional CSO BMP Special Conditions – Appendix B

- Maximizing Flow to WRRF;
- CSO Monitoring and Equipment;

[1] 2014 CSO BMP Order on Consent, DEC File No. R2-20140203-112.

- Wet Weather Operating Plan;
- Event Reporting and Corrective Actions; and
- Hydraulic Modeling Verification.

The City's BMP Annual Report, beginning with calendar year 2016, includes a section on the Additional CSO BMP Special Conditions including Appendix B, Item 5.b., "Key Regulator(s) Monitoring Reporting." That provision requires DEP to submit monthly reports of all known or suspected CSO discharges from key regulators outside the period of a critical wet-weather event, and to submit for DEC approval an engineering analysis of the cause(s) for each discharge and an analysis of options to reduce or eliminate similar future events. These analyses were required to be submitted on a quarterly basis for the first year pursuant to the 2014 CSO BMP Order and annually thereafter with the SPDES Annual BMP Report. The 2014 CSO BMP Order also included the following specific requirement:

> *On August 1, 2014, Respondent shall commence a 12-month data gathering period of all known or suspected CSO discharges, from early tipping regulators with CSO monitoring equipment identified in Subparagraph 3(b) above. Within 18 months of August 1, 2014, DEP shall submit a report ("Report") for the first twelve month period after August 1, 2014, with the report due six months later (February 1, 2016), for all known or suspected CSO discharges, from early tipping regulators with CSO monitoring equipment identified in Subparagraph 3(b) above, which occurred outside the periods of critical wet-weather events. The Report shall include an engineering analysis of the cause(s), identify system limitations and evaluate options for reducing or eliminating future similar events. A schedule must be provided for all reasonable and cost effective options which can be completed within two years (exclusive of the time required for procurement) and DEP must complete those projects in accordance with a DEC approved schedule. Other capital intensive projects requiring more than two years to implement (exclusive of the time required for procurement) shall be considered as part of the LTCP process towards achieving the water quality goals of the Clean Water Act.*

DEP submitted the *Regulator(s) with CSO Monitoring Equipment Identification Program Reporting* on February 1, 2016 (DEP, 2016), in accordance with the Consent Order. That report did not identify any cost-effective projects that could be implemented within two years to mitigate discharges outside of the period of critical wet-weather events, but did identify a subset of regulators to be evaluated further under the LTCP. Section 3.1 below presents a brief summary of each BMP and its respective relationship to the federal NMCs. A more detailed discussion of CSO BMPs can be found in DEP's Annual BMP Report. Section 3.2 below presents the evaluation of regulators discharging outside of periods of critical wet-weather events ("BMP Regulators").

3.1 Summary of BMP Implementation

BMP 1 - CSO Maintenance and Inspection Program

This BMP addresses NMC 1 (Proper Operations and Regular Maintenance Programs for the Sewer System and the CSOs) and NMC 9 (Monitoring to Effectively Characterize CSO Impacts and the Efficacy of CSO Controls). Through regularly scheduled inspections of the CSO regulator structures and the performance of required repair, cleaning, and maintenance work, dry-weather overflows and leakage can be prevented and flow to the WRRF can be maximized. Specific components of this BMP include:

- Inspection and maintenance of CSO tide gates;
- Telemetering of regulators;
- Reporting of regulator telemetry results;
- Recording and reporting of events that cause discharge at outfalls during dry-weather; and
- DEC review of inspection program reports.

Details of recent preventative and corrective maintenance reports can be found in the appendices of the BMP Annual Reports.

BMP 2 - Maximum Use of Collection Systems for Storage

This BMP addresses NMC 2 (Maximum Use of the Collection System for Storage) and requires cleaning and flushing to remove and prevent solids deposition within the collection system, and an evaluation of hydraulic capacity. These practices enable regulators and weirs to be adjusted to maximize the use of system capacity for CSO storage, which reduces the amount of overflow. In its 2018 BMP Annual Report, DEP describes the status of citywide Supervisory Control and Data Acquisition (SCADA), regulators, tide gates, interceptors, in-line storage projects, storage tanks, and collection system inspections and cleaning.

Additional data gathered in accordance with the requirements set forth in the Additional CSO BMP Special Conditions has been used to verify and/or further calibrate the hydraulic model developed for the CSO LTCPs.

BMP 3 - Maximize Flow to POTW

This BMP addresses NMC 4 (Maximization of Flow to the POTW for Treatment), and reiterates the WRRF operating targets established by the SPDES permits for each WRRF's ability to receive and treat minimum flows during wet-weather. The WRRF must be physically capable of receiving a minimum of two times design dry-weather flow (2xDDWF) through the plant headworks; a minimum of 2xDDWF through the primary treatment works (and disinfection works, if applicable); and a minimum of 1.5xDDWF (with the exception of Hunts Point WRRF which is permitted to treat 1.3xDDWF) through the secondary treatment works during wet-weather. The actual process control set points may be established by the WWOP required in BMP 4.

NYC's WRRFs are physically capable of receiving a minimum of twice their permit-rated design flow through primary treatment and disinfection in accordance with their DEC-approved WWOPs. However, the maximum flow that can reach a particular WRRF is controlled by a number of factors, including: hydraulic capacities of the upstream flow regulators; storm intensities within different areas of the collection system; and plant operators, who can restrict flow using "throttling" gates located at the WRRF entrance to protect the WRRF from flooding and process upsets. DEP's operations staff is trained in how to maximize pumped flows during wet-weather without impacting the treatment process, critical infrastructure, or public safety. For guidance, DEP's operations staff follow their plant's DEC-approved WWOP, which specifies the actual process control set points, including average flow, in accordance with Sections VIII (3) and (4) of the SPDES permits. Analyses presented in the 2018 BMP Annual Report indicate that DEP's WRRFs generally complied with this BMP during 2018.

The Additional CSO BMP Special Conditions have a number of requirements related to maximizing wet-weather flows to WRRFs including, but not limited to:

- An enforceable compliance schedule requiring DEP to maximize flow to and through the WRRF during wet-weather events;
- Incorporating throttling protocol and guidance at the WRRFs;
- Updating the critical equipment lists for WRRFs, which includes screening facilities at pumping stations that deliver flow directly to the WRRF and at WRRF headworks; and
- Reporting bypasses to DEC.

BMP 4 - Wet Weather Operating Plan

This BMP addresses NMC 1 (Proper Operations and Regular Maintenance Programs for the Sewer System and the CSOs) and NMC 4 (Maximization of Flow to the Publicly Owned Treatment Works for Treatment). To maximize treatment during wet-weather events, WWOPs were developed for each WRRF sewershed in accordance with the DEC publication entitled *Wet Weather Operating Practices for POTWs with Combined Sewers*. Components of the WWOPs include:

- Unit process operating procedures;
- CSO retention/treatment facility operating procedures, if relevant for that sewershed; and
- Process control procedures and set points to maintain the stability and efficiency of biochemical nutrient removal (BNR) processes, if required.

DEP has submitted to DEC all WWOPs required by the Additional CSO BMP Special Conditions.

BMP 5 - Prohibition of Dry Weather Overflows

This BMP addresses NMC 5 (Prohibition of CSOs During Dry Weather) and NMC 9 (Monitoring to Effectively Characterize CSO Impacts and the Efficacy of CSO Controls), and requires that any dry-weather overflow event be promptly abated and reported to DEC within 24 hours. A written report must follow within 14 days and contain the information required by the corresponding SPDES permit. The status of the Shoreline Survey, the Dry Weather Discharge Investigation Report, and a summary of the total bypasses from the treatment and collection system are provided in the BMP Annual Reports.

Dry-weather overflows from the combined sewer system are prohibited, and DEP's goal is to reduce and/or eliminate dry-weather bypasses. In accordance with requirements, DEP reported to DEC all of the dry-weather overflows. In 2018approximately 2 MG of dry-weather overflow was reported at outfalls that discharge to the Citywide/Open Waters waterbodies.

BMP 6 - Industrial Pretreatment Program

This BMP addresses three NMCs: NMC 3 (Review and Modification of Pretreatment Requirements to Assure CSO Impacts are Minimized); NMC 7 (Pollution Prevention); and NMC 9 (Monitoring to Effectively

Characterize CSO Impacts and the Efficacy of CSO Controls). By regulating the discharges of toxic pollutants from unregulated, relocated, or new Significant Industrial Users[2] tributary to CSOs, this BMP addresses the maximization of persistent toxics treatment from industrial sources upstream of CSOs. Specific components of this BMP include:

- Scheduled discharge during conditions of non-CSO, if appropriate for batch discharges of industrial wastewater;
- Analysis of system capacity to maximize delivery of industrial wastewater to the WRRF, especially for continuous discharges;
- Exclusion of non-contact cooling water from the combined sewer system and permitting of direct discharges of cooling water; and
- Prioritization of industrial waste containing toxic pollutants for capture and treatment by the WRRF over residential/commercial sewersheds.

BMP 7 - Control of Floatables and Settleable Solids

This BMP addresses NMC 6 (Control of Solid and Floatable Material in CSOs), NMC 7 (Pollution Prevention), and NMC 9 (Monitoring to Effectively Characterize CSO Impacts and the Efficacy of CSO Controls), by requiring the implementation of the following four practices to eliminate or minimize the discharge of floating solids, oil and grease, or solids of sewage origin that cause deposition in receiving waters.

- Catch Basin Repair and Maintenance: This practice includes inspection and maintenance scheduled to facilitate proper operations of basins.
- Catch Basin Retrofitting: This program is intended to increase the control of floatables and settleable solids citywide by upgrading obsolete basin designs with contemporary designs that capture street-litter.
- Booming, Skimming and Netting: This practice implements floatables containment systems within the receiving waterbody associated with applicable CSO outfalls. Requirements for system inspection, service, and maintenance are also established.
- Institutional, Regulatory, and Public Education: The DEP continues to implement the City-Wide Floatables Plan in accordance with permit requirements. Specific activities under this category are described in the 2018 BMP Report.

BMP 8 - Combined Sewer Replacement

This BMP addresses NMC 1 (Proper Operations and Regular Maintenance Programs for the Sewer System and the CSOs), requiring all combined sewer replacements are done in conformance with drainage plans approved by the New York City Department of Health and Mental Hygiene (DOHMH) and

[2] Significant Industrial Users are defined by EPA under federal law.

specified within DEP's Master Plan for Sewage and Drainage. Whenever possible, separate sanitary and storm sewers should be used to replace combined sewers.

BMP 9 - Combined Sewer Extension

This BMP addresses NMC 1 (Proper Operations and Regular Maintenance Programs for the Sewer System and the CSOs). To minimize stormwater entering the combined sewer system, this BMP requires combined sewer extensions to be accomplished using separate sewers whenever possible. If separate sewers must be extended from combined sewers, analyses must be performed to demonstrate that the sewage system and treatment plant are able to convey and treat the increased dry--weather flows with minimal impact on receiving water quality. As reported in the 2018 BMP Annual Report, DEP reviewed and approved three private combined sewer extensions in 2018; two out of three private combined sewers are under construction, one is not in construction.

BMP 10 - Sewer Connection & Extension Prohibitions

This BMP addresses NMC 1 (Proper Operations and Regular Maintenance Programs for the Sewer System and the CSOs), and prohibits, upon letter notification from DEC, sewer connections and extensions that would exacerbate recurrent instances of either sewer back-up or manhole overflows. Wastewater connections to the combined sewer system downstream of the last regulator or diversion chamber are also prohibited. Each BMP Annual Report contains a brief status report for this BMP and provides details pertaining to chronic sewer back-up and manhole overflow notifications submitted to DEC when necessary. For the calendar year 2018, conditions did not require DEP to prohibit additional sewer connections or sewer extensions.

BMP 11 - Septage and Hauled Waste

This BMP addresses NMC 1 (Proper Operations and Regular Maintenance Programs for the Sewer System and the CSOs). The discharge or release of septage or hauled waste upstream of a CSO (e.g., scavenger waste) is prohibited under this BMP. Scavenger wastes may only be discharged at designated manholes that never drain into a CSO, and only with a valid permit. The 2008 BMP Annual Report summarizes the four scavenger waste acceptance facilities controlled by DEP, and the regulations governing discharge of such material at the facilities. The facilities are located in the Hunts Point, Oakwood Beach, Bowery Bay, and 26th Ward WRRF sewersheds. The program remained unchanged through the 2018 BMP Annual Report.

BMP 12- Control of Runoff

This BMP addresses NMC 7 (Pollution Prevention) by requiring all sewer certifications for new development to follow DEP rules and regulations, to be consistent with the DEP Master Plan for Sewers and Drainage, and to be permitted by the DEP. This BMP requires that only allowable flow is discharged into the combined or storm sewer system.

A rule to "reduce the release rate of storm flow from new developments to 10 percent of the drainage plan allowable or 0.25 cfs, whichever is higher (for cases when the allowable storm flow is more than 0.25 cfs)," was promulgated on January 4, 2012, and became effective on July 4, 2012.

BMP 13 - Public Notification

BMP 13 addresses NMC 8 (Public Notification to Ensure that the Public Receives Adequate Notification of CSO Occurrences and CSO Impacts), as well as, NMC 1 (Proper Operations and Regular Maintenance Programs for the Sewer System and the CSOs), and NMC 9 (Monitoring to Effectively Characterize CSO Impacts and the Efficacy of CSO Controls).

This BMP requires easy-to-read identification signage to be placed at or near CSO outfalls, with contact information for DEP, to allow the public to report observed dry-weather overflows. All signage information and appearance must comply with the Discharge Notification Requirements listed in the SPDES permit. This BMP also requires that a system be in place to determine the nature and duration of an overflow event, and that potential users of the receiving waters are notified of any resulting, potentially harmful conditions. The BMP allows the DOHMH to implement and manage the notification program. Accordingly, the Wet Weather Advisories, Pollution Advisories, and Closures are tabulated for all NYC public and private beaches along the shorelines of the Citywide/Open Waters waterbodies. Table 3-2 summarizes the closures and warnings due to significant rain events at the Citywide/Open Waters beaches for 2018.

Table 3-2. Number of Beach Closings and Warnings due to Significant Rain Events for Citywide/Open Waters Waterbodies in 2018

Beach	Public/Private	Waterbody	2018 Closures	2018 Warnings Due to Significant Rain Events
Cedar Grove	Public	Lower New York Bay	0	25
Coney Island	Public	Lower New York Bay	0	0
Manhattan Beach	Public	Lower New York Bay	0	0
Midland Beach	Public	Lower New York Bay	0	2
South Beach	Public	Lower New York Bay	1	22
Wolfe's Pond Park	Public	Lower New York Bay	0	0
Orchard Beach	Public	Long Island Sound	0	0
Public Beaches Sub-Total			**1**	**49**
American Turners	Private	Long Island Sound	0	19
Breezy Point Reid	Private	Long Island Sound	0	13
Danish American Beach Club	Private	Long Island Sound	0	19
Trinity Danish	Private	Long Island Sound	0	0

Table 3-2. Number of Beach Closings and Warnings due to Significant Rain Events for Citywide/Open Waters Waterbodies in 2018

Beach	Public/Private	Waterbody	2018 Closures	2018 Warnings Due to Significant Rain Events
Loctus Point Yacht Club	Private	Long Island Sound	0	19
Manhem Beach Club	Private	Long Island Sound	0	19
Morris Yacht and Beach Club	Private	Long Island Sound	0	19
Schuyler Hill Civic Association	Private	Long Island Sound	0	19
West Fordham Street Association	Private	Long Island Sound	0	19
White Cross Fishing Club	Private	Long Island Sound	0	25
Whitestone Booster Civic Association	Private	Upper East River	0	27
Kingsborough Community College	Private	Lower New York Bay	0	0
Seagate 42nd	Private	Lower New York Bay	0	0
Seagate Beach Club	Private	Lower New York Bay	0	0
		Private Beaches Sub-Total	**0**	**306**
		Citywide/Open Waters Beaches Total	**1**	**355**

Characterization and Monitoring

Previous studies have characterized and described most of the WRRF systems that have CSO outfalls that discharge to the Citywide/Open Waters waterbodies. These studies include various WWFPs and the 10 LTCPs covering tributary waterbodies submitted to DEC under the current LTCP program. For those WRRF systems that were not covered in detail in earlier studies, the Citywide/Open Waters LTCP provides the appropriate characterization, summarized in Sections 2 and 6. Section 2, in particular, summarizes additional data collected and analyzed in this LTCP. Continued monitoring occurs under a variety of DEP initiatives, such as the floatables monitoring programs, the Harbor Survey Monitoring Program, and the Sentinel Monitoring Program. Data from these programs are reported in the BMP Annual Reports under SPDES BMPs 1, 5, 6, and 7, as described above.

The SPDES Permit Additional CSO BMP Special Conditions require the installation of CSO monitoring equipment (Doppler sensors in the telemetry system and inclinometers where feasible) at locations identified on the lists of key and other CSO regulators approved by DEC on September 28, 2015 for the purpose of detecting CSO discharges. The DEC-approved list included regulators referred to in the 2014 CSO BMP Order and SPDES Permits as "Early Tipping Regulators." As the BMP Consent Order includes additional requirements for Early Tipping Regulators that extend beyond the requirements of the EPA CSO Control Policy, they have been referred to as "BMP Regulators" throughout this LTCP for the purposes of differentiating them from the other system-wide regulators.

In accordance with Additional CSO BMP Special Condition 5.b., following installation of the CSO monitoring equipment, monthly reports of all known or suspected CSO discharges from key regulators outside the period of a critical wet-weather event have been submitted to DEC within 45 days after the end of each month. On February 1, 2016, DEP submitted a report summarizing twelve months of data gathering that commenced August 1, 2014 of all known or suspected CSO discharges from regulators with monitoring equipment and describing the cause of each. The report evaluated options to reduce or eliminate similar future events. That report categorized the various outfalls with known or suspected discharges outside the period of a critical wet-weather event. Section 3.2 below describes the evaluation of optimization alternatives to address these regulators. See Additional CSO BMP Special Conditions in the WRRF SPDES permits, Items 3(a) and (b); 5(b).

Annual CSO BMP Report Summaries

In accordance with the SPDES permit requirements, annual reports summarizing the citywide implementation of the 13 BMPs and Additional CSO BMP Special Conditions described above are submitted to DEC. DEP has submitted 16 annual reports to-date, covering calendar years 2003 through 2018. The BMP Annual Report for calendar year 2018 is divided into 15 sections, one for each of the BMPs in the SPDES permits, one section for Characterization and Monitoring, and one section for the SPDES Permit Additional CSO BMP Special Conditions. Each section of the Annual BMP Report describes ongoing DEP programs, provides statistics for initiatives occurring during the preceding calendar year, and discusses overall environmental improvements.

3.2 Evaluation of BMP Regulators

Background

In 2014, NYSDEC and DEP executed the CSO BMP Order on Consent ("the BMP Order"). Appendix B of the BMP Order was incorporated into the WRRF SPDES permits. Appendix B to the BMP Order concerned maximizing wet-weather flow and provided that no CSO discharges shall occur from any approved key regulators outside the period of a critical wet-weather event as a result of either: (1) inadequate or improper operation or maintenance of the WRRF; (2) inadequate or improper maintenance of the sewage collection system and regulators; (3) improper throttling/unthrottling of flow to the WRRF; (4) critical WRRF equipment out of service for prolonged periods; (5) negligence; (6) the system not being operated as designed; (7) or any combination thereof. A critical wet-weather event is defined both in the BMP Order and the SPDES permit as "a wet-weather event which causes or would cause the influent flow at the WWTP to exceed the wet-weather flow identified in the associated SPDES permit." Generally, the wet-weather flow identified in the associated SPDES permit for each WRRF is 2xDDWF unless critical equipment is out of service.

In February 2016, DEP submitted to DEC a report entitled "Regulator(s) with CSO Monitoring Equipment Identification Program Report" in fulfillment of a BMP Order and SPDES permit requirement. This report identified known or suspected CSO discharges from the regulators with CSO monitoring equipment based on telemetry data, meteorological and tidal observations, and plant operational data. The report evaluated observations from August 2014 to July 2015. The results of the February 2016 assessment of the monitored regulators from the period of August 2014 to July 2015 is presented in Table 3-3. DEP continues to monitor the key regulators on a monthly basis and this LTCP has included evaluations of potential collection system optimization measures to mitigate CSO discharges from the BMP Regulators.

Table 3-3. Summary of Classification of All Telemetered Regulators (August 2014 through July 2015)

Category	Definition	Key	Other	Total
A	Current or future capital improvements potentially render data unrepresentative of future conditions	13	22	35
B	Average one or fewer potential discharges per month outside the period of a critical wet-weather event	9	23	32
C	Average two or more potential discharges per month outside the period of a critical wet-weather event	5	18	23
D	Data collection issue/data not reported	0	2	2
E	Telemetered regulator that does not directly discharge to a waterbody	0	8	8
	TOTALS:	**27**	**73**	**100**

The February 2016 report also provided "an engineering analysis of the cause(s), identify system limitations and evaluate options for reducing or eliminating similar future events" in accordance with the BMP Order. Cost-effective and reasonable alternatives that could be implemented within 2 years were assessed to reduce and eliminate the discharges that occur outside a critical wet-weather event; however, no reasonable options were identified and the Category C regulators were deferred to the LTCP process for further evaluations.

Since submitting the February 2016 report, DEP has updated the analysis and classification of the 27 key regulators in each subsequent Annual CSO BMP Report, based on telemetry data for each year. These updated annual assessments have gathered a larger data set to allow for more accurate interpretation and better decision making on future capital commitments. Table 3-4 presents the number and duration of discharges outside the period of critical wet-weather flow, and DEP's updated classification, for the 27 key regulators as reported in the 2016, 2017, and 2018 Annual CSO BMP Reports. As highlighted in Table 3-4, reductions in activations of BMP Regulators OH-01 and OH-06 have resulted in reclassifications from C to B, while increases in activations have resulted in the reclassification of BMP Regulators NCB-01, NCM-47, and NR-23 to C.

Table 3-4. Summary of Activations, Duration and Classification of Key Regulators from Annual CSO BMP Reports for CY 2016 through 2018

Key Regulator (Outfall)	2016 BMP Report			2017 BMP Report			2018 BMP Report		
	Events	Total Duration (hrs.)	Class	Events	Total Duration (hrs.)	Class	Events	Total Duration (hrs.)	Class
26W-01 (26W-004)	26	29.75	A	11	5.00	A	15	13.25	A
26W-02 (26W-003)	16	37.00	A	11	11.75	A	21	51.75	A
BBH-02 (BB-002)	5	6.50	A	2	1.25	A	2	1.00	A
BBH-06 (BB-008)	5	0.75	A	1	0.25	A	4	0.25	A
BBL-04(2) (BB-026)	5	6.50	A	18	7.75	A	35	14.50	A
BBL-22 (BB-029)	7	2.25	A	9	8.75	A	20	8.50	A
HP-05(3) (HP-011)	26	56.00	A	21	51.25	A	25	53.50	A
HP-10 (HP-003)	23	29.25	C	16	18.25	C	20	15.80	C
HP-13 (HP-009)	30	56.00	C	29	51.25	C	53	101.00	C
JA-03(1) (JA-003)	8	19.00	A	47	128.00	A	60	216.65	A
NCB-01(2) (NCB-015)	1	0.00	A	2	1.25	A	24	7.75	C
NCB-04 (NCB-014)	18	36.05	C	27	33.00	C	25	23.00	C
NCM-47 (NCM-036)	7	3.50	B	5	1.25	B	16	7.00	C
NR-16 (NR-006)	14	4.00	C	10	3.50	B/C	27	17.80	C
NR-23 (NR-043)	11	2.75	B	6	7.50	B	14	8.00	C
NR-33 (NR-033)	4	1.00	B	4	1.00	B	4	1.50	B
OH-01 (OH-017)	9	6.50	C	3	0.75	B/C	5	0.75	B
OH-06 (OH-002)	13	5.00	C	2	0.25	B/C	4	1.25	B
PR-06W (PR-029)	21	45.00	C	25	66.25	C	51	150.50	C

Table 3-4. Summary of Activations, Duration and Classification of Key Regulators from Annual CSO BMP Reports for CY 2016 through 2018

Key Regulator (Outfall)	2016 BMP Report			2017 BMP Report			2018 BMP Report		
	Events	Total Duration (hrs.)	Class	Events	Total Duration (hrs.)	Class	Events	Total Duration (hrs.)	Class
PR-13E (PR-031)	44	100.75	C	50	141.75	C	76	275.00	C
RH-02 (RH-028)	1	0.00	B	0	0.00	B	2	0.25	B
RH-20 (RH-005)	0	0.00	B	0	0.00	B	1	0.00	B
TI-09 (TI-011)	23	16.75	C	7	8.25	B/C	51	177.75	C
TI-10A (TI-003)	0	0.00	B	0	0.00	B	0	0.00	B
WIB-53 (WIB-068)	1	1.75	A	0	0.00	A	5	2.00	A
WIB-67 (WIB-056)	5	8.00	A	1	0.25	A	13	23.25	A
WIM-23 (WIM-023)	6	3.00	A	6	1.5	A	10	2.55	A

Notes:
(1) Meter was out of service for a portion of 2016.
(2) Meter was out of service for portions of 2016 and 2017.
(3) Meter malfunctioned for an extended period of time in 2018.

DEP continuously monitors the influent flow rates at each of its WRRFs, and this flow data, in addition to the monitoring data at the regulators and other inputs such as tide data, are used to develop the number and duration of discharges outside the period of critical wet-weather flow presented in Table 3-4 above. Figure 3-1 presents a summary of the number of hours that each WRRF experienced influent flow greater than 2xDDWF for calendar years 2017, 2018 and 2019.

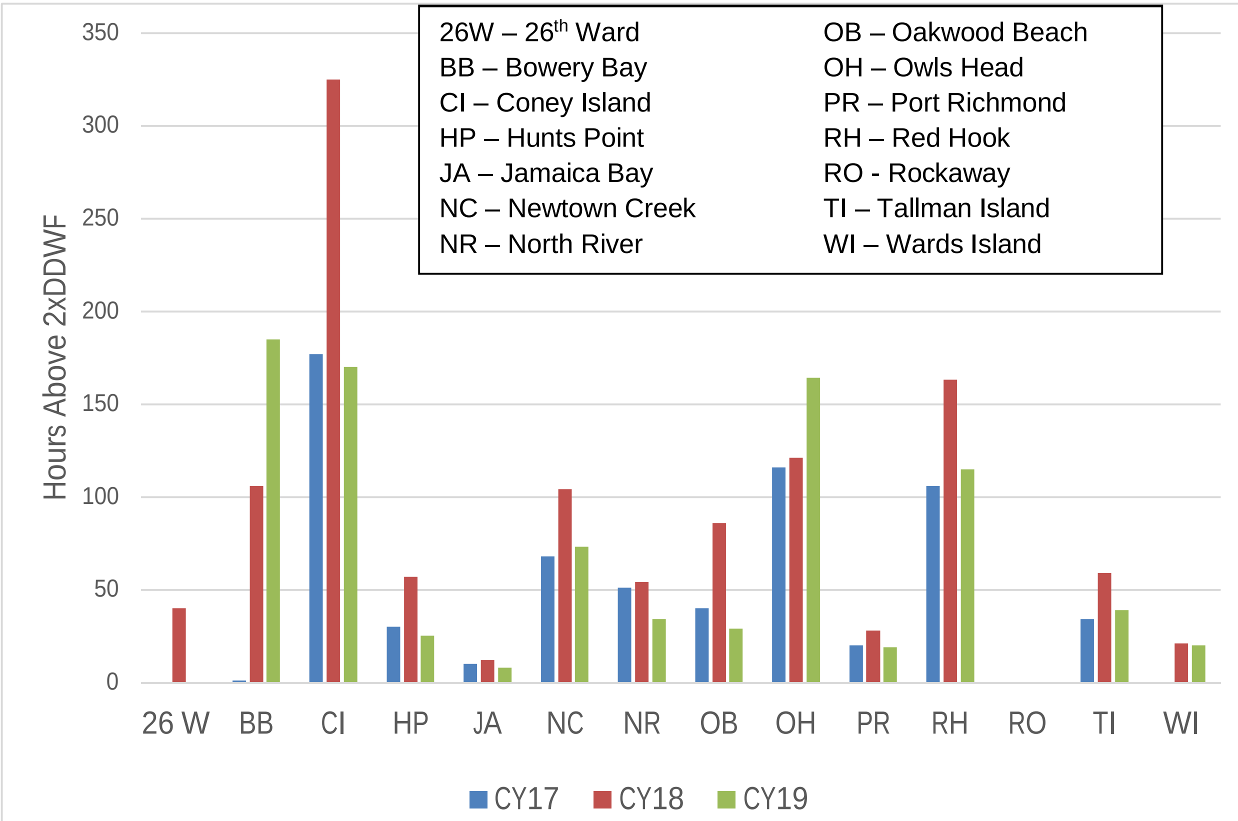


Figure 3-1. Annual Hours Above 2xDDWF at WRRFs for 2017 to 2019

BMP Regulator Flow Monitoring

To improve model calibration and performance for the BMP Regulator optimization evaluations, meters were installed at 34 regulator sites, 30 of which were BMP Regulators and four were high volume/activation regulators. The selection of flow monitoring sites focused on high volume and activation regulators where it was believed that there was a strong opportunity to collect data from a sufficient number and range of storm events that would cause CSO activations. Due to the large number of sites, the flow monitoring was performed in three phases. Table 3-5 identifies each of the regulators monitored, the related CSO outfall, the BMP Regulator category, and the monitoring period.

Flow monitoring equipment was installed within the incoming sewers and the outgoing branch interceptor and CSO outfall. In addition, inclinometers were installed on tide gates to track the gate position and verify whether the gate opened during overlapping periods of high tide and CSO activation. Field inspections were performed by the meter installation crews to assess site accessibility, flow conditions within the sewers, and to identify the appropriate equipment for the application. Adjustments were made in the field and coordinated with modeling staff to identify alternative locations where flow conditions and accessibility were not found to be suitable. Collections system model calibration and validation was performed using the same approach as past LTCPs as discussed in Section 2.

Table 3-5. Summary of BMP Regulator Flow Monitoring Locations and Periods

BMP Regulator	Outfall	Category	Receiving Waters	Monitoring Period	
				Start	Finish
26W-02	26W-003	A (K)	Fresh Creek	September 2015	December 2015
BBH-04	BB-005	Non-BMP	Bowery Bay	May 2017	July 2017
24th Ave Weir	BB-005	Non-BMP	Bowery Bay	October 2018	March 2019
BBH-06	BB-008	A (K)	Flushing Bay	July 2015	November 2015
BBH-09	BB-008	A	Flushing Bay	July 2015	November 2015
BBL-04	BB-026	A (K)	Dutch Kills	July 2016	December 2016
BBL-21	BB-028	A	East River	May 2017	July 2017
HP-02	HP-021	C	East River	March 2017	July 2017
HP-05	HP-011	A (K)	East River	March 2017	July 2017
HP-08	HP-025	C	East River	October 2018	March 2019
HP-10	HP-003	C (K)	East River	March 2017	September 2017
HP-11	HP-017	C	East River	October 2018	March 2019
HP-13	HP-009	C (K)	Bronx River	May 2014	August 2014
JA-03	JA-003	A (K)	Bergen Basin	September 2015	December 2015
JA-14	JA-003A	A	Bergen Basin	September 2015	December 2015
NCB-01	NCB-015	A (K)	English Kills	July 2016	December 2016
NCB-04	NCB-014	C (K)	Wallabout Channel	August 2017	December 2017
NCB-09	NCB-006	C	East River	October 2018	March 2019
NCM-01	NCM-076	C	Hudson River	March 2016	December 2016
NCQ-01	NCQ-077	A	Maspeth Creek	July 2016	December 2016
NR-45	NR-027	C	Hudson River	October 2018	March 2019
OH-01	OH-017	C (K)	Upper New York Bay	July 2017	December 2017
OH-06	OH-002	C (K)	Upper New York Bay	October 2018	March 2019
OH-07	OH-003	C	Upper New York Bay	July 2017	December 2017
OH-10	OH-021	C	Coney Island Creek	September 2018	March 2019
PR-01	PR-023A	Non-BMP	Upper New York Bay	November 2018	March 2019
PR-03	PR-023A	Non-BMP	Upper New York Bay	December 2018	March 2019
PR-06W	PR-029	C (K)	Kill Van Kull	September 2018	March 2019
PR-13E	PR-031	C (K)	Upper New York Bay	October 2017	December 2017
TI-09	TI-011	C (K)	Flushing Creek	November 2013	May 2014
TI-13	TI-023	C	East River	October 2018	March 2019
WI-53	WI-068	A (K)	East River	October 2018	March 2019

Table 3-5. Summary of BMP Regulator Flow Monitoring Locations and Periods

BMP Regulator	Outfall	Category	Receiving Waters	Monitoring Period	
				Start	Finish
WI-62	WI-060	A	Harlem River	March 2016	December 2016
WI-67	WI-056	A	Harlem River	March 2016	December 2016

BMP Regulator Analysis

The primary focus of the BMP Regulator Analysis was to evaluate opportunities to reduce the volume and frequency of CSO discharge outside the period of critical wet-weather flow at the BMP Regulators. However, the analysis also considered high volume/frequency CSO outfalls, and CSO outfalls near public access locations (beaches, kayak launches, marinas). In the evaluation of optimization alternatives, priorities were established based on categories of regulators as follows:

- Category 1: BMP Regulators
- Category 2: High Frequency Non-BMP Regulators
- Category 3: Regulators contributing to CSO outfalls that discharge near beaches, marinas, boat launches and floating pools
- Category 4: Regulators tributary to remaining Tier 1, 2, and 3 City-Wide CSO Outfalls.

Benefits at Category 1 and 2 regulators were given the highest priority in the evaluation of alternatives, with subsequent categories receiving proportionally lower priority.

Optimization Software

The BMP Regulator evaluations were conducted with the Optimatics software, which uses genetic algorithms to perform tens of thousands of sewer system optimization permutations to determine the optimum regulator and sewer system configurations based on defined hydraulic constraints. The Optimatics software used a simplified version of the InfoWorks collection system models to run the multiple iterations. For each iteration, the software assigned monetized penalties for adverse outcomes (e.g., CSO activations or volumes outside the period of 2xDDWF, or increases in hydraulic grade line [HGL]). This approach allowed for the development of cost-benefit curves, identifying the best performing (lowest penalty) strategies for different levels of capital invesment. Potentially favorable alternatives identified through the Optimatics evaluations were checked using the full InfoWorks collections system models for each WRRF sewershed.

Hydraulic Constraints Applied to the Optimization Runs

One of the key performance criteria assessed by the Optimatics software was the impact to HGL. Limits to increases in the HGL for the design storm were addressed as follows:

1) Design storm for assessing HGL impacts: The HGL for the 5-year storm (1.59 inches total accumulation over two hours) under the Baseline Conditions served as the initial basis for evaluating HGL impacts for all collection systems.

2) Branch interceptors, trunk and collector sewers: The HGL for an alternative could not exceed the HGL under Baseline Conditions for the applicable design storm.
3) Main interceptor sewers: The HGL could be raised along portions of the interceptor with cover in excess of 20 feet as long as the HGL increases did not impact trunk or collector sewers connecting to the main interceptor.
4) Basement threshold: If the interceptor HGL for an alternative exceeded Baseline Conditions, a minimum of10 feet of freeboard from manhole rim elevations had to be maintained.
5) "Penalties" were applied within the Optimizer software to discourage optimization alternatives that did not comply with the above criteria. A sensitivity analysis was performed to better understand the impacts of the application of a wide range of penalties. The penalty criteria were finalized based on those combinations that achieve the greatest wet-weather benefits while managing the risk of back-up and flooding.

Upon reviewing the results of the optimization anaylses, potentially favorable alternatives were assessed in more detail using the full InfoWorks collection system models, to confirm the predicted HGL impacts and other performance indicators. For HGL impacts, the 5-year design storm was used for collection systems within Manhattan and Staten Island (North River, Wards Island, Newtown Creek [upstream of the Manhattan Pumping Station], and Port Richmond), and the 3-year design storm (1.48 inches total accumulation over two hours) was used for collection systems in Brooklyn, Queens and the Bronx (Hunts Point, Tallman Island, Bowery Bay, Newtown Creek [upstream of the Brooklyn Pumping Station], Red Hook, and Owls Head). For these more detailed evaluations, the following specific criteria were applied:

1) Design Storm Rainfall events (3-year storm for Queens, 5-year storm for Manhattan and Staten Island)
    a. Interceptor/Sanitary and combined sewers with less than 9 feet of cover surcharge is not allowed
    b. Interceptor/sanitary and combined sewers with greater than 9 feet of cover – surcharge of 1 foot is allowed
    c. Interceptor/sanitary and combined sewers with greater than 20 feet of cover – surcharge of 2 feet is allowed
2) Design Storm Rainfall events (3-year storm for Brooklyn)
    a. Interceptor/Sanitary and combined sewers with less than 9 feet of cover - surcharge is not allowed
    b. Interceptor/sanitary and combined sewers with greater than 20 feet of cover – surcharge of 1 foot is allowed
3) 2008 Typical Year
    a. Interceptor/Sanitary and combined sewers with less than 9 feet of cover – surcharge should remain the same as the baseline condition
    b. Interceptor/Sanitary and combined sewers with greater than 9 feet of cover – surcharge can be within 1 foot of the baseline condition

c. Interceptor/Sanitary and combined sewers with greater than 20 feet of cover – surcharge can be within 2 feet of the baseline condition

Approach for Analyzing Alternatives

The optimization analysis initially evaluated low cost alternatives followed by more costly collection system upgrades for the purposes of maximizing flow to the WRRF and reducing BMP and total CSO activations. Alternatives also considered expansion of the Recommended Plans included in each of the 10 CSO LTCPs submitted to-date, to the extent that modifications to those plans would affect the regulators and outfalls prioritized in this evaluation (BMP regulators, outfalls near public access locations, high volume/frequency outfalls).

Collection system optimization alternatives were sequentially analyzed using the Optimatics software to assess over 65,000 iterations of orifice and weir modifications for each WRRF sewershed. The highest performing alternatives were then evaluated using InfoWorks to assess performance and reduction in CSO volume and frequency for the 2008 typical year. Subsequent InfoWorks model runs were performed to assess bending weirs, replacement of regulators, parallel sewers and other more comprehensive alternatives. The following summarizes the approach and strategies used to sequentially evaluate optimization alternatives for each sewershed.

1) Orifice Modifications (first pass using the Optimatics software)
    a. Confirmed that dry-weather flow capacity would not be adversely impacted.
    b. Limited the orifice area increases used by the software so that they did not exceed the cross sectional area of the downstream branch interceptor.
    c. The software incrementally increased orifice width/height or diameter in 6” increments.
2) Orifice Modifications (second pass using the Optimatics software)
    a. The software incrementally increased orifice and branch interceptor size beyond those evaluated in the first pass orifice modifications.
    b. Limited maximum branch interceptor sizes to the downstream interceptor size.
3) Regulator Weir Modifications – fixed weirs (using the Optimatics software)
    a. Identified ceiling heights for each regulator, as they limit how high weirs can be raised.
    b. As regulators can operate under surcharged conditions, orifice equations were applied to weirs when the HGL exceeded the ceiling height.
    c. Weir lengths were incrementally adjusted by the software to manage the HGL related to weir height increases. The cross sectional area of the opening between the weir crest and ceiling was limited so that it remained equal to or greater than the area of the existing opening.
    d. Limits were established (within the software) on the maximum extent that weirs could be lengthened within the existing regulator structures. Exceeding this length triggered additional cost associated with expanding the size of the regulator structure.
    e. Weirs were raised by the software using 3” increments.

   f. Combinations of weir modifications were applied by the software at each regulator based upon the viable orifice and branch interceptor limitations provide in the input file.

4) Bending Weirs (using InfoWorks)

   a. Bending weirs were only evaluated where fixed weir modifications indicated a CSO capture benefit, but HGL was an issue.

   b. As manufacturers recommend against applications perpendicular to the incoming flow or under tidal influence, the use of bending weirs was limited to side overflow applications without tidal influence. Due to the configuration of most regulators, this limited opportunities to apply bending weirs without major modification or reconstruction of the existing regulator chambers.

5) Regulator Chamber Replacement (using InfoWorks)

   a. Reviewed opportunities to optimize select Long Island City regulators (BB) that are planned for replacement under the current capital improvement plan (Regulators L-09, L-10, L-11, L-12, L-12A, L-15, L-16 and L-17).

6) Collection System Conveyance Capacity (using InfoWorks)

   a. The installation of parallel conveyances was evaluated near WRRFs to improve conveyance to the WRRF and reduce the time needed for peak plant flow to reach 2xDDWF. Reducing the time to reach 2xDDWF at the WRRF could potentially eliminate upstream BMP Regulator activations.

   b. The benefits of increasing capacity of existing pump stations were assessed.

   c. Additional parallel siphons or gravity sewers were evaluated where collection system capacity was found to limit the performance of the other optimization alternatives.

7) Optimization Alternatives Utiltizing Proposed LTCP Recommendations (using InfoWorks)

   a. Synergies were identified with the recommended facilities under the applicable LTCPs.

   b. Tunnel or tank size adjustments were considerd to accomodate diversion of CSO from BMP Regulators (Bowery Bay, Gowanus and Newtown Creek).

   c. Modifications to screening and disinfection facility capacities were considered to accommodate additional CSO from BMP Regulators (Flushing Creek, Alley Creek, Hutchinson River).

The optimization runs performed for steps 1 through 3 were conducted using a series of five representative storms selected from the typical year rainfall, that approximate a range of storms and CSO activations. To account for the fact that smaller magnitude storms occur more frequently than larger storms, higher penalties were applied for CSO activations occurring during the smaller storms in the analysis. The optimization runs also included the 3-year or 5-year storm for the purposes of assessing HGL impacts.

Ranking and Selection of Retained Alternatives

Alternatives were ranked using a weighted analysis that considered the following criteria:

1) Reduction of BMP Regulator activations.
2) Reduction in frequency of overflow at outfalls discharging near sensitive areas.
3) Reduction in annual volume and frequency of overflow at Tier 1, 2 and 3 City-Wide Outfalls.
4) Impact to annual volume and frequency of activation at other outfalls.
5) Construction costs.

The weighted ranking was developed by applying monetized weighted penalties (within the Optimatics software) for criteria that fell outside of established bounds. A Relative Performance Factor was generated (by the Optimatics software) for baseline conditions (no optimization projects) and each optimization alternative consisting of the sum of all penalties for HGL impact, BMP activations, total CSO activations, increased volume or frequency to sensitive areas, etc. The software also generated a Relative Cost Factor using cost curves provided as input files. The Relative Cost Factor was then plotted against the Relative Performance Factor to develop a cost-benefit curve. Potentially favorable alternatives were then identified from inflection points on the curve (i.e., knee(s)-of-the-curve).

Sensitivity analyses were performed during preliminary evaluations to better understand the influence of the ranking criteria. The ranking criteria were refined in the Optimatics software prior to running the final optimization runs. The emphasis of the final weighted ranking system was to identify alternatives that provided the best performance with the lowest Relative Cost Factors. Alternatives that were identified as promising from the optimization analysis were then evaluated in more detail using the LTCP InfoWorks models to confirm annual performance for the 2008 Typical Year. Planning-level construction cost estimates were developed to refine the probable bid cost (PBC) and net present worth (NPW) cost for each retained alternative. The findings of the BMP optimization evaluations are presented in Section 8 of this report.

4.0 GREY INFRASTRUCTURE

4.1 Historical Context for Water Quality Improvements through DEP Capital Investments

CSO planning in New York City dates back to the 1950's, when conceptual plans for reduction of CSO to the tributaries of Jamaica Bay and the East River were first initiated. Passage of the Clean Water Act in the 1970's and development of a National CSO Policy in 1994 triggered further planning and implementation of projects for CSO control. An Administrative Consent Order signed in 1992 was followed by a series of CSO Orders on Consent to establish enforceable compliance schedules for elements of the CSO program. As described in Section 1, the current CSO LTCP program is driven by the 2005 Order on Consent, as modified by the 2012 Order on Consent and subsequent minor modifications. Figure 4-1 presents a timeline of capital investments in wastewater infrastructure in the categories of WRRF upgrades to secondary treatment, WRRF upgrades for biological nitrogen removal, existing grey/green infrastructure projects to mitigate CSOs, and projects recommended in the current CSO LTCP program. As indicated in Figure 4-1, DEP spent $41.1B to upgrade its WRRFs to secondary treatment, construct two new WRRFs, and install upgraded biological nutrient removal facilities at eight WRRFs. With these WRRFs operating at their peak wet-weather flow capacity of 2xDDWF, annual CSO volumes were reduced significantly. The $4.3B investment in green infrastructure and cost-effective grey infrastructure recommended in the WWFPs further reduced annual CSO volumes and pollutant loads.

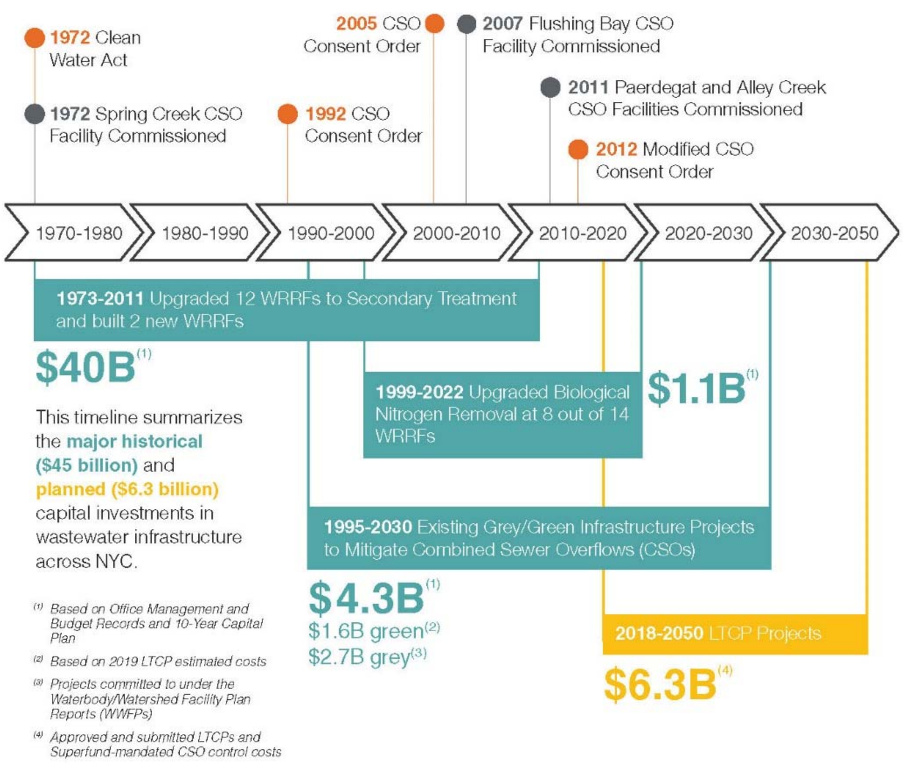


Figure 4-1. Timeline of Major Capital Investments in Wastewater Infrastructure

The benefits of these investments to-date are evident in the improvement in water quality in the waters in and around NYC. Figure 4-2 presents a comparison of summer geometric mean fecal coliform sampling results from DEP's Harbor Survey Monitoring Program for 1985 versus 2018. As indicated in Figure 4-2, sampling for much of the Citywide/Open Waters waterbodies in 1985 had geometric mean fecal coliform concentrations of greater than 200 cfu/100mL, and portions of the Hudson River, East River, and Upper New York Bay had geometric mean concentrations greater than 2,000 cfu/100mL. By 2018, however, the summer geometric mean fecal coliform concentrations from sampling data were under 100 cfu/100mL for the Citywide/Open Waters waterbodies. The $6.3B investment in projects recommended in the previously-submitted LTCPs and Superfund mandated CSO control for the tributaries in and around NYC will result in further improvement in the water quality in those waterbodies. Projected attainment with water quality standards for the tributary waterbodies associated with the previously-submitted LTCPs is presented below in Section 4.3. Impacts of the Citywide/Open Waters Recommended Plan on attainment of water quality standards are presented in Section 8.

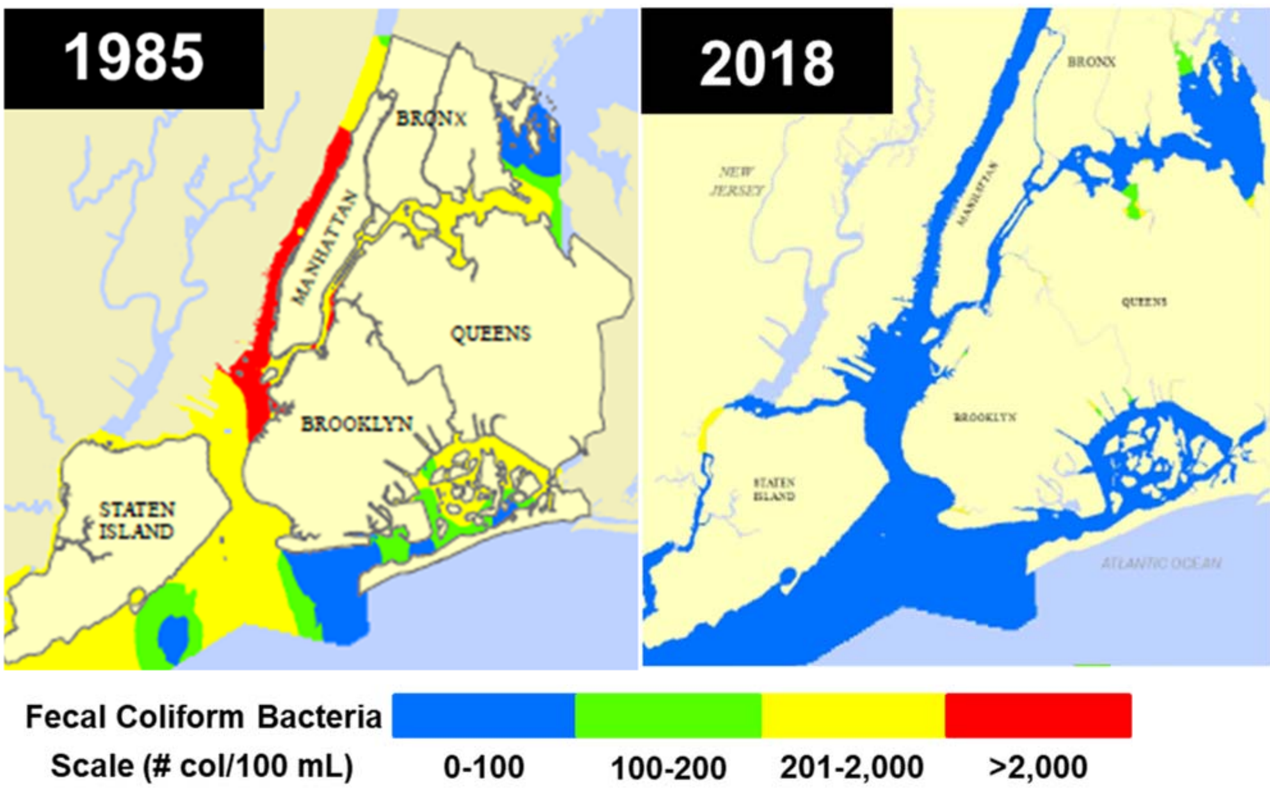


Figure 4-2. Comparison of Summer Geometric Mean Fecal Coliform Sampling Results for 1985 vs. 2018

4.2 Status of Grey Infrastructure Projects Recommended in Facility Plans

As described in Section 1, DEP submitted the East River and Open Waters Waterbody/Watershed Facility Plan Report to DEC in June 2007. This report recommended a series of projects focusing on maximizing the utilization of the existing collection system infrastructure and treatment of combined sewage at the City owned WRRFs. Although this WWFP was not approved by DEC, a number of grey infrastructure projects were implemented that had beneficial impacts on CSO outfalls discharging to the Citywide/Open Waters waterbodies. These projects included the following:

- Headworks Upgrades to the Bowery Bay, Hunts Point, North River, Tallman Island and Wards Island WRRFs to sustain 2xDDWF
- Port Richmond WRRF Throttling Facilities
- Tallman Island Conveyance Improvements
- Outer Harbor CSO Regulator Improvements
- Inner Harbor In-line Storage

The total cost of the grey infrastructure projects that are complete or under construction is $196M.

4.3 Summary of Recommended Plans from LTCPs Developed Under the LTCP Program

Prior to submittal of this Citywide/Open Waters LTCP, DEP submitted 10 LTCPs that focused on waterbodies that are tributary to the Citywide/Open Waters waterbodies. The waterbodies addressed by the 10 previous LTCPs include:

- Alley Creek
- Westchester Creek
- Hutchinson River
- Flushing Creek
- Bronx River
- Gowanus Canal
- Coney Island Creek
- Flushing Bay
- Newtown Creek
- Jamaica Bay and Tributaries

The general locations of the waterbodies covered by these previous LTCPs are shown in Figure 4-3.

As described further in Section 6, the Baseline Conditions for the Citywide/Open Waters LTCP includes the implementation of the Recommended Plans from the 10 previous LTCPs. The following sections provide summaries of those Recommended Plans, organized by the waterbodies. These sections also list the cost-effective grey infrastructure projects that have been or will be implemented for these waterbodies as a result of recommendations from the previous WWFPs. The reader is referred to each specific LTCP for further details on the waterbody-specific Recommended Plans and the cost-effective grey projects.

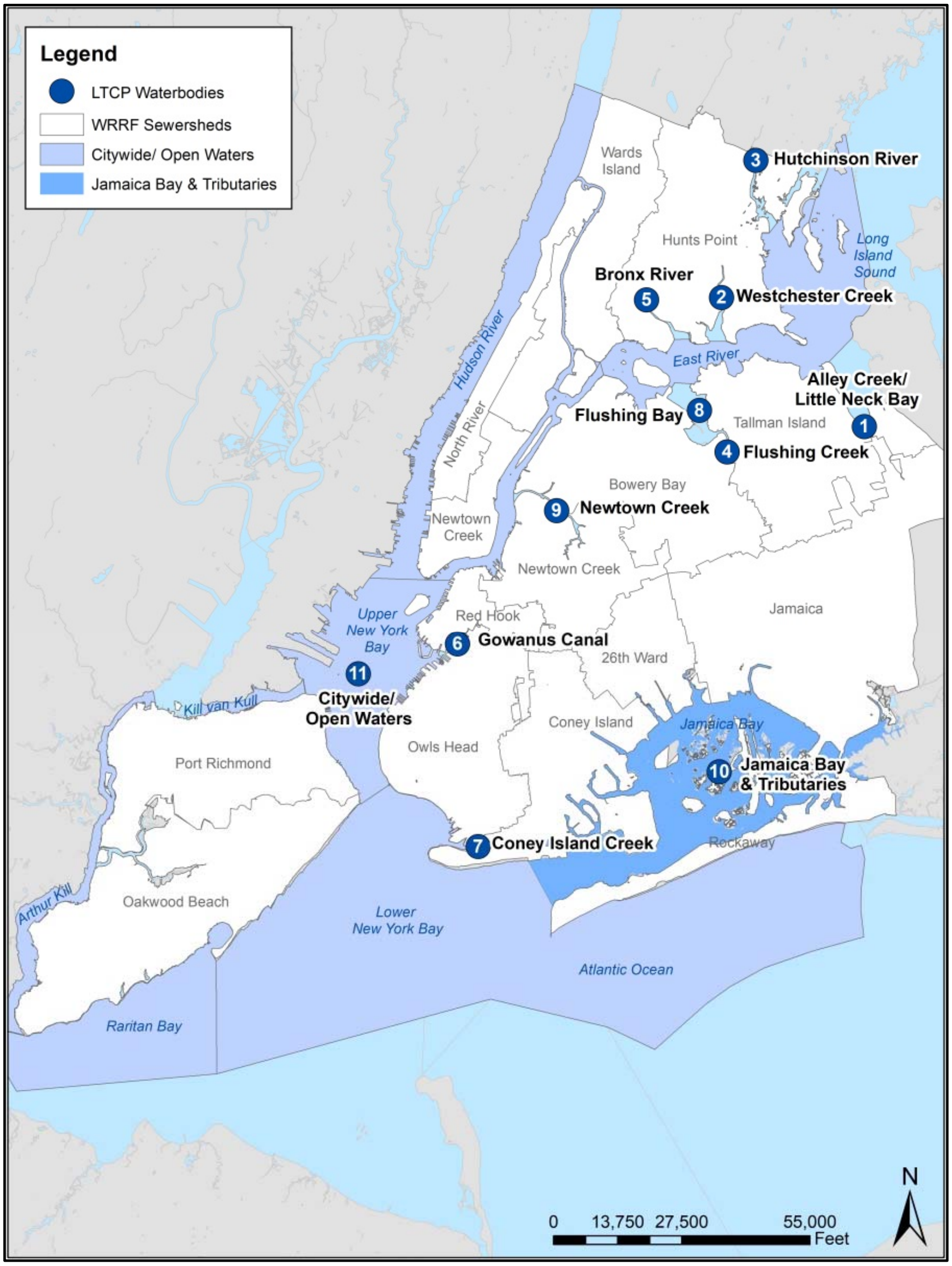


Figure 4-3. Locations of Waterbodies Addressed in LTCPs

4.3.a Alley Creek

4.3.a.1 WWFP Projects

The following summarizes the cost-effective grey projects implemented for Alley Creek based on the WWFP recommendations.

- 5 Million Gallon (MG) Alley Creek CSO Retention Facility
- Diversion chamber (Chamber 6) to direct CSO to the new Alley Creek CSO Retention Facility and to provide tank bypass to Outfall TI-008
- 1,475 foot long multi-barrel outfall sewer extending to a new outfall on Alley Creek (TI-025)
- New CSO outfall, TI-025, for discharge from the Alley Creek CSO Retention Facility
- Fixed baffle at Outfall TI-025 for floatables retention, minimizing release of floatables to Alley Creek
- Expansion and upgrade of Old Douglaston Pumping Station to empty the storage tank and convey flow to Tallman Island WRRF after the end of the storm

The total cost of the constructed grey infrastructure projects was $141M.

4.3.a.2 Approved LTCP Recommended Plan

The following summarizes the Recommended Plan from the June 2014 Alley Creek and Littleneck Bay LTCP that was approved by DEC on March 7, 2017.

- **Description:** Seasonal disinfection with dechlorination of the discharge from the Alley Creek CSO Retention Facility (Figure 4-4)
- **Probable bid cost presented in the LTCP:** $7.6M (May 2013 dollars)
- **Current total project cost, including engineering, escalated to the midpoint of construction:** $25M

  Current Completion Milestone*: 2024

  ***** *Milestone dates may be subject to revision by DEC based on additional facility planning.*

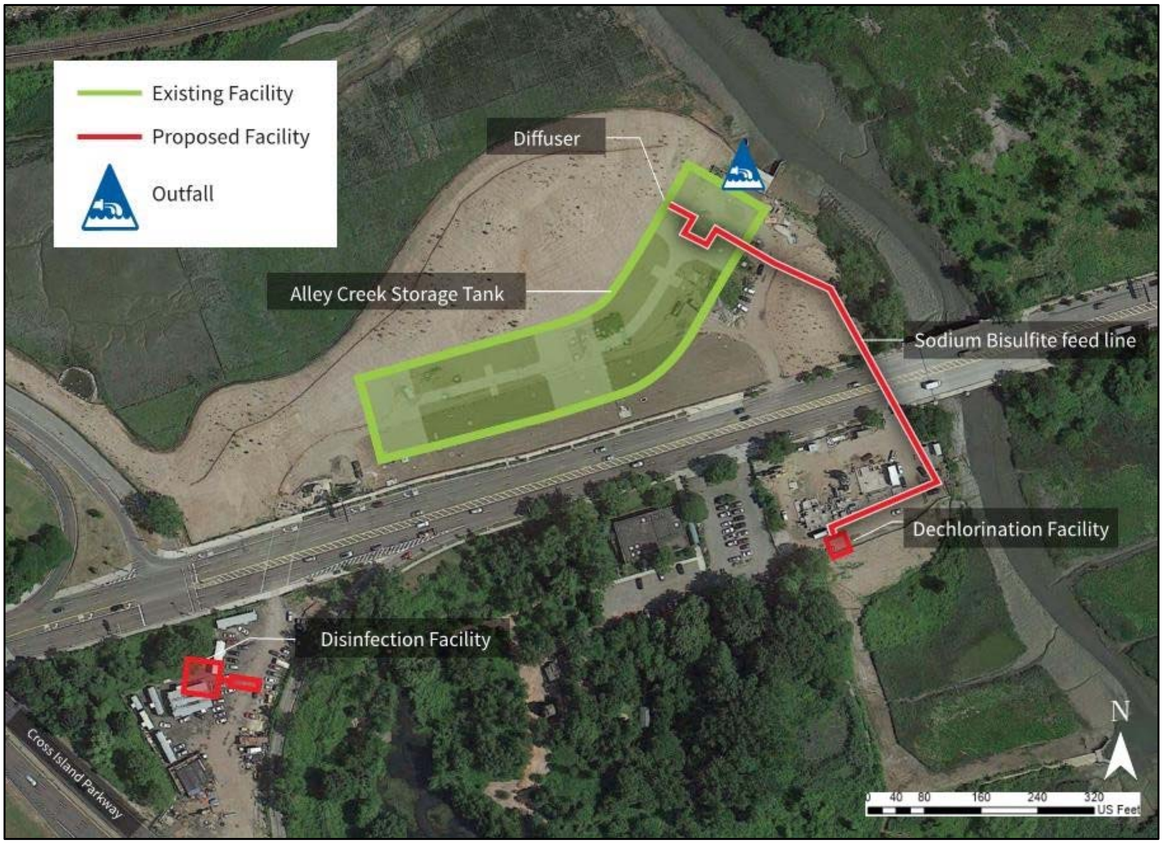


Figure 4-4. Disinfection at Alley Creek CSO Retention Facility

4.3.a.3 Benefits and Challenges of Implementing the Recommended Plan for Alley Creek

Figure 4-5 presents the reductions in CSO volume associated with the WWFP cost-effective grey projects and the LTCP Recommended Plan. As indicated in Figure 4-5, the cost-effective grey projects (post WWFP) resulted in a 198 million gallons per year (MGY) (60 percent) reduction in the annual CSO volume to Alley Creek. The LTCP Recommended Plan does not change the volume of CSO discharged but will provide disinfection for 78 MG of the remaining 132 MG of discharge, based on the Typical Year rainfall. The disinfection facilities will be operated during the recreational season (May 1st through October 31st). Additional benefits include the following:

- The Recommended Plan sought to identify retrofits to existing infrastructure to cost-effectively enhance facility performance.
- DEP staff are familiar with the procedures for safe handling and use of sodium hypochlorite and sodium bisulfite through its application at each of the City's WRRFs.

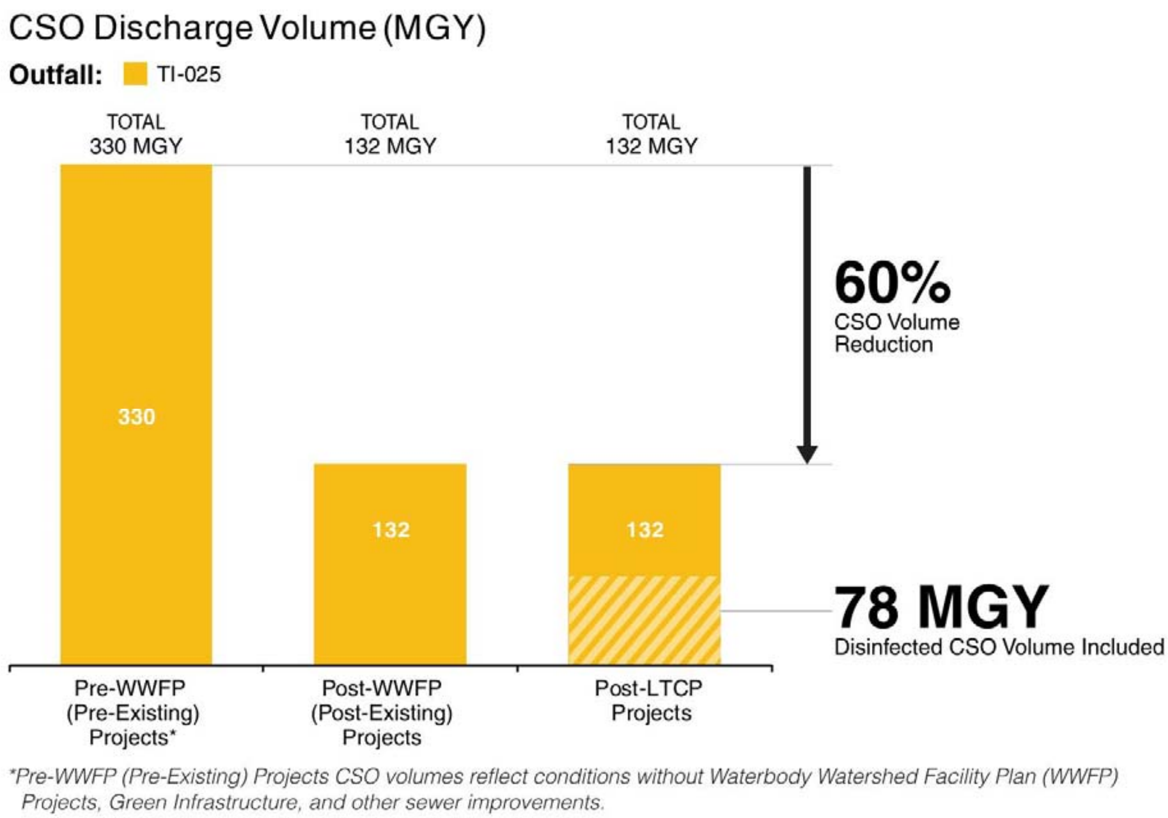


Figure 4-5. Benefits to Alley Creek and Little Neck Bay

While seasonal disinfection is a highly cost-effective approach to reduce the pathogen loads from the remaining CSO discharges to Alley Creek by an additional 60 percent, several construction and operational challenges must be overcome. The challenges and associated risks include the following:

- Chemical feed facilities for chlorination and dechlorination will need to be constructed and maintained at multiple locations.
- Available space for new facilities is limited, and much of the area around the existing facility is parkland.
- The existing retention facility is currently operated remotely but will require staffing during wet-weather events to monitor and maintain the disinfection facilities.
- The outfall sewer feeding the CSO retention facility is tidally influenced and consists of multiple pipe barrels resulting in variable flow conditions within each sewer barrel during overflow events.
- Multiple feed lines must be provided and individually controlled for application of chemicals to each of the individual sewer barrels and channels within the CSO tank.
- To address the highly variable flow conditions and multiple feed points an extremely high degree of system automation and sophistication will be required to operate the disinfection system.

- As the disinfection chemicals are being applied to multiple sewer barrels, it may be difficult to simulate the highly variable operational conditions for accurate calibration of instrumentation and controls.

- There is a risk that overdosing to overcome operational complexities and achieve anticipated permit limits for pathogens may make it difficult to achieve the chlorine residual permit limits.

- Thorough flushing of the chemical feed lines will be required after each storm event to minimize the risk of crystallization of the chemicals and the formation of blockages within the feed lines.

The siting challenges are expected to affect the project cost and schedule given the surrounding parkland and limited space for siting of new facilities. As determined in the BODR, the combination of siting and operating challenges for this facility will require DEP to conduct additional assessments in order to proceed. In response to the multiple siting and operational challenges DEP is exploring alternatives to disinfection. Any proposed alternatives would be subject to DEC review and approval.

4.3.a.4 Water Quality Standards Attainment

At the time that the Alley Creek LTCP was submitted, the water quality classification for Alley Creek was Class I, and the classification for Little Neck Bay was Class SB. While the classification for Alley Creek has not changed, Little Neck Bay is now classified as a coastal primary contact recreational waterbody. In addition, the water quality criteria associated with these classifications have changed. For Alley Creek, the previous water quality criteria for bacteria included a fecal coliform monthly geometric mean of ≤2,000 cfu/100mL, assessed on an annual basis. The current criterion is for a fecal coliform monthly geometric mean of ≤200 cfu/100mL. Since Littleneck Bay has been reclassified as a coastal primary contact recreational waterbody, the bacteria criteria include a fecal coliform monthly geometric mean of ≤200 cfu/100mL, an *Enterococcus* 30-day geometric mean of ≤35 cfu/100mL, and a 30-day 90th percentile STV for *Enterococcus* of ≤130 cfu/100mL, applicable for the recreational season (May 1st through October 31st).

Table 4-1 presents the percent attainment with the current Class I water quality criteria for bacteria at Harbor Survey Monitoring (HSM) Station AC-1 in Alley Creek for Baseline Conditions and the Recommended Plan, for the 10-year simulation (2002 to 2011). Also shown in Table 4-1 is the percent attainment with an annual fecal coliform geometric mean of 200 cfu/100mL, and attainment with recreational season (May 1st through October 31st) *Enterococcus* criteria. The *Enterococcus* criteria do not apply to Alley Creek, and are shown for informational purposes only. Table 4-2 presents the percent attainment with the current Class SB and coastal primary contact recreational waters water quality criteria for bacteria at HSM Stations OW-1, LN-1, and E-11, along with a station at the Douglaston Manor Association (DMA) beach in Little Neck Bay for Baseline Conditions and the Recommended Plan.

Table 4-3 presents the annual percent attainment with the applicable DO criteria for the Alley Creek and Little Neck Bay stations for Baseline Conditions and the Recommended Plan, based on 2008 rainfall.

The locations of the sampling stations referenced in Table 4-1, Table 4-2, and Table 4-3 are shown in Figure 4-6.

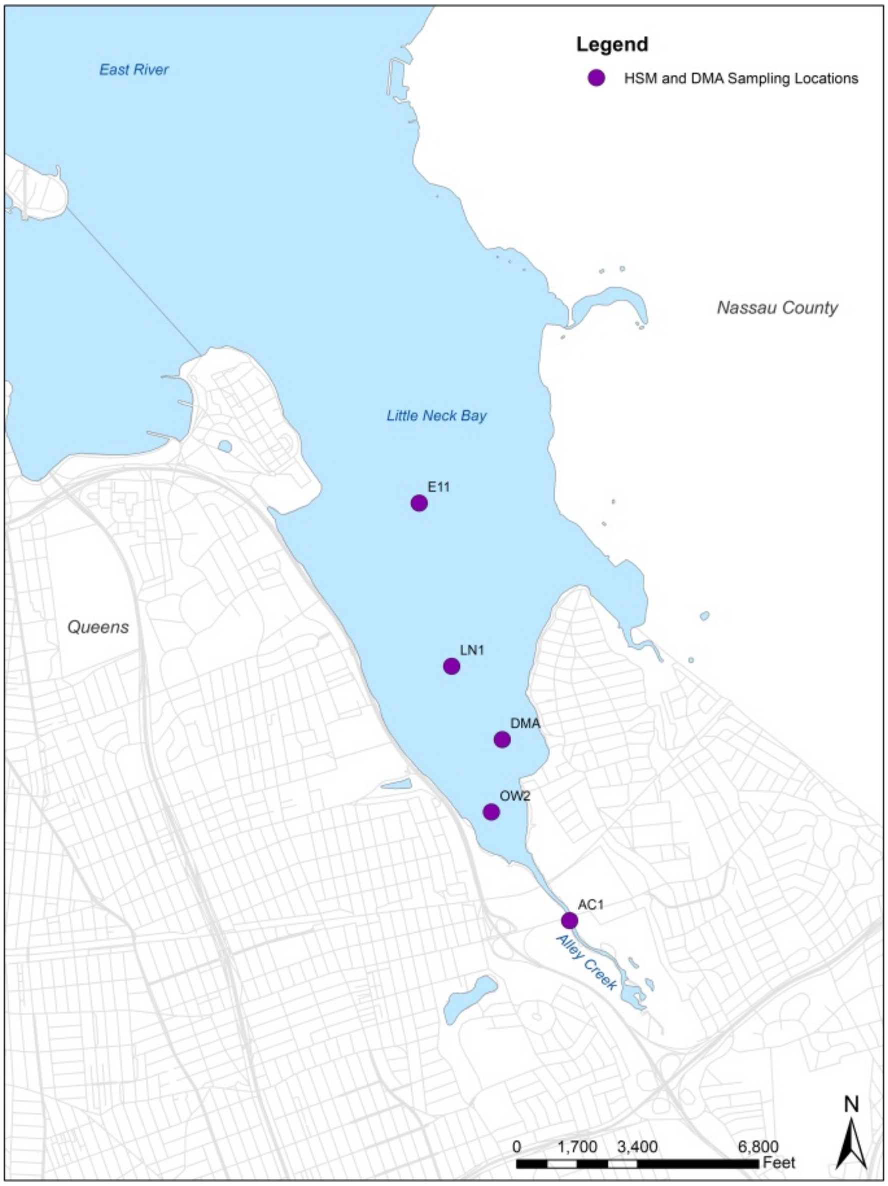


Figure 4-6. HSM and DMA Stations in Alley Creek and Little Neck Bay

Table 4-1. Calculated 10-year Bacteria Attainment in Alley Creek for Baseline Conditions and the Recommended Plan

Location	Percent Attainment with Criteria							
	Baseline				Recommended Plan			
	Class I Fecal Coliform Criteria		*Enterococcus* Criteria for Recreational Season(1)(2)(3)		Class I Fecal Coliform Criteria		*Enterococcus* Criteria for Recreational Season(1)(2)(3)	
	Recreational Season(1)	Annual			Recreational Season(1)	Annual		
	Monthly Geometric Mean ≤200 cfu/100mL	Monthly Geometric Mean ≤200 cfu/100mL	30-day Geometric Mean ≤35 cfu/100mL	30-day 90th Percentile ≤130 cfu/100mL	Monthly Geometric Mean ≤200 cfu/100mL	Monthly Geometric Mean ≤200 cfu/100mL	30-day Geometric Mean ≤35 cfu/100mL	30-day 90th Percentile ≤130 cfu/100mL
AC1	93%	87%	53%	9%	98%	90%	59%	10%

Notes:
(1) The Recreational Season is from May 1st through October 31st.
(2) *Enterococcus* Criteria do not apply to Alley Creek. Attainment with these criteria is shown for informational purposes only.
(3) The *Enterococcus* criteria have been updated from the original LTCP, which presented attainment with a 30-day GM of ≤30 cfu/100mL and a 30-day STV of ≤110 cfu/100mL.

Table 4-2. Calculated 10-year Bacteria Attainment in Littleneck Bay for Baseline Conditions and the Recommended Plan

Location	Percent Attainment with Criteria							
	Baseline				Recommended Plan			
	Class SB Fecal Coliform Criteria		Coastal Recreational Waters *Enterococcus* for Recreational Season(1)(3)		Class SB Fecal Coliform Criteria		Coastal Recreational Waters *Enterococcus* for Recreational Season(1)(3)	
	Recreational Season(1)	Annual			Recreational Season(1)	Annual		
	Monthly Geometric Mean ≤200 cfu/100mL	Monthly Geometric Mean ≤200 cfu/100mL	30-day Geometric Mean ≤35 cfu/100mL	30-day 90th Percentile ≤130 cfu/100mL	Monthly Geometric Mean ≤200 cfu/100mL	Monthly Geometric Mean ≤200 cfu/100mL	30-day Geometric Mean ≤35 cfu/100mL	30-day 90th Percentile ≤130 cfu/100mL
OW2	N/A(2)	98%	91%	25%	100%	97%	92%	29%
LN1	N/A(2)	99%	95%	51%	100%	99%	97%	62%
E11	100%	100%	99%	75%	100%	100%	99%	80%
DMA	100%	100%	95%	49%	100%	100%	97%	62%

Notes:
(1) The Recreational Season is from May 1st through October 31st.
(2) Recreational season fecal coliform attainment was not developed at these stations for this LTCP.
(3) The *Enterococcus* criteria have been updated from the original LTCP, which presented attainment with a 30-day GM of ≤30 cfu/100mL and a 30-day STV of ≤110 cfu/100mL.

Table 4-3. Model Calculated DO Attainment for Alley Creek and Little Neck Bay Stations for Baseline Conditions and the Recommended Plan (2008 Rainfall)

Station	Percent Annual Average Attainment			
	Baseline		Recommended Plan	
	Alley Creek Class I (≥4.0 mg/L)			
AC1	98%		98%	
	Little Neck Bay Class SB[3]			
	Acute[1] (≥3.0 mg/L)	Chronic[2] (≥4.8 mg/L)	Acute[1] (≥3.0 mg/L)	Chronic[2] (≥4.8 mg/L)
OW2	100%	100%	100%	100%
LN1	100%	93%	100%	93%
E11	100%	94%	100%	94%

Notes:

(1) Acute standard (never less than).
(2) Chronic standard based on daily average. See Table 2-5 in Section 2 for further details on the DO criteria.
(3) DO attainment values presented in the LTCP have been updated to reflect the current water quality criteria.

4.3.b Westchester Creek

4.3.b.1 WWFP Projects

The following summarizes the cost-effective grey projects currently being implemented for Westchester Creek based on the WWFP recommendations.

- Weir modifications to relief structures CSO-29 and CSO-29A
- Pugsley Creek parallel relief sewer

The total cost of the grey infrastructure projects under construction is $126M.

4.3.b.2 Approved LTCP Recommended Plan

The following summarizes the Recommended Plan from the June 2014 Westchester Creek LTCP that was approved by DEC on August 1, 2017.

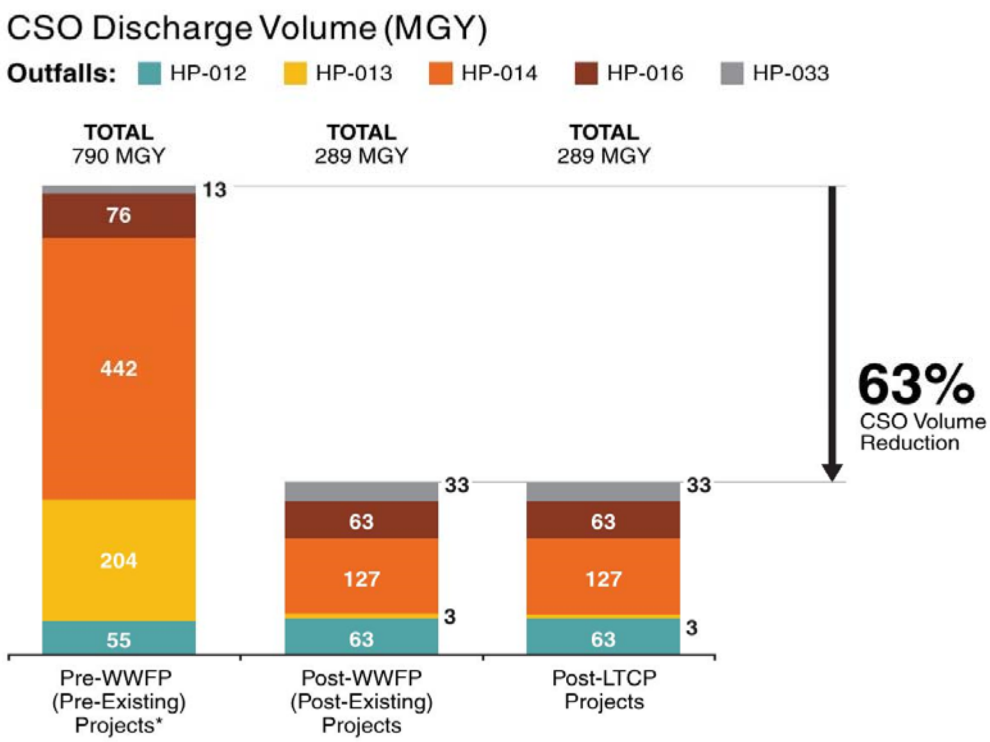
- **Description:** The cost-effective grey projects from the WWFP implemented in Westchester Creek were demonstrated to result in attainment of the monthly geometric mean fecal coliform criterion during the recreational season (May 1st through October 31st) in Westchester Creek. Therefore, no additional projects were recommended in the LTCP.

4.3.b.3 Benefits to Westchester Creek

Figure 4-7 presents the reductions in CSO volume associated with the WWFP cost-effective grey projects and the LTCP Recommended Plan. As indicated in Figure 4-7, the cost-effective grey projects (post WWFP) resulted in a 501 MGY (63 percent) reduction in the annual CSO volume to Westchester Creek.

4.3.b.4 Water Quality Standards Attainment

At the time that the Westchester Creek LTCP was submitted, the water quality classification for Westchester Creek was Class I. That classification has not changed, but the water quality criteria associated with that classification have changed. For Westchester Creek, the previous water quality criteria for bacteria included a fecal coliform monthly geometric mean of ≤2,000 cfu/100mL, assessed on an annual basis. The current criterion is for a fecal coliform monthly geometric mean of ≤200 cfu/100mL. Westchester Creek is a non-coastal tributary, so the *Enterococci* criteria for coastal primary contact recreational waters do not apply to Westchester Creek.



Pre-WWFP (Pre-Existing) Projects CSO volumes reflect conditions without Waterbody Watershed Facility Plan (WWFP) Projects, Green Infrastructure, and other sewer improvements.

Figure 4-7. Benefits to Westchester Creek

Table 4-4 presents the percent attainment with the current Class I water quality criteria for bacteria at Stations WC1, WC2, WC3, and E13 in Westchester Creek for Baseline Conditions and the Recommended Plan, for the 10-year simulation (2002 to 2011). Also shown in Table 4-4 is the percent attainment with an annual fecal coliform geometric mean of 200 cfu/100mL, and the percent attainment with *Enterococcus* criteria. The *Enterococcus* criteria do not apply to Westchester Creek, and are shown for informational purposes only.

Table 4-5 presents the annual percent attainment with the applicable DO criteria for the Westchester Creek stations for Baseline Conditions and the Recommended Plan, based on 2008 rainfall.

The locations of the sampling stations referenced in Table 4-4 and Table 4-5 are shown in Figure 4-8.

Table 4-4. Calculated 10-year Bacteria Attainment in Westchester Creek for Baseline Conditions and the Recommended Plan

Location	Percent Attainment with Criteria			
	Class I Fecal Coliform Criteria		*Enterococcus* Criteria for Recreational Season(1)(2)(3)	
	Recreational Season(1)	Annual		
	Monthly Geometric Mean ≤200 cfu/100mL	Monthly Geometric Mean ≤200 cfu/100mL	30-day Geometric Mean ≤35 cfu/100mL	30-day 90th Percentile ≤130 cfu/100mL
WC2	95%	93%	88%	25%
WC1	98%	95%	90%	29%
WC3	98%	97%	95%	39%
E13	100%	100%	99%	77%

Notes:
(1) The Recreational Season is from May 1st through October 31st.
(2) *Enterococcus* Criteria do not apply to Westchester Creek. Attainment with these criteria is shown for informational purposes only.
(3) *Enterococcus* attainment has been updated from values presented in the LTCP.

Table 4-5. Model Calculated DO Attainment for Westchester Creek Stations for Baseline Conditions and the Recommended Plan (2008 Rainfall)

Station	Percent Annual Average Attainment
	Class I ≥4.0 mg/L
WC2	80%
WC1	97%
WC3	99%
E13	99%

AECOM with Hazen

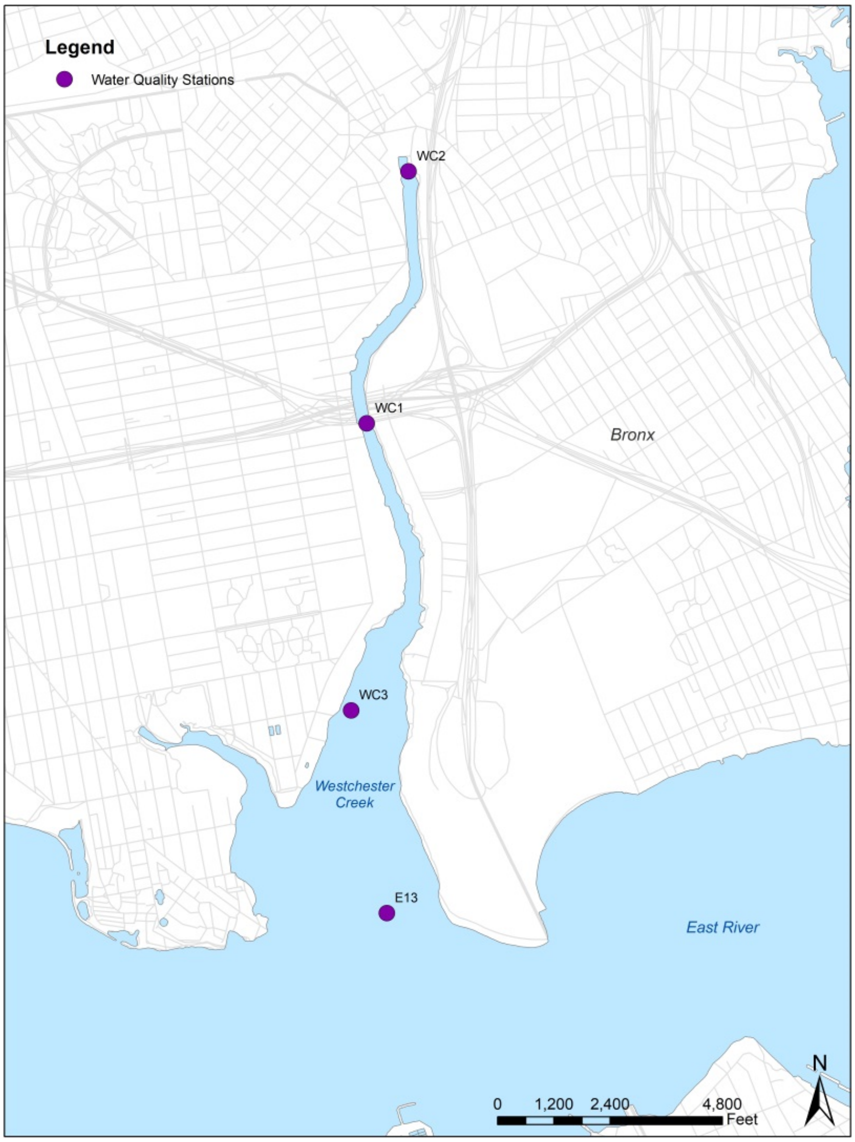


Figure 4-8. Water Quality Stations in Westchester Creek

4.3.c Hutchinson River

4.3.c.1 WWFP Projects

No grey infrastructure projects were planned or implemented in the Hutchinson River as a result of the previous CSO facilities planning or the 2012 Order on Consent. Other work completed in the Hunts Point system included Hunts Point WRRF headworks improvements. The cost of that work was $3M.

4.3.c.2 Approved LTCP Recommended Plan

The following summarizes the Recommended Plan from the September 2014 Hutchinson River LTCP that was approved by DEC on March 7, 2017.

- **Description:** Seasonal disinfection with dechlorination, floatables control, and construction of an extension of Outfall HP-024 (Figure 4-9)
- **Probable bid cost presented in the LTCP:** $90M (June 2014 dollars)
- **Current total project cost, including engineering, escalated to the midpoint of construction:** $204M
- **Current Completion Milestone*:** 2030

***** *Milestone dates may be subject to revision by DEC based on additional facility planning.*

Figure 4-9. CSO Outfall HP-024 Extension

4.3.c.3 Benefits and Challenges of Implementing the Recommended Plan for Hutchinson River

Figure 4-10 presents the reductions in CSO volume associated with the WWFP cost-effective grey projects and the LTCP Recommended Plan. As indicated in Figure 4-10, the cost-effective grey projects (post WWFP) resulted in a 39 MGY (11 percent) reduction in the annual CSO volume to the Hutchinson River. The LTCP Recommended Plan does not change the volume of CSO discharged, but will provide disinfection for 65 MG of the remaining 323 MG of discharge, based on the Typical Year rainfall. The disinfection will be applied during the recreational season (May 1st through October 31st). Additional benefits include the following:

- City owned properties and road rights-of-way are potentially available for siting of facilities.
- DEP staff are familiar with the procedures for safe handling and use of sodium hypochlorite and sodium bisulfite through its application at each of the City's WRRFs.

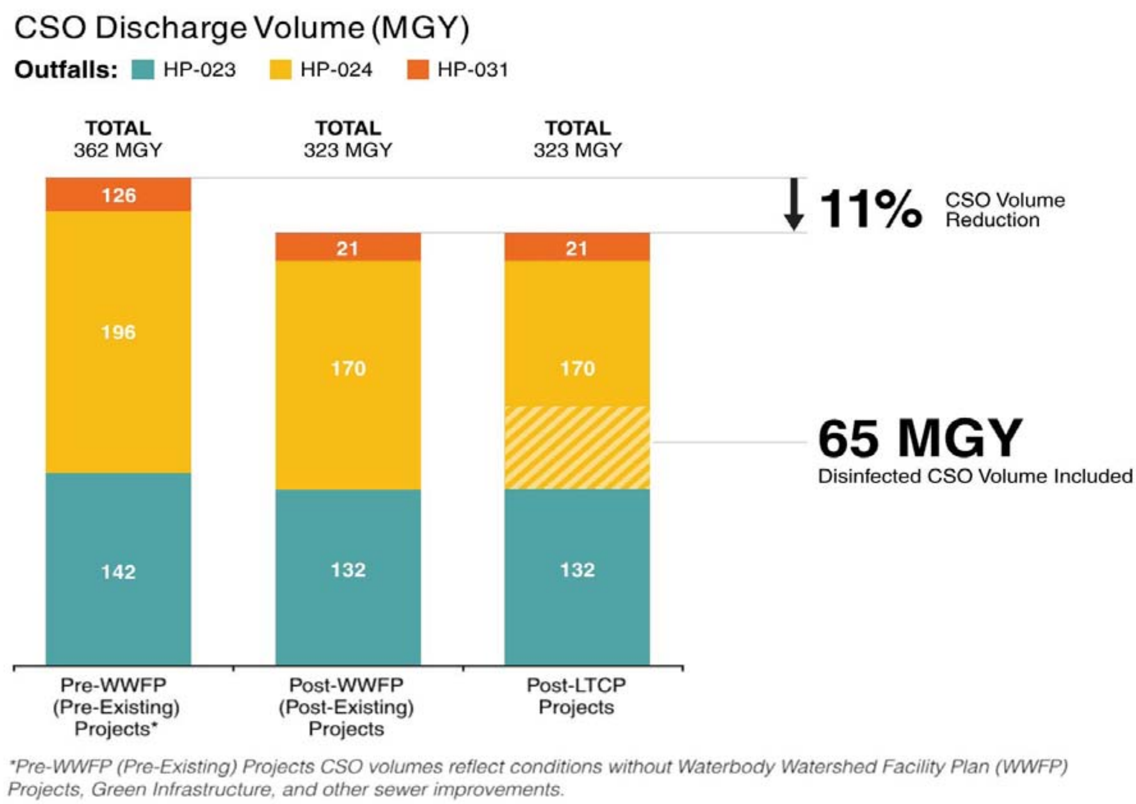


Figure 4-10. Benefits to Hutchinson River

While seasonal disinfection is a cost-effective approach to reduce the pathogen loads from the remaining CSO discharges to the Hutchinson River by an additional 20 percent, there are several construction and operational challenges that must be overcome. The challenges and associated risks are as follows:

- Chemical feed facilities for chlorination and dechlorination will need to be constructed and maintained at multiple locations.
- Site acquisition for the necessary facilities will be challenging.
- To address the highly variable flow conditions, an extremely high degree of system automation and sophistication will be required to operate the disinfection system.
- There is a risk that overdosing to overcome operational complexities and achieve anticipated permit limits for pathogens may make it difficult to achieve the chlorine residual permit limits.
- Thorough flushing of the chemical feed lines will be required after each storm event to minimize the risk of crystallization of the chemicals and the formation of blockages within the feed lines.

The siting challenges may affect the project cost and schedule if site acquisition becomes problematic. Operational challenges are significant and additional assessment and study is required to fully develop the best treatment alternative for the variable CSO entering this facility. DEP will seek to address these challenges during design through the provision of technical enhancements in the form of additional design and operational criteria. DEP may also need to consider evaluating alternative technologies in consultation with DEC.

4.3.c.4 Water Quality Standards Attainment

At the time that the Hutchinson River LTCP was submitted, the water quality classification for the Hutchinson River was Class SB. That classification has not changed. The water quality criteria for bacteria includes a fecal coliform monthly geometric mean of ≤200 cfu/100mL, assessed on an annual basis. The Hutchinson River is a non-coastal tributary, so the *Enterococci* criteria for coastal primary contact recreational waters do not apply to the Hutchinson River.

Table 4-6 presents the percent attainment with the current Class SB water quality criteria for bacteria at Stations HR-01 to HR-09 in the Hutchinson River for Baseline Conditions and the Recommended Plan, for the 10-year simulation (2002 to 2011). Also shown in Table 4-6 is the percent attainment with an annual fecal coliform geometric mean of 200 cfu/100mL, and percent attainment with *Enterococcus* criteria. The *Enterococcus* criteria do not apply to the Hutchinson River, and are shown for informational purposes only. The attainment percentages in Table 4-6 are based on an assumption that the water quality of the Hutchinson River flowing into NYC from Westchester County is in compliance with water quality standards. Refer to the Hutchinson River LTCP for further discussion of the impact of pollutant loads from Westchester County, and the total maximum daily load calculations for the Hutchinson River.

Table 4-7 presents the annual percent attainment with the applicable DO criteria for the Hutchinson River stations for Baseline Conditions and the Recommended Plan, based on 2008 rainfall.

The locations of the sampling stations referenced in Table 4-6 and Table 4-7 are shown in Figure 4-11.

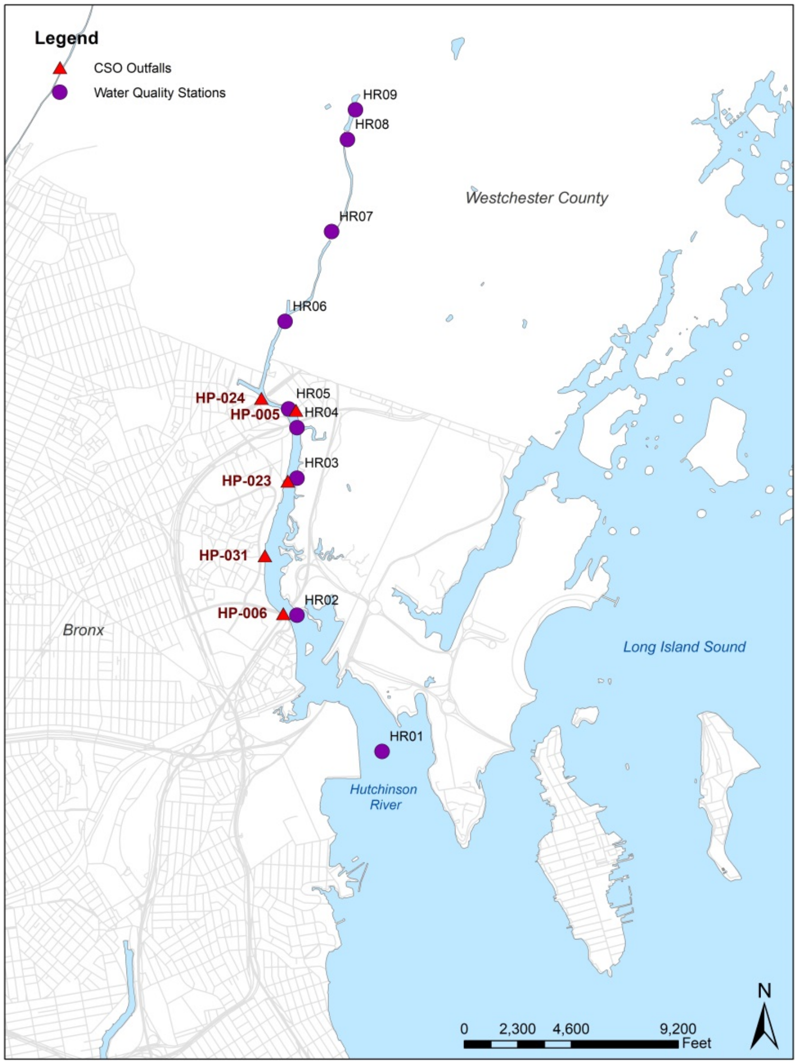


Figure 4-11. Water Quality Stations in the Hutchinson River

Table 4-6. Calculated 10-year Bacteria Attainment in Hutchinson River for Baseline Conditions and the Recommended Plan

Location	Percent Attainment with Criteria							
	Baseline				Recommended Plan			
	Class SB Fecal Coliform Criteria		*Enterococcus* Criteria for Recreational Season(1)(2)(5)		Class SB Fecal Coliform Criteria		*Enterococcus* Criteria for Recreational Season(1)(2)(5)	
	Recreational Season(1)	Annual			Recreational Season(1)	Annual		
	Monthly Geometric Mean ≤200 cfu/100mL	Monthly Geometric Mean ≤200 cfu/100mL	30-day Geometric Mean ≤35 cfu/100mL	30-day 90th Percentile ≤130 cfu/100mL	Monthly Geometric Mean ≤200 cfu/100mL	Monthly Geometric Mean ≤200 cfu/100mL	30-day Geometric Mean ≤35 cfu/100mL	30-day 90th Percentile ≤130 cfu/100mL
HR-09(4)	N/A(3)	0%	0%	0%	0%	0%	0%	0%
HR-08(4)	N/A(3)	0%	0%	0%	0%	0%	0%	0%
HR-07(4)	N/A(3)	0%	0%	0%	0%	0%	0%	0%
HR-06(4)	N/A(3)	74%	47%	3%	92%	77%	48%	3%
HR-05	N/A(3)	81%	57%	5%	95%	84%	61%	5%
HR-04	N/A(3)	89%	71%	9%	95%	90%	74%	10%
HR-03	N/A(3)	89%	76%	10%	97%	91%	78%	12%
HR-02	N/A(3)	93%	86%	15%	97%	94%	89%	15%
HR-01	N/A(3)	100%	99%	60%	100%	100%	99%	66%

Notes:

(1) The Recreational Season is from May 1st through October 31st.
(2) *Enterococcus* Criteria do not apply to Hutchinson River. Attainment with these criteria is shown for informational purposes only.
(3) 10-year recreational season fecal coliform attainment was not developed for this LTCP.
(4) Monitoring stations HR-06 through HR-09 are located along a segment of the Hutchinson River in Westchester County.
(5) The *Enterococcus* criteria have been updated from the original LTCP, which presented attainment with a 30-day GM of ≤30 cfu/100mL and a 30-day STV of ≤110 cfu/100mL.

Table 4-7. Model Calculated DO Attainment for Hutchinson River Stations for Baseline Conditions and the Recommended Plan (2008 Rainfall)

Station	Percent Annual Average Attainment			
	Baseline		Recommended Plan	
	Class SB		Class SB	
	Chronic ≥4.8 mg/L(1)	Acute ≥3.0 mg/L(2)	Chronic ≥4.8 mg/L(1)	Acute ≥3.0 mg/L(2)
HR-09(3)	100%	100%	100%	100%
HR-08(3)	100%	100%	100%	100%
HR-07(3)	97%	100%	98%	100%
HR-06(3)	60%	83%	73%	95%
HR-05	70%	92%	78%	97%
HR-04	79%	96%	90%	99%
HR-03	92%	99%	97%	100%
HR-02	98%	99%	98%	100%
HR-01	97%	99%	98%	100%

Notes:

(1) Chronic standard based on daily average. See Table 2-5 in Section 2 for further details on the DO criteria.
(2) Acute standard (never less than).
(3) Monitoring stations HR-06 through HR-09 are located along a segment of the Hutchinson River in Westchester County.

4.3.d Flushing Creek

4.3.d.1 WWFP Projects

The following summarizes the cost-effective grey projects implemented for Flushing Creek based on the WWFP recommendations.

- The 43 MG Flushing Bay CSO Retention Facility
- The Corona Avenue Vortex Facility

The total cost of the constructed grey infrastructure projects was $363M.

4.3.d.2 Approved LTCP Recommended Plan

The following summarizes the Recommended Plan from the December 2014 Flushing Creek LTCP that was approved by DEC on March 7, 2017.

- **Description:** Seasonal disinfection with dechlorination of the discharge from the existing Flushing Bay CSO Retention Facility and Diversion Chamber 5 for CSO Outfall TI-010 (Figure 4-12); seasonal disinfection with dechlorination at Outfall TI-011 (Figure 4-13); and floatables control
- **Probable bid cost presented in the LTCP:** $56M (October 2014 dollars)
- **Current total project cost, including engineering, escalated to the midpoint of construction:** $89M
- **Current Completion Milestone*:** 2025

  * Milestone dates may be subject to revision by DEC based on additional facility planning.

4.3.d.3 Benefits and Challenges of Implementing the Recommended Plan for Flushing Creek

Figure 4-14 presents the reductions in CSO volume associated with the WWFP cost-effective grey projects and the LTCP Recommended Plan. As indicated in Figure 4-14, the cost-effective grey projects (post WWFP) resulted in a 1,212 MGY (50 percent) reduction in the annual CSO volume to Flushing Creek. The LTCP Recommended Plan does not change the volume of CSO discharged but will provide disinfection for 584 MG of the remaining 1,201 MG of discharge, based on the Typical Year rainfall. The disinfection will be applied during the recreational season (May 1st through October 31st). Additional benefits include the following:

- Application of disinfection to existing tanks and outfalls reduces neighborhood construction impacts.
- City owned properties and road-rights-of-way are potentially available for siting of facilities.
- DEP staff are familiar with the procedures for safe handling and use of sodium hypochlorite and sodium bisulfite through its application at each of the City’s WRRFs.

Figure 4-12. Seasonal Disinfection at Flushing Bay CSO Retention Facility and Diversion Chamber 5

Figure 4-13. Seasonal Disinfection at CSO Outfall TI-011

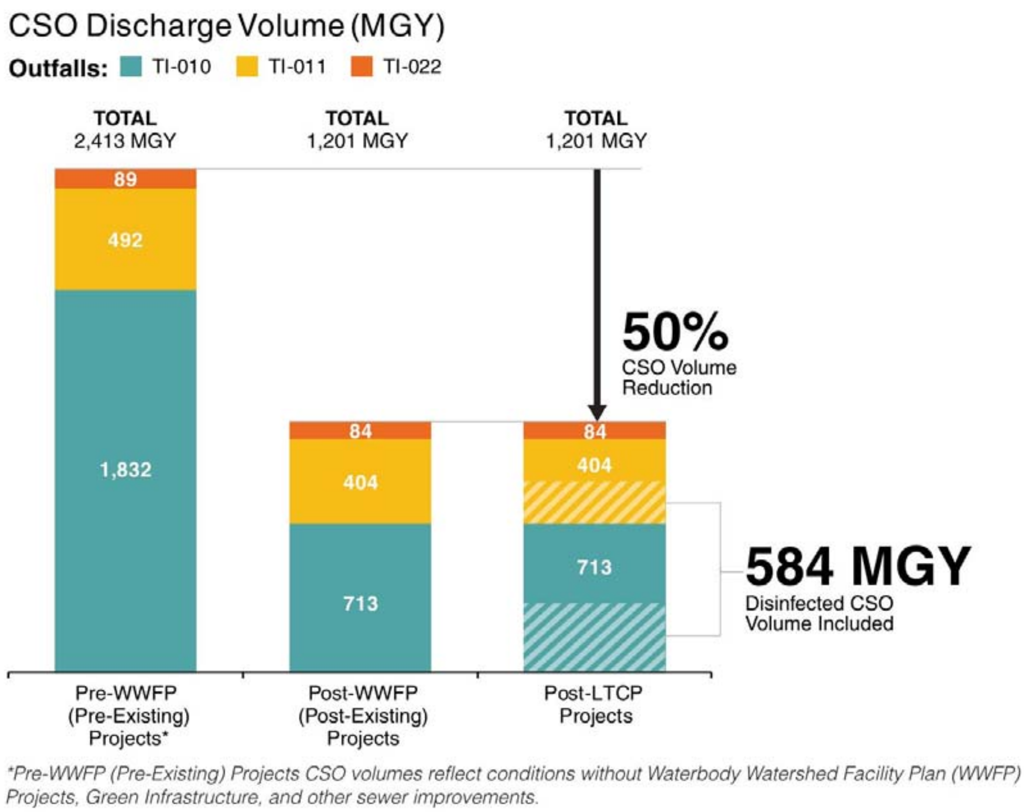


Figure 4-14. Benefits to Flushing Creek

While seasonal disinfection is a highly cost-effective approach to reduce the pathogen loads from the remaining CSO discharges to Flushing Creek by an additional 49 percent, several construction and operational challenges must be overcome. The challenges and associated risks are as follows:

- The existing retention facility is currently operated remotely but will require staffing during wet-weather events to monitor and maintain the disinfection facilities.
- The existing odor control facilities at the CSO retention facilities will need to be modified to provide a dual purpose of disinfection and odor control.
- Chemical feed facilities for chlorination and dechlorination will need to be constructed and maintained at multiple locations for TI-010 and TI-011.
- For TI-011, several sewers connect to the trunk sewer downstream of the disinfectant feed resulting in highly variable flow conditions from event to event.
- For TI-010, disinfectant will be introduced to multiple sewers entering the CSO retention facility resulting in variable flow conditions within each sewer barrel during overflow events.
- To address the highly variable flow conditions, an extremely high degree of system automation and sophistication will be required to operate the disinfection systems for TI-010 and TI-011.

- There is a risk that overdosing to overcome operational complexities and achieve anticipated permit limits for pathogens may make it difficult to achieve the chlorine residual permit limits.

- Thorough flushing of the chemical feed lines will be required after each storm event to minimize the risk of crystallization of the chemicals and the formation of blockages within the feed lines.

The siting challenges may affect the project cost and schedule if site acquisition becomes problematic. Operational challenges are significant and additional assessment and study is required to fully develop the best treatment alternative for the variable CSO entering this facility. DEP will seek to address these challenges during design through additional testing and the provision of design and operational criteria within the bid documents and facility O&M manuals to minimize these risks. DEP may also need to consider evaluating alternative technologies in consultation with DEC.

4.3.d.4 Water Quality Standards Attainment

At the time that the Flushing Creek LTCP was submitted, the water quality classification for Flushing Creek was Class I. That classification has not changed, but the water quality criteria associated with that classification has changed. For Flushing Creek, the previous water quality criteria for bacteria included a fecal coliform monthly geometric mean of ≤2,000 cfu/100mL, assessed on an annual basis. The current criterion is for a fecal coliform monthly geometric mean of ≤200 cfu/100mL. Flushing Creek is a non-coastal tributary, so the *Enterococcus* criteria for coastal primary contact recreational waters do not apply to Flushing Creek.

Table 4-8 presents the percent attainment with the current Class I water quality criteria for bacteria at Stations OW-03 to OW-06 in Flushing Creek for Baseline Conditions and the Recommended Plan, for the 10-year simulation (2002 to 2011). Also shown in Table 4-8 is the percent attainment with an annual fecal coliform geometric mean of 200 cfu/100mL, and the percent attainment with *Enterococcus* criteria. The *Enterococcus* criteria do not apply to Flushing Creek and are shown for informational purposes only.

Table 4-9 presents the annual percent attainment with the applicable DO criteria for Flushing Creek stations for Baseline Conditions and the Recommended Plan, based on 2008 rainfall.

The locations of the sampling stations referenced in Table 4-8 and Table 4-9 are shown in Figure 4-15.

Table 4-8. Calculated 10-year Bacteria Attainment in Flushing Creek for Baseline Conditions and the Recommended Plan

Location	Percent Attainment with Criteria							
	Baseline				Recommended Plan			
	Class I Fecal Coliform Criteria		*Enterococcus* Criteria for Recreational Season(1)(2)(3)		Class I Fecal Coliform Criteria		*Enterococcus* Criteria for Recreational Season(1)(2)(3)	
	Recreational Season(1)	Annual			Recreational Season(1)	Annual		
	Monthly Geometric Mean ≤200 cfu/100mL	Monthly Geometric Mean ≤200 cfu/100mL	30-day Geometric Mean ≤35 cfu/100mL	30-day 90th Percentile ≤130 cfu/100mL	Monthly Geometric Mean ≤200 cfu/100mL	Monthly Geometric Mean ≤200 cfu/100mL	30-day Geometric Mean ≤35 cfu/100mL	30-day 90th Percentile ≤130 cfu/100mL
OW-3	62%	39%	45%	3%	78%	67%	69%	7%
OW-4	68%	43%	55%	3%	82%	67%	79%	9%
OW-5	74%	48%	59%	5%	90%	75%	85%	12%
OW-6	78%	53%	62%	6%	92%	75%	93%	26%

Notes:

(1) The Recreational Season is from May 1st through October 31st.
(2) *Enterococcus* Criteria do not apply to Flushing Creek. Attainment with these criteria is shown for informational purposes only.
(3) The *Enterococcus* criteria have been updated from the original LTCP, which presented attainment with a 30-day GM of ≤30 cfu/100mL and a 30-day STV of ≤130 cfu/100mL.

Table 4-9. Model Calculated DO Attainment for Flushing Creek Stations for Baseline Conditions and the Recommended Plan (2008 Rainfall)

Station	Percent Annual Average Attainment Class I ≥4.0 mg/L	
	Baseline	Recommended Plan
OW-3	85%	85%
OW-4	88%	88%
OW-5	91%	91%
OW-6	96%	96%

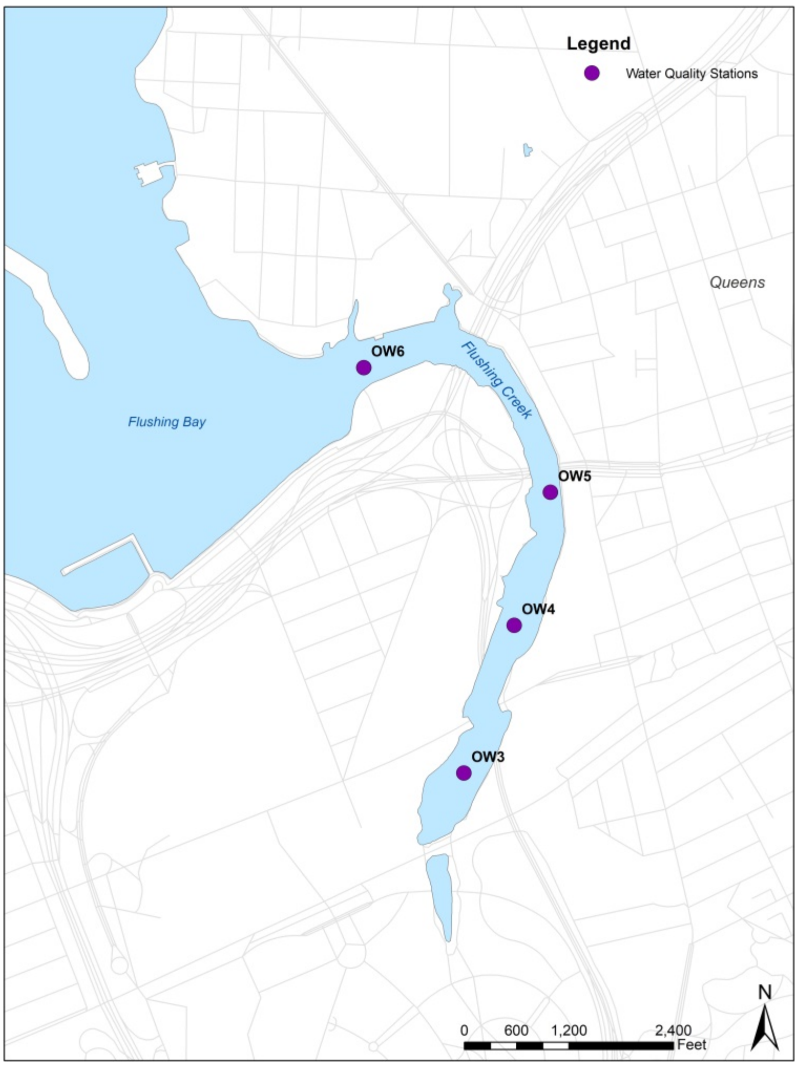


Figure 4-15. Water Quality Stations in Flushing Creek

4.3.e Bronx River

4.3.e.1 WWFP Projects

The following summarizes the cost-effective grey projects implemented for the Bronx River based on the WWFP recommendations.

- Hunts Point WRRF Headworks Upgrades
- Floatables Control Facilities for Outfalls HP-004, HP-007 and HP-009.

The total cost of the constructed grey infrastructure projects was $46M.

4.3.e.2 Approved LTCP Recommended Plan

The following summarizes the Recommended Plan from the June 2015 Bronx River LTCP that was approved by DEC on March 7, 2017.

- **Description:** Hydraulic relief sewers for Outfalls HP-007 and HP-009, and a bending weir with underflow baffle for Outfall HP-011 (Figure 4-16)
- **Probable bid cost presented in the LTCP:** $110M (February 2015 dollars)
- **Current total project cost, including engineering, escalated to the midpoint of construction:** $122M
- **Current Completion Milestone*:** 2026

  ***** *Milestone dates may be subject to revision by DEC based on additional facility planning.*

4.3.e.3 Benefits and Challenges of Implementing the Recommended Plan for the Bronx River

Figure 4-17 presents the reductions in CSO volume associated with the WWFP cost-effective grey projects and the LTCP Recommended Plan. As indicated in Figure 4-17, the cost-effective grey projects (post WWFP) resulted in a 44 MGY (9 percent) reduction in the annual CSO volume to the Bronx River. The LTCP Recommended Plan results in an additional 169 MG (37 percent) reduction in annual CSO volume.

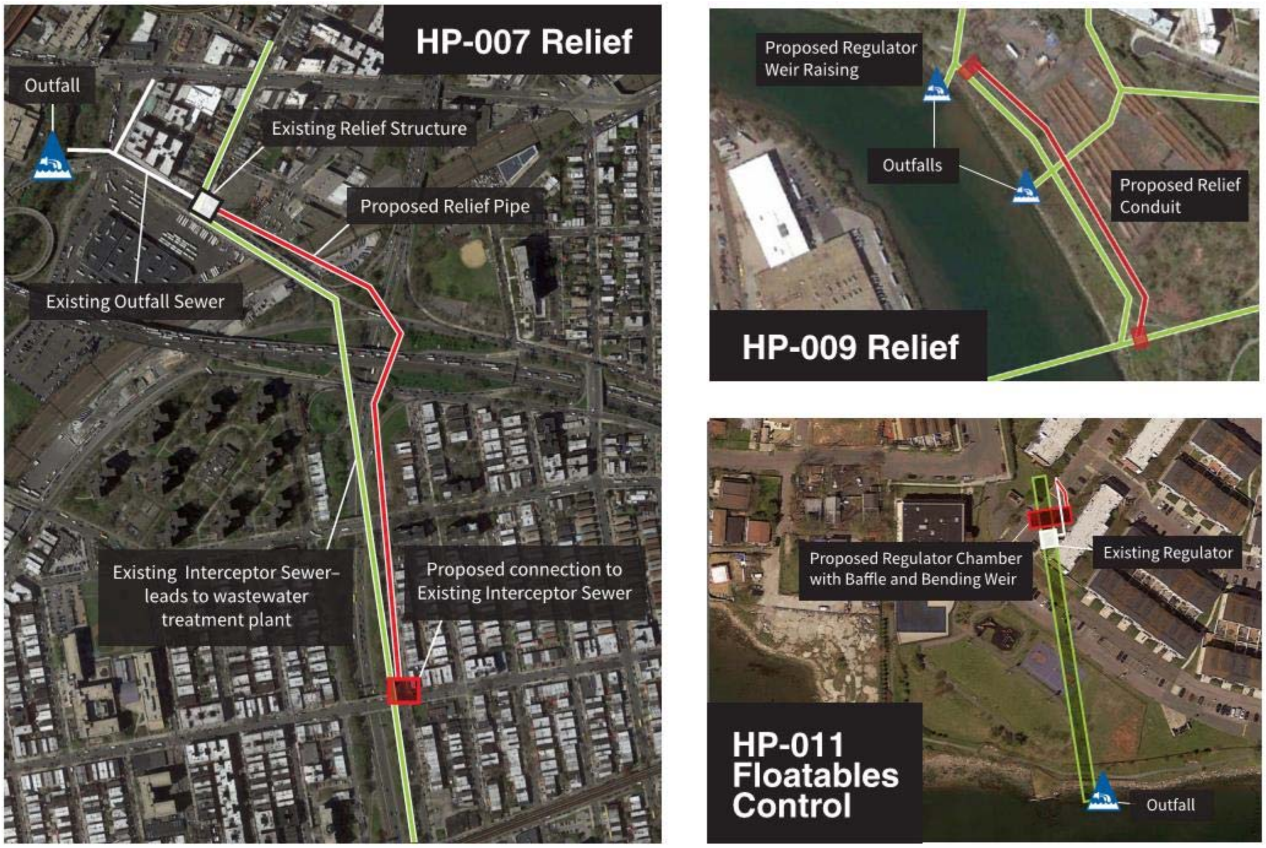


Figure 4-16. Hydraulic Relief at CSO Outfalls HP-007 and HP-009 and Floatables Control at CSO Outfall HP-011

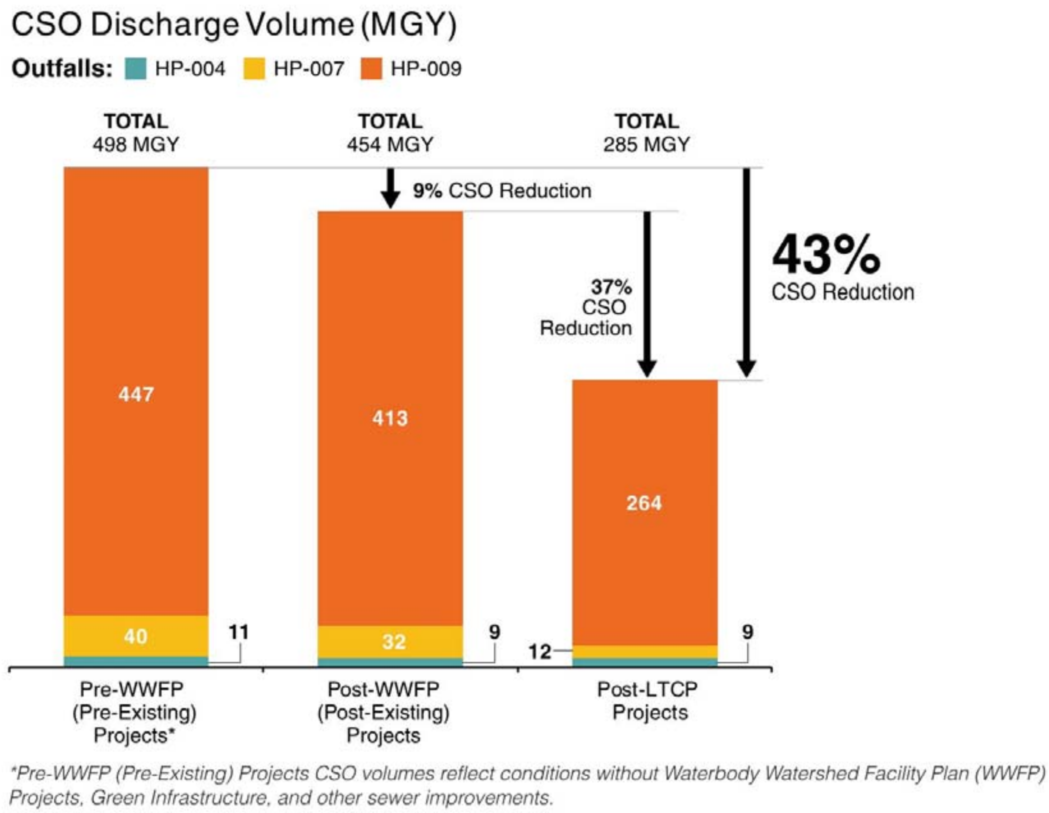


Figure 4-17. Benefits to Bronx River

Overall, from the pre-WWFP conditions to the LTCP Recommended Plan, the total annual CSO volume reduction is 213 MG (43 percent). Additional benefits include:

- The underflow baffle provides floatables control for remaining CSO discharges at Outfall HP-011 to complement the CSO capture benefits of the bending weir in Regulator HP-5.
- Reduced operation and maintenance of the bending weir and underflow baffle in comparison to netting facilities.
- Less neighborhood disruption in comparison to other CSO control alternatives.

While the Recommended Plan is a highly cost-effective approach to reducing the remaining CSO discharges to the Bronx River by an additional 37 percent, there are some construction and operational challenges that must be considered. The challenges and associated risks are as follows:

- Bending weir settings at Regulator HP-5 must balance between maximizing CSO capture while preventing upstream hydraulic impacts.
- Limited space is available within highway medians and traffic islands of the Bronx River Parkway for siting of microtunneling shafts and staging areas for construction of the HP-007 relief sewer.

- Construction of the relief sewer for HP-009 requires removal of mature trees and vegetation along the shoreline and within wetlands.

- While CSO discharges are reduced from HP-007, CSO discharges are increased at downstream Outfalls HP-009 (Bronx River) and HP-011 (East River).

DEP will seek to address these challenges during design through the provision of design and operational criteria.

4.3.e.4 Water Quality Standards Attainment

At the time that the Bronx River LTCP was submitted, the water quality classification for the freshwater reach of the river was Class B, and the saltwater reach was Class I. Those classifications have not changed, but the water quality criteria associated with the Class I saltwater reach has changed. For the freshwater reach of the Bronx River, the water quality criteria for bacteria includes a fecal coliform monthly geometric mean of ≤200 cfu/100mL, assessed on an annual basis. For the saltwater reach, the previous water quality criteria for bacteria included a fecal coliform monthly geometric mean of ≤2,000 cfu/100mL, assessed on an annual basis. The current criterion is for a fecal coliform monthly geometric mean of ≤200 cfu/100mL. The Bronx River is a non-coastal tributary, so the *Enterococcus* criteria for coastal primary contact recreational waters do not apply to the Bronx River.

Table 4-10 presents the percent attainment with the current Class B water quality criteria for bacteria at Stations BR-1 to BR-4, and the Class I water quality criteria for bacteria at Stations BR-5 to BR-9 in the Bronx River for Baseline Conditions and the Recommended Plan. Also shown in Table 4-10 is the percent attainment with an annual fecal coliform geometric mean of 200 cfu/100mL, and the percent attainment with *Enterococcus* criteria. The *Enterococcus* criteria do not apply to the Bronx River, and are shown for informational purposes only.

Table 4-11 presents the annual percent attainment with the applicable DO criteria for the Bronx River stations in the saline reach of the river based on 2008 rainfall and the Recommended Plan.

The locations of the sampling stations referenced in Table 4-10 and Table 4-11 are shown in Figure 4-18.

Table 4-10. Calculated 10-year Bacteria Attainment in Bronx River for Baseline Conditions and the Recommended Plan

Location[1]			Percent Attainment with Criteria							
			Baseline				Recommended Plan			
			Class I Fecal Coliform Criteria		*Enterococcus* Criteria for Recreational Season[2][3][5]		Class I Fecal Coliform Criteria		*Enterococcus* Criteria for Recreational Season[2][3][5]	
			Recreational Season[2][6]	Annual			Recreational Season[2]	Annual		
			Monthly Geometric Mean ≤200 cfu/100mL	Monthly Geometric Mean ≤200 cfu/100mL	30-day Geometric Mean ≤35 cfu/100mL	30-day 90^{th} Percentile ≤130 cfu/100mL	Monthly Geometric Mean ≤200 cfu/100mL	Monthly Geometric Mean ≤200 cfu/100mL	30-day Geometric Mean ≤35 cfu/100mL	30-day 90^{th} Percentile ≤130 cfu/100mL
BR-1	Fresh Water Class B	Non-tidal	100%	100%	100%	22%	100%	100%	100%	22%
BR-2			100%	100%	100%	22%	100%	100%	100%	22%
BR-3			93%	93%	99%	14%	93%	93%	99%	14%
BR-4[4]		Tidal	80%	83%	59%	3%	80%	83%	82%	10%
BR-5	Saline Class I		87%	83%	59%	3%	87%	83%	84%	10%
BR-6			95%	80%	76%	7%	98%	90%	95%	30%
BR-7			95%	83%	79%	9%	98%	90%	95%	36%
BR-8			95%	85%	81%	13%	98%	90%	94%	40%
BR-9			100%	94%	95%	50%	100%	96%	97%	58%

Notes:
1. (1) The Class B freshwater stations are not affected by the Bronx River CSOs, which are all located in the saline section of the Bronx River.
2. (2) The Recreational Season is from May 1^{st} through October 31^{st}.
3. (3) *Enterococcus* Criteria do not apply to the Bronx River. Attainment with these criteria is shown for informational purposes only.
4. (4) BR-4 is located south of the dam and north of Tremont Avenue and is therefore located in the freshwater portion of the Bronx River but is also tidally influenced.
5. (5) The *Enterococcus* criteria have been updated from the original LTCP, which presented attainment with a 30-day GM of ≤30 cfu/100mL and a 30-day STV of ≤130 cfu/100mL.
6. (6) The baseline conditions recreational season attainment with fecal coliform criteria has been updated from the LTCP, which did not provide 10-year results for the baseline conditions recreational season.

Table 4-11. Model Calculated DO Attainment for the Bronx River Saline Stations for Baseline Conditions and the Recommended Plan (2008 Rainfall)

Station		Percent Annual Average Attainment Class I ≥4.0 mg/L	
		Baseline Conditions	Recommended Plan
BR-5	Saline (Class I)	99%	99%
BR-6		95%	95%
BR-7		97%	97%
BR-8		99%	99%
BR-9		98%	98%

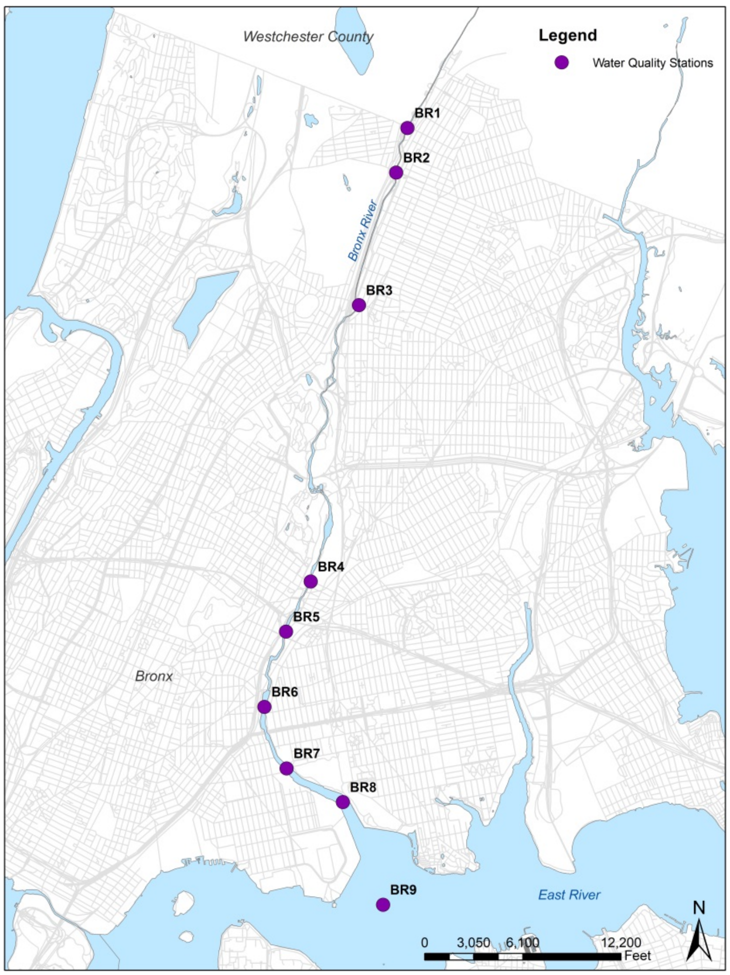


Figure 4-18. Water Quality Stations in the Bronx River

4.3.f Gowanus Canal

4.3.f.1 WWFP Projects

The following summarizes the cost-effective grey projects implemented for Gowanus Canal based on the WWFP recommendations.

- Restoration of the Gowanus flushing tunnel
- Reconstruction of the Gowanus Pumping Station

The total cost of the constructed grey infrastructure projects was $198M.

4.3.f.2 Approved LTCP Recommended Plan

The cost-effective grey projects from the WWFP implemented in Gowanus Canal were demonstrated to result in attainment of WQS in Gowanus Canal. Therefore, no additional projects were recommended in the LTCP to meet CWA requirements.

4.3.f.3 Projects to Meet Superfund Requirements

- **Description:** Through the Superfund process, two CSO storage tanks were determined to be required in order to meet Superfund requirements. The LTCP demonstrated that these tanks would further improve water quality in Gowanus Canal, but were not necessary to meet WQS. The two storage tanks determined to be required under the Superfund Program were an 8 MG storage tank for Outfall RH-034, and a 4 MG storage tank for Outfall OH-007 (Figure 4-19).
- **Probable bid cost:** $720M
- **Current total project cost, including engineering, escalated to the midpoint of construction:** $1,322M

4.3.f.4 Benefits to Gowanus Canal

Figure 4-20 presents the reductions in CSO volume associated with the WWFP cost-effective grey projects and the storage tanks associated with the Superfund Program. As indicated in Figure 4-20, the cost-effective grey projects (post WWFP) resulted in a 208 MGY (44 percent) reduction in the annual CSO volume to Gowanus Canal. The storage tanks proposed under the Superfund Program result in an additional 148 MG (56 percent) reduction in annual CSO volume. Overall, from the pre-WWFP conditions to the Superfund recommendation, the total annual CSO volume reduction is 356 MG (76 percent).

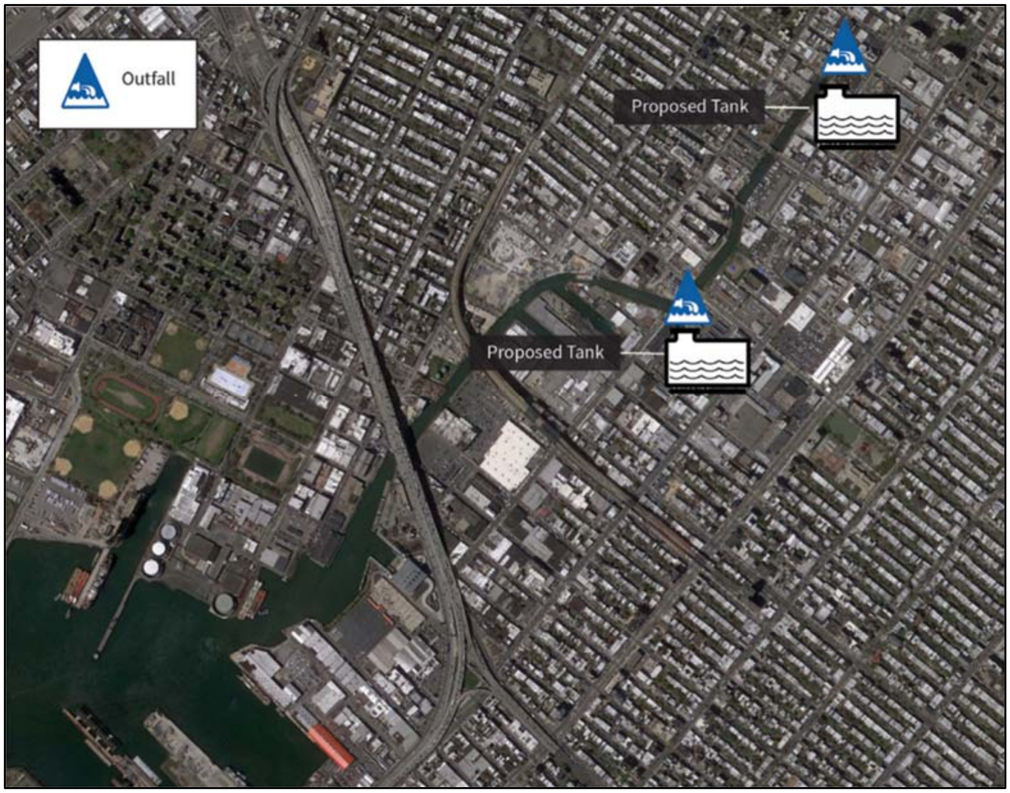


**Figure 4-19. Elements of the Superfund Plan
(8MG Tank at RH-034 and 4MG Tank at OH-007)**

4.3.f.5 Water Quality Standards Attainment

At the time that the Gowanus Canal LTCP was submitted, the water quality classification for Gowanus Canal was Class SD. That classification has not changed, but the water quality criteria associated with that classification have changed. Previously, Class SD waters had no numerical criteria for bacteria. The current Class SD criterion is for a fecal coliform monthly geometric mean of ≤200 cfu/100mL. Gowanus Canal is a non-coastal tributary, so the *Enterococcus* criteria for coastal recreational waters do not apply to Gowanus Canal.

Table 4-12 presents the percent attainment with the current Class SD water quality criteria for bacteria at the water quality stations in Gowanus Canal for Baseline Conditions and with the storage tanks proposed under the Superfund Program, for the 10-year simulation (2002 to 2011). Also shown in Table 4-12 is the percent attainment with an annual fecal coliform geometric mean of 200 cfu/100mL, and the percent attainment with *Enterococcus* criteria. The *Enterococcus* criteria do not apply to Gowanus Canal, and are shown for informational purposes only.

Table 4-13 presents the annual percent attainment with the applicable DO criteria for Gowanus Canal stations for Baseline Conditions and with the storage tanks proposed under the Superfund Program, based on 2008 rainfall.

The locations of the sampling stations referenced in Table 4-12 and Table 4-13 are shown in Figure 4-21.

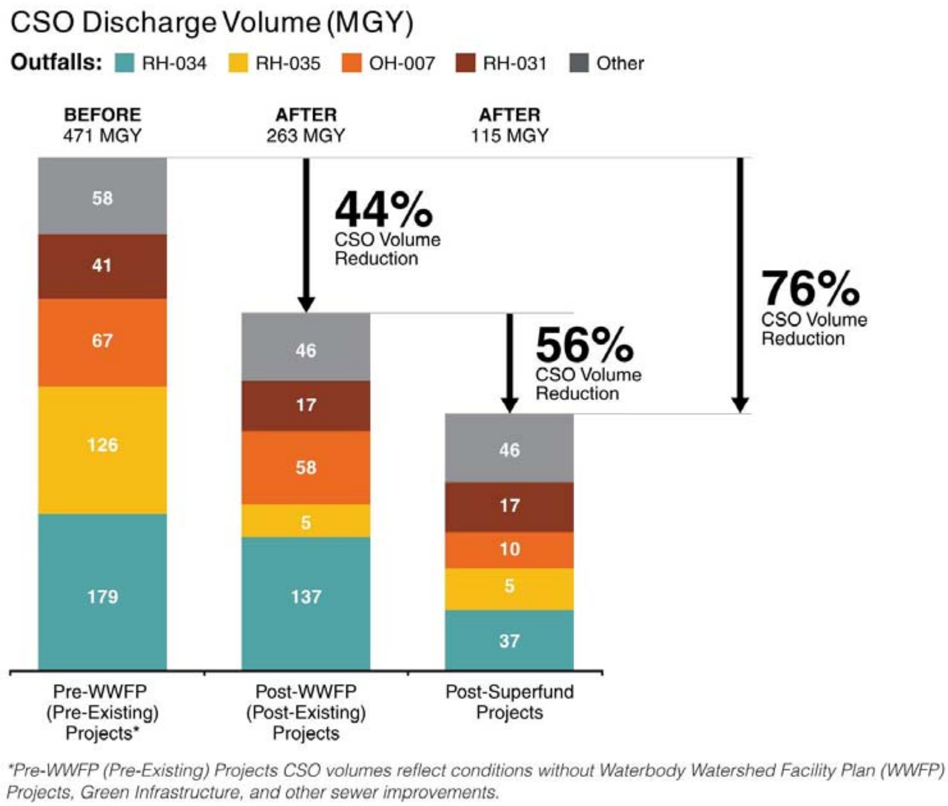


Figure 4-20. Benefits to Gowanus Canal

Table 4-12. Calculated 10-year Bacteria Attainment in Gowanus Canal for Baseline Conditions and with the Storage Tanks Proposed under the Superfund Program

Location	Percent Attainment with Criteria							
	Baseline				Storage Tanks Proposed under the Superfund Program			
	Class SD Fecal Coliform Criteria		*Enterococcus* Criteria for Recreational Season(1)(2)(3)		Class SD Fecal Coliform Criteria		*Enterococcus* Criteria for Recreational Season(1)(2)(3)	
	Recreational Season(1)	Annual			Recreational Season(1)	Annual		
	Monthly Geometric Mean ≤200 cfu/100mL	Monthly Geometric Mean ≤200 cfu/100mL	30-day Geometric Mean ≤35 cfu/100mL	30-day 90th Percentile ≤130 cfu/100mL	Monthly Geometric Mean ≤200 cfu/100mL	Monthly Geometric Mean ≤200 cfu/100mL	30-day Geometric Mean ≤35 cfu/100mL	30-day 90th Percentile ≤130 cfu/100mL
GC-1	100%	98%	99%	70%	100%	98%	100%	92%
GC-2	100%	99%	99%	75%	100%	99%	100%	92%
GC-3	100%	100%	99%	75%	100%	100%	100%	92%
GC-4	100%	100%	99%	74%	100%	100%	100%	91%
GC-5	100%	100%	99%	67%	100%	100%	100%	91%
GC-6	100%	98%	93%	37%	100%	98%	100%	90%
GC-7	100%	98%	94%	39%	100%	98%	100%	90%

Notes:
(1) The Recreational Season is from May 1st through October 31st.
(2) *Enterococcus* Criteria do not apply to Gowanus Canal. Attainment with these criteria is shown for informational purposes only.
(3) The *Enterococcus* criteria have been updated from the original LTCP, which presented attainment with a 30-day GM of ≤30 cfu/100mL and a 30-day STV of ≤130 cfu/100mL

Table 4-13. Model Calculated DO Attainment for Gowanus Canal Stations with Storage Tanks Proposed under the Superfund Program (2008 Rainfall)

Station	Percent Annual Average Attainment Class SD ≥3.0 mg/L	
	Baseline Conditions	Storage Tanks Proposed under the Superfund Program
GC-1	100%	100%
GC-2	100%	100%
GC-3	100%	100%
GC-4	100%	100%
GC-5	100%	100%
GC-6	98%	100%
GC-7	99%	100%

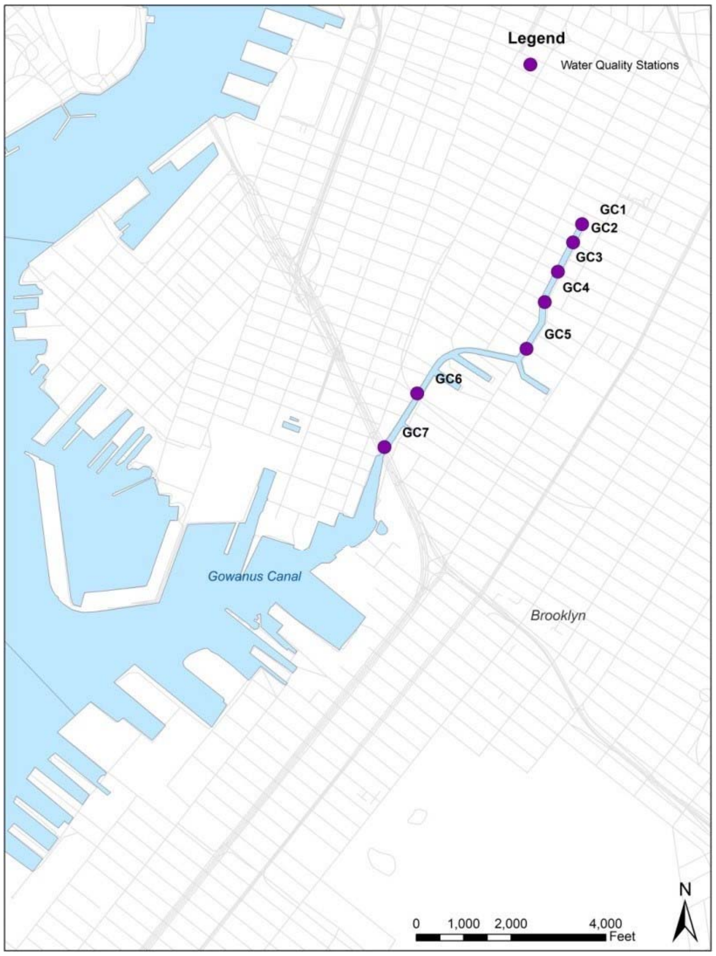


Figure 4-21. Water Quality Stations in Gowanus Canal

4.3.g Coney Island Creek

4.3.g.1 WWFP Projects

The following summarizes the cost-effective grey projects implemented for Coney Island Creek based on the WWFP recommendations.

- Upgrade of the Avenue V Pumping Station
- New wet-weather force main

The total cost of the grey infrastructure projects under construction is $197M.

4.3.g.2 Approved LTCP Recommended Plan

The following summarizes the Recommended Plan from the June 2016 Coney Island Creek LTCP that was approved by DEC on April 4, 2018.

- **Description:** The cost-effective grey projects from the WWFP implemented in Coney Island Creek were demonstrated to result in attainment of the Class I water quality standards in Coney Island Creek. Therefore, no additional projects were recommended in the LTCP.

4.3.g.3 Benefits to Coney Island Creek

Figure 4-22 presents the reductions in CSO volume associated with the WWFP cost-effective grey projects and the LTCP Recommended Plan. As indicated in Figure 4-22, the cost-effective grey projects (post WWFP) resulted in a 160 MGY (68 percent) reduction in the annual CSO volume to Coney Island Creek.

4.3.g.4 Water Quality Standards Attainment

At the time that the Coney Island Creek LTCP was submitted, the water quality classification for Coney Island Creek was Class I. That classification has not changed, but the water quality criteria associated with that classification have changed. For Coney Island Creek, the current water quality criteria for bacteria is a fecal coliform monthly geometric mean of ≤200 cfu/100mL, assessed on an annual basis Coney Island Creek is a non-coastal tributary, so the *Enterococcus* criteria for coastal primary contact recreational waters do not apply to Coney Island Creek.

Table 4-14 presents the percent attainment with the current Class I water quality criteria for bacteria at Stations CI-1 to CI-7 in Coney Island Creek for Baseline Conditions and the Recommended Plan, for the 10-year simulation (2002 to 2011). Also shown in Table 4-14 is the percent attainment with an annual fecal coliform geometric mean of 200 cfu/100mL, and the percent attainment with *Enterococcus* criteria. The *Enterococcus* criteria do not apply to Coney Island Creek and are shown for informational purposes only.

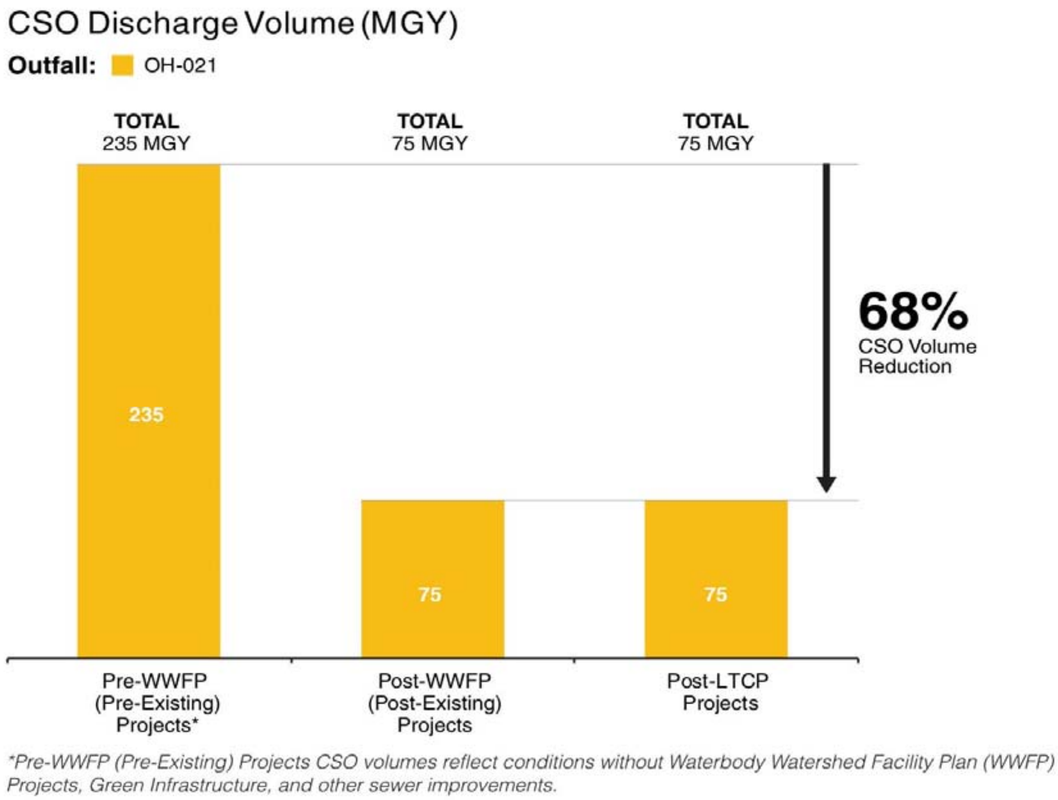


Figure 4-22: Benefits to Coney Island Creek

Table 4-15 presents the annual percent attainment with the applicable DO criteria for the Coney Island Creek stations for Baseline Conditions and the Recommended Plan, based on 2008 rainfall.

The locations of the sampling stations referenced in Table 4-14 and Table 4-15 are shown in Figure 4-23.

Table 4-14. Calculated 10-year Bacteria Attainment in Coney Island Creek for Baseline Conditions and the Recommended Plan

Location	Percent Attainment with Criteria			
	Class I Fecal Coliform Criteria		*Enterococcus* Criteria for Recreational Season(1)(2)(3)	
	Recreational Season(1)	Annual		
	Monthly Geometric Mean ≤200 cfu/100mL	Monthly Geometric Mean ≤200 cfu/100mL	30-day Geometric Mean ≤35 cfu/100mL	30-day 90th Percentile ≤130 cfu/100mL
CI-1	93%	57%	53%	3%
CI-2	93%	56%	54%	3%
CI-3	98%	65%	67%	5%
CI-4	100%	90%	84%	17%
CI-5	100%	91%	85%	19%
CI-6	100%	100%	100%	77%
CI-7	100%	100%	99%	67%

Notes:
(1) The Recreational Season is from May 1st through October 31st.
(2) *Enterococcus* Criteria do not apply to Coney Island Creek. Attainment with these criteria is shown for informational purposes only.
(3) The *Enterococcus* criteria have been updated from the original LTCP, which presented attainment with a 30-day GM of ≤30 cfu/100mL and a 30-day STV of ≤130 cfu/100mL.

Table 4-15. Model Calculated DO Attainment for Coney Island Creek Stations for Baseline Conditions and the Recommended Plan (2008 Rainfall)

Station	Percent Annual Average Attainment
	Class I ≥4.0 mg/L
CI-1	90%
CI-2	95%
CI-3	96%
CI-4	98%
CI-5	99%
CI-6	99%
CI-7	99%

Figure 4-23. Water Quality Stations in Coney Island Creek

4.3.h Flushing Bay

4.3.h.1 WWFP Projects

The following summarizes the cost-effective grey projects implemented for Flushing Bay based on the WWFP recommendations.

- Divert Low Lying Sewers to the Low Level Interceptor and Raise Weir in Regulator BB-02
- Modifications to Regulators BB-04, BB-05, BB-06, BB-09 and BB-10
- Dredging and restoration of select areas of Flushing Bay

The total cost of the constructed grey infrastructure projects was $71M.

4.3.h.2 Approved LTCP Recommended Plan

The following summarizes the Recommended Plan from the December 2016 Flushing Bay LTCP that was approved by DEC on March 7, 2017.

- **Description:** 25 MG CSO storage tunnel with dewatering pumping station to capture overflows from CSO Outfalls BB-006 and BB-008 (Figure 4-24)

- **Probable bid cost presented in the LTCP:** $829M (February 2016 dollars)

- **Current total project cost, including engineering, escalated to the midpoint of construction:** $1,471M

- **Current Completion Milestone*:** 2035

  *** *Milestone dates may be subject to revision by DEC based on additional facility planning.***

Figure 4-24. 25 MG CSO Storage Tunnel (Outfalls: BB-006 and BB-008)

4.3.h.3 Benefits and Challenges of Implementing the Recommended Plan for Flushing Bay

Figure 4-25 presents the reductions in CSO volume associated with the WWFP cost-effective grey projects and the LTCP Recommended Plan. As indicated in Figure 4-25, the cost-effective grey projects (post WWFP) resulted in a 347 MGY (19 percent) reduction in the annual CSO volume to Flushing Bay. The LTCP Recommended Plan results in an additional 747 MG (51 percent) reduction in annual CSO volume. Overall, from the pre-WWFP conditions to the LTCP Recommended Plan, the total annual CSO volume reduction is 1,094 MG (61 percent). Additional benefits include:

- Pump back will be discharged at the Bowery Bay WRRF eliminating the risk of re-deposition of solids along the interceptor as experienced with current CSO retention facilities.

- Trenchless construction methods can significantly reduce the extent of neighborhood disturbance associated with the construction of the storage tunnel and CSO diversion conduits.

- The tunnel alignment minimizes property acquisition requirements through the use of road rights-of-way and City owned properties.

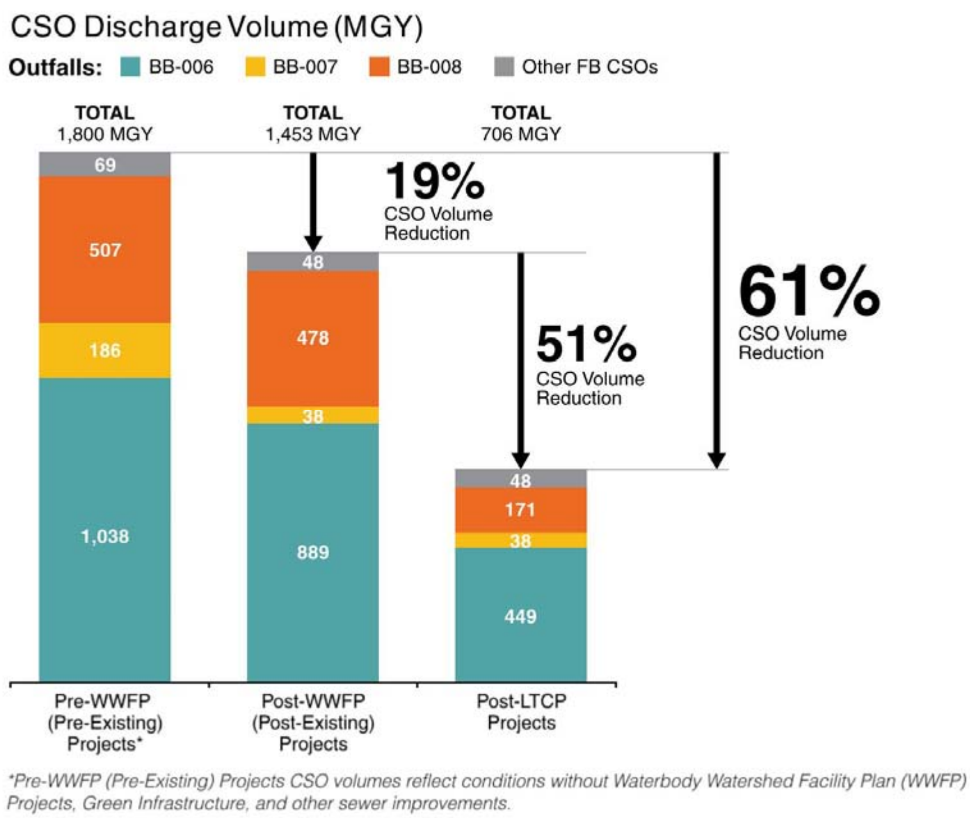


Figure 4-25. Benefits to Flushing Bay

While the Recommended Plan is a cost-effective approach to reducing the remaining CSO discharges to Flushing Bay by an additional 51 percent, a number of construction and operational challenges must be considered. The challenges and associated risks include the following:

- Construction of the dewatering pump station site will require either modification of the long term lease with the PANYNJ or acquisition of private property.
- As a result of past uses, the available sites for the dewatering pump station may require some level of environmental cleanup prior to construction.
- The tunnel and dewatering pump station will be at depths in the range of 100 to 150 feet and require more complex confined space entry for operation and maintenance.
- A portion of the proposed route of the tunnel will overlap with the proposed route for the LaGuardia Airport Access Improvement Project (AirTrain), which will connect the Airport to the NYCT Subway 7 Line and the Port Washington Branch of the LIRR commuter rail. The Federal Aviation Administration (FAA) released the Draft Environmental Impact Statement (DEIS) for this project in August 2020.
- Construction of the tunnel will require protection of existing utilities, highway infrastructure and building foundations.
- Mixed soils conditions require detailed geotechnical investigations and will require the development of a geotechnical baseline report to define geotechnical conditions and precautionary measures.
- Maintenance of regulator and outfall performance throughout construction.
- Hydraulic evaluations of the diversion chambers, diversion sewers, tunnel, and dewatering pump station will be necessary to address performance under a wide range of hydraulic conditions and to address air release and to reduce the risk of hydraulic surge conditions.
- Design of the tunnel and appurtenances to minimize sediment deposition and cleaning.
- The timing for design and construction of the recommended plan needs to be evaluated in light of affordability considerations and other large construction projects proceeding in and around the City, including the AirTrain and Superfund mandated CSO control projects.

DEP will seek to address these challenges during design through the provision of design and operational criteria.

4.3.h.4 Water Quality Standards Attainment

At the time that the Flushing Bay LTCP was submitted, the water quality classification for Flushing Bay was Class I. That classification has not changed. The water quality criteria for bacteria include a fecal coliform monthly geometric mean of ≤200 cfu/100mL, assessed on an annual basis. Flushing Bay is a non-coastal tributary, so the *Enterococcus* criteria for coastal primary contact recreational waters do not apply to Flushing Bay.

Table 4-16 presents the percent attainment with the current Class I water quality criteria for bacteria at the water quality stations in Flushing Bay for Baseline Conditions and the Recommended Plan. Also shown in Table 4-16 is the percent attainment with an annual fecal coliform geometric mean of 200 cfu/100mL, and the percent attainment with *Enterococcus* criteria. The *Enterococcus* criteria do not apply to Flushing Bay and are shown for informational purposes only. In reviewing Table 4-16, it should be noted that in the Flushing Bay LTCP, the Baseline Conditions attainment of fecal coliform criteria was only assessed for the 2008 typical year, while the Recommended Plan was assessed using the 10-year simulation. The 2008 typical year Baseline Conditions attainment is not directly comparable to the 10-year Recommended Plan attainment.

Table 4-17 presents the annual percent attainment with the applicable DO criteria for Flushing Bay stations for Baseline Conditions and the Recommended Plan, based on 2008 rainfall.

The locations of the sampling stations referenced in Table 4-16 and Table 4-17 are shown in Figure 4-26.

Table 4-16. Calculated 10-year Bacteria Attainment in Flushing Bay for Baseline Conditions and the Recommended Plan

Location		Percent Attainment with Criteria							
		Baseline				Recommended Plan			
		Class I Fecal Coliform Criteria		*Enterococcus* Criteria for Recreational Season(1)(2)(4)		Class I Fecal Coliform Criteria		*Enterococcus* Criteria for Recreational Season(1)(2)(4)	
		Recreational Season(1)	Annual			Recreational Season(1)	Annual		
		Monthly Geometric Mean ≤200 cfu/100mL(3)	Monthly Geometric Mean ≤200 cfu/100mL(3)	30-day Geometric Mean ≤35 cfu/100mL	30-day 90th Percentile ≤130 cfu/100mL	Monthly Geometric Mean ≤200 cfu/100mL	Monthly Geometric Mean ≤200 cfu/100mL	30-day Geometric Mean ≤35 cfu/100mL	30-day 90th Percentile ≤130 cfu/100mL
OW-7	Inner Flushing Bay	100%	100%	93%	16%	100%	100%	99%	61%
OW-7A		100%	100%	92%	12%	100%	100%	99%	55%
OW-7B		100%	100%	88%	11%	100%	100%	99%	58%
OW-7C		100%	100%	88%	12%	100%	100%	99%	60%
OW-8		100%	100%	93%	17%	100%	100%	98%	56%
OW-9		100%	100%	96%	22%	100%	100%	99%	66%
OW-10	Outer Flushing Bay	100%	100%	97%	35%	100%	100%	99%	71%
OW-11		100%	100%	99%	66%	100%	100%	100%	86%
OW-12		100%	100%	98%	45%	100%	100%	100%	75%
OW-13		100%	100%	98%	47%	100%	100%	100%	74%
OW-14		100%	100%	99%	71%	100%	100%	100%	79%
OW-15		100%	100%	99%	56%	100%	100%	100%	77%

Notes:

(1) The Recreational Season is from May 1st through October 31st.
(2) *Enterococcus* Criteria do not apply to Flushing Bay. Attainment with these criteria is shown for informational purposes only.
(3) Values for Baseline Conditions fecal coliform attainment are for 2008 rainfall only, not the 10-year simulation. The 10-year simulation fecal coliform attainment was not developed for Baseline Conditions for this LTCP. Attainment for 2008 is not directly comparable to the 10-year simulation attainment.
(4) The *Enterococcus* criteria have been updated from the original LTCP, which presented attainment with a 30-day GM of ≤30 cfu/100mL and a 30-day STV of ≤130 cfu/100mL.

Table 4-17. Model Calculated DO Attainment for Flushing Bay Stations with Recommended Plan (2008 Rainfall)

Station		Percent Annual Average Attainment Class I ≥4.0 mg/L	
		Baseline Conditions	Recommended Plan
OW-7	Inner Flushing Bay	100%	100%
OW-7A		100%	100%
OW-7B		100%	100%
OW-7C		100%	100%
OW-8		100%	100%
OW-9		100%	100%
OW-10	Outer Flushing Bay	99%	99%
OW-11		99%	99%
OW-12		99%	99%
OW-13		99%	99%
OW-14		97%	97%
OW-15		98%	98%

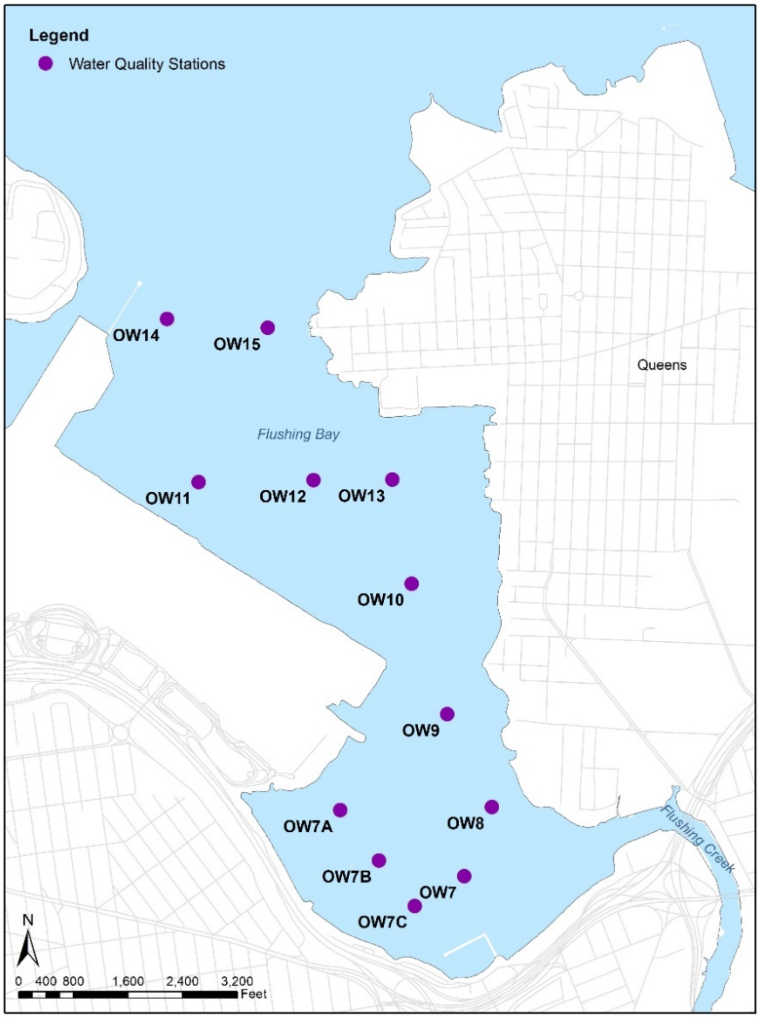


Figure 4-26. Water Quality Stations in Flushing Bay

4.3.i Newtown Creek

4.3.i.1 WWFP Projects

The following summarizes the cost-effective grey projects implemented for Newtown Creek based on the WWFP recommendations.

- Sewer system improvements including bending weirs and floatables control at Regulators NCB-01, NCB-02, NCQ-01, and BB-L4.
- Upgrade of the Brooklyn/Queens Pumping Station main sewage pumps, headworks upgrades and odor control.
- In-stream aeration in the Upper English Kills, Lower English Kills, East Branch and Dutch Kills.

The total cost of the constructed grey infrastructure projects was $262M.

4.3.i.2 Approved LTCP Recommended Plan

The following summarizes the Recommended Plan from the June 2017 Newtown Creek LTCP that was approved by DEC on June 27, 2018.

- **Description:** 39 MG CSO storage tunnel to capture overflows from Outfalls NCB-015, NCB-083, and NCQ-077, and 26 MGD expansion of the Borden Avenue Pumping Station to reduce overflows at Outfall BB-026 (Figure 4-27)

- **Probable bid cost presented in the LTCP:** $597M (February 2017 Dollars)

- **Current total project cost, including engineering, escalated to the midpoint of construction:** $2,401M

- **Current Completion Milestones*:** 2029 for the Borden Avenue Pumping Station Expansion, 2042 for the 39 MG CSO Storage Tunnel

  * Milestone dates may be subject to revision by DEC based on additional facility planning.

4.3.i.3 Benefits and Challenges of Implementing the Recommended Plan for Newtown Creek

Figure 4-28 presents the reductions in CSO volume associated with the WWFP cost-effective grey projects and the LTCP Recommended Plan. As indicated in Figure 4-28, the cost-effective grey projects (post WWFP) resulted in a 295 MGY (20 percent) reduction in the annual CSO volume to Newtown Creek. The LTCP Recommended Plan results in an additional 707 MG (61 percent) reduction in annual CSO volume. Overall, from the pre-WWFP conditions to the LTCP Recommended Plan, the total annual CSO volume reduction is 1,002 MG (69 percent). Additional benefits include:

- For the long tunnel alignment options, pump back will be discharged at the Newtown Creek WRRF eliminating the risk of re-deposition of solids along the interceptor as experienced with current CSO retention facilities.

- Trenchless construction methods significantly reduce the extent of neighborhood disturbance associated with the construction of the storage tunnel and CSO diversion conduits.

- The tunnel alignment minimizes property acquisition requirements through the use of the creek corridor, road rights-of-way and City owned properties.

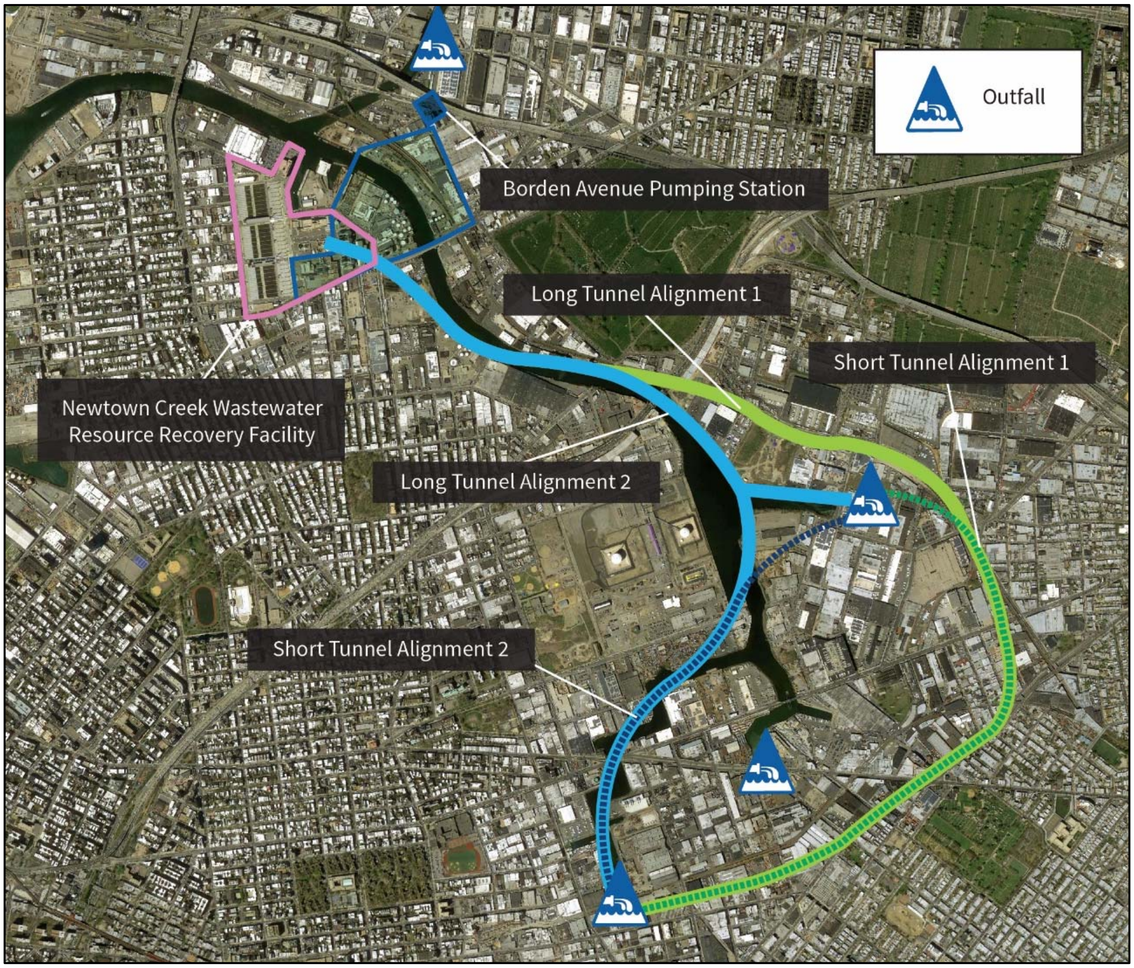
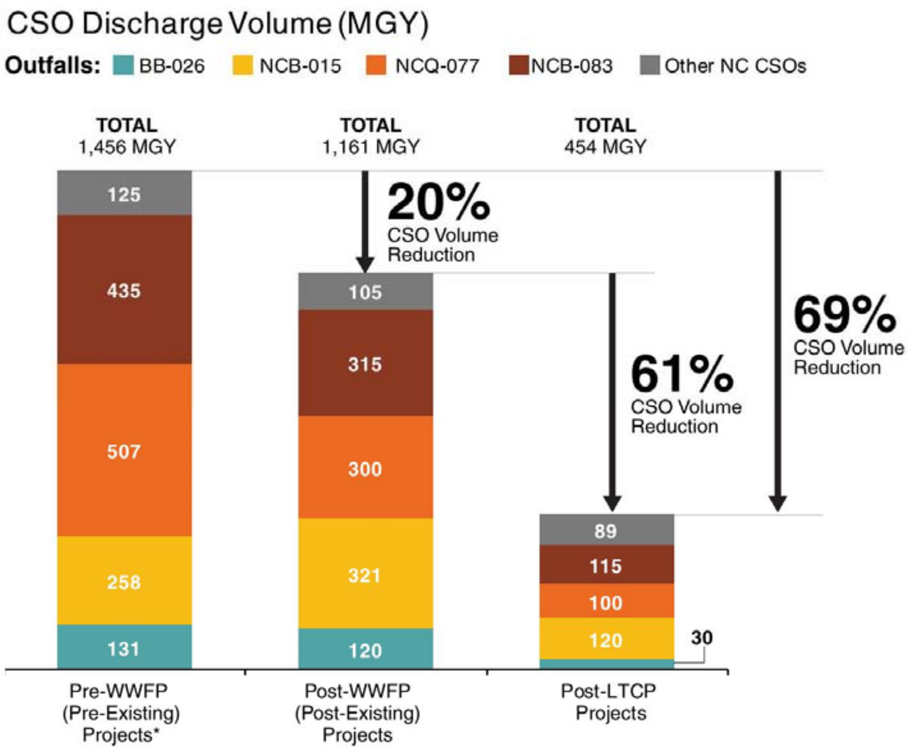


Figure 4-27. 26 MGD Borden Avenue Pumping Station Expansion and 39 MG CSO Storage Tunnel

Figure 4-28. Benefits to Newtown Creek



***Pre-WWFP (Pre-Existing) Projects CSO volumes reflect conditions without Waterbody Watershed Facility Plan (WWFP) Projects, Green Infrastructure, and other sewer improvements.*

While the Recommended Plan is a cost-effective approach to reducing the remaining CSO discharges to Newtown Creek by an additional 61 percent, a number of construction and operational challenges must be considered. The challenges and associated risks include the following:

- Construction of the dewatering pump station site could require relocation of sanitation department facilities or acquisition of private property.

- As a result of past uses, the available sites for the dewatering pump station may require some level of environmental cleanup prior to construction.

- For the short tunnel alignments, there is a risk of deposition of sediment in the interceptor from dewatering operations similar to what is currently experienced at existing CSO retention facilities.

- The tunnel and dewatering pump station will be at depths in excess of 300 feet and require more complex confined space entry equipment for accessing these facilities to perform operations and maintenance.

- Construction of the tunnel will require protection of existing utilities, highway infrastructure and building foundations.

- While the tunnel will be bored in rock, shafts and CSO diversion sewers will be constructed in a range of mixed soils and groundwater conditions that must be addressed in the geotechnical baseline report.

- Maintenance of regulator and outfall performance throughout construction.

- Hydraulic evaluations of the diversion chambers, diversion sewers, tunnel and dewatering pump station will be necessary to address performance under a wide range of hydraulic conditions and to address air release and to reduce the risk of hydraulic surge conditions.

- Design of the tunnel and appurtenances to minimize sediment deposition and cleaning.

DEP will seek to address these challenges during design through the provision of design and operational criteria.

4.3.i.4 Water Quality Standards Attainment

At the time that the Newtown Creek LTCP was submitted, the water quality classification for Newtown Creek was Class SD. That classification has not changed. The bacteria criteria for Class SD waters includes a fecal coliform monthly geometric mean of ≤200 cfu/100mL, assessed on an annual basis.

Newtown Creek is a non-coastal tributary, so the *Enterococcus* criteria for coastal recreational waters do not apply to Newtown Creek.

Table 4-18 presents the percent attainment with the current Class SD water quality criteria for bacteria at the water quality stations in Newtown Creek for Baseline Conditions and the Recommended Plan, for the 10-year simulation (2002 to 2011). Also shown in Table 4-18 is the percent attainment with an annual fecal coliform geometric mean of 200 cfu/100mL, and the percent attainment with *Enterococcus* criteria. The *Enterococcus* criteria do not apply to Newtown Creek, and are shown for informational purposes only. In reviewing Table 4-18, it should be noted that in the Newtown Creek LTCP, the Baseline Conditions attainment of fecal coliform criteria was only assessed for the 2008 typical year, while the Recommended Plan was assessed using the 10-year simulation. The 2008 typical year Baseline Conditions attainment is not directly comparable to the 10-year Recommended Plan attainment.

Table 4-19 presents the annual percent attainment with the applicable DO criteria for Newtown Creek stations for Baseline Conditions and the Recommended Plan, based on 2008 rainfall.

The locations of the sampling stations referenced in Table 4-18 and Table 4-19 are shown in Figure 4-29.

Table 4-18. Calculated 10-year Bacteria Attainment in Newtown Creek for Baseline Conditions and the Recommended Plan

Location		Percent Attainment with Criteria							
		Baseline				Recommended Plan			
		Class I Fecal Coliform Criteria		*Enterococcus* Criteria for Recreational Season(1)(2)(4)		Class I Fecal Coliform Criteria		*Enterococcus* Criteria for Recreational Season(1)(2)(4)	
		Recreational Season(1)	Annual			Recreational Season(1)	Annual		
		Monthly Geometric Mean ≤200 cfu/100mL(3)	Monthly Geometric Mean ≤200 cfu/100mL(3)	30-day Geometric Mean ≤35 cfu/100mL	30-day 90th Percentile ≤130 cfu/100mL	Monthly Geometric Mean ≤200 cfu/100mL	Monthly Geometric Mean ≤200 cfu/100mL	30-day Geometric Mean ≤35 cfu/100mL	30-day 90th Percentile ≤130 cfu/100mL
NC4	Main Channel	100%	75%	89%	20%	93%	90%	94%	35%
NC5	Main Channel	100%	75%	87%	15%	93%	90%	93%	25%
NC6	Dutch Kills	83%	50%	81%	14%	93%	88%	92%	27%
NC7	Main Channel	100%	75%	86%	16%	93%	90%	94%	26%
NC8	Main Channel	83%	50%	86%	16%	93%	90%	94%	28%
NC9	Main Channel	83%	50%	85%	14%	93%	90%	94%	26%
NC10	Maspeth Creek	67%	42%	77%	11%	92%	89%	94%	31%
NC11	English Kills	67%	42%	65%	5%	92%	89%	87%	13%
NC12	East Branch	67%	42%	46%	3%	88%	83%	78%	8%
NC13	English Kills	67%	42%	66%	7%	92%	89%	87%	14%
NC14	English Kills	67%	42%	50%	3%	83%	83%	78%	7%

Notes:

(1) The Recreational Season is from May 1st through October 31st.
(2) *Enterococcus* Criteria do not apply to Newtown Creek. Attainment with these criteria is shown for informational purposes only.
(3) Values for Baseline Conditions fecal coliform attainment are for 2008 rainfall only, not the 10-year simulation. The 10-year simulation fecal coliform attainment was not developed for Baseline Conditions for this LTCP. Attainment for 2008 is not directly comparable to the 10-year simulation attainment.
(4) The *Enterococcus* criteria have been updated from the original LTCP, which presented attainment with a 30-day GM of ≤30 cfu/100mL and a 30-day STV of ≤130 cfu/100mL.

Table 4-19. Model Calculated DO Attainment for Newtown Creek Stations for Baseline Conditions and the Recommended Plan (2008 Rainfall) – Aeration System Operational

Station		Percent Annual Average Attainment Class SD ≥3.0 mg/L	
		Baseline Conditions	Recommended Plan
Main Channel	NC4	100%	100%
	NC5	100%	100%
Dutch Kills	NC6	98%	99%
Main Channel	NC7	100%	100%
	NC8	100%	100%
	NC9	99%	100%
Maspeth Creek	NC10	96%	100%
English Kills	NC11	95%	100%
East Branch	NC12	95%	100%
English Kills	NC13	94%	100%
	NC14	90%	97%

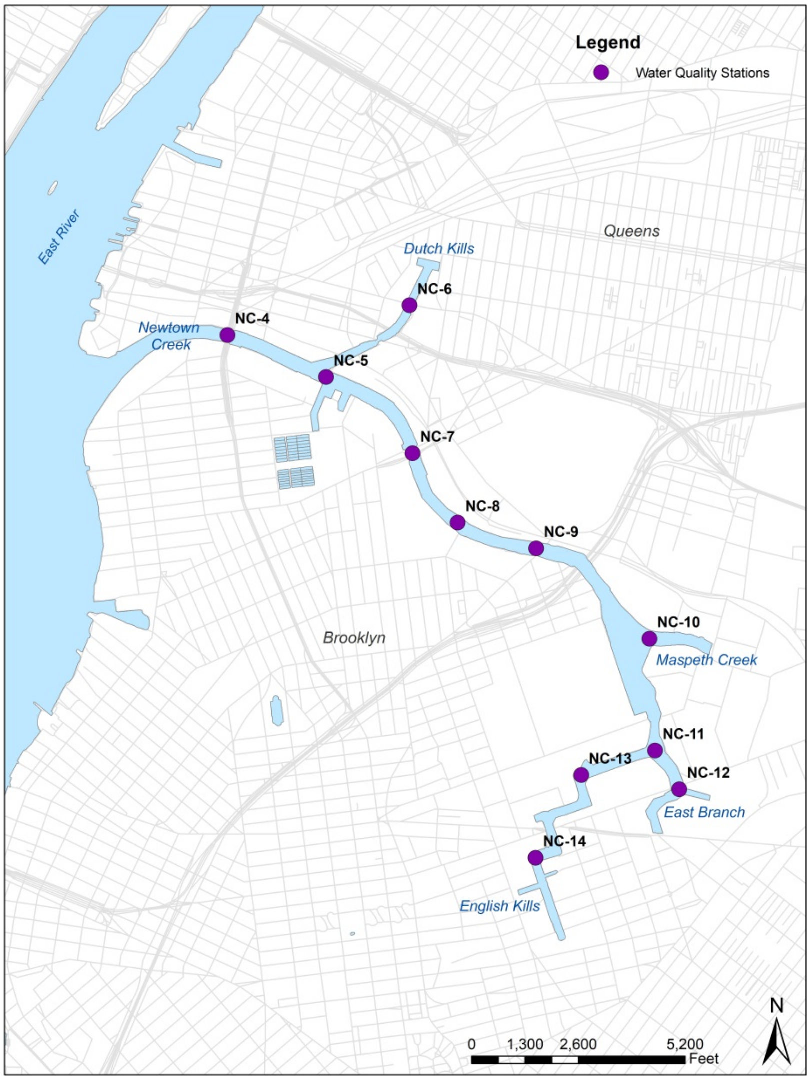


Figure 4-29. Water Quality Stations in Newtown Creek

4.3.j Jamaica Bay and Tributaries

4.3.j.1 WWFP Projects

The following summarizes the cost-effective grey projects implemented for Jamaica Bay and Tributaries based on the WWFP recommendations.

- Spring Creek Auxiliary WRRF Upgrade
- 50 MG Paerdegat Basin CSO Facility (30 MG tank and 20 MG in-line storage)
- 26^{th} Ward WRRF wet-weather stabilization

- 26th Ward WRRF sewershed sewer cleaning and high level storm sewers
- New sewer parallel to the west interceptor and Bergen Basin lateral sewer
- Hendrix Creek and Paerdegat Basin dredging
- Warnerville Pumping Station and forcemain
- Shellbank Basin de-stratification
- Regulator improvements including automation of JA-02 and bending weirs at JA-03, JA-06 and JA-14

The total cost of the constructed grey infrastructure projects was $1,100M.

4.3.j.2 LTCP Recommended Plan

The following summarizes the Recommended Plan from the June 2018 Jamaica Bay and Tributaries LTCP. This LTCP is currently under review by DEC.

- **Description:** GI expansion in Bergen and Thurston Basin watersheds; ribbed mussel colony creation in Bergen and Thurston Basins; environmental dredging in Bergen Basin; and tidal wetland restoration in Spring Creek, Hendrix Creek, Fresh Creek, Paerdegat Basin and Jamaica Bay (Figure 4-30)
- **Probable bid cost presented in the LTCP:** $310M (June 2018 Dollars)
- **Current total project cost, including engineering, escalated to the midpoint of construction:** $579M
- **Current Completion Milestone:** LTCP schedule shows 14 years from DEC approval of the LTCP. Since the LTCP has not yet been approved, this pending date is not yet a Milestone.

4.3.j.3 Benefits and Challenges of Implementing the Recommended Plan for Jamaica Bay and Tributaries

Figure 4-31 presents the reductions in CSO volume associated with the WWFP cost-effective grey projects and the LTCP Recommended Plan. As indicated in Figure 4-31, the cost-effective grey projects (post WWFP) resulted in a 1,534 MGY (46 percent) reduction in the annual CSO volume to the tributaries to Jamaica Bay. The LTCP Recommended Plan results in an additional 8 MG reduction in annual CSO volume. Overall, from the pre-WWFP conditions to the LTCP Recommended Plan, the total annual CSO volume reduction is 1,542 MG (47 percent). Additional benefits include:

- The Green Infrastructure will continue to provide water quality benefits as the sewer system transitions from combined to separate sewers upon implementation of the Southeast Queens Buildout Program.
- Tidal wetland restoration enhances fish and wildlife habitat, as well as filters direct drainage.
- Environmental dredging will remove sediments that contribute to historical odor issues at the head end of Bergen Basin.
- Ribbed mussels enhance aquatic and wildlife habitats and provide continuous filtration of pathogens and other contaminants within waterways regardless of the contributing source.

While the Recommended Plan is a cost-effective approach to reducing the remaining CSO discharges to Bergen and Thurston Basins by an additional 15 MG, a number of construction and maintenance challenges must be considered. The challenges and associated risks include the following:

- Coordination with airport security for performance of work in Bergen and Thurston Basins.
- Maintenance of access to airport fuel transfer docks during performance of environmental dredging and installation of ribbed mussels.
- Potential impacts of chlorine residual from Jamaica WRRF effluent on Bergen Basin ribbed mussel installations.
- Coordination of the siting of green infrastructure with the Southeast Queens Buildout, Downtown Jamaica Facilities Planning and other ongoing programs where planning and design of sewer routes are still being developed.

DEP will seek to address these challenges during planning and design. Laboratory and scaled field applications will be performed to verify ribbed mussel performance and identify the design criteria to be used in preparing construction documents. Maintenance manuals will also be prepared for each of the environmental projects to minimize these risks and maximize their long term performance.

4.3.j.4 Water Quality Standards Attainment

At the time that the Jamaica Bay and Tributaries LTCP was submitted, the water quality classification for the tributaries was Class I, and the classification for Jamaica Bay was Class SB. Those classifications have not changed, but the water quality criteria associated with Jamaica Bay has changed. The fecal coliform bacteria criteria for Class I and SB remains as a monthly geometric mean of ≤200 cfu/100mL, assessed on an annual basis.

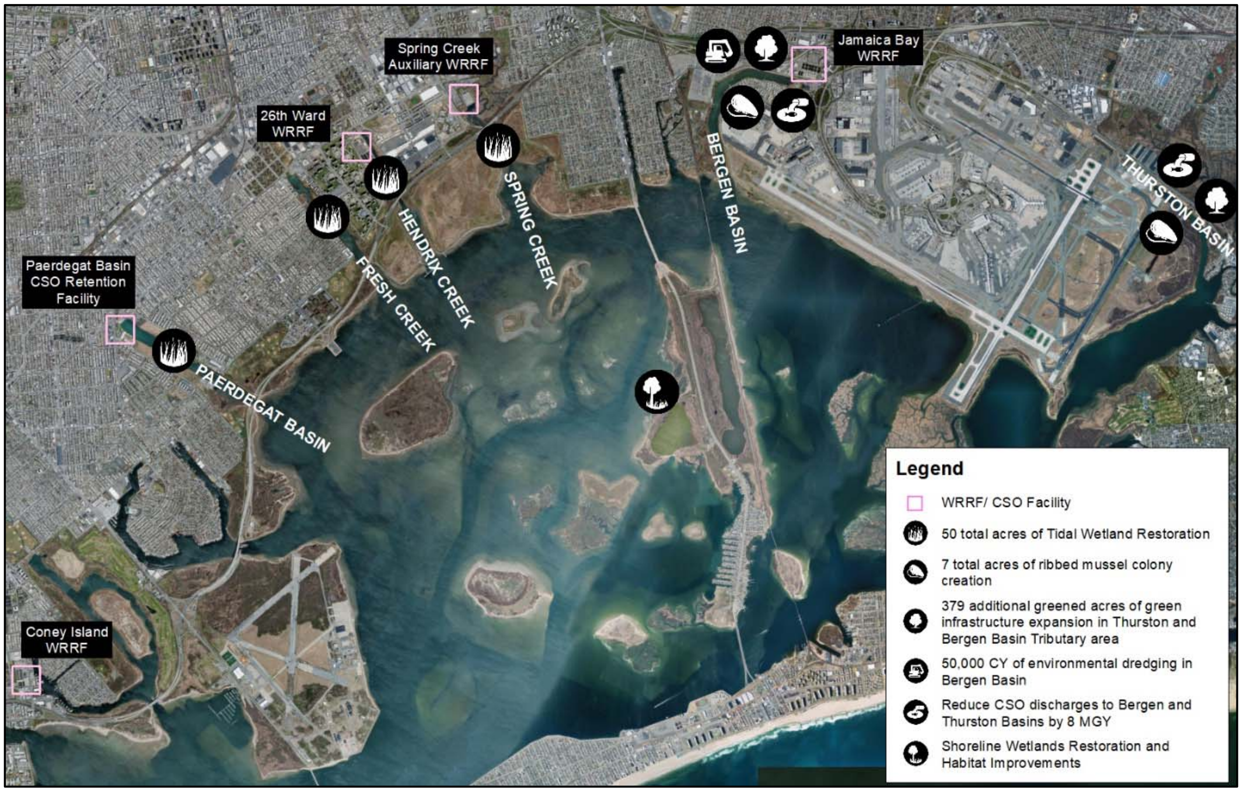


Figure 4-30. Elements of the LTCP

However, Jamaica Bay is now classified as a coastal primary contact recreational waterbody, so the bacteria criteria also include a 30-day *Enterococcus* geometric mean of ≤35 cfu/100mL, and a 30-day 90th percentile limit of ≤130 cfu/100mL. The tributaries to Jamaica Bay are non-coastal tributaries, so the *Enterococci* criteria for coastal primary contact recreational waters do not apply to the Jamaica Bay tributaries.

Table 4-20 presents the percent attainment with the current Class I and Class SB water quality criteria for fecal coliform at the water quality stations in Jamaica Bay and Tributaries for the Recommended Plan, for the 10-year simulation (2002 to 2011). Also shown in Table 4-20 is the percent attainment with an annual fecal coliform geometric mean of 200 cfu/100mL, and percent attainment with *Enterococcus* criteria. The *Enterococcus* criteria apply to Jamaica Bay, but do not apply to the tributaries, where they are shown for informational purposes only.

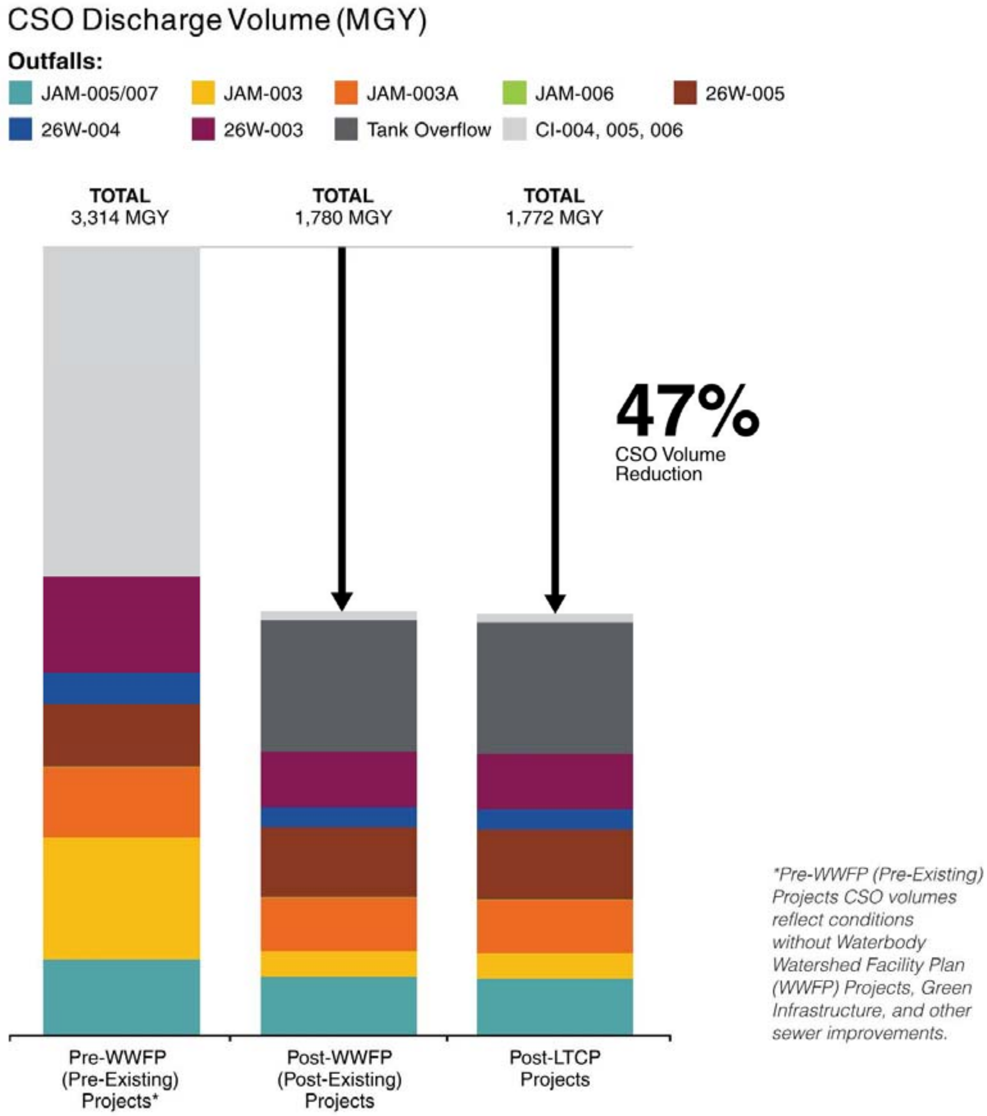


Figure 4-31. Benefits to Jamaica Bay and Tributaries

Table 4-21 presents the annual percent attainment with the applicable DO criteria for the Jamaica Bay tributaries stations for Baseline Conditions and the Recommended Plan, based on 2008 rainfall. Table 4-22 presents the annual percent attainment with the applicable DO criteria for the Jamaica Bay stations for Baseline Conditions and the Recommended Plan, based on 2008 rainfall.

The locations of the sampling stations referenced in Table 4-20, Table 4-21 and Table 4-22 are shown in Figure 4-32.

Table 4-20. Calculated 10-year Bacteria Attainment in Jamaica Bay and Tributaries for the Recommended Plan

Location	Percent Attainment with Criteria							
	Baseline Conditions				Recommended Plan			
	Class I/SB Fecal Coliform Criteria		*Enterococcus* Criteria for Recreational Season(1)(2)(4)		Class I/SB Fecal Coliform Criteria		*Enterococcus* Criteria for Recreational Season(1)(2)(4)	
	Recreational Season(1)	Annual			Recreational Season(1)	Annual		
	Monthly Geometric Mean ≤200 cfu/100mL	Monthly Geometric Mean ≤200 cfu/100mL	30-day Geometric Mean ≤35 cfu/100mL	30-day 90th Percentile ≤130 cfu/100mL	Monthly Geometric Mean ≤200 cfu/100mL	Monthly Geometric Mean ≤200 cfu/100mL	30-day Geometric Mean ≤35 cfu/100mL	30-day 90th Percentile ≤130 cfu/100mL
Thurston Basin								
TBH1(3)	88%	77%	65%	5%	88%	77%	65%	5%
TBH3(3)	93%	89%	84%	11%	93%	89%	84%	11%
TB9(3)	95%	91%	89%	14%	95%	91%	89%	14%
TB10(3)	100%	98%	95%	24%	100%	98%	95%	24%
TB11	100%	100%	100%	87%	100%	100%	100%	87%
TB12	100%	100%	100%	96%	100%	100%	100%	96%
Bergen Basin								
BB5(3)	72%	57%	29%	0%	72%	57%	29%	0%
BB6(3)	93%	89%	69%	6%	93%	89%	69%	6%
BB7(3)	100%	100%	93%	14%	100%	100%	93%	14%
BB8	100%	100%	100%	57%	100%	100%	100%	57%
Spring Creek								
SP1	100%	100%	100%	78%	100%	100%	100%	78%

Table 4-20. Calculated 10-year Bacteria Attainment in Jamaica Bay and Tributaries for the Recommended Plan

Location	Percent Attainment with Criteria							
	Baseline Conditions				Recommended Plan			
	Class I/SB Fecal Coliform Criteria		*Enterococcus* Criteria for Recreational Season(1)(2)(4)		Class I/SB Fecal Coliform Criteria		*Enterococcus* Criteria for Recreational Season(1)(2)(4)	
	Recreational Season(1)	Annual			Recreational Season(1)	Annual		
	Monthly Geometric Mean ≤200 cfu/100mL	Monthly Geometric Mean ≤200 cfu/100mL	30-day Geometric Mean ≤35 cfu/100mL	30-day 90th Percentile ≤130 cfu/100mL	Monthly Geometric Mean ≤200 cfu/100mL	Monthly Geometric Mean ≤200 cfu/100mL	30-day Geometric Mean ≤35 cfu/100mL	30-day 90th Percentile ≤130 cfu/100mL
SP2	100%	100%	100%	94%	100%	100%	100%	94%
Hendrix Creek								
HC1	98%	99%	98%	33%	98%	99%	98%	32%
HC2	100%	100%	98%	38%	100%	100%	98%	38%
HC3	100%	100%	100%	71%	100%	100%	100%	71%
Fresh Creek								
FC1	93%	85%	98%	16%	93%	85%	98%	16%
FC2	100%	98%	98%	17%	100%	98%	98%	17%
FC3	100%	100%	100%	51%	100%	100%	100%	51%
FC4	100%	100%	100%	92%	100%	100%	100%	92%
Paerdegat Basin								
PB2	95%	97%	96%	28%	95%	97%	96%	28%
PB3	100%	100%	100%	69%	100%	100%	100%	69%

Table 4-20. Calculated 10-year Bacteria Attainment in Jamaica Bay and Tributaries for the Recommended Plan

Location	Percent Attainment with Criteria							
	Baseline Conditions				Recommended Plan			
	Class I/SB Fecal Coliform Criteria		*Enterococcus* Criteria for Recreational Season(1)(2)(4)		Class I/SB Fecal Coliform Criteria		*Enterococcus* Criteria for Recreational Season(1)(2)(4)	
	Recreational Season(1)	Annual			Recreational Season(1)	Annual		
	Monthly Geometric Mean ≤200 cfu/100mL	Monthly Geometric Mean ≤200 cfu/100mL	30-day Geometric Mean ≤35 cfu/100mL	30-day 90th Percentile ≤130 cfu/100mL	Monthly Geometric Mean ≤200 cfu/100mL	Monthly Geometric Mean ≤200 cfu/100mL	30-day Geometric Mean ≤35 cfu/100mL	30-day 90th Percentile ≤130 cfu/100mL
Jamaica Bay (Northern Shore)								
J10	100%	100%	100%	85%	100%	100%	100%	85%
J3	100%	100%	100%	97%	100%	100%	100%	97%
J9a	100%	100%	100%	92%	100%	100%	100%	92%
J8	100%	100%	100%	92%	100%	100%	100%	92%
J7	100%	100%	100%	57%	100%	100%	100%	57%
JA1	100%	100%	100%	86%	100%	100%	100%	86%
Jamaica Bay (Inner Bay)								
J2	100%	100%	100%	98%	100%	100%	100%	98%
J12	100%	100%	100%	97%	100%	100%	100%	97%
J14	100%	100%	100%	100%	100%	100%	100%	100%
J16	100%	100%	100%	99%	100%	100%	100%	99%

Table 4-20. Calculated 10-year Bacteria Attainment in Jamaica Bay and Tributaries for the Recommended Plan

Location	Percent Attainment with Criteria							
	Baseline Conditions				Recommended Plan			
	Class I/SB Fecal Coliform Criteria		*Enterococcus* Criteria for Recreational Season(1)(2)(4)		Class I/SB Fecal Coliform Criteria		*Enterococcus* Criteria for Recreational Season(1)(2)(4)	
	Recreational Season(1)	Annual			Recreational Season(1)	Annual		
	Monthly Geometric Mean ≤200 cfu/100mL	Monthly Geometric Mean ≤200 cfu/100mL	30-day Geometric Mean ≤35 cfu/100mL	30-day 90th Percentile ≤130 cfu/100mL	Monthly Geometric Mean ≤200 cfu/100mL	Monthly Geometric Mean ≤200 cfu/100mL	30-day Geometric Mean ≤35 cfu/100mL	30-day 90th Percentile ≤130 cfu/100mL
Jamaica Bay (Rockaway Shore)								
J1	100%	100%	100%	100%	100%	100%	100%	100%
J5	100%	100%	100%	100%	100%	100%	100%	100%

Notes:
(1) The Recreational Season is from May 1st through October 31st.
(2) *Enterococcus* Criteria apply to stations in Jamaica Bay, but not to the stations in the tributaries. Attainment with these criteria in the tributaries is shown for informational purposes only.
(3) Monitoring station is located in a portion of the waterbody where unauthorized access is prohibited by JFK Airport security and/or a physical barrier.
(4) *Enterococcus* attainment has been updated from values presented in the LTCP.

Table 4-21. Model Calculated DO Attainment for Jamaica Bay Tributaries Stations for Baseline Conditions and the Recommended Plan (2008 Rainfall)

	Annual Attainment (%) Tributaries – Class I ≥4.0 mg/L	
Station	**Baseline Conditions**	**Recommended Plan**
Thurston Basin		
TBH1[(1)]	90%	90%
TBH3[(1)]	90%	90%
TB9[(1)]	92%	92%
TB10[(1)]	92%	92%
TB11	97%	97%
TB12	99%	99%
Bergen Basin		
BB5[(1)]	89%	89%
BB6[(1)]	95%	95%
BB7[(1)]	99%	99%
BB8	100%	100%
Spring Creek		
SP1	99%	99%
SP2	100%	100%
Hendrix Creek		
HC1	94%	94%
HC2	98%	98%
HC3	100%	100%
Fresh Creek		
FC1	99%	99%
FC2	100%	100%
FC3	100%	100%
FC4	100%	100%
Paerdegat Basin		
PB2	99%	99%
PB3	100%	100%

Note:
(1) Monitoring station is located in a portion of the waterbody where unauthorized access is prohibited by JFK Airport security and/or a physical barrier.

Table 4-22. Model Calculated DO Attainment for Jamaica Bay Stations with Recommended Plan (2008 Rainfall)

Station	Annual Attainment (%) Jamaica Bay - Class SB			
	Baseline Conditions		Recommended Plan	
	Acute(1) (≥3.0 mg/L)	Chronic(2) (≥4.8 mg/L)	Acute(1) (≥3.0 mg/L)	Chronic(2) (≥4.8 mg/L)
Jamaica Bay (Northern Shore)				
J10	100%	100%	100%	100%
J3	100%	100%	100%	100%
J9a	100%	100%	100%	100%
J8	100%	100%	100%	100%
J7	100%	100%	100%	100%
JA1	100%	99%	100%	99%
Jamaica Bay (Inner Bay)				
J2	100%	100%	100%	100%
J12	100%	100%	100%	100%
J14	100%	100%	100%	100%
J16	100%	100%	100%	100%
Jamaica Bay (Rockaway Shore)				
J1	100%	100%	100%	100%
J5	100%	100%	100%	100%

Notes:
(1) Acute standard (never less than).
(2) Chronic standard based on daily average. See Table 2-5 in Section 2 for further details on the DO criteria.

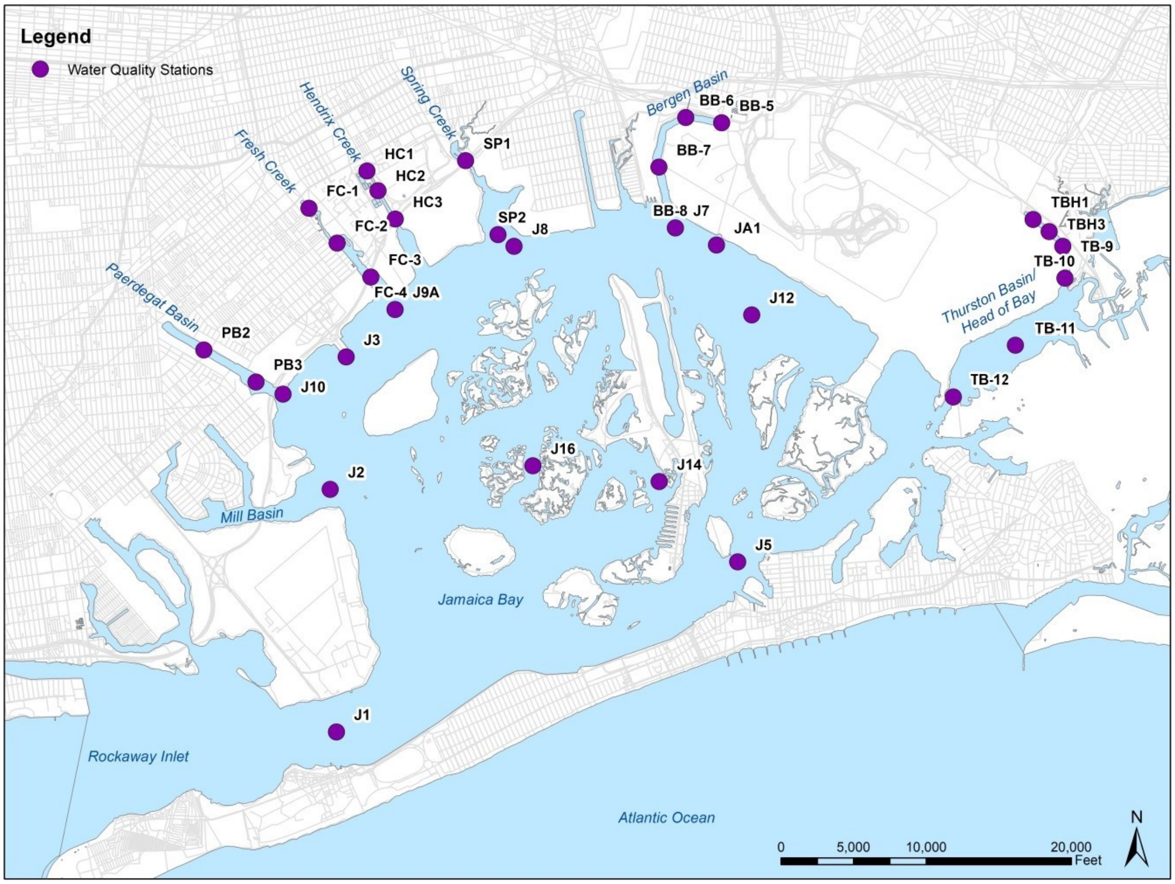


Figure 4-32. Water Quality Stations in Jamaica Bay and Tributaries

4.4 Post-Construction Monitoring

Since no CSO-specific grey infrastructure projects were implemented for outfalls discharging to the Citywide/Open Waters, a post-construction compliance monitoring (PCM) program specific to the Citywide/Open Waters waterbodies has not been implemented. However, ongoing sampling has been conducted over many years in the Citywide/Open Waters waterbodies as part of DEP's Harbor Survey Monitoring (HSM) and Sentinel Monitoring (SM) programs. A PCM program for the Recommended Plan from the Citywide/Open Waters LTCP is expected to consist of two basic components:

1. Receiving water data collection in Citywide/Open Waters using existing DEP HSM and SM stations; and

2. Modeling the collection system and receiving waters to characterize water quality using the existing InfoWorks ICM™ (IW) and LTCP Regional Model (LTCPRM), respectively.

4.4.a Collection and Monitoring of Water Quality in the Receiving Waters

The HSM and SM sampling programs have been collecting data from stations in the Harlem River, Hudson River, East River, New York Harbor, Arthur Kill, and Kill Van Kull Stations for many years. Current HSM and SM sampling stations that would be used for the PCM in the Citywide/Open Waters include the following:

- Harlem River – One HSM station (H3); four SM stations (S54 to S57)
- Hudson River – Six HSM stations (N1, NR1, N3B, N3C, N4, and N5); seven SM stations (S47 to S53)
- East River – Eight HSM stations (E2, E4, E6, E7, E8, E12, E13, and E14); 12 SM stations (S3, S4, S8, S9, S10, S11, S16, S17, S58, S63, S65, and S67)
- New York Harbor – Seven HSM stations (N6-N9, K5A, K6, and GB1); nine SM stations (S18, S19, S39-S44, and S73)
- Arthur Kill/Kill Van Kull – Five HSM stations (K1-K5); five SM stations (S45, S69-S72)

Figure 4-33 shows the locations of the PCM Stations in the Citywide/Open Waters waterbodies. Sampling at the stations shown in Figure 4-33 is typically scheduled monthly in the non-recreational season (November 1st through April 31st) and weekly in the recreational season (May 1st through October 31st). Measured parameters relating to receiving water quality at these stations include: dissolved oxygen, fecal coliform, *Enterococci*, chlorophyll 'a', and Secchi depth. With the exception of *Enterococci*, NYC has used these parameters for decades to identify historical and spatial trends in water quality throughout New York Harbor. The PCM program measures dissolved oxygen and chlorophyll 'a' at surface and bottom depths; the remaining parameters are measured at the surface only.

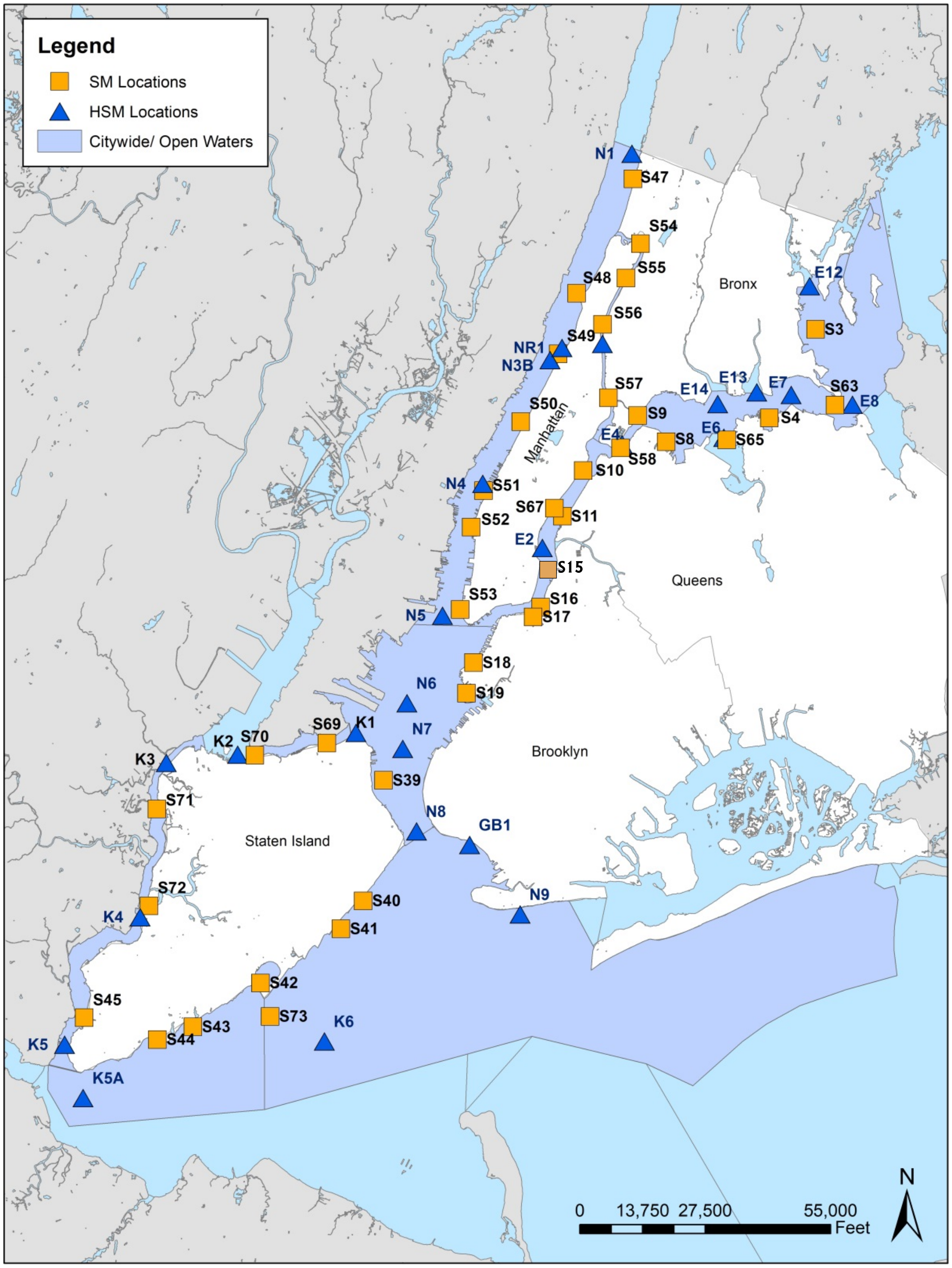


Figure 4-33. HSM and SM Sampling Locations in Citywide/Open Waters Waterbodies

AECOM with Hazen

4.4.b CSO Facilities Operations – Flow Monitoring and Effluent Quality

No CSO facilities currently discharge directly to the Citywide/Open Waters waterbodies, and no new CSO storage/treatment facilities are proposed under the Citywide/Open Waters LTCP.

4.4.c Assessment of Performance Criteria

CSO controls implemented under this LTCP will be designed to achieve a specific set of water quality and/or CSO reduction goals as established in this LTCP, and as directed in the subsequent Basis of Design Report (BODR). For waterbodies where no additional CSO controls are proposed, affirmation of water quality projections would still be necessary. In both cases, the PCM data, coupled with the modeling framework used for annual reporting, will be used to assess the performance of the CSO controls implemented in relation to the water quality goals.

Differences between actual overflows and model-predicted overflows are often attributable to the fact that the model results are based on the rainfall measured at a single NOAA rain gauge to represent the rainfall over the entire watershed. In reality, storms move through the area, and the rainfall varies over time and space. Because rainfall patterns tend to even out across the area over time, the practice of using the rainfall measurement from one nearby location typically provides good agreement with long term performance for the collection system as a whole; however, model results for any particular storm may vary somewhat from observations.

Given the uncertainty associated with potentially widely varying precipitation conditions, rainfall analysis is an essential component of the PCM. For the Citywide/Open Waters waterbodies, the most representative long term rainfall data record is available from the National Weather Service's JFK Airport gauge. Rain data for each calendar year of the PCM program will be compared to the 10-year model period (2002 –2011) and to the JFK 2008 rain data used for alternative evaluations. Statistics, including number of storms, duration, total annual and monthly depths, and peak intensities, will be used to classify the particular reporting year as wet or dry relative to the JFK 2008 Typical Year rainfall. Radar rainfall data may be used to supplement the analysis where evidence exists of large spatial variations in rainfall.

The reporting year will be modeled utilizing the existing IW/LTCPRM framework using the reporting year tides and precipitation. The resulting CSO discharges and water quality attainment will then be compared with available PCM data for the year as a means of validating model output. The level of attainment will be calculated from the modeling results and coupled with the precipitation analysis to determine relative improvement and the existence of any gap. Three successive years of evaluation will be necessary before capital improvements are considered, but operational adjustments will be considered throughout operation and reporting.

5.0 GREEN INFRASTRUCTURE

5.1 NYC Green Infrastructure Program (GI Program)

The New York City Green Infrastructure Program (GI Program) was initiated to manage stormwater to reduce CSOs in NYC and to provide resiliency and other co-benefits to local communities. More details on the overall program elements and GI Program status are described in the *Green Infrastructure Annual Report* published every April 30th. These reports can be found at www.nyc.gov/dep/greeninfrastructure.

In January 2011, DEP launched the GI Program and committed $1.5B in funding through 2030 to implement green infrastructure on public property. Current program funding commitments are at $1.6B in capital and $27M in expense. Expense funding is largely to support research, monitoring and modeling efforts. The GI Program is tasked with accomplishing the program goals through planning, design and construction, research and development on performance and operations, and modeling evaluations. In addition to its primary objective to improve water quality, the GI Program will yield climate change resiliency resulting in co-benefits including: improved air quality; urban heat island mitigation; carbon sequestration; and biodiversity co-benefits, including increased urban habitat for pollinators and wildlife.

5.2 Citywide Coordination and Implementation

DEP works directly with its partner agencies on retrofit projects within right-of-way (streets and sidewalks), and with public schools, public housing, parks, and other NYC-owned property within the combined sewer area. DEP coordinates on a regular basis with partner agencies to review designs for new projects and to gather current capital plan information to identify opportunities to integrate GI into planned public projects.

DEP manages several of its own design and construction contracts to implement right-of-way (ROW) and public property retrofit projects. The New York City Economic Development Corporation (EDC) and the Department of Design and Construction (DDC) also manage design and construction contracts for several area-wide contracts in conjunction with DEP. DEP has developed design standards for ROW GI Practices and is developing additional GI standards to address various field conditions and restrictions. The GI Program is also developing on-site GI standards to retrofit City-owned properties. These standards include porous pavement, rain gardens, retention systems, and synthetic turf.

5.2.a Community Engagement

Stakeholder participation is critical to the success of the GI Program. DEP's outreach efforts involve presentations and coordination with elected officials, community boards, stormwater advocacy organizations, green job non-profits, environmental justice organizations, schools and universities, citizens advisory committees, civic organizations, and other NYC agencies.

DEP maintains a public webmap that shows the status of GI assets (Final Design, In Construction, or Constructed). The map allows users to easily access and view information on the GI Program in their neighborhoods. DEP's website hosts all GI Program reports and materials, including standard designs and procedures for ROW GI Practices at www.nyc.gov/dep/greeninfrastructure.

DEP has print materials targeted at certain aspects of the GI Program. For instance, an informational brochure describing the site selection and construction processes for ROW includes frequently asked questions and explains the co-benefits of GI. This brochure is distributed to residents during early design stages when DEP staff is working in the field locating potential GI locations. In addition, DEP has expanded its GI design tool box and incorporated new infiltration basin designs with grass and concrete tops (Figure 5-1) to provide a better fit for different land uses (commercial, industrial, mixed use) for maintenance and to also accommodate constraints raised by residents such as special parking permits.

Figure 5-1. GI Asset Types

DEP also notifies abutting property owners in advance of ROW GI construction projects. In each contract area, DEP and its partner agencies provide construction liaison staff to be present during construction. Contact information for the construction liaison is affixed to door hangers should property owners wish to contact DEP with concerns during construction.

As part of its ongoing outreach efforts, DEP continues its presentations to elected officials and other civic and environmental organizations about upcoming construction schedules.

5.3 Completed Green Infrastructure to Reduce CSOs (Citywide and Watershed)

DEP's Green Infrastructure Annual Reports, due annually on April 30th, contain updated information on completed projects throughout the City and in the Citywide/Open Waters LTCP waterbodies (Harlem

River, Hudson River, East River, New York Bay, and Kill Van Kull/Arthur Kill). These Annual Reports can be found on DEP's website (www.nyc.gov/dep/greeninfrastructure). Note the GI Annual Reports refer to the Citywide/Open Waters LTCP watershed as "East River/Open Waters." In addition, Quarterly Progress Reports are posted on DEP's LTCP webpage: http://www.nyc.gov/html/dep/html/cso_long_term_control_plan/index.shtml.

5.3.a Green Infrastructure Demonstration and Pilot Projects

The GI Program applies an adaptive management approach to demonstration and pilot projects, based on information collected and evaluated from lessons learned in the field and performance monitoring results. For more information on DEP's 2009-2012 green infrastructure pilots, see the 2013 Annual Report on DEP's website (www.nyc.gov/dep/greeninfrastructure).

Neighborhood Demonstration Area Projects

The CSO Order included design, construction, and monitoring milestones for three Neighborhood Demonstration Area Projects (Demonstration Projects). DEP completed construction of GI practices within a total of 66 acres of tributary area in the Hutchinson River, Newtown Creek, and Jamaica Bay CSO watersheds. DEP monitored these GI practices to study the benefits of GI application on a neighborhood scale and from a variety of techniques. While DEP's early pilot projects provided performance data for individual GI installations, the Demonstration Projects provided standardized methods and information for calculating, tracking, and reporting derived stormwater volume reductions, impervious area managed, and other benefits associated with multiple installations within identified small tributary drainage areas. The data collected from each of the three Demonstration Areas enhanced DEP's understanding of the benefits of GI relative to runoff control and resulting CSO reduction and were used in the development of the 2016 Performance Metrics Report. DEP submitted a Post Construction Monitoring (PCM) Report to DEC in August 2014 and, after responding to DEC comments, submitted an updated PCM Report in January 2015. The PCM Report can be found on DEP's website (www.nyc.gov/dep/greeninfrastructure).

5.3.b Public Projects

In coordination with NYC agencies and non-profit partners, DEP continues to identify, design, and construct public property GI retrofit projects. Detailed information on project status, the site selection, and design processes for public property retrofit projects can be found in the Green Infrastructure Annual Reports on DEP's website (www.nyc.gov/dep/greeninfrastructure).

5.3.c Other Private Projects (Grant Program)

DEP continues to develop and encourage incentives for GI projects within privately owned property, primarily through the Green Infrastructure Grant Program. DEP is launching a new, innovative Private Property Retrofit Incentive Program which was anticipated to start in 2020 that will substantially scale-up investments in GI on private property. The program initiation is expected to be delayed due to the Covid-19 pandemic. DEP is currently assessing the schedule impacts which is unknown at the time of this publication.

The program utilizes a third-party administrator who is responsible for identifying the most cost-effective properties, 50,000 square feet or larger, to retrofit with GI and retrofitting them for a flat-rate incentive payment. This approach allows the administrator the flexibility to aggregate and bid projects in the most cost-effective manner. The goal for this program is 200 greened acres in five years. More information on the grant program and future private incentive program can be found in the Green Infrastructure Annual Reports on DEP's website (www.nyc.gov/dep/greeninfrastructure).

5.3.d Projected vs. Monitoring Results

For projected and monitored results, see the 2016 Green Infrastructure Performance Metrics Report and Appendices, which are available on DEP's website (www.nyc.gov/dep/greeninfrastructure).

5.4 Future Green Infrastructure in the Watershed

5.4.a Relationship Between Stormwater Capture and CSO Reduction

The 2016 Green Infrastructure Performance Metrics Report and Appendices (Performance Metrics Report), which are available on DEP's website (www.nyc.gov/dep/greeninfrastructure), created equivalency rates, as outlined in the CSO Order. The equivalency rates developed in the Performance Metrics Report incorporated data from existing and planned GI practices implemented by 2015, which primarily included retention-based rain gardens (formerly called bioswales) using site-specific information in order to model them as individual, distributed assets. By contrast, the equivalency rate for the projected 2030 GI implementation utilized a lumped modeling approach to estimate the future projects where GI asset specifics such as location, technology type, and design details are currently unknown.

To summarize the relationship between stormwater capture and CSO reduction, DEP has included two equivalency rates based on the 1.5 percent GI implementation rate that are defined as: (a) "Stormwater capture to CSO reduction ratio;" and (b) "Million gallons of CSO eliminated on an annual basis per acre (Ac) of impervious area managed by GI." The relationship between stormwater capture and CSO reduction varies based on the types of GI practices installed, watershed, and sewer system characteristics.

5.4.b Opportunities for Cost-Effective CSO Reduction Analysis

The level of GI anticipated to be implemented through 2030 in the Citywide/Open Waters LTCP waterbodies, and the resulting anticipated CSO reduction, are described in Section 5.4.c below.

5.4.c Watershed Planning to Determine 20 Year Implementation Rate for Inclusion in Baseline Performance

Waterbody-specific implementation rates for GI are estimated based on the best available information from known subsurface conditions, zoning and land use data, availability of publicly-owned properties, as well as modeling efforts, WWFPs, and CSO outfall tier data (current as of the LTCP report date).

The following criteria were applied to prioritize CSO tributary areas to determine waterbody-specific GI implementation rates:

- Water Quality Standards;
- Cost-effective grey investments; and
- Additional considerations:
  - Background water quality conditions

- Public concerns and demand for recreational uses
- Site-specific limitations (i.e., groundwater, bedrock, soil types, etc.)
- Additional planned CSO controls not captured in WWFPs or the CSO Order (i.e., high level storm sewers [HLSS]).

The overall goal for this prioritization is to apply implementation rates that allow DEP to saturate priority watersheds with GI in order to cost-effectively maximize benefits based on the specific opportunities and field conditions in the watersheds of the Citywide/Open Waters LTCP waterbodies.

Green Infrastructure Baseline Implementation Rate – Citywide/Open Waters LTCP (or "East River/Open Waters" as referred to in the GI Annual Report)

As of March 2020, DEP has constructed or is in construction on 900 GI assets that manage 195 greened acres in the watershed. GI assets include ROW practices, public property retrofits, and GI implementation on private properties. In addition, thousands of additional assets are currently in design or pending construction. All built and planned GI assets are projected to result in a CSO volume reduction of approximately 912 MGY by 2030, based on the 2008 baseline rainfall condition.

For the Citywide/Open Waters LTCP, the baseline reduction includes projects in the implementation areas as listed in Table 5-1:

Table 5-1. GI Implementation Areas

Implementation Area	Description
ROW GI Implementation	Figure 5-2 shows the ROW GI contract areas within the East River/ Open Waters area. Within these contract areas, DEP is designing and constructing thousands of ROW GI assets including rain gardens, infiltration basins, and stormwater green streets.
Public Property GI Retrofits	DEP is working with partner agencies to construct GI within schools, parks, NYCHA housing and on other publicly-owned property such as NYPD and Taxi and Limousine Commission property. Current public property retrofits within Citywide/Open Waters LTCP waterbodies are shown in the East River/Open Waters watershed map in the 2019 GI Annual Report.
Private Property GI Incentives	Through its Green Infrastructure Grant Program, DEP has funded GI on private property. Most recently, to align with new DEP incentives and elements of the Climate Mobilization Act of 2019, DEP has shifted the focus of the Green Infrastructure Grant Program to green roof retrofits. DEP is also launching a new Private Property Retrofit Incentive Program this year which will target 200 greened acres on properties 50,000 square feet or larger. Green infrastructure projects funded within private property in Citywide/Open Waters LTCP waterbodies are shown in the East River/Open Waters watershed map in the 2019 GI Annual Report.
New and Redevelopment Stormwater Regulations	DEP is updating and streamlining its policy for stormwater management within new and redevelopment projects through a new Unified Stormwater Rule. The policies will result in greater retention of stormwater on-site and more strict release rates for stormwater going into the City's combined sewers, therefore providing more effective CSO reduction. Due to the watershed's size and how new and redevelopment is concentrated in the City, future stormwater controls resulting from new and redevelopment projects will eventually generate the majority of CSO

Table 5-1. GI Implementation Areas

Implementation Area	Description
	reduction attributed to green infrastructure within the Citywide/Open Waters LTCP waterbodies.
Tibbetts Brook Daylighting and Van Cortlandt Lake Improvements	CSO reductions from the Tibbetts Brook Daylighting and Van Cortlandt Lake Improvements Project are included in Citywide/Open Waters LTCP waterbodies GI baseline reduction. See Section 5.4.d for details on this project.
Stormwater Recovery and Reuse	DEP is also embarking on two new stormwater recovery and reuse projects in the Citywide/Open Waters LTCP waterbodies that provide a synergistic approach to demand management and CSO reduction goals – the Central Park Jackie Onassis Reservoir Recirculation Project and the Prospect Park Valve Replacement Project. In addition to reducing potable demand, these projects also reduce discharge to the combined sewer system.

As more information on feasibility, development and redevelopment rates, and as individual GI projects progress, DEP will continue to report on the progress of these GI implementation areas in the Citywide/Open Waters LTCP waterbodies through its GI Annual Reports, which are published on DEP's website annually on April 30th.

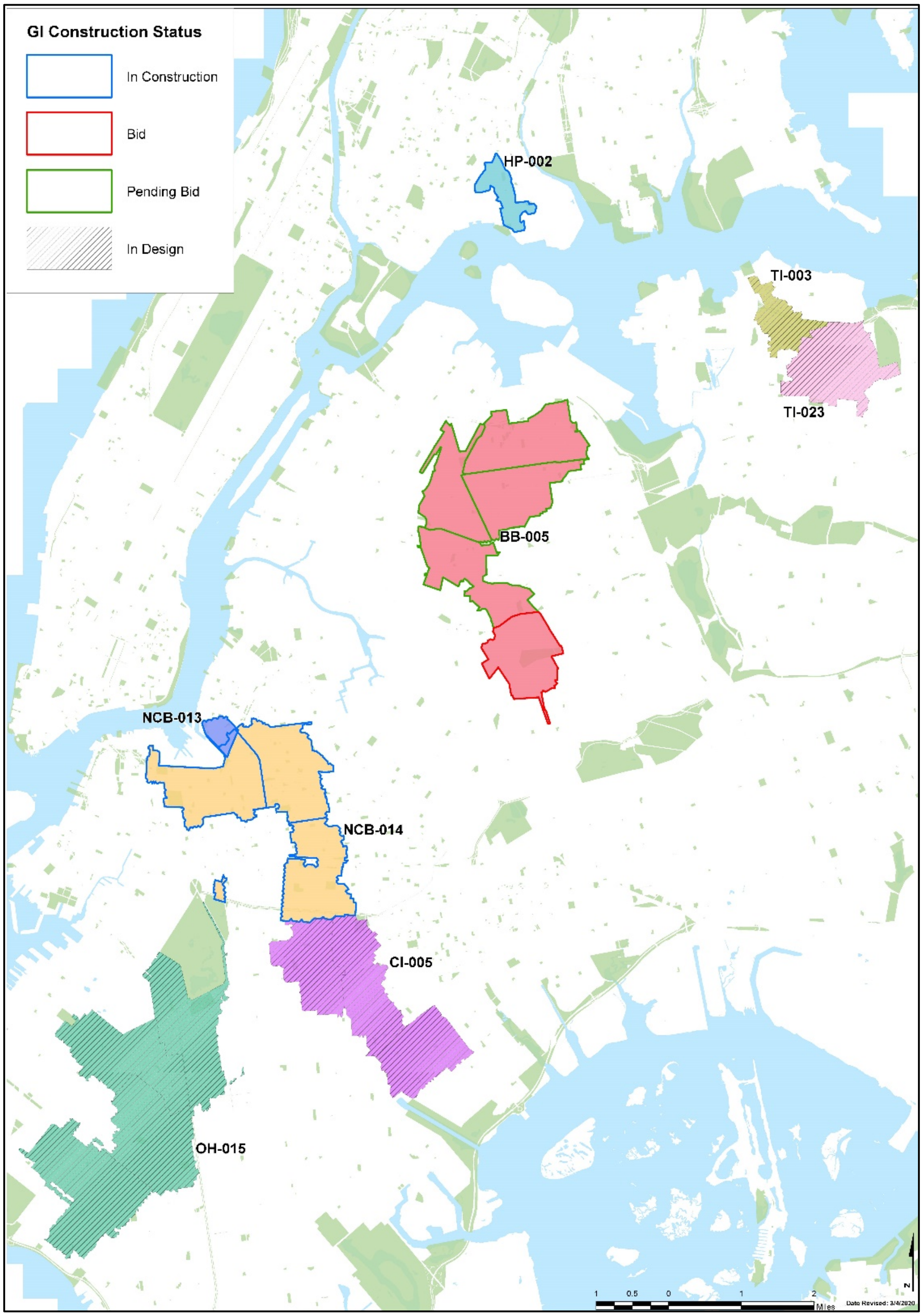


Figure 5-2. ROW Green Infrastructure Contract Areas for Citywide/Open Waters LTCP Waterbodies

5.4.d Tibbetts Brook Daylighting and Van Cortland Lake Improvements Project

Tibbetts Brook originates in Yonkers and flows through Van Cortlandt Park in the Bronx before discharging into Van Cortlandt Lake. Since the early 1900s, the stream has been diverted from Van

Cortlandt Lake through an 8'-0" diameter tunnel that connects to a combined sewer flowing to the Wards Island WRRF. During wet-weather events, overflows from the combined sewer system discharge to the Harlem River at an outfall on W. 192nd Street. (referred to as WI-056), which, volumetrically, is one of the largest CSO discharge points in New York City.

The original route of Tibbetts Brook split into two streams at what is today W. 237th Street. One branch ran along what is now Tibbett Avenue and another ran along what is currently a railroad ROW along the Major Deegan Expressway. With commuter rail service on the ROW discontinued in 1958 and freight service eliminated in the late 1980s, proposals to daylight Tibbetts Brook within the ROW have existed since the 1990s. In conjunction with the construction of an open channel, or stream daylighting, DEP and New York City Department of Parks & Recreation (DPR) propose to create a greenway providing a landscaped bike path and pedestrian walkway, which will be called the Putnam Greenway. The name pays respect to the New York and Putnam Railroad, the original owners of the ROW. Acquisition of property rights or easements that would be required are under review and discussion with relevant property owners.

Figure 5-3 shows the approximately 1.5-mile route of the proposed project, including a 1-mile long segment of open channel and two smaller segments of underground pipes, depending on the acquisition of privately owned easements. The proposed project has two components: (1) Van Cortlandt Lake improvements for additional dynamic storage; and (2) Baseflow daylighting of Tibbetts Brook. Baseflow daylighting could include additional storm flow of up to 31 cfs which, in combination with Van Cortlandt Lake improvements, could provide a reduction in annual CSO volume of up to 228 MG.

DEP had also evaluated full flow daylighting of Tibbetts Brook. This alternative, however, was eliminated due to the three large sewer crossings which are located along the proposed route of the open channel at Van Cortlandt Park South, 233rd Street and 225th Street (Figure 5-4). The crossings are located just below the surface with thick top slabs which were likely designed to support the railroad tracks. Rerouting the sewer crossings is not feasible. Based on the existing geometry of the crossings at Van Cortlandt Park South and 233rd Street, reconfiguration of those crossings to provide additional cover is not possible. The proposed project includes an open channel constructed on top of these crossings with up to four feet of fill (Figure 5-5) and a retaining wall along the eastern edge of the ROW next to the Major Deegan Expressway. The sewer crossing at 225th Street could potentially be reconfigured.

To minimize disruption to Van Cortlandt Park, an underground pipe would convey flow from the lake to the upstream end of the proposed project (Figure 5-6). The pipe would connect to the existing 8'-0" diameter tunnel that runs between Van Cortlandt Lake and the Broadway Sewer. An underground diversion structure would send dry-weather flow and a portion of the wet-weather flow to the daylighted section, while flows above the design flow rate of the open channel would continue to the Broadway Sewer. Historically, the route south of 225th Street, had anticipated to return underground before crossing under railroad tracks owned by Metro North to discharge to the Harlem River (Figure 5-7). However, since the Metro North MTA tracks are live, the preferred option would be to connect to an existing regulator (Regulator WI-67) located east of the tracks and routing flow through Outfall WI-056 where the connection would be made downstream of the regulator’s tide gates and would include an additional flap gate to prevent the backup of combined sewage into the daylighting system. Alternatively, a new pipe could be microtunneled under the Metro North tracks and connected to a new outfall point. Detailed engineering analyses need to be performed to provide more details on final configurations.

The proposed action would reroute flow into Van Cortlandt Lake from its current path through the Broadway sewer to a daylighted stream along the former CSX right-of-way, from which it would discharge directly to the Harlem River, reducing combined sewer overflows from Outfall WI-056 by the volumes shown below.

Closed Channel
Open Channel

Summary of Alternatives

CSO Reduction | **Channel Dimensions**

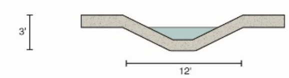
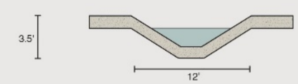
Alternative	CSO Reduction (MG/year)	Need Siphons	Maintenance Requirements	Safety Requirements	Constructability Concerns	Open Channel Flow (cfs)	Open Channel Cross Section
Base Flow Daylighting I w/ Van Cortlandt Lake Improvements	156 I 202	No	Low	Low	Medium	Up to 14	
Base Flow Daylighting w/ Van Cortlandt Lake Improvements and Additional Storm Flow	228	No	Low	Low/Moderate	Medium	Up to 31	

Figure 5-3. Daylighting Alternatives Considered for Tibbetts Brook

Figure 5-4. Location of Sewer Crossings along the Proposed Route of Tibbetts Brook Daylighting

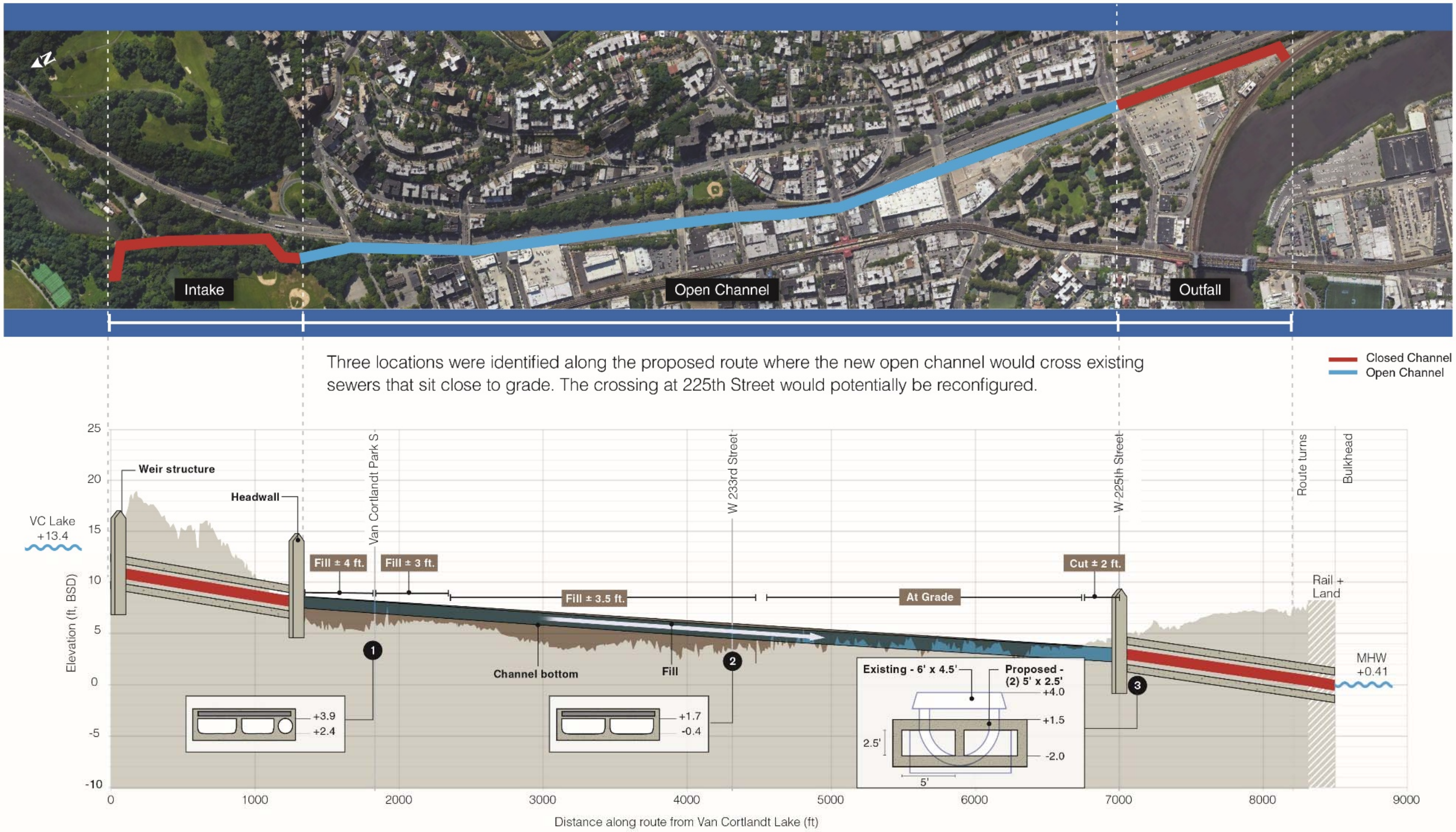
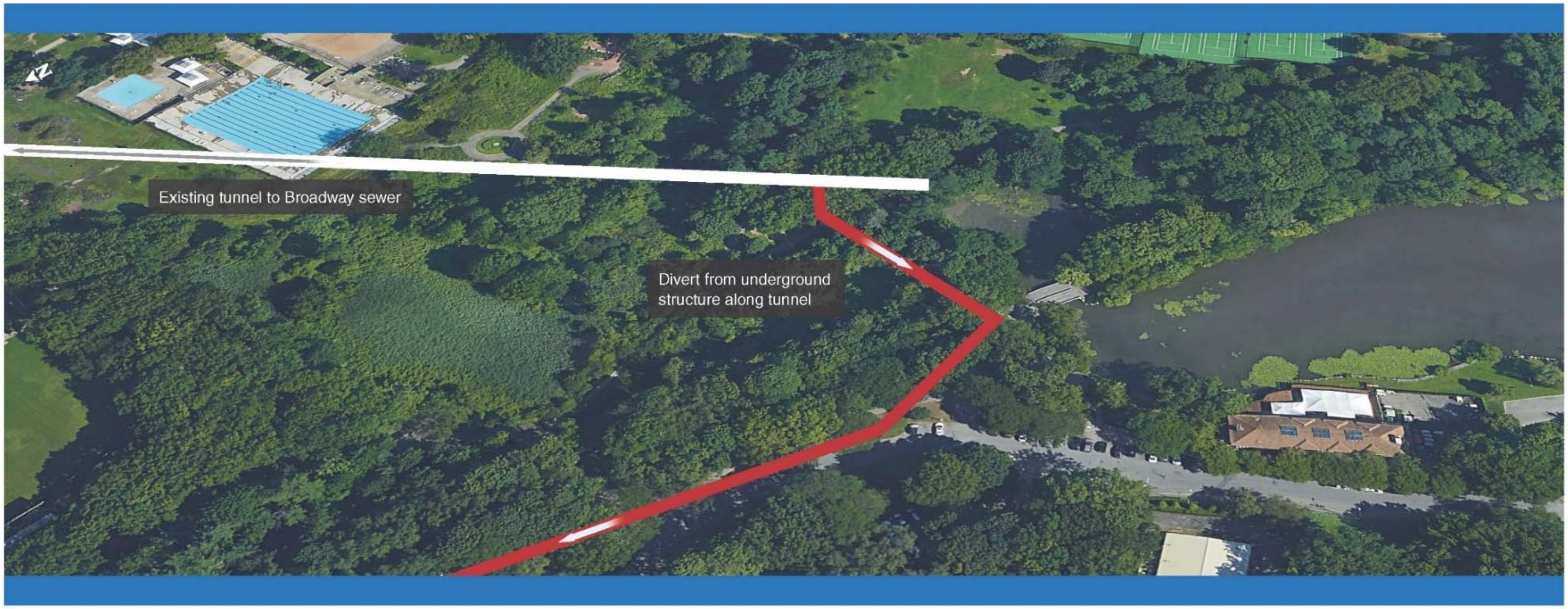


Figure 5-5. Proposed Cut and Fill along Daylighted Route



Flow from Van Cortlandt Lake would be diverted through a new sewer in the park before daylighting into an open channel.

The proposed alternative would divert flow from an underground tunnel which connects an existing weir structure in Van Cortlandt Lake to the Broadway sewer.

Figure 5-6. Upstream Connection to Flow from Van Cortlandt Lake

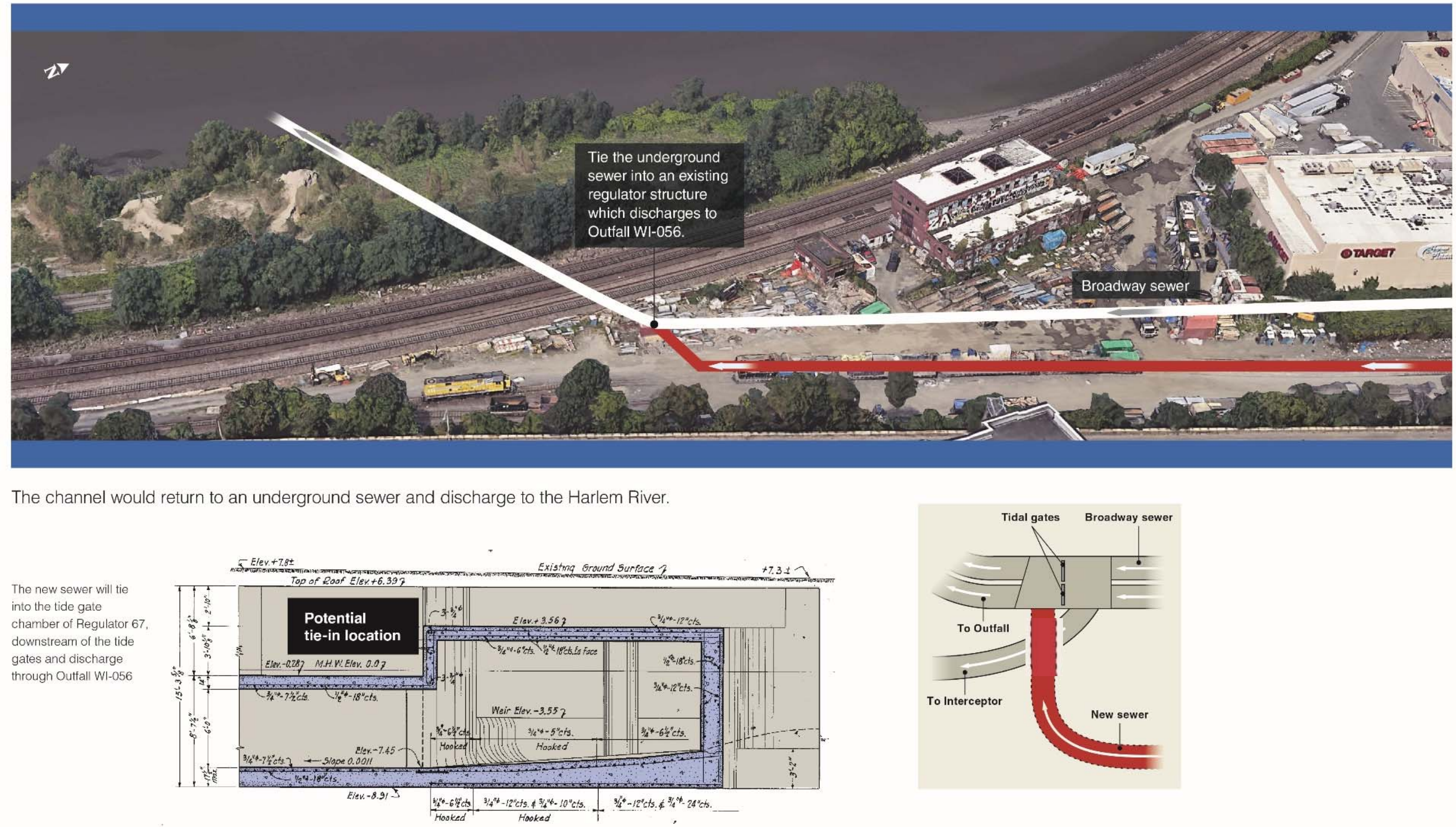


Figure 5-7. Proposed Piped Connection to Outfall at the Downstream End of the Daylighted Section

Based on the space available along the ROW and the restrictions imposed by the existing sewer crossings, the proposed configuration of the Tibbetts Brook Daylighting Project is as described on the second row of Figure 5-3. This configuration would include a V-shaped open channel sized to convey a peak flow of 31 MGD, which would allow for approximately 17 MGD of wet-weather flow above the base dry-weather flow rate of 14 MGD. This alternative, in conjunction with improvements to Van Cortlandt Lake, would result in a reduction of approximately 228 MGY of CSO to the Harlem River. The Van Cortlandt Lake improvements would include modifying the existing downstream dam structure to allow for dynamic storage in the lake during wet-weather, along with constructing a new dam structure between Van Cortlandt Lake and the Upper Basin so that the Upper Basin water level would not be affected by the dynamic storage in the Van Cortlandt Lake.

6.0 BASELINE CONDITIONS AND PERFORMANCE GAP

Before starting on the analysis of CSO control alternatives for the Citywide/Open Waters waterbodies, it was important to establish baseline water quality conditions, identify gaps between baseline water quality and attainment of water quality standards, and to determine if further CSO controls could close any identified gaps. Water quality was assessed using the LTCP Regional Model (LTCPRM), which was recalibrated using 2016 and 2017 DEP Harbor Survey and Sentinel Monitoring Data, and data collected as part of the LTCP project in 2016 and 2017. The LTCPRM water quality model was used to simulate ambient bacteria and DO concentrations within the waterbodies covered by the Citywide/Open Waters LTCP for a set of baseline conditions as described in this section. The IW sewer system models for each of 13 WRRFs were used to provide wet-weather flows and pollutant loads as input to the LTCPRM water quality model. In addition to these 13 IW models, a separate IW model was developed to represent the separate stormwater runoff discharged from the Oakwood Beach WRRF sewershed.

The assessment of baseline water quality conditions identified future bacteria and DO levels assuming no additional control of the CSOs discharging directly to the Citywide/Open Waters waterbodies beyond those already required under the CSO Order as of the date of this LTCP. This baseline condition, however, did include implementation of the Recommended Plans for the 10 LTCPs covering tributary waterbodies previously submitted under the DEP's LTCP Program. Simulations were then performed to determine bacteria and DO levels under both the baseline condition defined above and for a theoretical scenario in which all NYC CSO discharges are eliminated into the open waters that is referred to herein as the "No NYC CSO Loads" scenario. The baseline simulation results were compared to the No NYC CSO Loads simulation results, and the gap between the two scenarios was then assessed to determine the highest level of bacterial and DO WQ attainment with complete elimination of CSO discharges into the open waters. For bacteria, the gap was assessed for fecal coliform and, for Coastal Primary Contact Recreational waters, *Enterococci*. As detailed below, a ten-year simulation using 2002-2011 JFK Airport rainfall was performed for bacteria and a one-year simulation using 2008 JFK Airport rainfall was performed for DO. This section of the LTCP describes the baseline conditions, the bacteria concentrations and loads calculated by the IW model, and the resulting bacteria and DO concentrations calculated by the LTCPRM water quality model. This section also assesses whether any gaps between calculated baseline bacteria and DO concentrations and Existing WQ Criteria can be closed through CSO reductions alone (No NYC CSO Loads).

6.1 Define Baseline Conditions

Baseline conditions were used as a basis from which to compare the effectiveness of CSO control alternatives identified as part of the LTCP process. Baseline conditions for this LTCP were established in accordance with guidance set forth by DEC to represent future conditions. Specifically, these conditions included the following assumptions:

- Dry-weather flows at the WRRFs associated with the Citywide/Open Waters waterbodies were based on CY2040 projections, and the peak capacities of the WRRFs were based on their rated capacities of two times design dry-weather flow (2xDDWF). The CY2040 dry-weather flows and rated capacities for the WRRFs are summarized in Table 6-1.

Table 6-1. WRRF 2040 Dry-Weather Flow, and Rated Capacities

WRRF[(1)]	2040 Dry-Weather Flow (MGD)	Wet-Weather Capacity – 2XDDWF (MGD)
Hunts Point	111	400
Wards Island	194	550
North River	123	340
Tallman Island	57	160
Bowery Bay	114	300
Newtown Creek	221	700[(2)]
Red Hook	28	120
Owls Head	85	240
Coney Island	79	220
Port Richmond	25	120

Notes:

(1) The Oakwood Beach WRRF is not included in this list, since it serves a separate sanitary system with no CSOs, and the sanitary sewer system was not modeled. The separate stormwater system was modeled to allow stormwater loads from the tributary area to be incorporated into the WQ model.

(2) Design dry-weather flow is 310 MGD, but rated capacity per SPDES permit is 700 MGD.

- The Recommended Plans from the 10 previously-submitted LTCPs are assumed to be fully implemented, along with the levels of GI implementation within the sewersheds of the tributary waterbodies in accordance with the GI implementation plan. Refer to Section 4 for summary descriptions of the Recommended Plans for the previously-submitted LTCPs.

- Constructed or planned GI projects within the Citywide/Open Waters sewersheds resulting in a total reduction in system-wide annual CSO volume of 912 MGY in the sewersheds were included. Also included under the category of green infrastructure in the baseline conditions are the daylighting project for Tibbetts Brook, and potable water demand management projects for Harlem Meer and Prospect Park (see Section 5 for further details on the GI program).

- Cost-effective Grey Infrastructure CSO controls included in the CSO Consent Order as summarized in Section 4.1.

- The 2008 rainfall from the JFK rainfall gauge has been selected as the typical year rainfall. The 2002-2011 JFK rainfall period was also used to assess performance over a wider range of rainfall conditions. Tide data corresponding to the same timeframes as the rainfall were also incorporated into the IW model.

- The IW model was developed to represent the sewer system on a macro scale, including conveyance elements generally greater than 48-inches in equivalent diameter, along with regulator structures and CSO outfall pipes. Smaller-diameter sewers are included for specific areas where greater model definition was desired. Post-interceptor cleaning levels of sediments were included for the interceptors in the collection system, to better reflect actual conveyance capacities to the WRRFs.

The IW model software was used to develop CSO, stormwater and direct drainage loadings to the Citywide/Open Waters waterbodies and tributaries. A total of 13 distinct IW models were used to cover the various waterbodies included in the Citywide/Open Waters LTCP. The starting points for these IW models were the 2012 recalibrated IW models, based on the InfoWorks Citywide Recalibration Report, Updates to and Recalibration of the October 2007 Landside Models, New York City, Department of Environmental Protection, June 2012. Each of these IW models was updated with new information developed since the 2012 recalibration. Specific updates to the various models are described in Section 2.0. In addition to these 13 IW models, a separate IW model was developed to represent the separate stormwater runoff discharged from the Oakwood Beach WRRF sewershed. This model only has the stormwater runoff areas, and does not include a representation of the actual storm sewer system and associated MS4 outfalls. Minor improvements made to the water quality model as part of this LTCP included updating and refining the model segmentation. Changes to, and recalibration of, the IW and water quality models are discussed in more detail in the *CSO-LTCP: Sewer System and Water Quality Modeling for Citywide/Open Waters LTCP.*

6.1.a Hydrological Conditions

As described in Section 2.1.a.1, 2008 rainfall from the JFK rain gage was determined to be the most representative of average annual rainfall across four regional rainfall gauges (CPK, LGA, JFK, EWR), for the period between 1969 to 2018. The 2008 JFK rainfall was therefore selected to be representative of a typical rainfall year and was used for alternative analysis in Section 8 along with the corresponding 2008 tidal conditions. The baseline conditions, No NYC CSO Loads (for the gap analysis), and the Recommended Plan were also assessed using 2002-2011 JFK Airport rainfall and corresponding tides from that period.

6.1.b Flow Conservation

Consistent with previous studies, the dry-weather sanitary sewage flows used in the baseline modeling were escalated to reflect anticipated population growth in NYC. In 2014, DEP completed a detailed analysis of water demand and wastewater flow projections. A detailed GIS analysis was also performed to apportion total population among the 14 WRRF sewersheds throughout NYC. For this analysis, Transportation Analysis Zones were overlaid with WRRF sewersheds. Population projections for 2010-2040 were derived from population projections developed by DCP and the New York Metropolitan Transportation Council. These analyses used the 2010 census data to reassign population values to the watersheds in the model and project sanitary flows to 2040. These projections also reflect water conservation measures that already have significantly reduced flows to the WRRFs and freed capacity in the conveyance system.

6.1.c Best Management Practices Findings and Optimization

Brief summaries of the BMPs pertaining to the CSOs discharging to the Citywide/Open Waters waterbodies, along with their respective relationship to the EPA Nine Minimum Controls, are presented in Section 3.0. The BMPs include operation and maintenance procedures, maximum use of existing systems and facilities, and related planning efforts to maximize capture of CSO and reduce contaminants in the combined sewer system, thereby improving water quality conditions.

The following provides an overview of the specific elements of various DEP, SPDES, and BMP activities as they relate to the development of the baseline conditions, specifically in developing and using the IW models to simulate CSO discharges and in establishing non-CSO discharges that impact water quality in the Citywide/Open Waters waterbodies:

- Sentinel Monitoring: In accordance with BMPs #1 and #5, DEP collects quarterly samples of bacteria water quality at 41 locations in the Citywide/Open Waters waterbodies in dry-weather to assess whether dry-weather sewage overflows occur, or whether illicit connections to storm sewers exist. The locations of the Sentinel Monitoring sampling stations are shown in Figure 6-1. The Sentinel Monitoring Program samples were consistent with dry-weather samples from the Harbor Survey Monitoring Program and the LTCP sampling program in not indicating the presence of significant dry-weather sources of bacteria to the Citywide/Open Waters waterbodies. Accordingly, and as DEP is actively investigating and correcting identified illicit connections under a separate consent order, no illicit sources were included in the baseline conditions.
- Interceptor Sediments: Sewer sediment levels determined through the post-cleaning inspections are included in the IW model.
- Combined Sewer Sediments: The IW models assume no sediment in upstream combined trunk sewers in accordance with BMP #2.
- WRRF Flow Maximization: In accordance with BMP #3 and the 2014 CSO BMP Order on Consent, the WRRFs treat wet-weather flows that are conveyed to the plant, up to 2xDDWF. Cleaning of the interceptor sediments has increased the ability of the system to convey 2xDDWF to the WRRFs.
- Wet Weather Operating Plan (WWOP): The WWOPs for the WRRFs associated with the Citywide/Open Waters waterbodies establish procedures for pumping at the plant headworks to facilitate treatment of 2xDDWF, in accordance with BMP #4.

6.1.d Elements of Facility Plan and GI Plan

As described in Sections 1.0 and 4.0, DEP submitted the East River and Open Waters Waterbody/Watershed Facility Plan Report to DEC in June 2007. This report recommended a series of projects focusing on maximizing the utilization of the existing collection system infrastructure and treatment of combined sewage at the City-owned WRRFs. However, this WWFP was not approved by DEC, and no CSO-specific grey infrastructure projects were implemented for outfalls discharging to the Citywide/Open Waters waterbodies.

As discussed in Section 5.0, sewersheds tributary to the Citywide/Open Waters waterbodies have been targeted for varying degrees of GI projects by DEP. The list of GI projects presented in Section 5.0 has been assumed to be fully implemented in the baseline model.

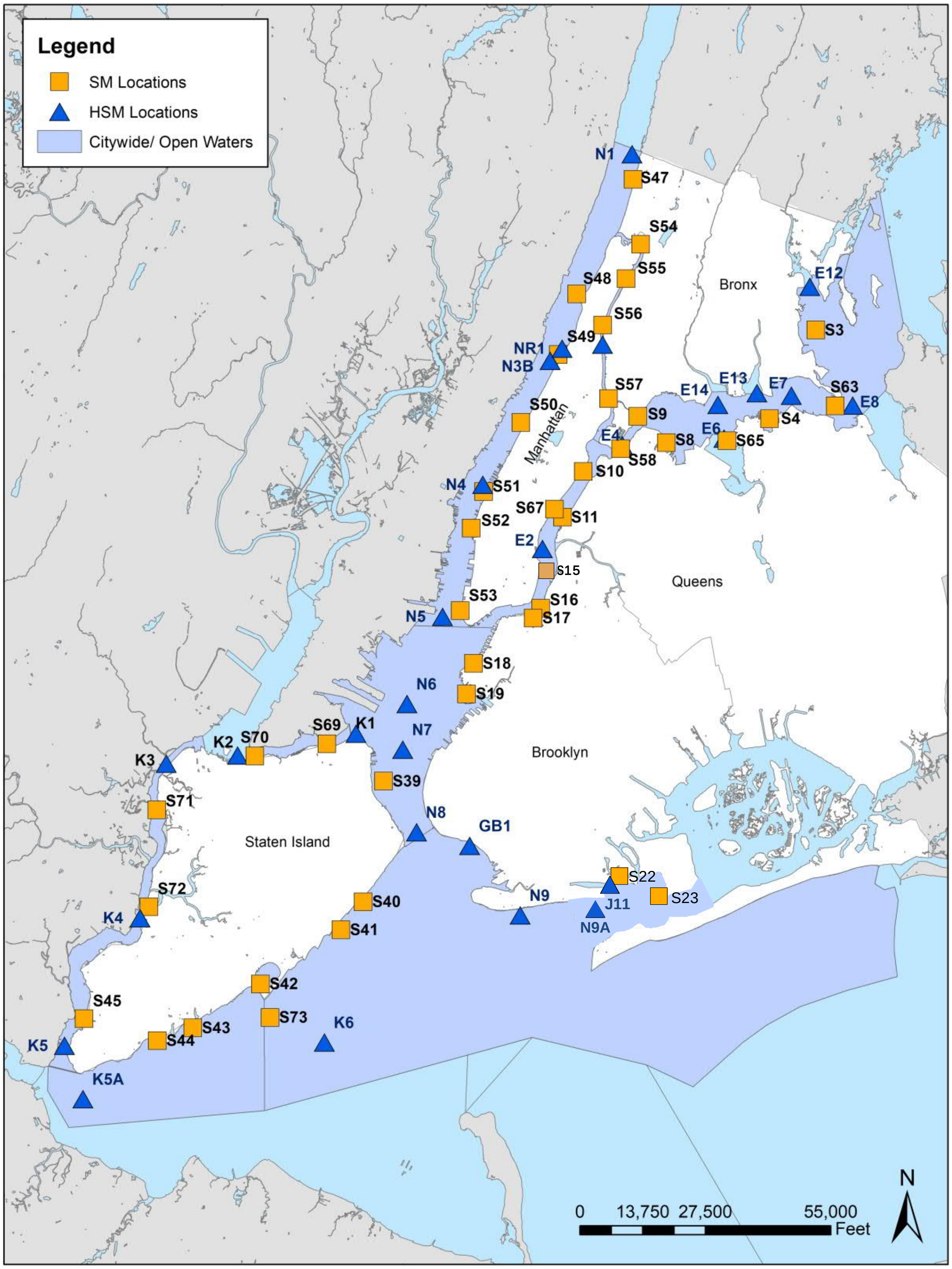


Figure 6-1. HSM and SM Sampling Locations in Citywide/Open Waters Waterbodies

AECOM with Hazen

6.1.e Non-CSO Discharges

Over the past approximately 30 years, DEP has invested heavily in mapping and delineating combined sewer drainage areas and piping systems as part of CSO facility planning and WWFP efforts. However, non-CSO drainage areas have not received the same level of effort. Non-CSO drainage areas were first identified during WWFP activities as land areas that were not located within the CSO drainage areas. They were labeled as direct drainage and stormwater drainage areas, but that distinction was inconsequential since both areas were assigned the same runoff characteristics. As part of DEP's LTCP work, these areas were further refined. Direct drainage areas (parks, cemeteries, large un-occupied open areas, etc.) are now assigned lower pathogen runoff concentrations than more urbanized non-CSO drainage areas (residential, commercial areas with a separate storm sewer system). In general, highway runoff has been established as a stand-alone category, but in many cases, highway runoff is combined with other stormwater discharges. Figures showing the breakdown of drainage areas by type (CSO, MS4 stormwater, direct discharge) for each of the Citywide/Open Waters waterbodies are presented in Section 2.0.

MS4 areas in the IW models were updated based on desktop analyses conducted by DEP. Non-MS4 stormwater areas and direct drainage areas are meant to represent the remaining parts of the drainage areas not covered by the MS4 delineations. The modeled discharge locations of the non-MS4 and direct drainage areas may not tie to actual locations of individual outfalls, but the loads to the receiving water are appropriately accounted for in the IW model.

6.2 Baseline Conditions – Projected CSO Volumes and Loadings after the Facility Plan and GI Plan

The IW models provided pollutant loadings to the WQ model by applying fecal coliform, *Enterococci*, and BOD concentrations to the projected flows from the IW models. Fecal coliform, *Enterococci,* and BOD CSO concentrations were developed by employing either a mass balance procedure, or a Monte Carlo randomization of measured CSO concentrations. Based on an analysis of sampling conducted at 14 Citywide/Open Waters CSOs, the mass balance method was determined to adequately reproduce measured concentrations at most of the locations. Where the mass balance method did reproduce measured concentrations, that method was applied. The mass balance approach applies assigned stormwater and sanitary concentrations to the flow calculated by the IW models. The IW models then determine the sanitary/stormwater mix, and the resultant pollutant concentration.

The calculation of the CSO concentration from sanitary and stormwater flows using mass balance is as follows:

$C_{cso} = fr_{san} * C_{san} + fr_{sw} * C_{sw}$

where: C_{cso} = CSO concentration

C_{san} = sanitary concentration

C_{sw} = stormwater concentration

fr_{san} = fraction of flow that is sanitary

fr_{sw} = fraction of flow that is stormwater

The sanitary and stormwater concentrations used for the mass balance calculations are presented in Table 6-2.

At the Wards Island and Owls Head CSOs, the mass balance method under-estimated the CSO concentrations, so a Monte Carlo distribution was applied. A Monte Carlo distribution of 100 unique concentrations was developed based on the mean and the standard deviation of the log of the measured data from each outfall. The Monte Carlo analysis produced a unique randomized concentration for each hour for each outfall, with the overall statistical distribution of all the values for each outfall matching the statistical distribution of the data for each outfall.

In addition to CSO loadings, storm sewer discharges and direct drainage can impact the water quality in the Citywide/Open Waters waterbodies. The concentrations assigned to the various discharge sources to each waterbody are summarized in Table 6-2. The concentrations represent typical stormwater, direct drainage, and sanitary sewage concentrations, based on water quality data collected for LTCP program as well as other sources as noted. Further details on the concentrations and loading used in the Citywide/Open Waters modeling are provided in the technical memorandum *"Citywide/Open Waters Basis for Modeling."*

Baseline CSO volumes and annual activations to the Citywide/Open Waters waterbodies for the 2008 typical year are summarized by outfall and waterbody in Table 6-3 to Table 6-7.

Table 6-2. Source Concentrations Used for Water Quality Modeling

<table>
<tr><th>Source</th><th>Fecal Coliform (cfu/100mL)</th><th>Enterococci (cfu/100mL)</th><th>BOD_5 (mg/L)</th></tr>
<tr><td>Low Density MS4(1)</td><td>18,200</td><td>21,100</td><td rowspan="4">15(2)</td></tr>
<tr><td>High Density MS4(1)</td><td>18,200</td><td>28,600</td></tr>
<tr><td>Direct Drainage(3)</td><td>4,000</td><td>6,000</td></tr>
<tr><td>Highway/ Airport Runoff (4)</td><td>20,000</td><td>8,000</td></tr>
<tr><td>WI-056, WI-060, OH-015, OH-017, OH-003</td><td>Monte Carlo</td><td>Monte Carlo</td><td>Mass Balance (Sanitary =110-120)(6)</td></tr>
<tr><td>CSOs (All others)</td><td>Mass Balance
Sanitary = 4,000,000(5)
Storm = 18,200</td><td>Mass Balance
Sanitary = 1,000,000(5)
Storm = 21,100/28,600</td><td>Mass Balance
Sanitary = 110-180(5)
Storm = 15</td></tr>
<tr><td>WRRF Effluent(6)</td><td>50</td><td>10</td><td>3.5 to 13.7</td></tr>
</table>

Notes:

(1) Stormwater bacteria concentrations based on LTCP stormwater data.
(2) Stormwater BOD_5 based on Open Water Waterbody/Watershed Report (2007).
(3) Direct drainage bacteria concentrations based on NYS Stormwater Manual, Charles River data, and National Stormwater Data Base for commercial and industrial land uses. Direct drainage BOD_5 concentrations specified as stormwater.
(4) Highway/Airport runoff concentrations estimated from NYS Stormwater Manual, Charles River data, National Stormwater Data Base.
(5) Sanitary bacteria concentrations from the HydroQual Memo to DEP, 2005a. BOD concentrations based on Open Water Waterbody/Watershed Report (2007).
(6) WRRF effluent bacteria concentrations are representative estimates based on -Discharge Monitoring Report data. BOD concentrations based on daily plant WRRF.

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Table 6-3. 2008 CSO Volume and Overflows per Year – Harlem River

CSO	Volume	Activation Frequency	CSO	Volume	Activation Frequency
	Total Discharge (MG/yr)	Total (No./yr)		Total Discharge (MG/yr)	Total (No./yr)
WIM-020	0.0	0	WIB-056	582	44
WIM-021	0.1	11	WIB-057	124	41
WIM-022	0.2	15	WIB-058	31.3	29
WIM-023	23.5	20	WIB-059	6.7	16
WIM-024	10.0	6	WIB-060	285	35
WIM-025	24.4	47	WIB-061	4.0	17
WIM-026	0.1	10	WIB-062	147	38
WIM-027	0.1	9	WIB-063	5.3	58
WIM-028	0.1	15	WIB-064	17.4	21
WIM-029	0.8	19	WIB-065	0.2	28
WIM-030	0.1	15	WIB-066	0.6	19
WIM-031	0.7	16	WIB-067	6.2	22
WIM-032	0.0	8	WIB-068	17.2	5
WIM-033	1.0	19	WIB-069	0.0	1
WIM-034	0.1	16	WIB-073	0.0	22
WIM-035	2.7	21	WIB-075	68.0	27
WIM-036	0.7	42	WIB-076	58.5	42
WIM-037	1.7	17	WIB-077	81.2	38
WIM-038	11.0	29	WIB-078	34.5	41
WIM-039	1.3	25	NR-007	0.90	10
WIM-040	0.8	29	NR-008	19.2	34
WIM-041	4.1	39	NR-009	1.7	20
WIM-042	0.5	33	NR-010	9.3	18
WIM-043	0.3	12	NR-011	1.4	7
WIM-044	1.5	38	NR-012	0.6	6
WIM-045	34.1	37	NR-013	0.5	6
WIM-046	123	43	NR-014	1.5	6
WIM-047	18.3	47	NR-016	1.1	6
WIM-048	11.1	48	NR-017	25.5	17
WIM-050	15.7	41	NR-018	0.1	1
WIM-051	21.7	37	NR-045	12.5	15
WIM-052	44.5	45	NR-055	0.7	6
Total				**1,899**	**58 (max)[(1)]**

Note:
(1) Maximum number of activations at individual outfalls. Activations based on an inter-event time of 12 hours.

Table 6-4. 2008 CSO Volume and Overflows per Year – Hudson River

CSO(1)	Volume	Activation Frequency	CSO(1)	Volume	Activation Frequency
	Total Discharge (MG/yr)	Total (No./yr)		Total Discharge (MG/yr)	Total (No./yr)
WIB-053	46.3	50	NR-036	9.6	15
WIB-054	31.7	39	NR-037	0.9	4
WIB-055	19.5	54	NR-038	5.6	8
WIB-079	0.0	0	NR-039	0.0	0
NR-002	1.0	12	NR-040	44.7	21
NR-003	3.8	10	NR-041	1.5	9
NR-004	4.9	10	NR-042	2.3	13
NR-005	0.02	1	NR-043	45.4	10
NR-006	35.7	18	NR-044	1.2	12
NR-019	3.5	17	NR-046	7.4	12
NR-020	11.6	19	NR-047	0.1	1
NR-021	3.6	13	NR-048	0.3	8
NR-022	6.5	10	NR-049	7.8	12
NR-023	20.1	10	NR-050	0.02	1
NR-024	8.9	11	NR-052	0.5	5
NR-025	8.0	10	NR-056	3.6	9
NR-026	13.9	19	NCM-070	8.4	21
NR-027	69.8	11	NCM-071	8.1	19
NR-028	2.7	6	NCM-072	9.2	12
NR-029	3.6	9	NCM-073	29.0	18
NR-030	4.9	12	NCM-074	10.9	15
NR-031	2.1	8	NCM-075	77.8	21
NR-032	0.7	6	NCM-076	225	47
NR-033	19.4	10	NCM-080	0.6	16
NR-034	4.5	15	NCM-081	0.2	6
NR-035	6.5	18			
Total				**833**	**54 (max)(2)**

Notes:

(1) CSOs from outside of NYC also discharge to the Hudson River. Those CSOs are not listed in this table.

(2) Maximum number of activations at individual outfalls. Activations based on an inter-event time of 12 hours.

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Table 6-5. 2008 CSO Volume and Overflows per Year – East River

CSO	Volume	Activation Frequency	CSO	Volume	Activation Frequency
	Total Discharge (MG/yr)	Total (No./yr)		Total Discharge (MG/yr)	Total (No./yr)
HP-002	47.8	19	NCM-046	3.4	13
HP-003	138	30	NCM-047	2.4	9
HP-011	665	34	NCM-048	5.4	13
HP-017	38.3	28	NCM-049	17.6	12
HP-018	3.4	15	NCM-050	34.8	19
HP-019	15.5	35	NCM-051	1.0	8
HP-020	83.9	29	NCM-052	24.4	15
HP-021	202	44	NCM-053	10.1	9
HP-022	29.2	29	NCM-054	2.6	9
HP-025	95.9	45	NCM-055	1.2	13
HP-026	48.5	19	NCM-056	21.8	22
HP-029	3.2	12	NCM-057	4.5	11
WIB-070	8.6	37	NCM-058	16.5	19
WIB-071	12.9	19	NCM-059	7.8	16
WIB-072	31.9	26	NCM-060	0.6	6
WIM-002	6.2	46	NCM-061	2.7	16
WIM-003	89.6	43	NCM-062	13.4	34
WIM-004	5.6	42	NCM-063	16.4	13
WIM-005	4.2	36	NCM-064	9.6	14
WIM-006	4.5	41	NCM-065	0.2	5
WIM-007	4.1	37	NCM-066	4.9	12
WIM-008	115	45	NCM-067	7.4	11
WIM-009	0.0	1	NCM-068	0.4	4
WIM-010	0.0	0	NCM-069	9.2	12
WIM-011	3.3	19	NCM-078	1.1	4
WIM-012	8.2	17	NCM-087	4.6	8
WIM-013	0.1	24	TI-003	71.3	45
WIM-014	0.0	11	TI-004	3.6	16
WIM-015	0.8	17	TI-005	0.01	1
WIM-016	13.2	38	TI-019	0	0
WIM-017	1.9	20	TI-020	0	0
WIM-018	0.1	15	TI-023	138	39
WIM-019	0.0	11	BB-002	12.9	19
NCB-003	0.5	10	BB-003	53.2	32
NCB-004	17.9	36	BB-005	732	35
NCB-006	113	17	BB-016	1.6	15
NCB-007	8.6	29	BB-017	1.5	18
NCB-008	23.2	26	BB-018	1.1	14
NCB-010	0.1	2	BB-021	20.9	30

Table 6-5. 2008 CSO Volume and Overflows per Year – East River

CSO	Volume	Activation Frequency	CSO	Volume	Activation Frequency
	Total Discharge (MG/yr)	Total (No./yr)		Total Discharge (MG/yr)	Total (No./yr)
NCB-012	16.3	8	BB-022	0.9	9
NCB-013	98.2	28	BB-023	15.5	23
NCB-014	727	30	BB-024	32.0	24
NCB-024	0.01	1	BB-025	10.0	27
NCB-025	0.6	11	BB-027	5.3	22
NCB-026	0.4	9	BB-028	317.	43
NCB-027	18.8	30	BB-029	89.6	29
NCB-082	0.6	10	BB-030	24.7	39
NCM-005	49.9	38	BB-031	2.8	14
NCM-011	0	0	BB-032	1.9	17
NCM-016	3.4	12	BB-033	5.5	28
NCM-017	0.7	7	BB-034	186	47
NCM-018	11.7	34	BB-035	3.8	31
NCM-020	8.2	14	BB-036	8.4	29
NCM-028	0	0	BB-037	0.7	8
NCM-030	0.3	9	BB-041	85.0	61
NCM-031	3.9	21	BB-045	0.0	1
NCM-032	5.6	11	BB-046	6.6	30
NCM-033	0.4	7	BB-047	1.7	17
NCM-034	1.9	8	RH-002	0.0	0
NCM-035	4.3	14	RH-003	0.8	10
NCM-036	79.9	15	RH-005	134	20
NCM -037	0.9	4	RH-006	8.1	26
NCM-038	10.2	14	RH-007	1.2	12
NCM-039	1.4	9	RH-008	3.1	16
NCM-040	0.1	1	RH-009	2.5	18
NCM-041	29.2	16	RH-010	0.2	6
NCM-042	1.7	8	RH-011	4.5	16
NCM-043	4.3	14	RH-012	9.6	14
NCM-044	0.17	2	RH-013	0.3	6
NCM-045	22.1	14	RH-040	24.4	23
Total				**5,193**	**61 (max)(1)**

Note:
(1) Maximum number of activations at individual outfalls. Activations based on an inter-event time of 12 hours.

Table 6-6. 2008 CSO Volume and Overflows per Year – New York Bay

CSO(1)	Volume	Activation Frequency	CSO(1)	Volume	Activation Frequency
	Total Discharge (MG/yr)	Total (No./yr)		Total Discharge (MG/yr)	Total (No./yr)
RH-014	33.2	43	OH-020	1.3	25
RH-016	34.9	19	OH-022	0.0	0
RH-018	10.4	19	OH-025	0.0	0
RH-019	15.0	20	PR-010	1.0	8
RH-020	1.5	13	PR-011	0.2	3
RH-021	2.7	21	PR-013	40.7	30
RH-022	4.1	15	PR-014	28.3	30
RH-023	4.1	19	PR-015	2.1	15
RH-024	4.2	17	PR-016	1.7	16
RH-025	6.5	17	PR-017	13.1	30
RH-028	22.0	14	PR-018	2.9	20
RH-029	2.5	22	PR-019	67.4	38
OH-002	407	41	PR-020	25.2	44
OH-003	374	57	PR-021	7.2	38
OH-004	9.2	12	PR-023A	41.9	25
OH-015	1,105	64	PR-030	8.6	41
OH-017	449	39	PR-031	183	34
OH-018	121	32	PR-032	7.4	26
OH-019	22.7	26			
Total				**3,062**	**64 (max)(2)**

Notes:
(1) CSOs from outside of NYC also discharge to New York Bay. Those CSOs are not listed in this table.
(2) Maximum number of activations at individual outfalls. Activations based on an inter-event time of 12 hours.

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Table 6-7. 2008 CSO Volume and Overflows per Year – Kill Van Kull

CSO(1)	Volume	Activation Frequency
	Total Discharge (MG/yr)	Total (No./yr)
PR-002	0.0	0
PR-003	0.0	0
PR-004	0.0	0
PR-005	0.0	0
PR-006	6.4	15
PR-007	0.0	0
PR-008	0.0	0
PR-009	0.0	0
PR-024	0.0	0
PR-025	0.0	0
PR-026	1.4	6
PR-027	1.7	10
PR-028	15.1	23
PR-029	146	47
PR-033	0.0	0
PR-034	0.0	0
PR-035	0.0	0
PR-036	0.0	0
PR-037	2.9	12
Total	**173**	**47 (max)(2)**

Notes:
(1) CSOs from outside of NYC also discharge to Kill Van Kull. Those CSOs are not listed in this table.
(2) Maximum number of activations at individual outfalls. Activations based on an inter-event time of 12 hours.

The following general observations from Table 6-3 to Table 6-7 are summarized below, by waterbody:

- Harlem River (Table 6-3):
  - The largest outfall by volume is WIB-056, representing 31 percent of the total annual volume to the waterbody
  - 66 percent of the total annual CSO volume is generated from five outfalls: WIB-056, WIB-060, WIB-062, WIB-057, and WIM-046
  - 34 outfalls have annual overflow volumes of less than 5 MG/yr
  - The most active outfall is WIB-063, with 58 activations per year
- Hudson River (Table 6-4):
  - The largest outfall by volume is NCM-076, representing 27 percent of the total annual volume to the waterbody
  - 45 percent of the total annual CSO volume is generated from three outfalls: NCM-076, NCM-075, and NR-027
  - 25 outfalls have annual overflow volumes of less than 5 MG/yr
  - The most active outfalls are WIB-055, with 54 activations per year, and WIB-053, with 50 activations per year
- East River (Table 6-5)
  - The largest outfalls by volume are BB-005 (732 MG), NCB-014 (727 MG), and HP-011 (665 MG), representing 41 percent of the total annual volume to the waterbody
  - 67 percent of the total annual CSO volume is generated from 11 outfalls: BB-005, NCB-014, HP-011, BB-028, HP-021, BB-034, TI-023, HP-003, RH-005, WIM-008, and NCB-006
  - 70 outfalls have annual overflow volumes of less than 5 MG/yr
  - The most active outfall is BB-041, with 61 activations per year
- New York Bay (Table 6-6)
  - The largest outfall by volume is OH-015, representing 36 percent of the total annual volume to the waterbody
  - 76 percent of the total annual CSO volume is generated from four outfalls: OH-015, OH-017, OH-002 and OH-003
  - 14 outfalls have annual overflow volumes of less than 5 MG/yr
  - The most active outfall is OH-015, with 64 activations per year

- Kill Van Kull (Table 6-7)
  - The largest outfall by volume is PR-029, representing 84 percent of the total annual volume to the waterbody
  - 16 outfalls have annual overflow volumes of less than 5 MG/yr
  - The most active outfall is PR-029, with 47 activations per year

Annual stormwater volumes originating from NYC and discharging directly to the Citywide/Open Waters waterbodies are summarized by stormwater type in Table 6-8. The total baseline volumes of CSO, stormwater and direct drainage from NYC sources discharging directly to the Citywide/Open Waters waterbodies along with the associated fecal coliform, *Enterococci*, and BOD annual loadings, are summarized in Table 6-9 for the 2008 typical year. Additional tables that summarize annual volumes and loadings can be found in Appendix A. The information in these tables is provided for the 2008 rainfall condition.

Table 6-8. 2008 Annual Stormwater Volume

Waterbody	Total (MG)(1)	DEP MS4 (MG)(2)	SW (MG)(2)(3)	Direct (MG)(2)(4)
Harlem River	561	0	0	561
Hudson River(5)	749	0	20	729
East River/Long Island Sound	3,103	312	688	2,103
Upper/Lower New York Bay(5)	7,658	1,404	5,092	1,091
Kill Van Kull(5)	2,808	395	2,414	0
Arthur Kill(5)	3,183	868	2,315	0
Total	**18,062**	**2,979**	**10,528**	**4,484**

Notes:
(1) Volumes are from non-CSO subcatchments.
(2) Tributary drainage areas for direct drainage and other sources of stormwater have not been fully delineated by DEP or obtained from other agencies. These drainage areas were estimated based on GIS mapping, aerial photographs, land use maps, and topographic maps, rather than detailed topographic surveys and sewer maps. The IW models, therefore, have a simplified representation of stormwater areas and features. As a result, urban stormwater flows and loads will represent estimates rather than definitive values. In addition, ongoing updates to MS4 area delineations may not be reflected in the model.
(3) Stormwater (SW) consists of all NYC outfalls except for DEP MS4.
(4) Direct drainage consists of all remaining NYC drainage areas not tributary to defined CSO, MS4, and SW subcatchments.
(5) These waterbodies also receive separate stormwater from outside of NYC.

Table 6-9. 2008 Baseline Loading Summary

Totals by Source by Waterbody		Volume	*Enterococci*(1)	Fecal Coliform(1)	BOD
Waterbody	**Source**	**Total Discharge (MG/yr)**	**Total Org (10^12/yr)**	**Total Org (10^12/yr)**	**Total (lbs/yr x 10^3)**
Harlem River	CSO	1,899	38,142	87,591	838
	MS4 SW	0	-	-	-
	Non-MS4 SW	0	-	-	-
	Direct Drainage	561	128	85	70
	Subtotal	**2,460**	**38,270**	**87,676**	**908**
Hudson River	CSO	833	6,479	23,426	260
	MS4 SW	0	-	-	-
	Non-MS4 SW	20	16	14	3
	Direct Drainage	729	166	111	92
	North River WRRF	46,855	18	89	3,113
	Subtotal-NYC	**48,437**	**6,679**	**23,639**	**3,467**
	Sources from Outside of NYC(2)	**Not Available**	**30,060**	**49,242**	**Not Available**
East River/Long Island Sound	CSO	5,192	32,913	115,665	1,267
	MS4 SW	312	263	216	39
	Non-MS4 SW	688	686	476	87
	Direct Drainage	2,103	508	346	266
	Airport/Transport	189	58	145	24
	Hunts Point WRRF	45,889	17	87	1,343
	Wards Island WRRF	76,199	30	150	2,503
	Tallman Island WRRF	24,289	9	46	1,159
	Bowery Bay WRRF	46,844	9	44	828
	Newtown Creek WRRF	92,034	35	174	8,967
	Red Hook WRRF	12,328	5	23	574
	Subtotal	**306,068**	**34,533**	**117,372**	**17,058**
Upper/Lower New York Bay	CSO	3,062	68,745	278,386	686
	MS4 SW	1,404	1,525	970	176
	Non-MS4 SW	5,092	4,116	3,510	637
	Direct Drainage	1,091	299	198	138
	Coney Island WRRF	32,216	66	132	2,688
	Owls Head WRRF	35,417	13	67	4,069

Table 6-9. 2008 Baseline Loading Summary

Totals by Source by Waterbody		Volume	*Enterococci*(1)	Fecal Coliform(1)	BOD
Waterbody	**Source**	**Total Discharge (MG/yr)**	**Total Org (10^12/yr)**	**Total Org (10^12/yr)**	**Total (lbs/yr x 10^3)**
	Oakwood Beach WRRF	11,115	4	21	675
	Subtotal-NYC	**89,468**	**74,785**	**283,295**	**9,078**
	Sources Outside of NYC(2)	**Not Available**	**2,523**	**4,688**	**Not Available**
Kill Van Kull	CSO	173	598	1,988	35
	MS4 SW	395	316	272	49
	Non-MS4 SW	2,414	1,930	1,664	302
	Direct Drainage	0	0	0	0
	Port Richmond WRRF	10,600	4	20	751
	Subtotal-NYC	**13,582**	**2,847**	**3,944**	**1,138**
	Sources Outside of NYC(2)	**Not Available**	**2,536**	**6,145**	**Not Available**
Arthur Kill	CSO	0	0	0	0
	MS4 SW	868	693	598	109
	Non-MS4 SW	2,315	1,850	1,596	290
	Direct Drainage	0	0	0	0
	Subtotal-NYC	**3,183**	**2,544**	**2,194**	**398**
	Sources Outside of NYC(2)	**Not Available**	**29,636**	**20,585**	**Not Available**
Total – NYC Sources		**463,198**	**159,657**	**518,121**	**32,048**
Total – Sources Outside of NYC(2)		**Not Available**	**64,756**	**80,660**	**Not Available**

Notes:

(1) Bacteria loads for Outfalls WI-056, WI-060, OH-015, OH-017, and OH-003 were generated using Monte Carlo randomizations of the bacteria concentrations from the LTCP sampling program. Bacteria loads at all other NYC CSO outfalls were generated using bacteria concentrations computed in the IW model from the sanitary sewage/stormwater mass balance.

(2) Fecal coliform and *Enterococci* loadings from sources outside of NYC include CSO and various stormwater sources. Volumes and BOD loadings were not available.

6.3 Performance Gap

Bacteria and DO concentrations in the Citywide/Open Waters waterbodies are affected by a number of factors, including the volumes of CSO, stormwater, and WRRF effluent, the concentrations of the respective loadings, flows and tidal exchanges at the boundaries of the waterbodies (Hudson River, Long Island Sound, Atlantic Ocean), and pollutant loadings from outside of NYC. Because most of the flow and loads discharged into these waterbodies are the result of runoff from rainfall events, the frequency, duration, and amounts of rainfall strongly influence the water quality of the Citywide/Open Waters waterbodies.

The LTCPRM model was used to simulate bacteria concentrations using 2002-2011 rainfall and tide data and DO concentrations using 2008 rainfall and tide data for the baseline conditions. Hourly model calculations were saved for post-processing and comparison with the Existing WQ Criteria for bacteria and DO. The performance gap was then developed as the difference between the model calculated baseline waterbody DO and bacteria concentrations and the applicable numerical WQS.

Within the following sections, analyses are described that reflect the differences in attainment both spatially and temporally. The temporal assessment focuses on compliance with the applicable fecal coliform WQ Criteria over the entire year as well as the recreational season of May 1^{st} through October 31^{st}. For *Enterococci*, the temporal assessment focuses on compliance during the recreational season of May 1^{st} through October 31^{st}. A summary of the criteria that were applied is shown in Table 6-10.

Table 6-10. Classifications and Standards Applied

Location	Numerical Criteria Applied	
• Long Island Sound east of Throgs Neck Bridge • Upper New York Bay • Lower New York Bay (including Rockaway Inlet and portions of Raritan Bay)	Class SB Coastal Primary Contact Recreational Waters	Fecal coliform monthly GM ≤ 200[1] *Enterococci*: rolling 30-day GM ≤ 35 cfu/100mL[2] *Enterococci*: rolling 30-day 90^{th} percentile STV ≤ 130 cfu/100mL[2] Chronic DO between 3.0 & 4.8 mg/L[3] Acute DO ≥ 3.0 mg/L
• Hudson River north of Harlem River • East River between Whitestone Bridge and Throgs Neck Bridge	Class SB	Fecal coliform monthly GM ≤ 200[1] Chronic DO between 3.0 & 4.8 mg/L[3] Acute DO ≥ 3.0 mg/L
• East River from Battery to Whitestone Bridge • Hudson River from Battery to Harlem River • Harlem River • Arthur Kill from Raritan Bay to Outerbridge Crossing	Class I	Fecal coliform monthly GM ≤ 200[1] DO ≥ 4.0 mg/L

Table 6-10. Classifications and Standards Applied

Location	Numerical Criteria Applied	
• Arthur Kill from Outerbridge Crossing to Kill Van Kull • Kill Van Kull	Class SD	Fecal coliform monthly GM ≤ 200(1) DO ≥ 3.0 mg/L

Notes:
(1) On an annual basis.
(2) For recreational season May 1st through October 31st.
(3) This is an excursion-based limit that allows for the average daily DO concentrations to fall between 3.0 and 4.8 mg/L for a limited number of days as described in more detail in Section 2.

6.3.a CSO Volumes and Loadings Needed to Attain Current Water Quality Standards

To assess the performance gap, the LTCPRM model calculated fecal coliform, *Enterococci*, and DO concentrations under baseline conditions and conditions of 100% control of the CSOs for the Citywide/Open Waters waterbodies. The bacteria assessments were conducted with the 10-year continuous simulation, and the DO assessments were conducted with the 2008 typical year. The water quality monitoring stations are shown in Figure 6-1 above.

10-Year Annual Rainfall Simulation – Bacteria

A ten-year simulation of bacteria water quality was performed for the 2002-2011 baseline loading conditions, assuming dry-weather illicit discharges have been eliminated. Figure 6-2 to Figure 6-15 present mosaics of the percent attainment with the monthly fecal coliform geometric mean criterion on an annual basis and for the recreational season (May 1st through October 31st) across the Citywide/Open Waters waterbodies, for the baseline conditions 10-year simulation. For the Coastal Primary Contact Recreational waters of Long Island Sound and New York Bay, mosaics of the attainment with the *Enterococci* 30-day geometric mean and STV criteria are also presented.

As indicated in these figures, greater than 95 percent attainment with the fecal coliform monthly GM criterion was achieved on an annual basis in all of the Citywide/Open Waters model grids, except for locations along Arthur Kill and Kill Van Kull. Greater than 95 percent attainment with the fecal coliform monthly GM criterion was achieved during the recreational season (May 1st through October 31st) in all of the Citywide/Open Waters model grids, except for a short reach in the northern section of Arthur Kill.

Greater than 95 percent attainment with the *Enterococci* 30-day GM criterion was achieved during the recreational season (May 1st through October 31st) in all of the model grids within the applicable Coastal Primary Contact Recreational waters. Greater than 95 percent attainment with the *Enterococci* 30-day STV criterion was achieved during the recreational season (May 1st through October 31st) in all of the model grids within the applicable Coastal Primary Contact Recreational waters of Long Island Sound. Within the Coastal Primary Contact Recreational waters of New York Bay, attainment with the *Enterococci* 30-day STV criterion fell short of 95 percent in portions of the Upper Bay, extending along the Brooklyn shoreline to Gravesend Bay, along with some individual model cells along the Staten Island shoreline, part of Raritan Bay adjacent to the southwest corner of Staten Island, and one model cell in Rockaway Inlet.

Figure 6-2. Harlem River Fecal Coliform Annual Attainment, Baseline Conditions, 10-Year Simulation

Figure 6-3. Harlem River Fecal Coliform Recreational Season Attainment, Baseline Conditions, 10-Year Simulation

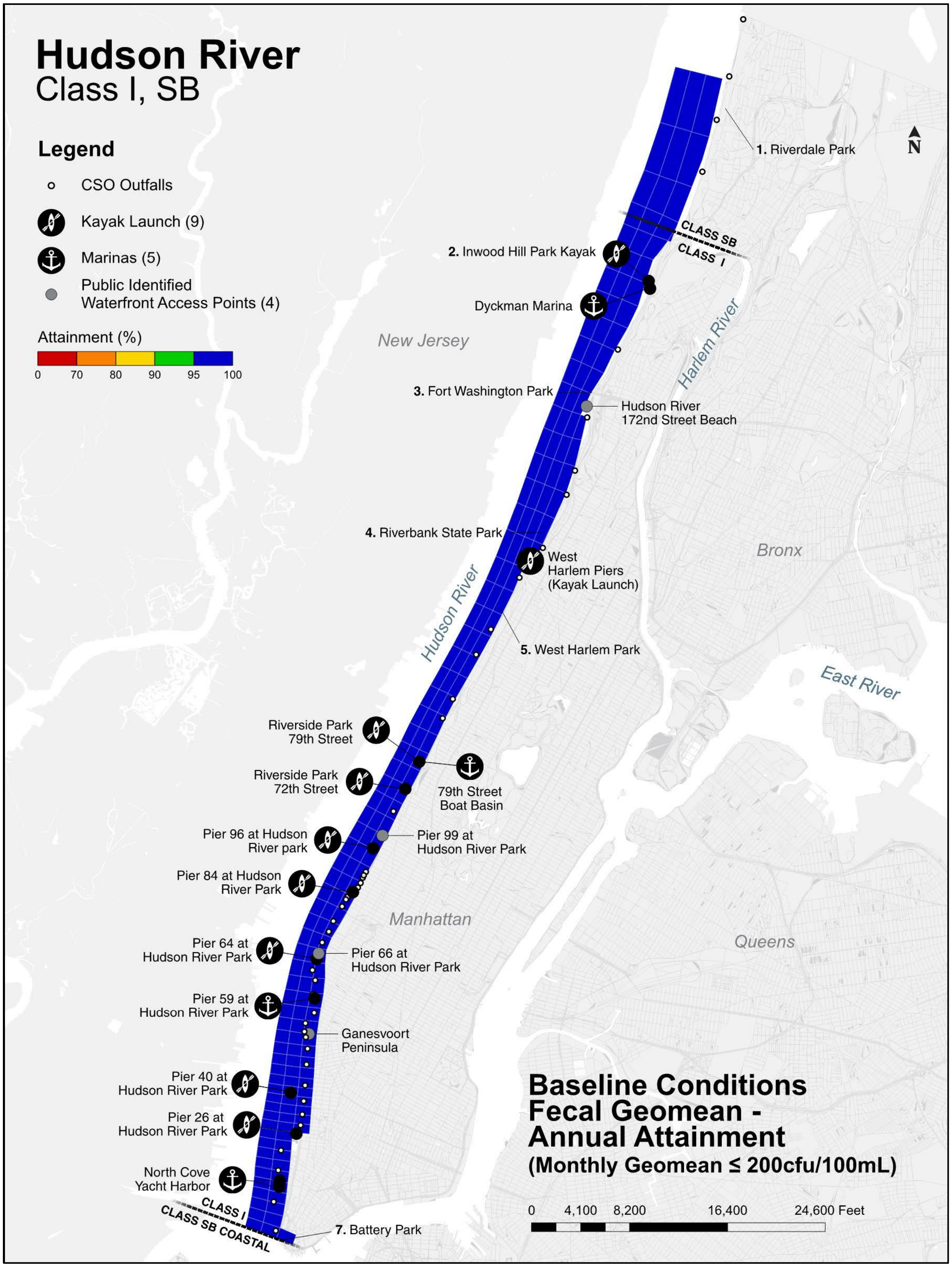

Figure 6-4. Hudson River Fecal Coliform Annual Attainment, Baseline Conditions, 10-Year Simulation

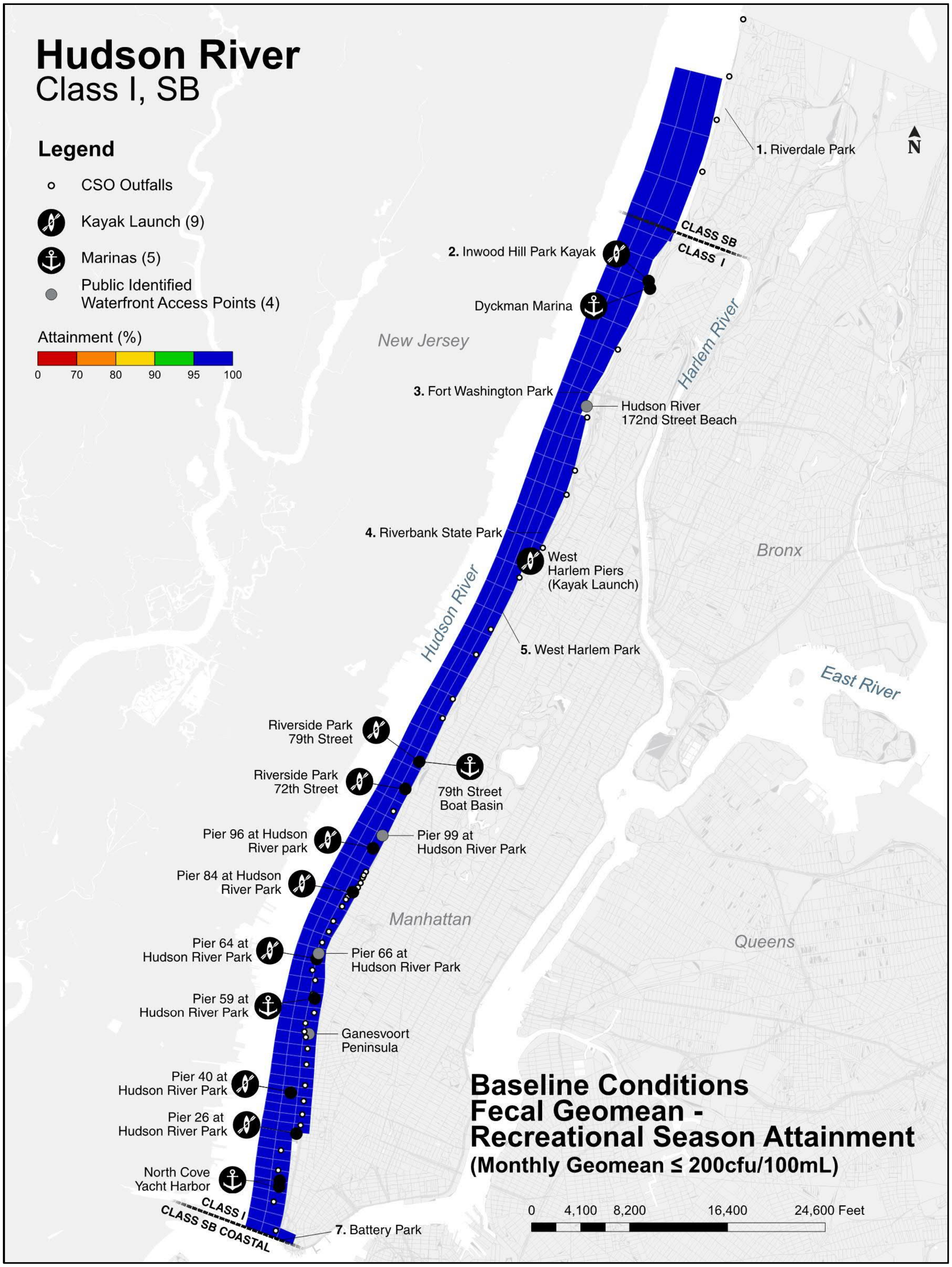

Figure 6-5. Hudson River Fecal Coliform Recreational Season Attainment, Baseline Conditions, 10-Year Simulation

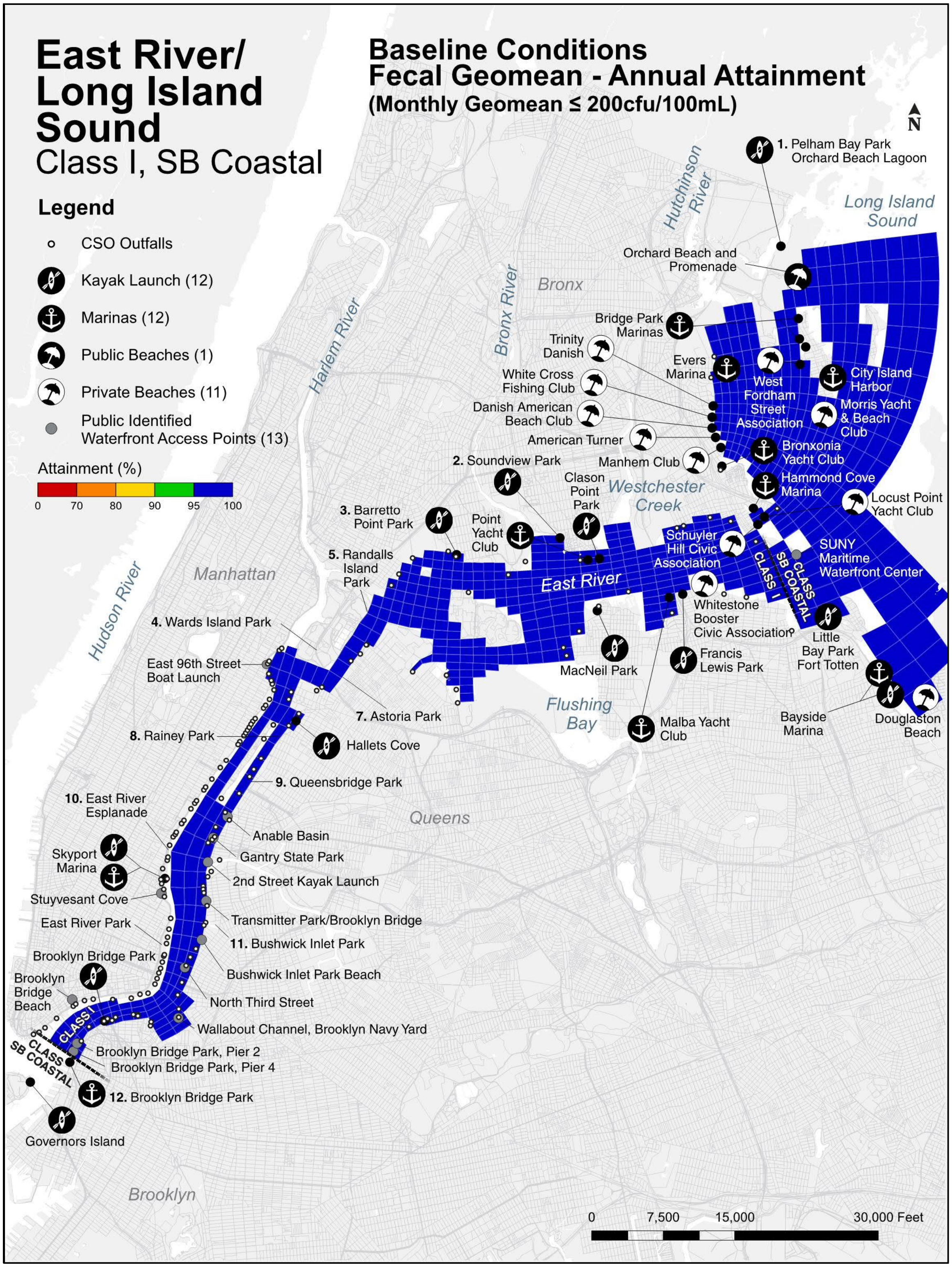

Figure 6-6. East River/Long Island Sound Fecal Coliform Annual Attainment, Baseline Conditions, 10-Year Simulation

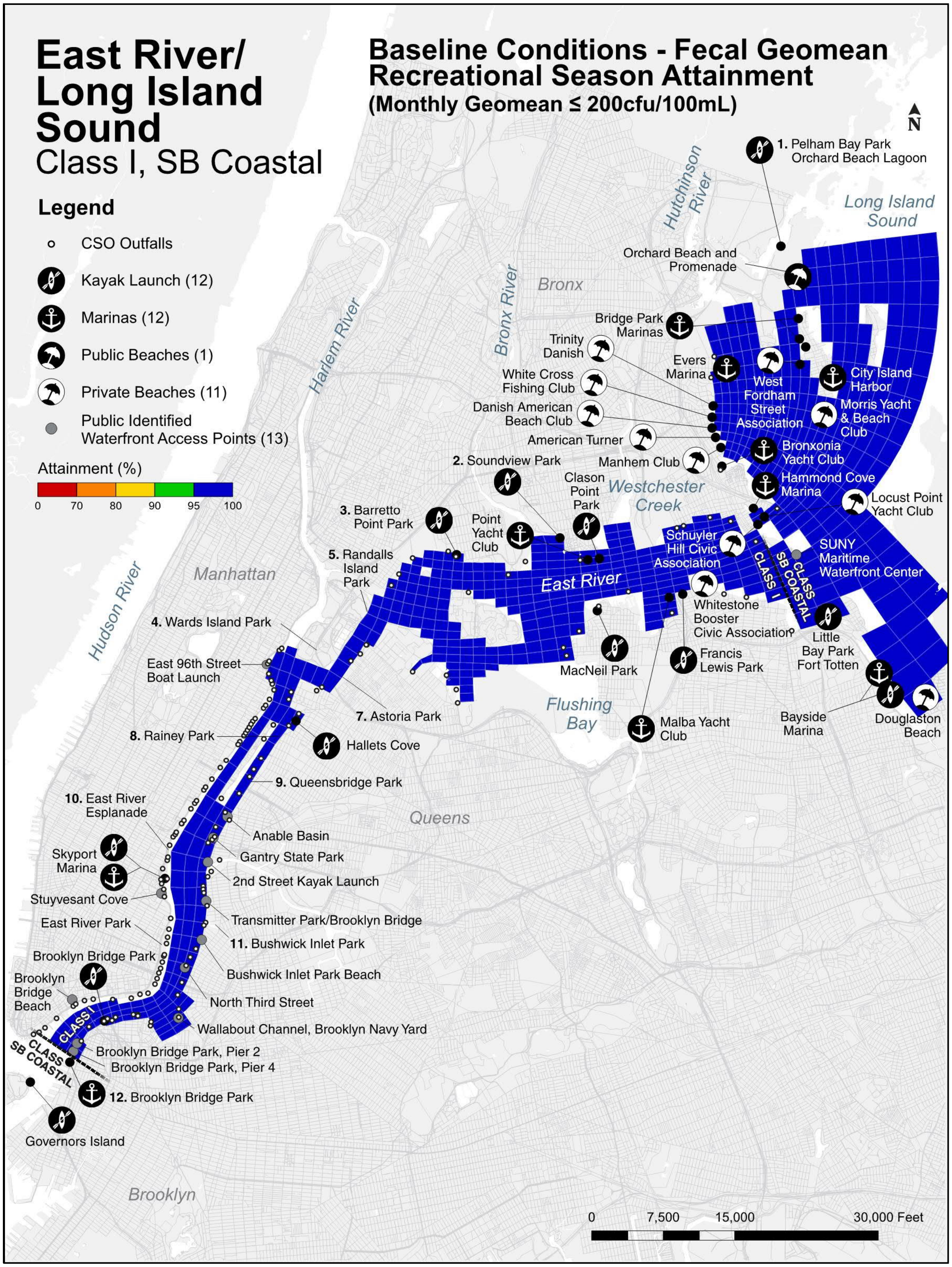

Figure 6-7. East River/Long Island Sound Fecal Coliform Recreational Season Attainment, Baseline Conditions, 10-Year Simulation

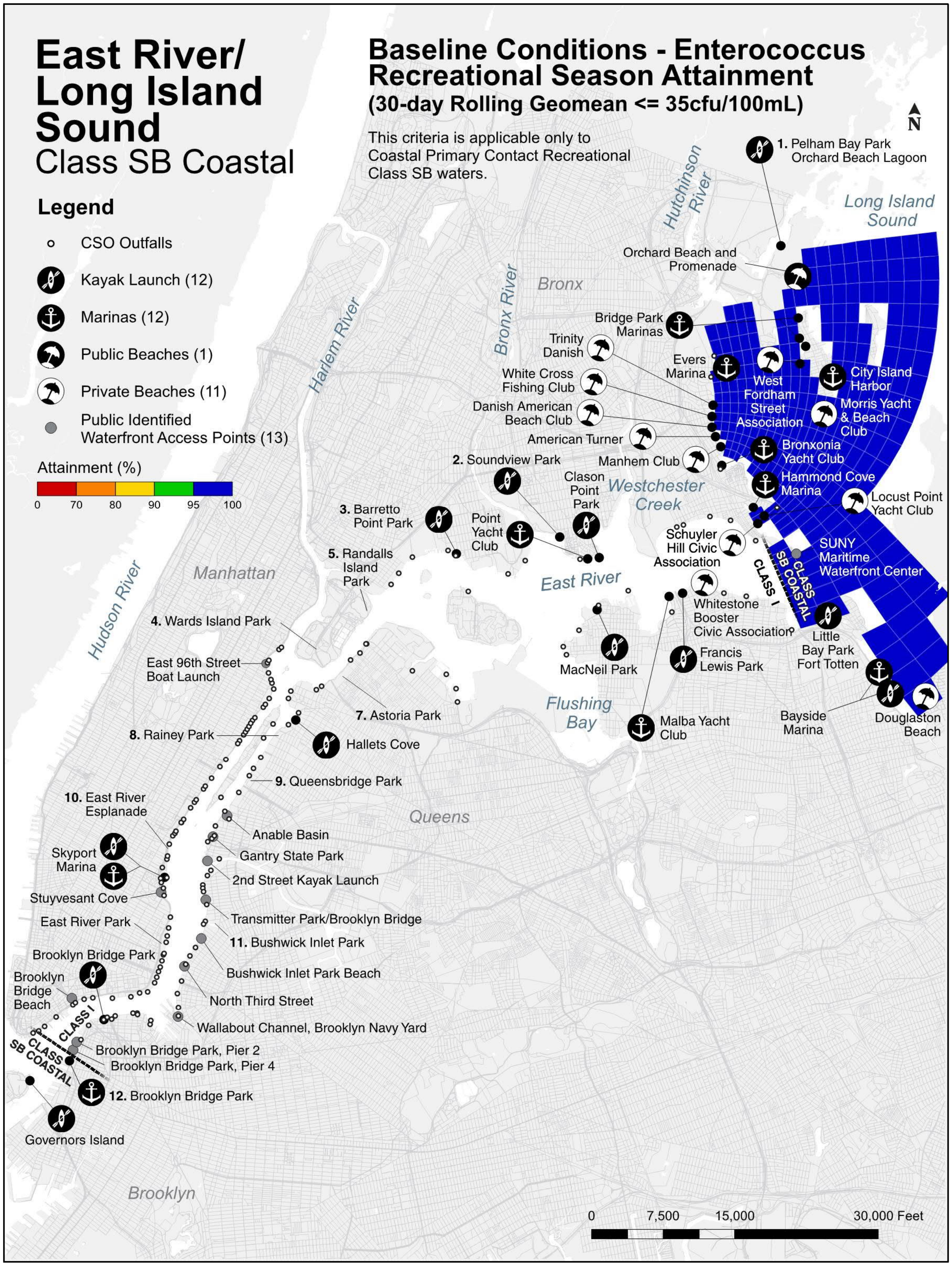

Figure 6-8. East River/Long Island Sound Enterococcus 30-Day Geometric Mean Recreational Season Attainment, Baseline Conditions, 10-Year Simulation

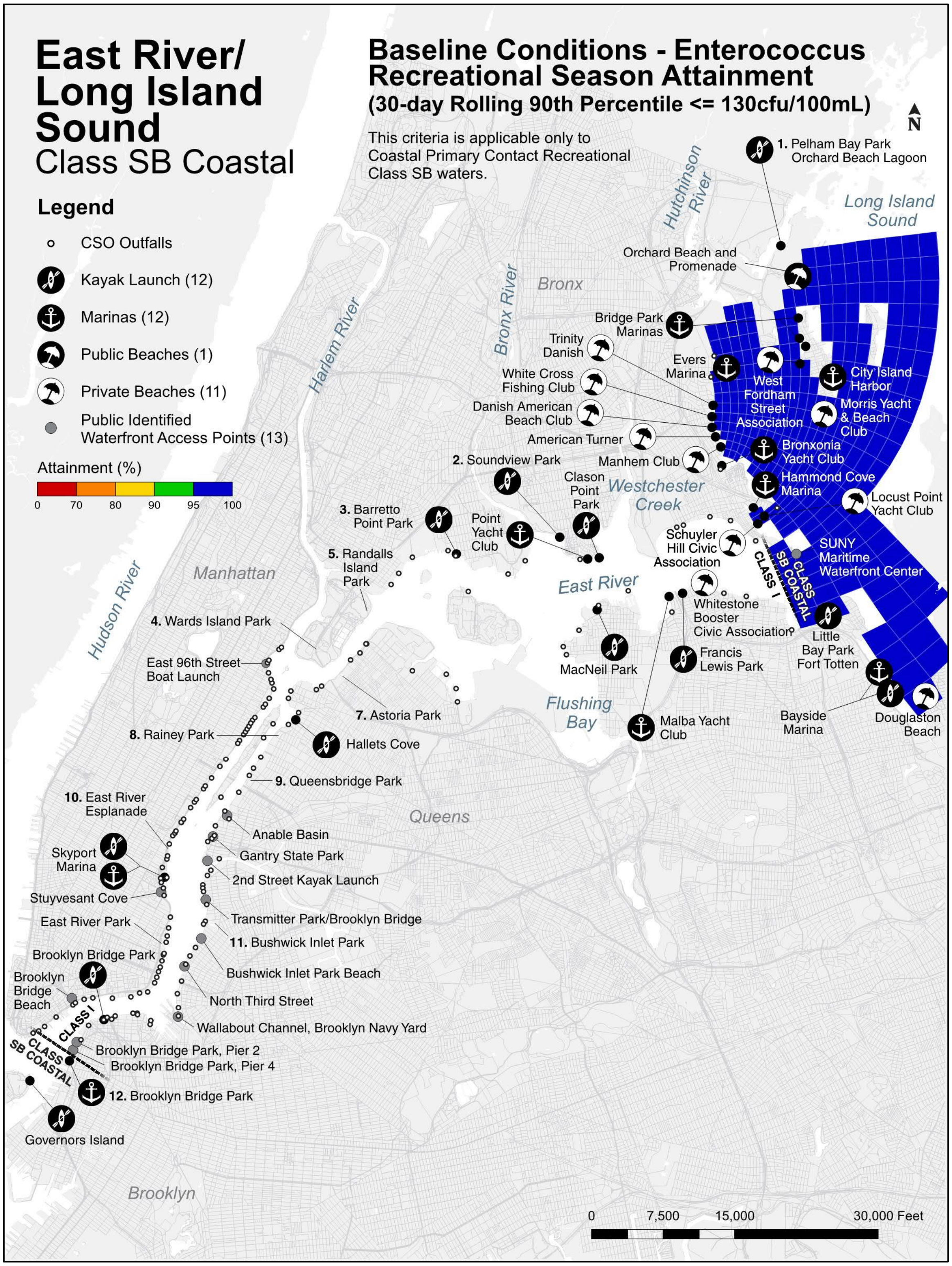

Figure 6-9. East River/Long Island Sound Enterococcus 30-Day STV Recreational Season Attainment, Baseline Conditions, 10-Year Simulation

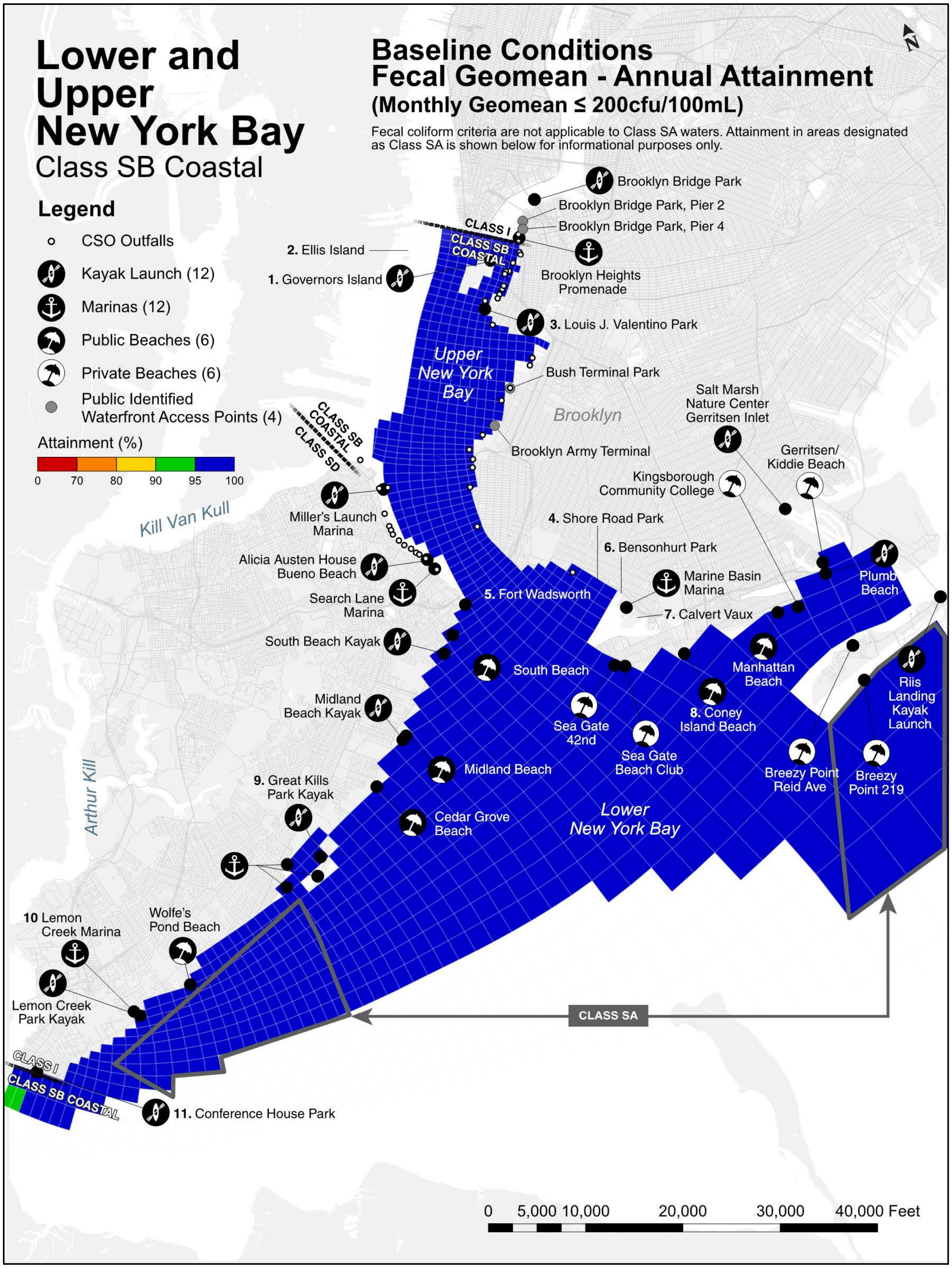

Figure 6-10. New York Bay Fecal Coliform Annual Attainment, Baseline Conditions, 10-Year Simulation

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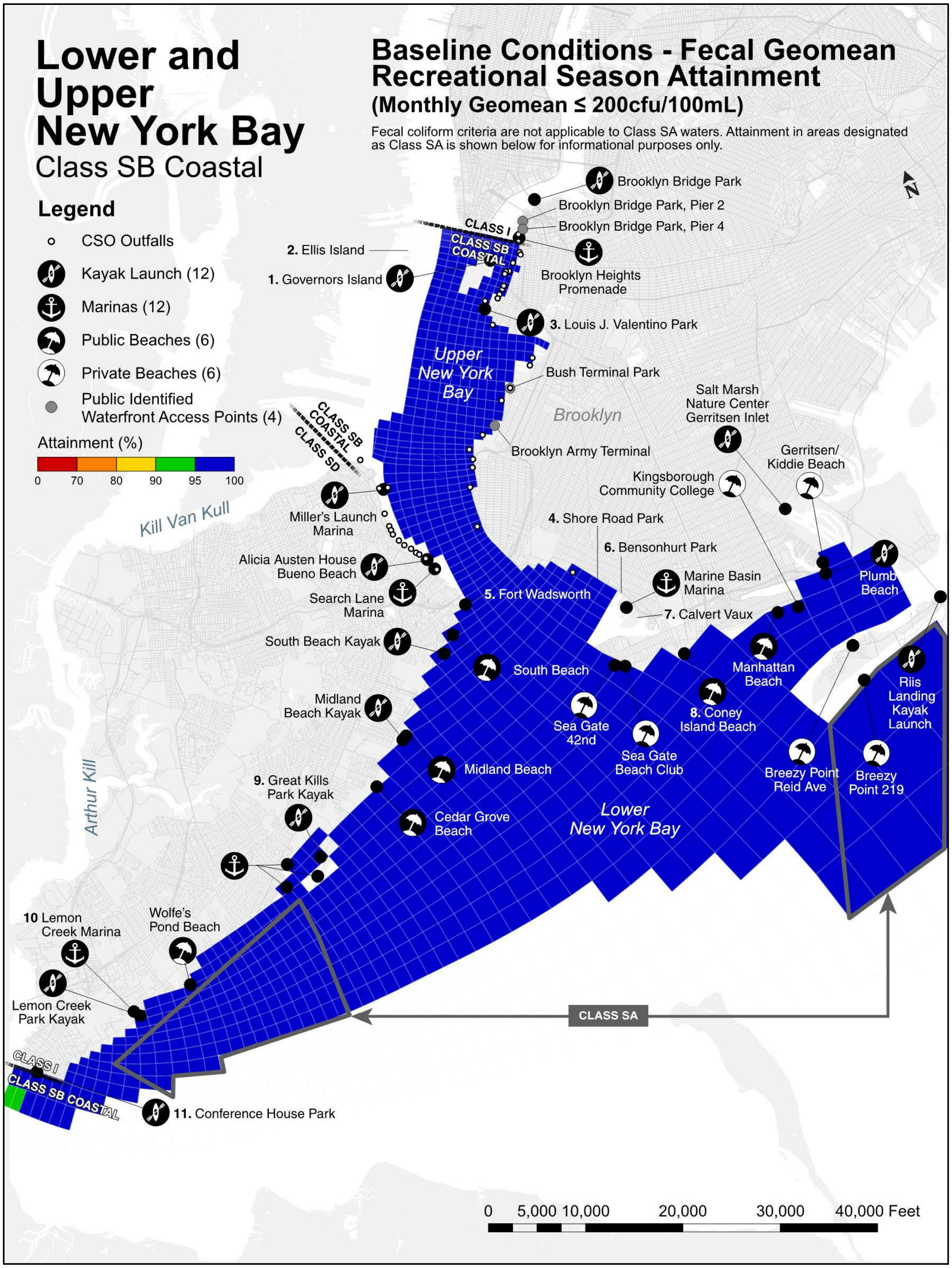

Figure 6-11. New York Bay Fecal Coliform Recreational Season Attainment, Baseline Conditions, 10-Year Simulation

AECOM *with* Hazen

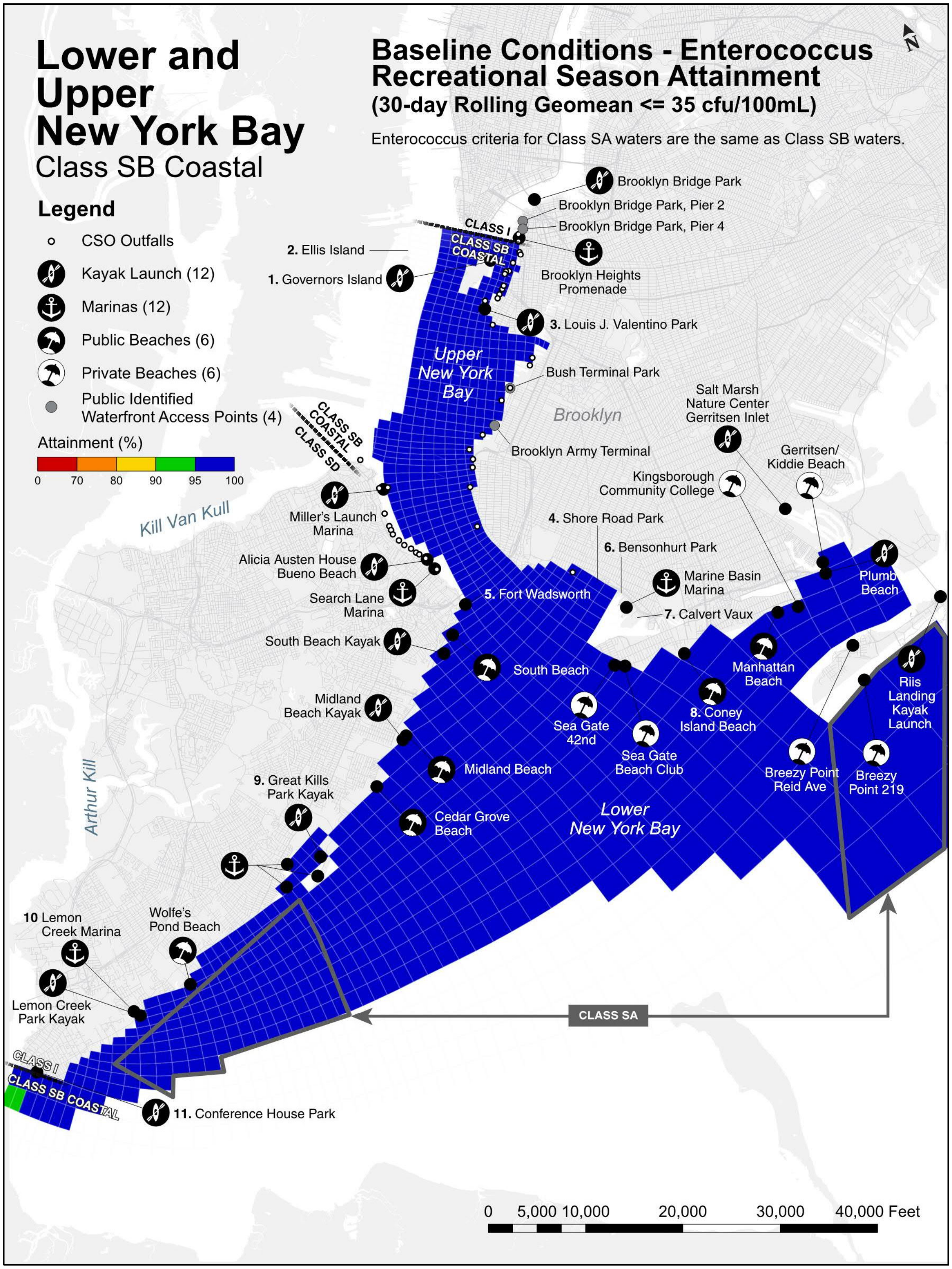

Figure 6-12. New York Bay Enterococcus 30-Day Geometric Mean Recreational Season Attainment, Baseline Conditions, 10-Year Simulation

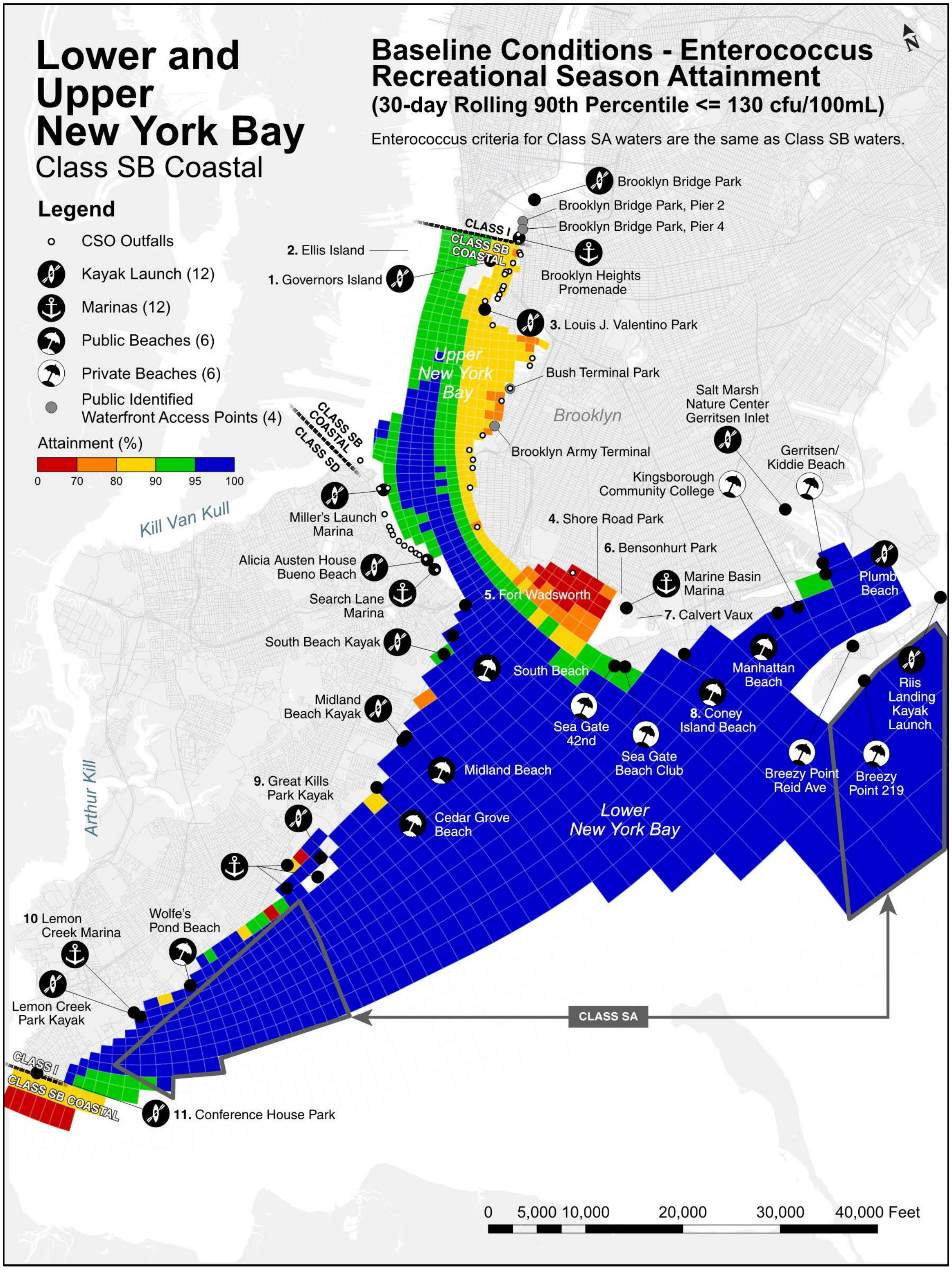

Figure 6-13. New York Bay Enterococcus 30-Day STV Recreational Season Attainment, Baseline Conditions, 10-Year Simulation

AECOM with Hazen

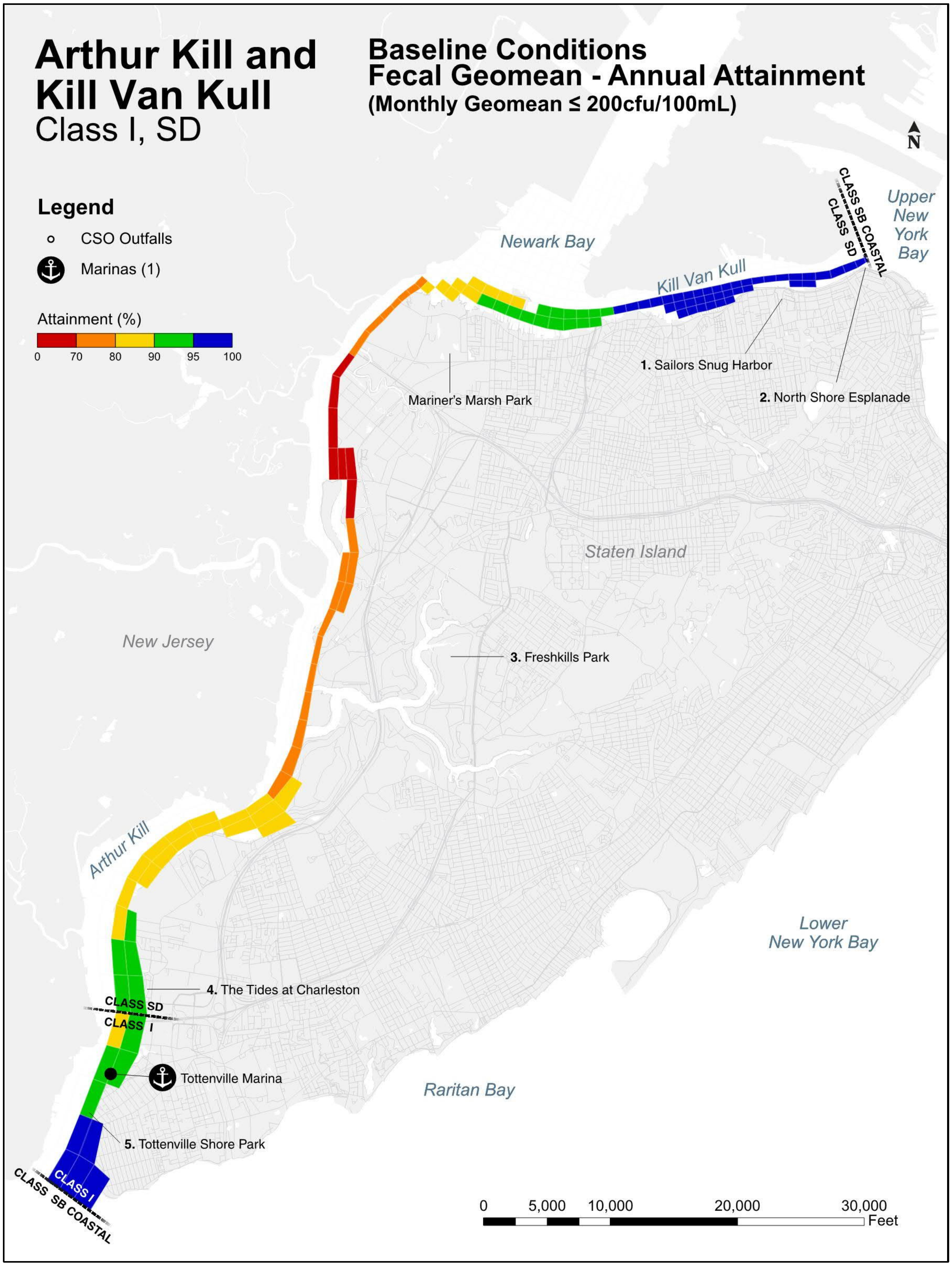

Figure 6-14. Arthur Kill/Kill Van Kull Fecal Coliform Annual Attainment, Baseline Conditions, 10-Year Simulation

Figure 6-15. Arthur Kill/Kill Van Kull Fecal Coliform Recreational Season Attainment, Baseline Conditions, 10-Year Simulation

Table 6-11 and Table 6-12 below present modeled values of maximum monthly GM and percent attainment at LTCP or HSM sampling stations in the Citywide/Open Waters waterbodies. The locations of the sampling stations are shown in Figure 6-16 to Figure 6-20.

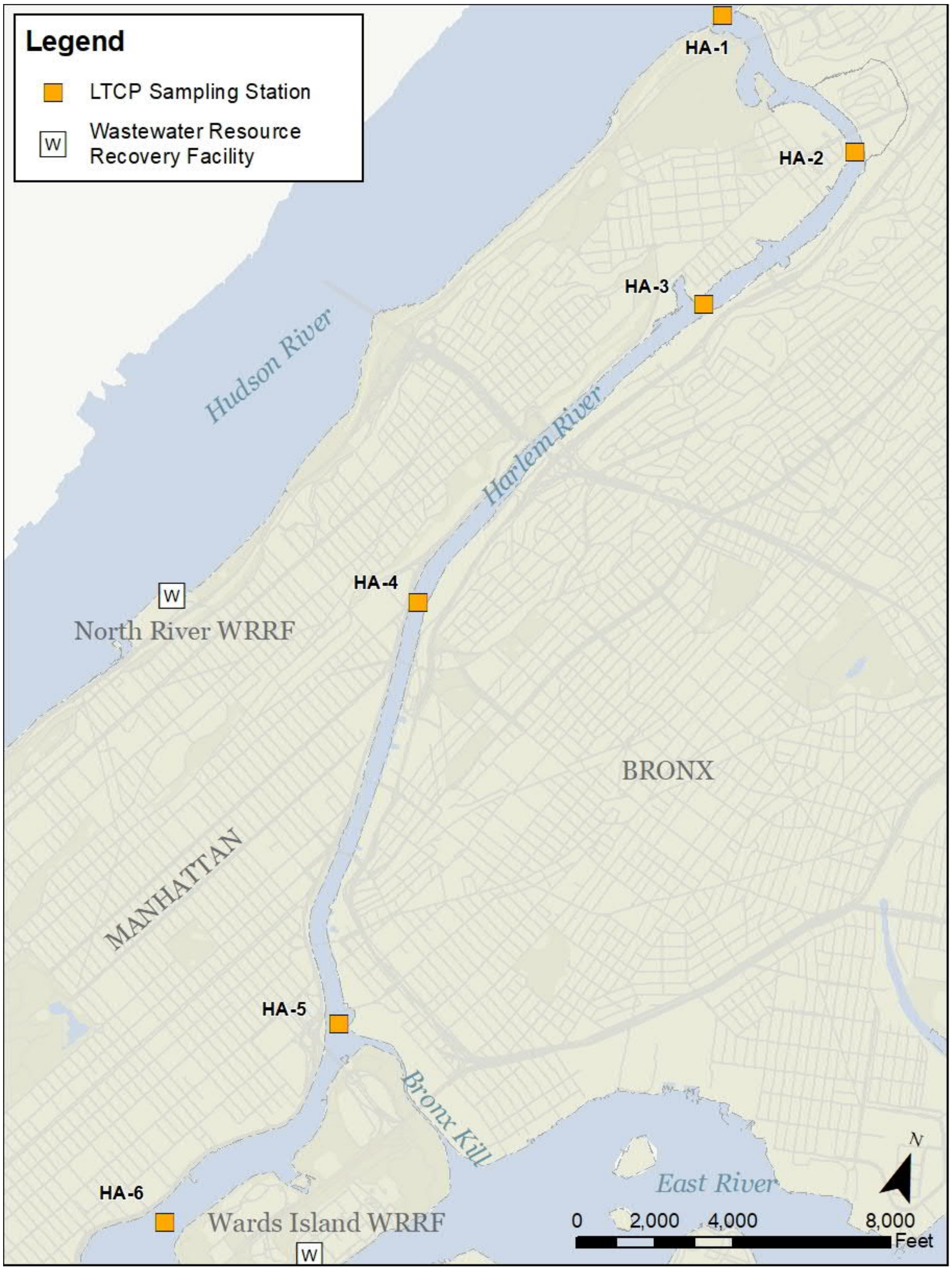

Figure 6-16. LTCP Sampling Stations in Harlem River

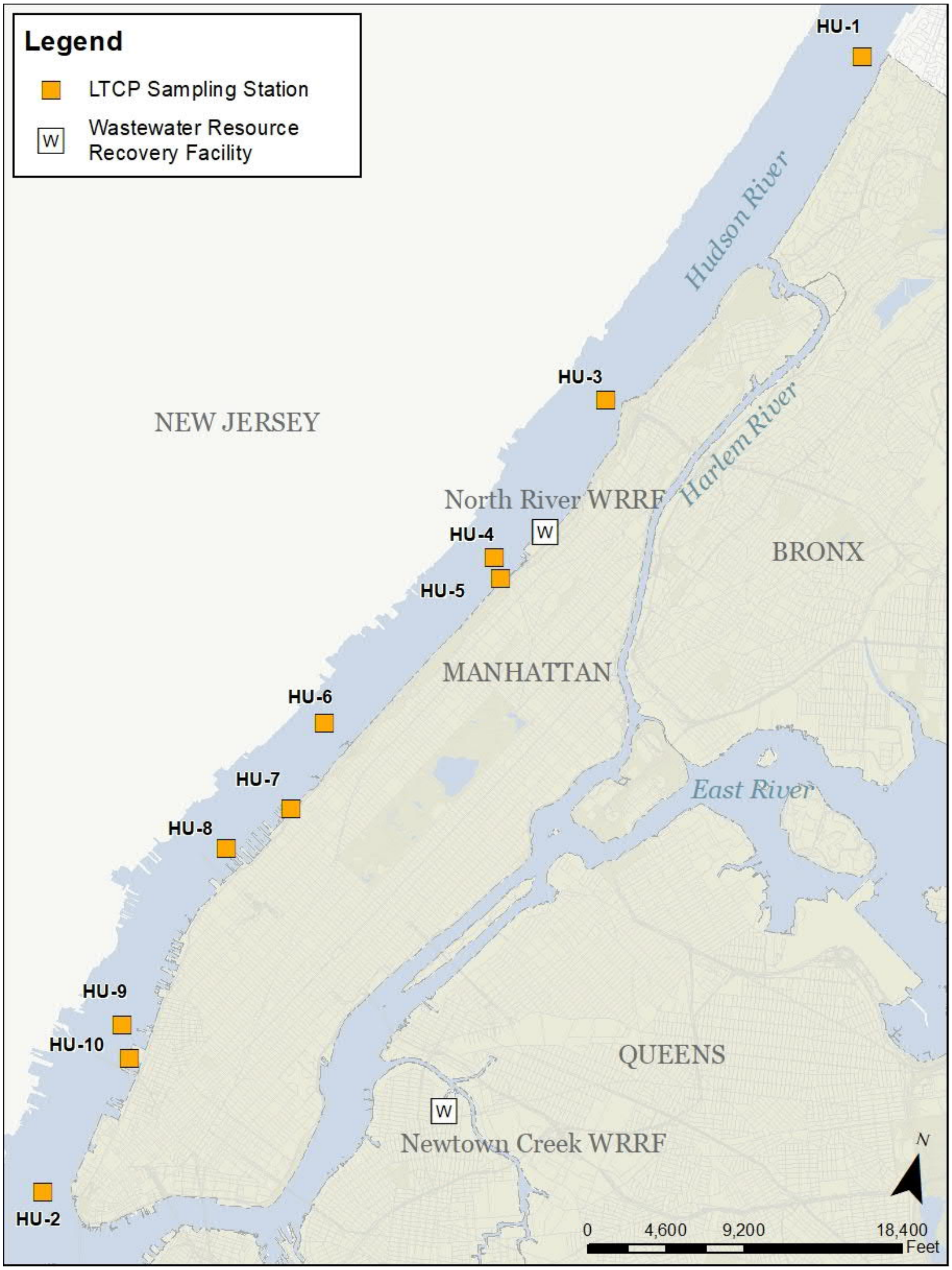

Figure 6-17. LTCP Sampling Stations in Hudson River

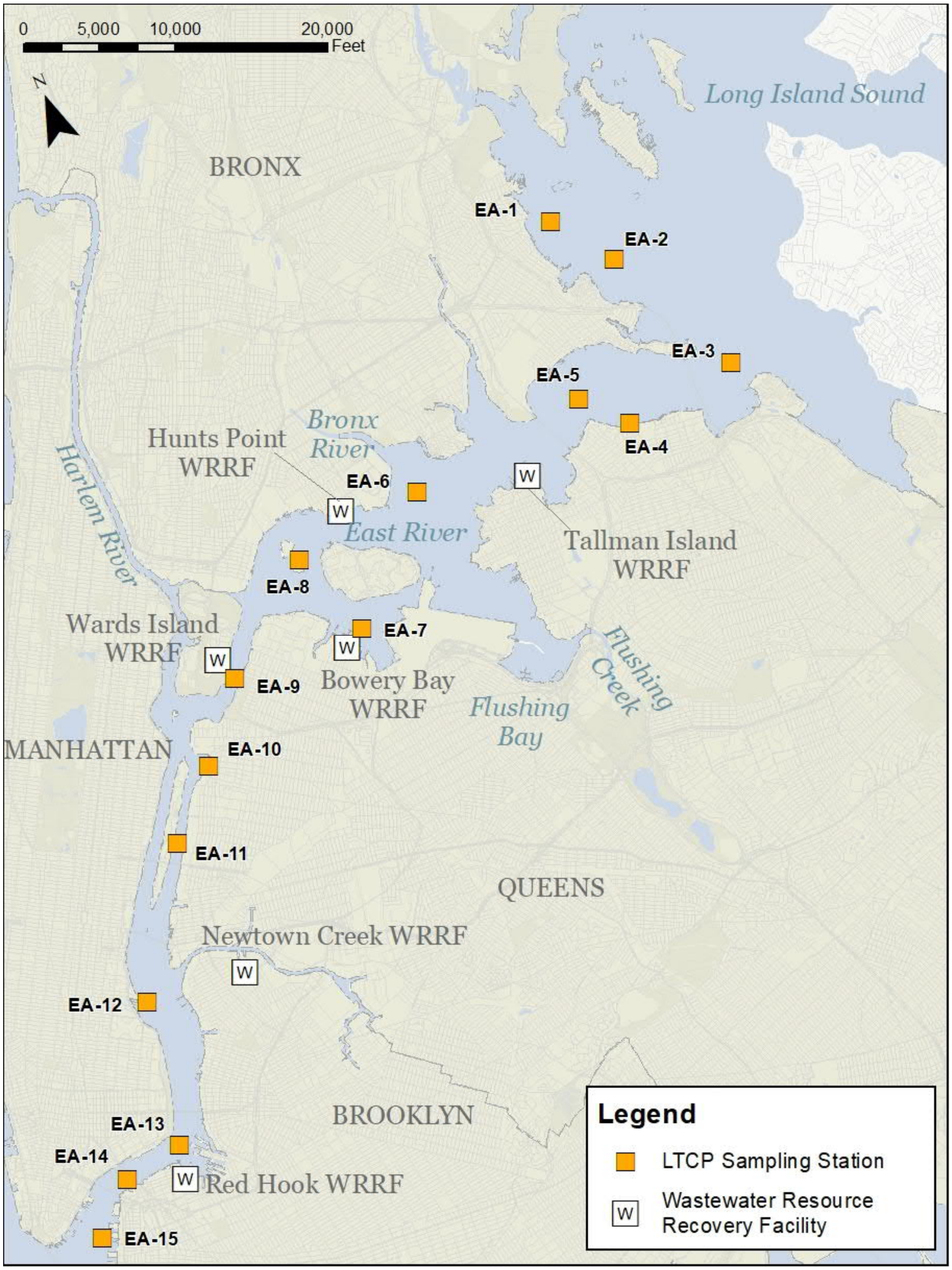

Figure 6-18. LTCP Sampling Stations in East River/Long Island Sound

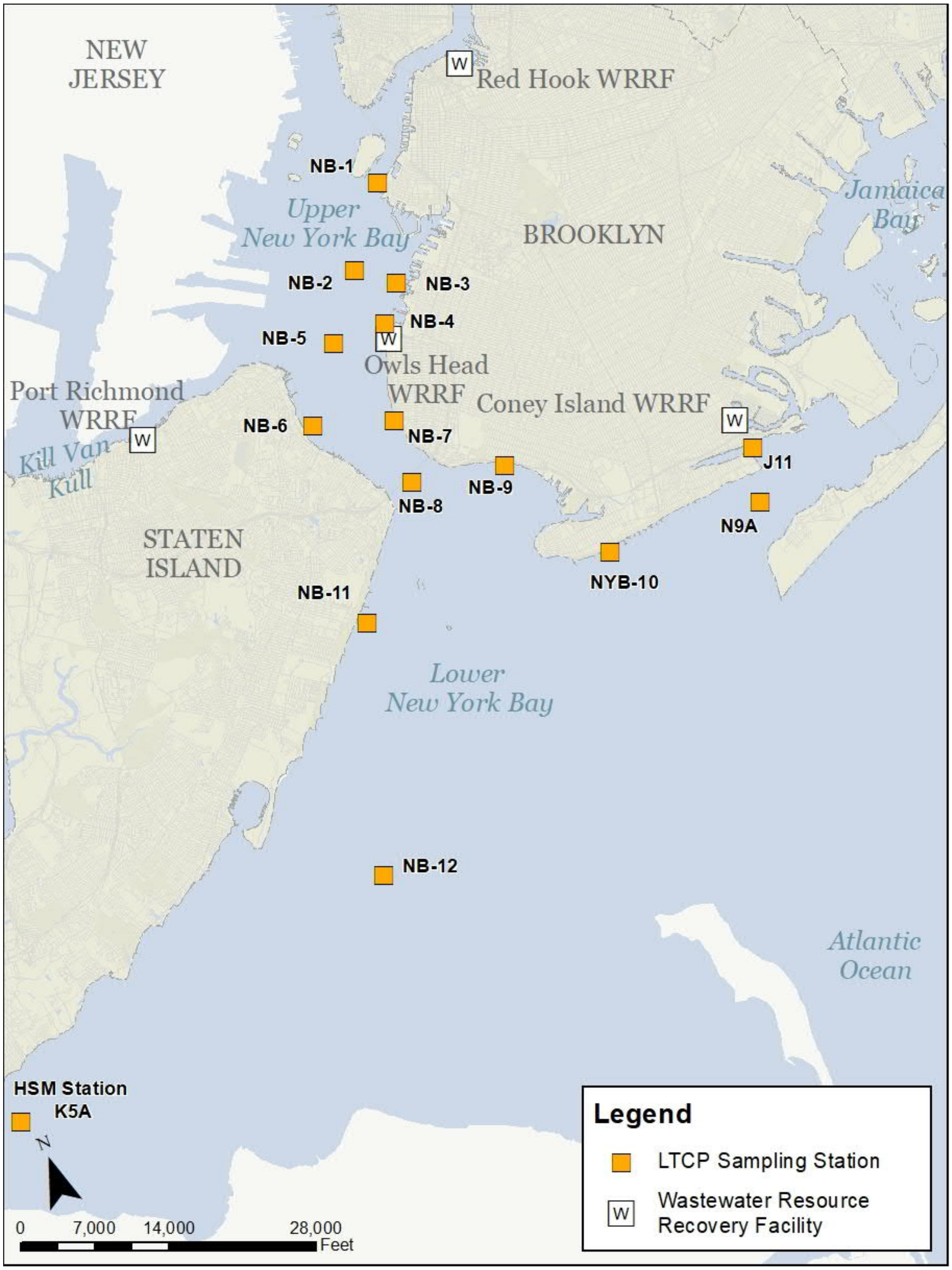

Figure 6-19. LTCP/HSM Sampling Stations in New York Bay

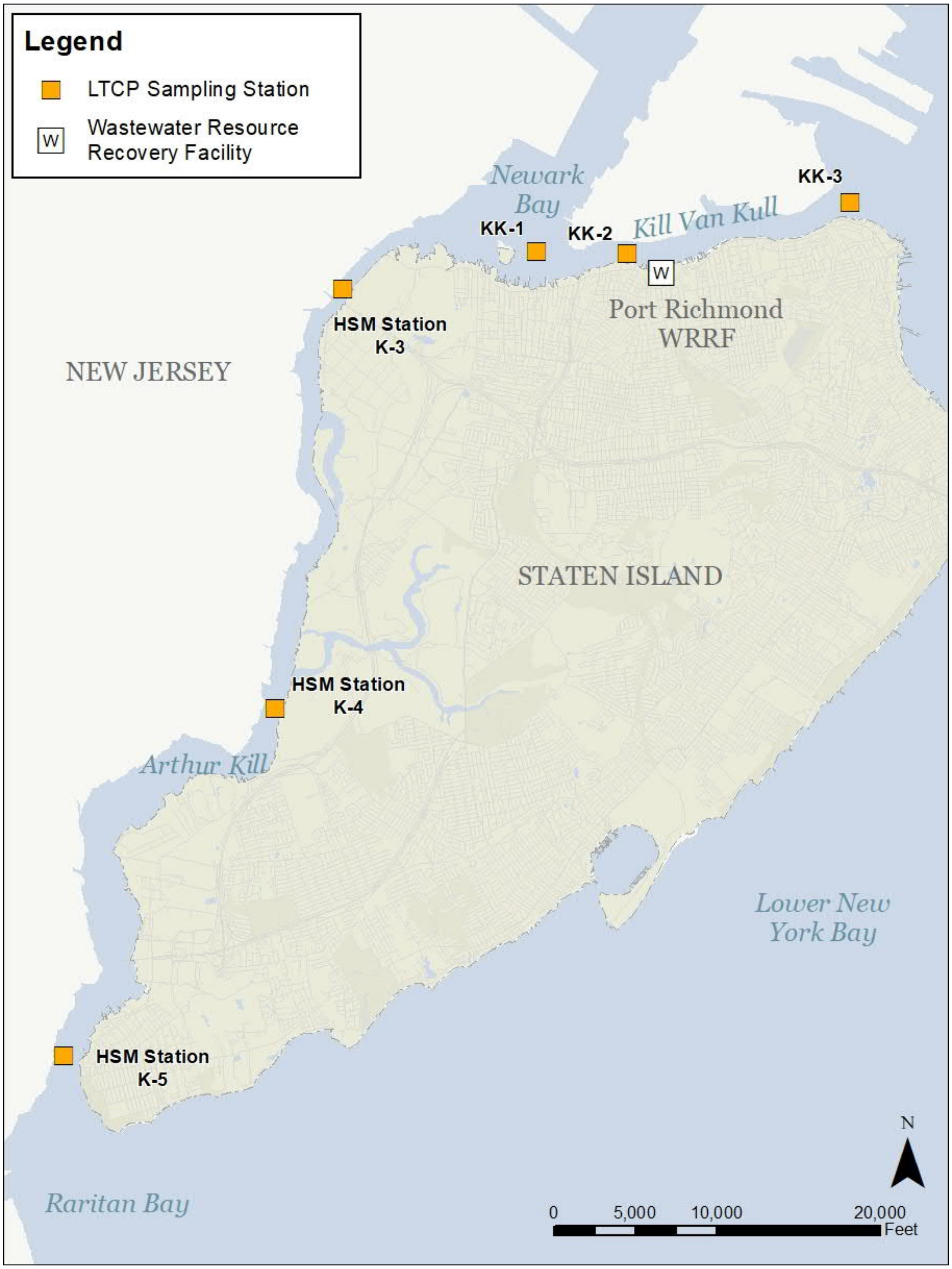

Figure 6-20. LTCP/HSM Sampling Stations in Arthur Kill and Kill Van Kull

Table 6-11 presents the highest calculated monthly fecal coliform GM at LTCP sampling locations in the Citywide/Open Waters waterbodies during the 10-year period on an annual basis and during the recreational season (May 1st through October 31st), for the baseline conditions. Table 6-11 also presents the percent of time that the fecal coliform monthly GM criterion of 200 cfu/100mL would be attained over the 10-year simulation period. The locations of the stations listed in Table 6-11 are shown above on Figure 6-16 to Figure 6-20.

Table 6-11. Model Calculated 10-Year Baseline Fecal Coliform Maximum Monthly GM and Percent Attainment of WQ Criteria

	Maximum Monthly GMs (cfu/100mL)		% Attainment (GM ≤200 cfu/100mL)	
Description	**Annual**	**Recreational Season(1)**	**Annual**	**Recreational Season(1)**
Long Island Sound east of Throgs Neck Bridge (Class SB Coastal Primary Contact Recreational)				
EA-1	41	22	100%	100%
EA-2	39	18	100%	100%
EA-3	67	35	100%	100%
Upper and Lower New York Bay (Class SB Coastal Primary Contact Recreational)				
NB-1	177	112	100%	100%
NB-2	170	103	100%	100%
NB-3	165	113	100%	100%
NB-4	166	113	100%	100%
NB-5	158	93	100%	100%
NB-6	152	92	100%	100%
NB-7	157	106	100%	100%
NB-8	127	74	100%	100%
NB-9	218	157	99%	100%
NB-10	69	27	100%	100%
NB-11	76	33	100%	100%
NB-12	83	26	100%	100%
Raritan Bay (Class SB Coastal Primary Contact Recreational)				
K5A	276	134	95%	100%
Rockaway Inlet (Class SB Coastal Primary Contact Recreational)				
J11	53	21	100%	100%
N9A	33	13	100%	100%
East River between Whitestone Bridge and Throgs Neck Bridge (Class SB)				
EA-4	85	49	100%	100%
EA-5	91	55	100%	100%
Hudson River, North of Harlem River (Class SB)				
HU-1	125	87	100%	100%
Hudson River, Battery to Harlem River (Class I)				
HU-2	158	96	100%	100%

Table 6-11. Model Calculated 10-Year Baseline Fecal Coliform Maximum Monthly GM and Percent Attainment of WQ Criteria

	Maximum Monthly GMs (cfu/100mL)		% Attainment (GM ≤200 cfu/100mL)	
Description	**Annual**	**Recreational Season(1)**	**Annual**	**Recreational Season(1)**
HU-3	189	99	100%	100%
HU-4	197	103	100%	100%
HU-5	192	102	100%	100%
HU-6	205	102	99%	100%
HU-7	203	106	99%	100%
HU-8	194	108	100%	100%
HU-9	206	131	99%	100%
HU-10	184	102	100%	100%
Harlem River (Class I)				
HA-1	280	196	98%	100%
HA-2	445	303	97%	97%
HA-3	484	296	97%	97%
HA-4	618	308	97%	97%
HA-5	769	326	98%	98%
HA-6	360	150	99%	100%
East River, Battery to Whitestone Bridge (Class I)				
EA-6	134	95	100%	100%
EA-7	178	123	100%	100%
EA-8	162	111	100%	100%
EA-9	182	118	100%	100%
EA-10	215	140	99%	100%
EA-11	206	132	99%	100%
EA-12	193	126	100%	100%
EA-13	194	122	100%	100%
EA-14	196	122	100%	100%
EA-15	193	118	100%	100%
Arthur Kill, Raritan Bay to Outerbridge Crossing (Class I)				
K5	340	143	93%	100%
Arthur Kill, Outerbridge Crossing to Kill Van Kull (Class SD)				
K3	650	459	60%	90%
K4	520	281	77%	98%
Kill Van Kull (Class SD)				
KK-1	255	144	95%	100%
KK-2	251	142	96%	100%
KK-3	168	100	100%	100%

Note:
(1) The recreational season is from May 1st through October 31st.

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Table 6-12 presents the maximum 30-day rolling geometric mean *Enterococcus* concentration, and the maximum 30-day 90th percentile STV *Enterococcus* value at LTCP sampling stations in the Class SB Coastal Primary Contact Recreational Citywide/Open Waters waterbodies for the recreational season periods in the 10-year baseline conditions continuous simulation.

Table 6-12. Model Calculated 10-Year Baseline Maximum Recreational Season *Enterococci* GM and 90th Percentile STV, and Percent Attainment with *Enterococci* Criteria

	Maximum Recreational Season(1) 30-day *Enterococci* (cfu/100mL)		% Attainment	
Description	**GM**	**90th Percentile STV**	**Recreational Season(1) GM ≤ 35 cfu/100mL**	**Recreational Season(1) 90th Percentile STV ≤ 130 cfu/100mL**
Long Island Sound east of Throgs Neck Bridge (Class SB Coastal Primary Contact Recreational)				
EA-1	7	238	100%	99%
EA-2	7	50	100%	100%
EA-3	14	114	100%	100%
Upper and Lower New York Bay (Class SB Coastal Primary Contact Recreational)				
NB-1	43	640	99.6%	84%
NB-2	37	498	99.8%	89%
NB-3	42	745	99.7%	82%
NB-4	42	779	99.6%	83%
NB-5	35	390	100%	94%
NB-6	35	343	100%	94%
NB-7	40	815	99.7%	82%
NB-8	30	309	100%	97%
NB-9	57	4,475	99%	50%
NB-10	10	152	100%	99%
NB-11	14	168	100%	98%
NB-12	13	131	100%	99%
Raritan Bay (Class SB Coastal Primary Contact Recreational)				
K5A	119	1,417	97%	68%
Rockaway Inlet (Class SB Coastal Primary Contact Recreational)				
J11	7	226	100%	91%
N9A	3	25	100%	100%

Note:
(1) The recreational season is from May 1st through October 31st.

The 10-year baseline condition scenario was then run with the CSO loadings from the CSO outfalls to the Citywide/Open Waters waterbodies removed. This projection represents the maximum possible reduction of CSO loads to the Citywide/Open Waters waterbodies and is referred to as the No NYC CSO Loads scenario. All other conditions from the baseline projection remain unchanged in the No NYC CSO Loads scenario. Figure 6-21 to Figure 6-30 present mosaics of the percent attainment with the monthly fecal coliform geometric mean criterion on an annual basis and for the recreational season (May 1st through October 31st) across the Citywide/Open Waters waterbodies, for the No NYC CSO Loads 10-year simulation.

As shown in these figures, the mosaics of the percent attainment with the monthly fecal coliform geometric mean criterion for the No NYC CSO Loads 10-year simulation for the Harlem, Hudson and East Rivers and New York Bay are identical to the Baseline Conditions mosaics shown above, as all the model cells in those waterbodies achieve greater than 95 percent attainment with the criteria on both an annual and recreational season (May 1st through October 31st) basis. For Arthur Kill and Kill Van Kull, the mosaics of the percent attainment with the monthly fecal coliform geometric mean criterion for the No NYC CSO Loads 10-year simulation were also identical to the Baseline Conditions mosaics shown above in Figure 6-14 and Figure 6-15. The locations where the Baseline Conditions attainment fell below 95 percent did not change under the No NYC CSO Loads simulation.

Table 6-13 presents the highest calculated monthly fecal coliform GM at LTCP sampling locations in the Citywide/Open Waters waterbodies during the 10-year period on an annual basis and during the recreational season (May 1st through October 31st), for the baseline conditions and No NYC CSO Loads.

Figure 6-21. Harlem River Fecal Coliform Annual Attainment, No NYC CSO Loads, 10-Year Simulation

Figure 6-22. Harlem River Fecal Coliform Recreational Season Attainment, No NYC CSO Loads, 10-Year Simulation

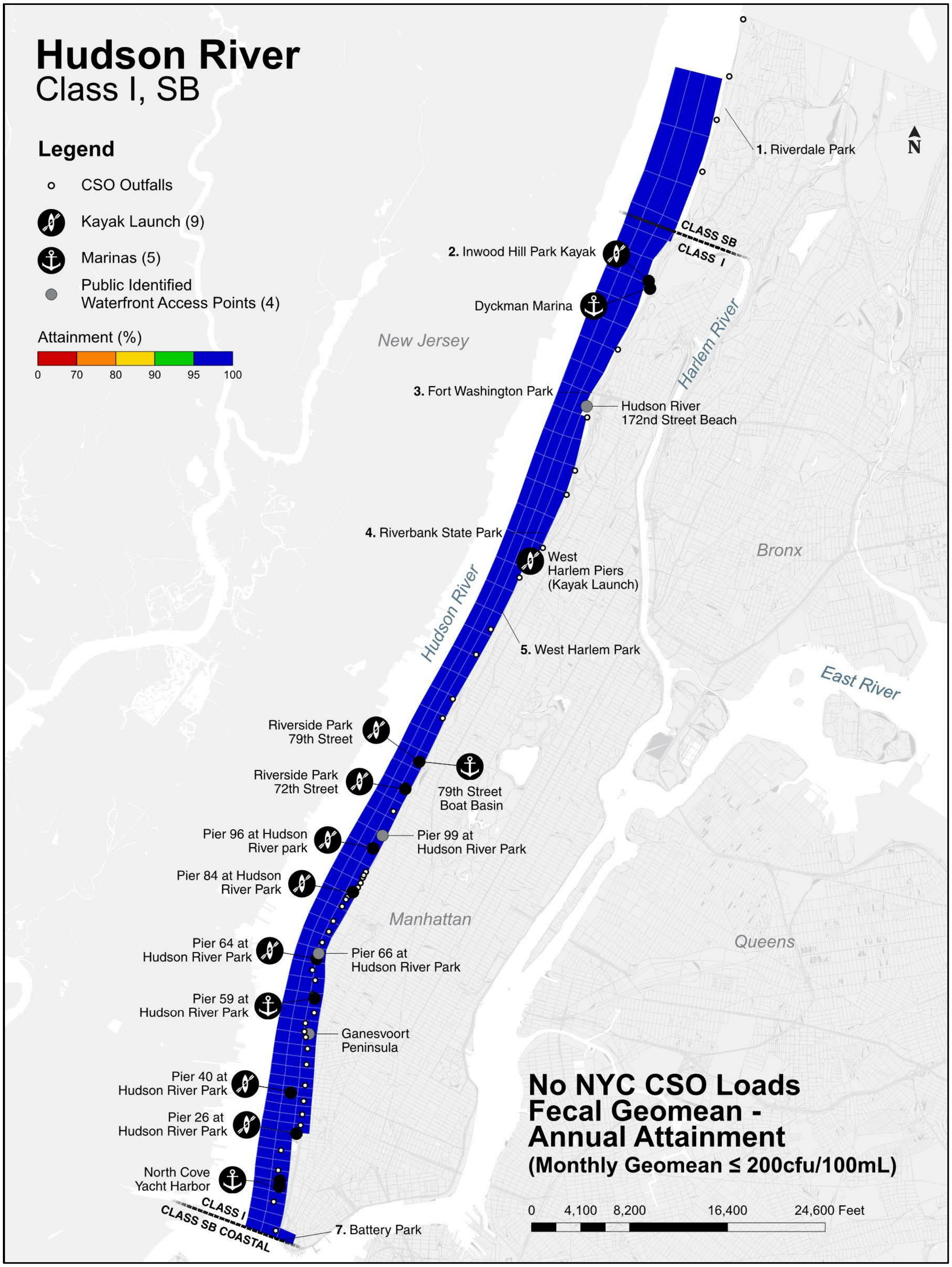

Figure 6-23. Hudson River Fecal Coliform Annual Attainment, No NYC CSO Loads, 10-Year Simulation

AECOM with Hazen

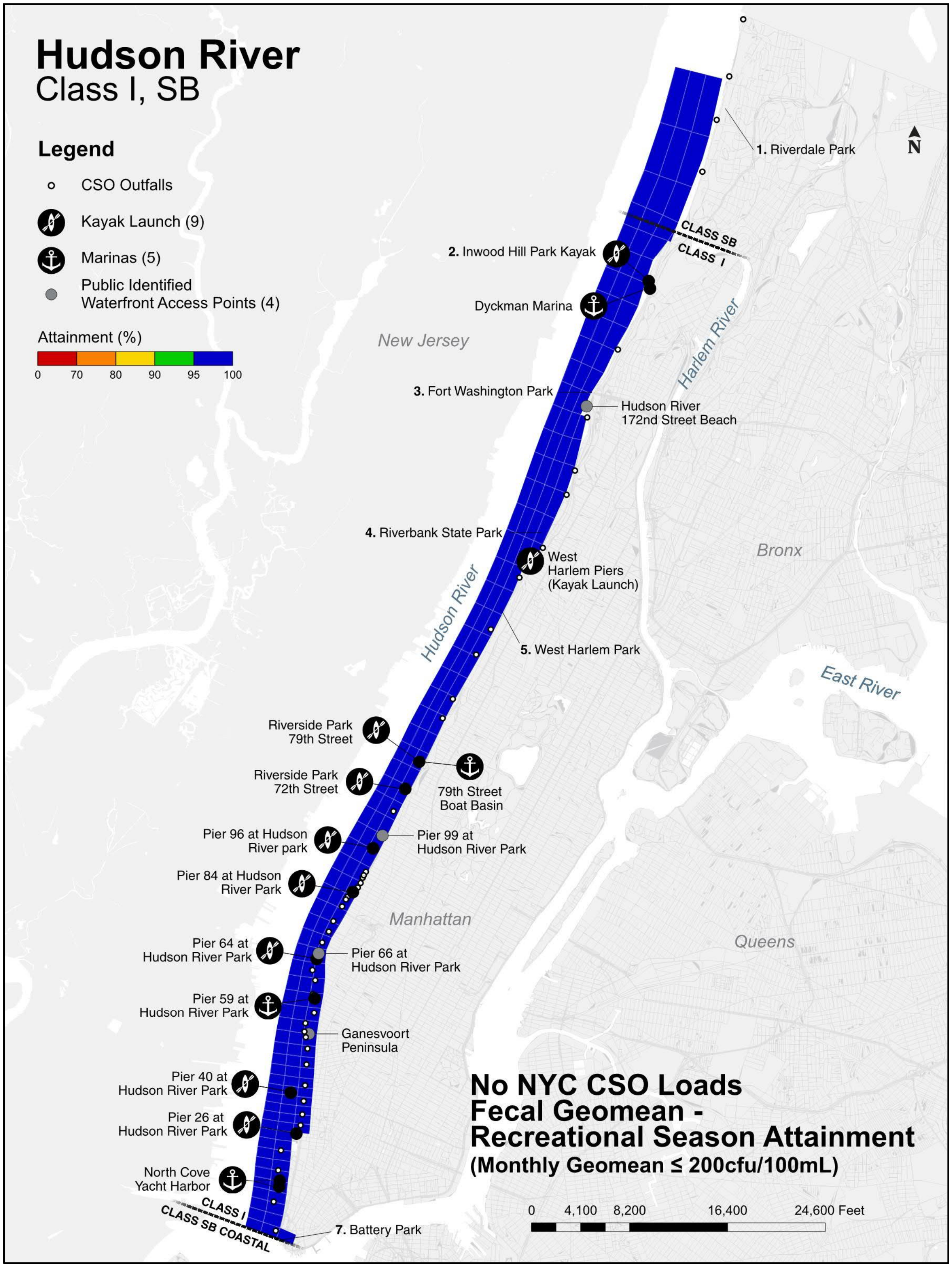

Figure 6-24. Hudson River Fecal Coliform Recreational Season Attainment, No NYC CSO Loads, 10-Year Simulation

AECOM with Hazen

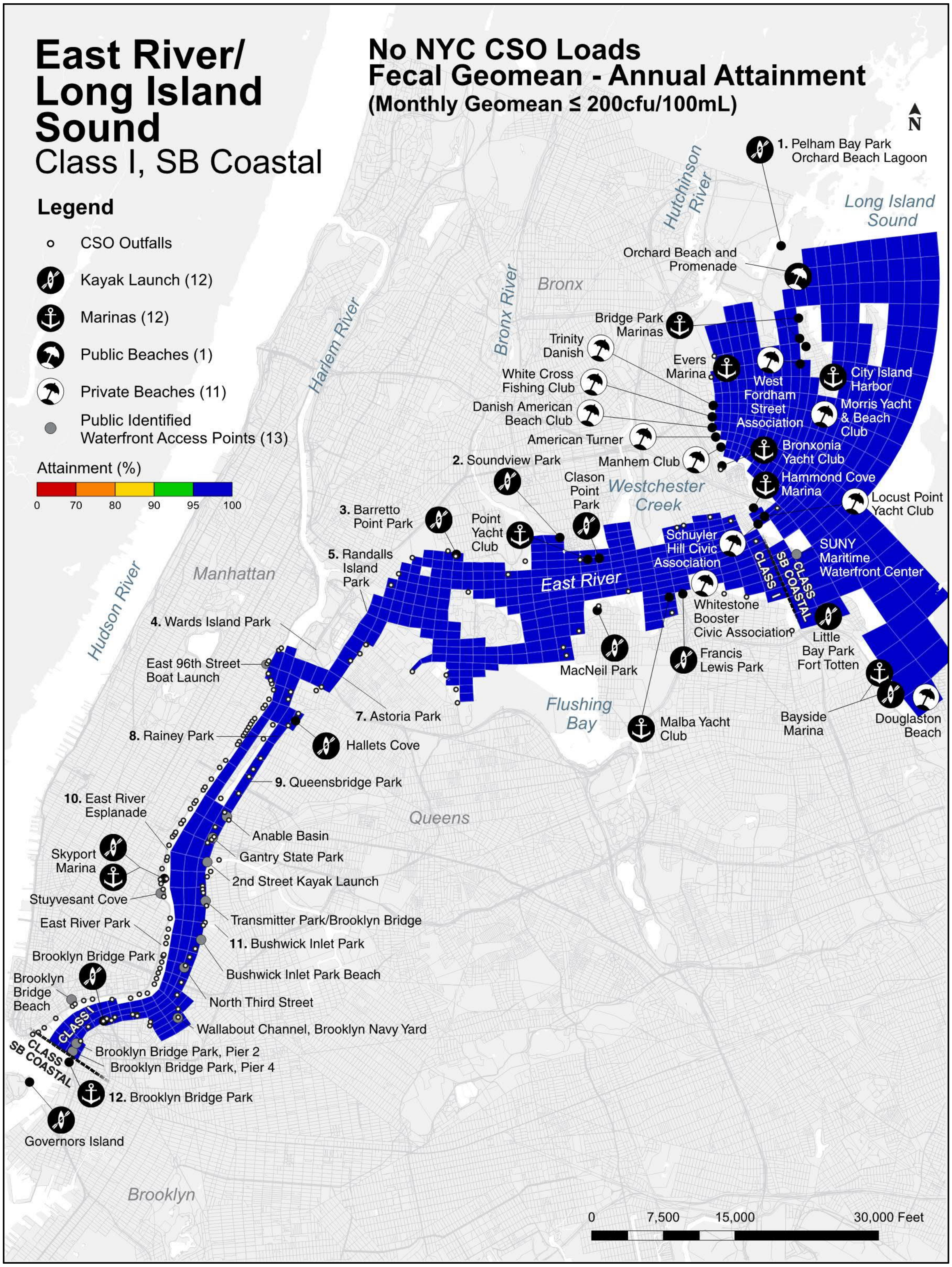

Figure 6-25. East River/Long Island Sound Fecal Coliform Annual Attainment, No NYC CSO Loads, 10-Year Simulation

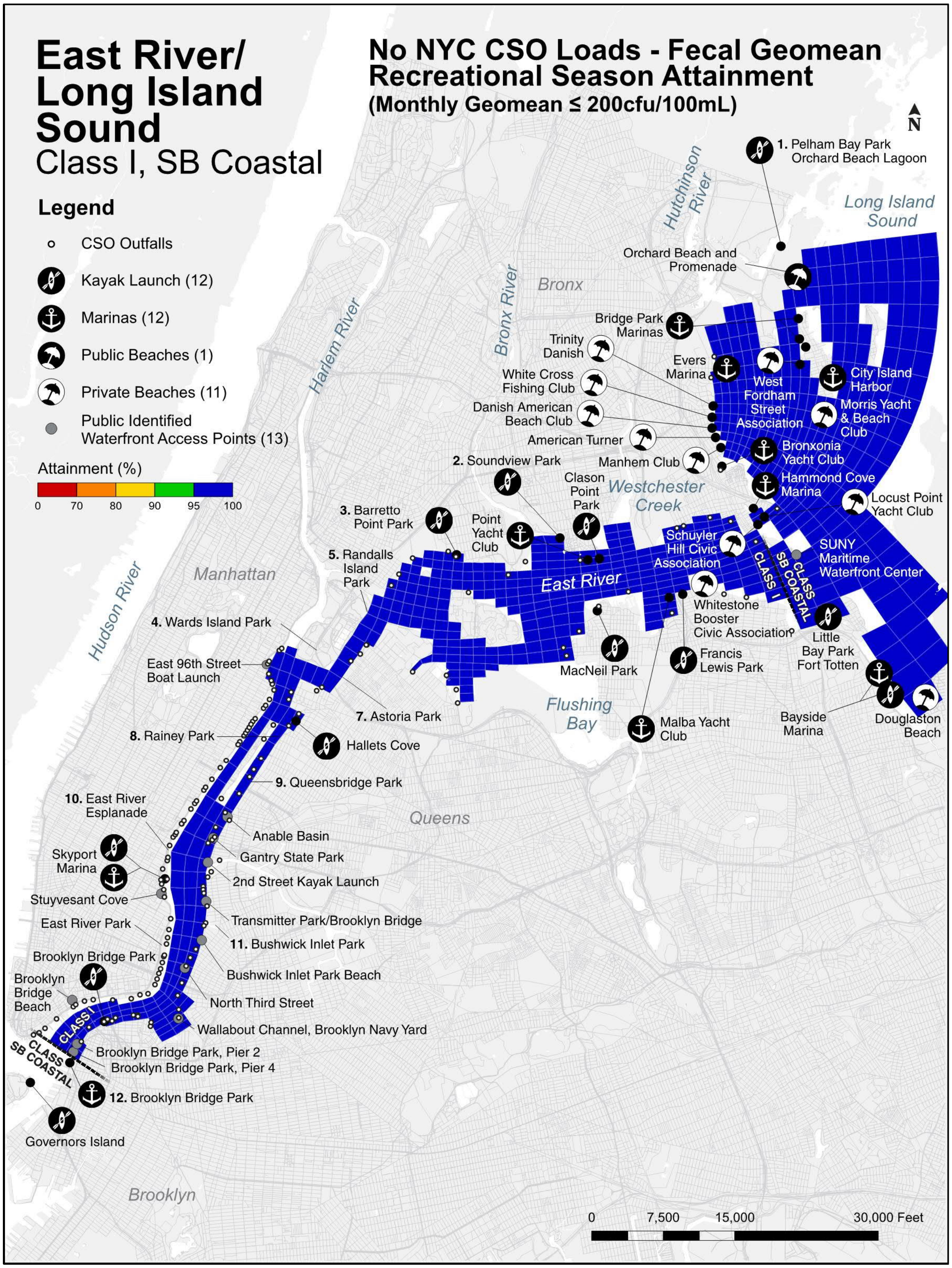

Figure 6-26. East River/Long Island Sound Fecal Coliform Recreational Season Attainment, No NYC CSO Loads, 10-Year Simulation

AECOM with Hazen

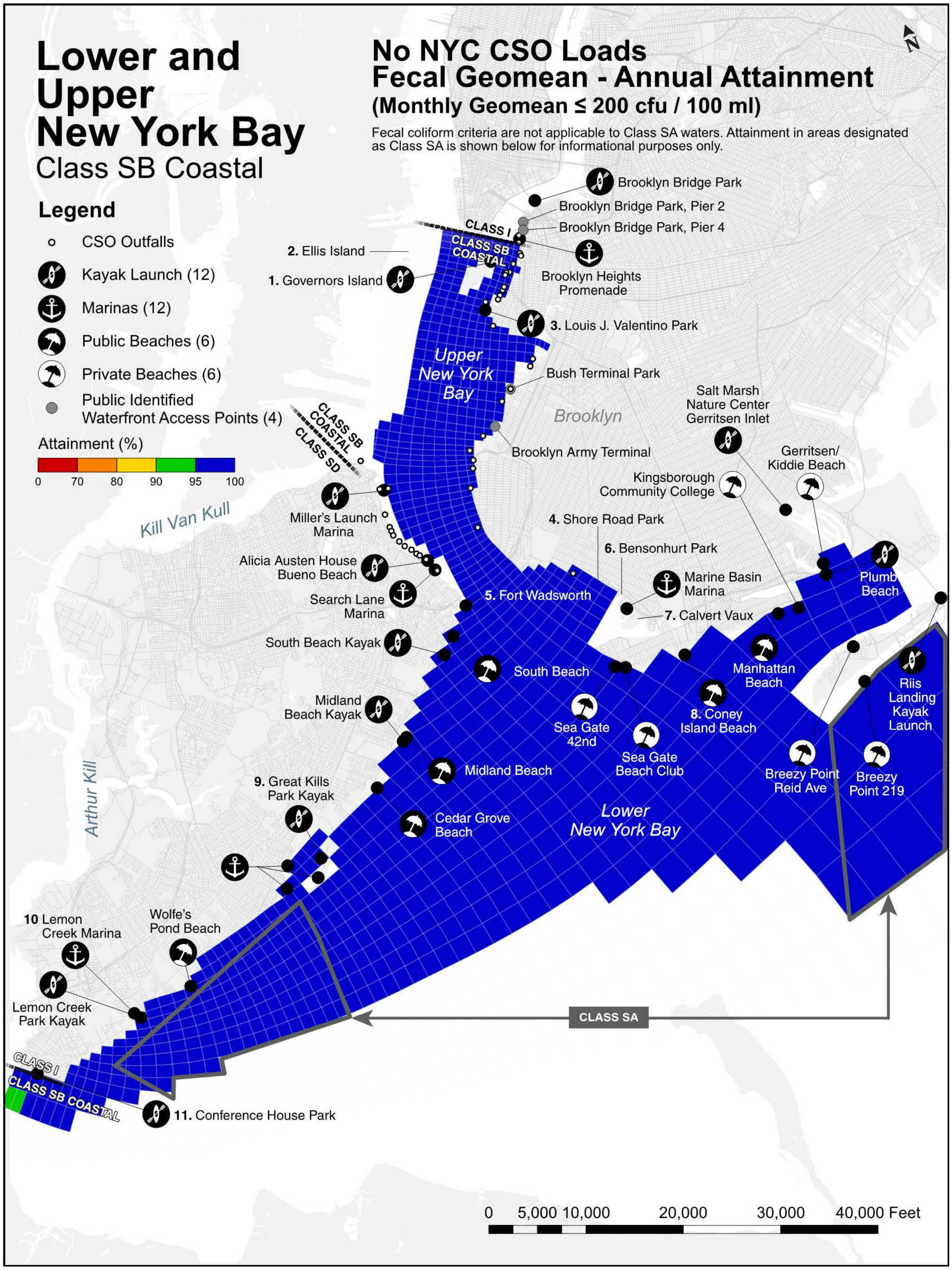

Figure 6-27. New York Bay Fecal Coliform Annual Attainment, No NYC CSO Loads, 10-Year Simulation

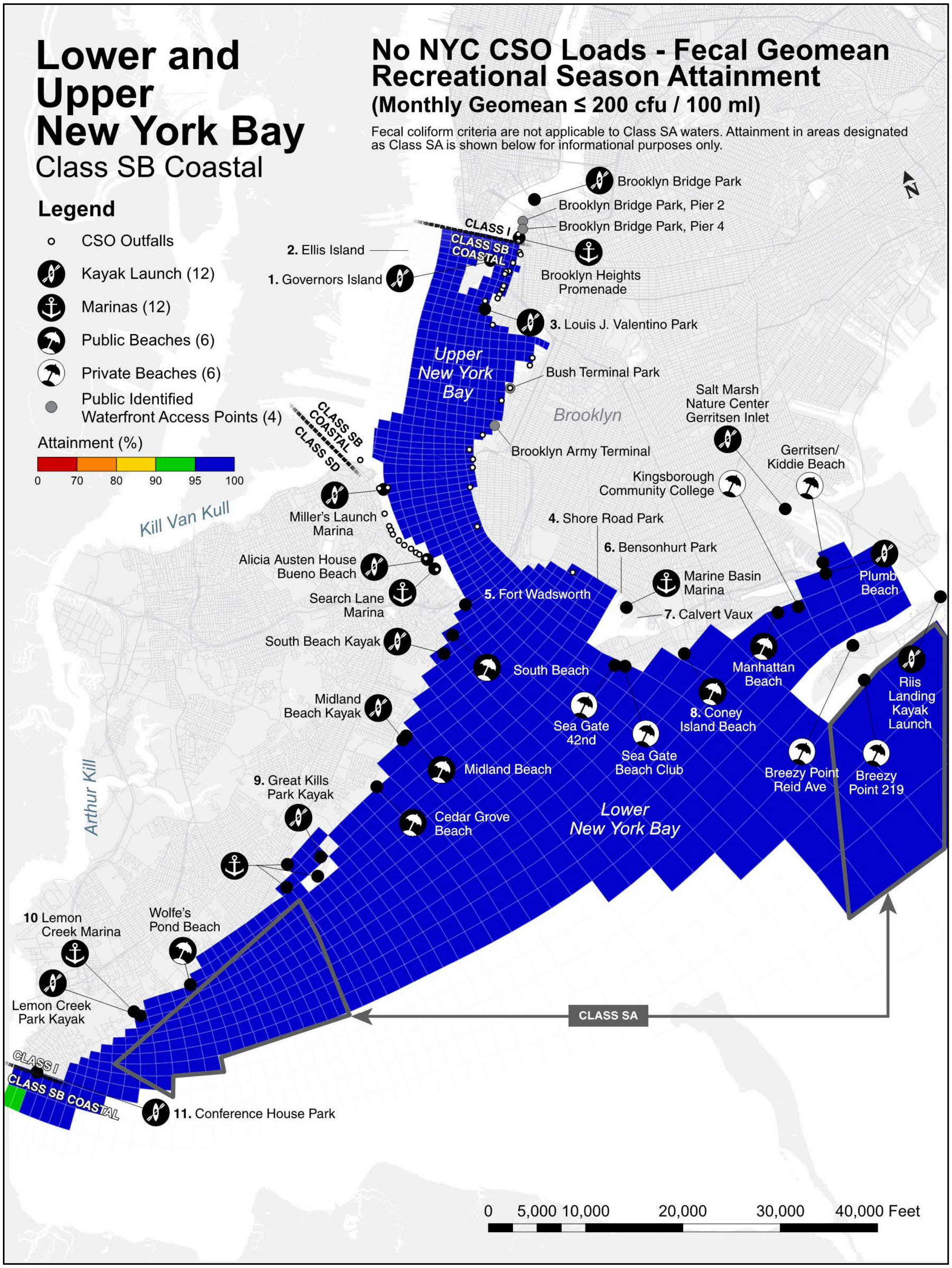

Figure 6-28. New York Bay Fecal Coliform Recreational Season Attainment, No NYC CSO Loads, 10-Year Simulation

AECOM with Hazen

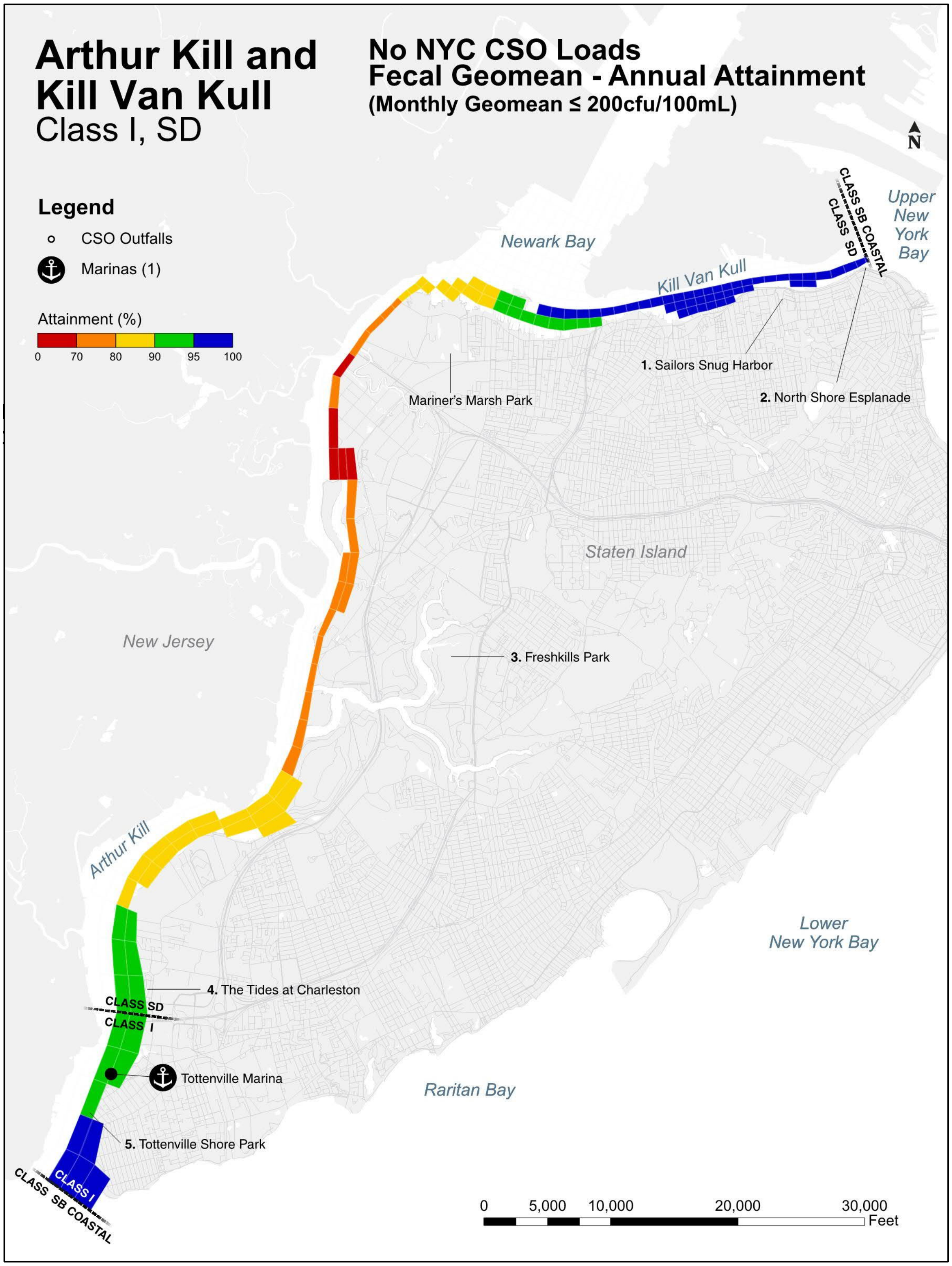

Figure 6-29. Arthur Kill/Kill Van Kull Fecal Coliform Annual Attainment, No NYC CSO Loads, 10-Year Simulation

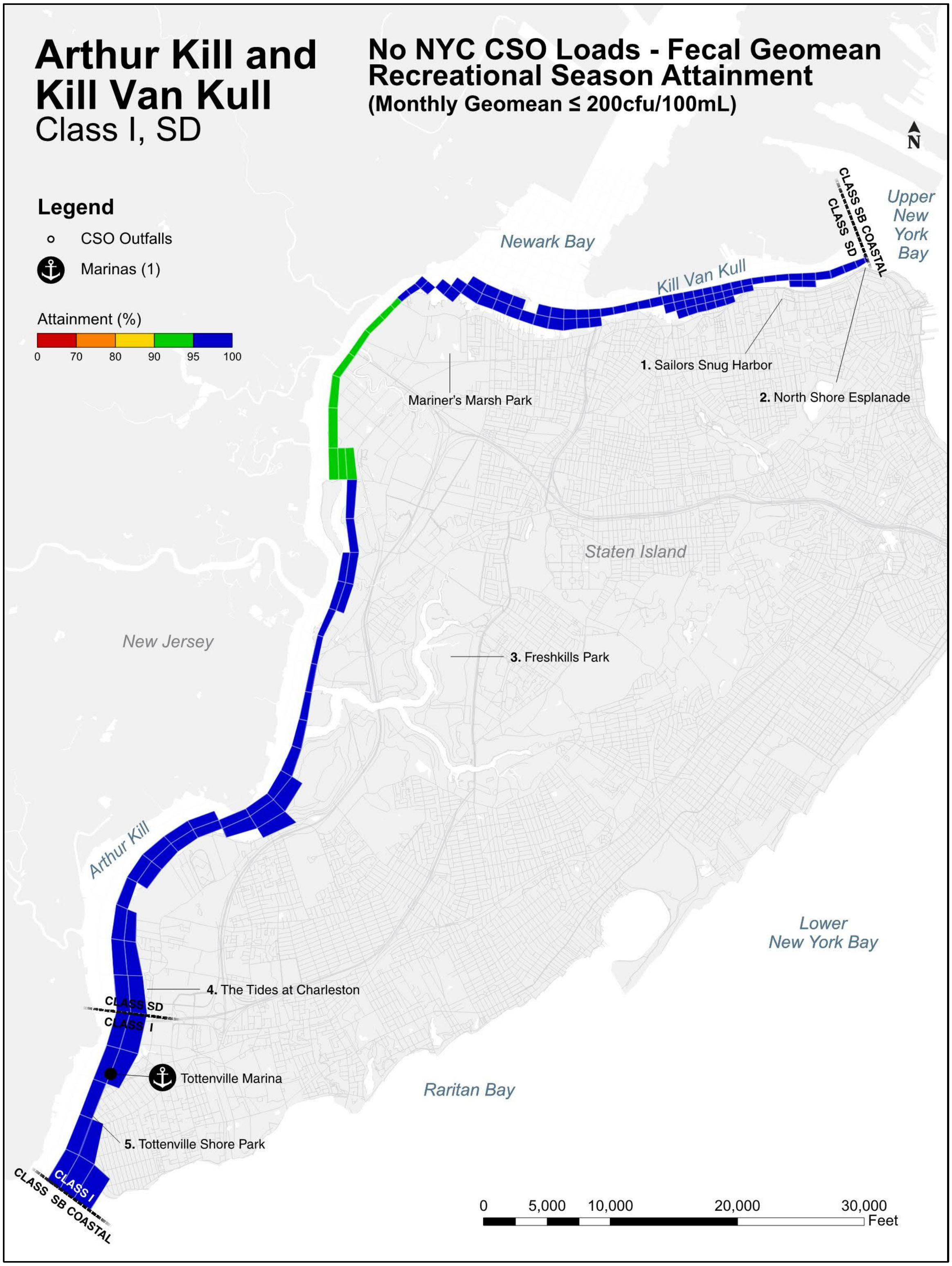

Figure 6-30. Arthur Kill/Kill Van Kull Fecal Coliform Recreational Season Attainment, No NYC CSO Loads, 10-Year Simulation

Table 6-13. Comparison of the Model Calculated Citywide/Open Waters Waterbodies 10-Year Baseline and No NYC CSO Loads Fecal Coliform Maximum Monthly GM and Attainment of Existing WQ for Fecal Coliform Bacteria

	Maximum Monthly GMs (Annual - cfu/100mL)		% Attainment - Annual (GM<200 cfu/100mL)		% Attainment – Recreational Season[1] (GM<200 cfu/100mL)	
Description	**Baseline**	**No NYC CSO Loads**	**Baseline**	**No NYC CSO Loads**	**Baseline**	**No NYC CSO Loads**
Long Island Sound east of Throgs Neck Bridge (Class SB Coastal Primary Contact Recreational)						
EA-1	41	3	100%	100%	100%	100%
EA-2	39	2	100%	100%	100%	100%
EA-3	67	4	100%	100%	100%	100%
Upper and Lower New York Bay (Class SB Coastal Primary Contact Recreational)						
NB-1	177	45	100%	100%	100%	100%
NB-2	170	51	100%	100%	100%	100%
NB-3	165	48	100%	100%	100%	100%
NB-4	166	47	100%	100%	100%	100%
NB-5	158	55	100%	100%	100%	100%
NB-6	152	65	100%	100%	100%	100%
NB-7	157	48	100%	100%	100%	100%
NB-8	127	51	100%	100%	100%	100%
NB-9	218	33	99%	100%	100%	100%
NB-10	69	17	100%	100%	100%	100%
NB-11	76	30	100%	100%	100%	100%
NB-12	83	37	100%	100%	100%	100%
Raritan Bay (Class SB Coastal Primary Contact Recreational)						
K5A	276	267	95%	96%	100%	100%
Rockaway Inlet (Class SB Coastal Primary Contact Recreational)						
J11	53	49	100%	100%	100%	100%
N9A	33	30	100%	100%	100%	100%

AECOM with Hazen

Table 6-13. Comparison of the Model Calculated Citywide/Open Waters Waterbodies 10-Year Baseline and No NYC CSO Loads Fecal Coliform Maximum Monthly GM and Attainment of Existing WQ for Fecal Coliform Bacteria

	Maximum Monthly GMs (Annual - cfu/100mL)		% Attainment - Annual (GM<200 cfu/100mL)		% Attainment – Recreational Season(1) (GM<200 cfu/100mL)	
Description	**Baseline**	**No NYC CSO Loads**	**Baseline**	**No NYC CSO Loads**	**Baseline**	**No NYC CSO Loads**
East River between Whitestone Bridge and Throgs Neck Bridge (Class SB)						
EA-4	85	6	100%	100%	100%	100%
EA-5	91	6	100%	100%	100%	100%
Hudson River north of Harlem River (Class SB)						
HU-1	125	115	100%	100%	100%	100%
Hudson River, Battery to Harlem River (Class I)						
HU-2	158	92	100%	100%	100%	100%
HU-3	189	91	100%	100%	100%	100%
HU-4	197	88	100%	100%	100%	100%
HU-5	192	94	100%	100%	100%	100%
HU-6	205	82	99%	100%	100%	100%
HU-7	203	82	99%	100%	100%	100%
HU-8	194	82	100%	100%	100%	100%
HU-9	206	76	99%	100%	100%	100%
HU-10	184	82	100%	100%	100%	100%
Harlem River (Class I)						
HA-1	280	82	98%	100%	100%	100%
HA-2	445	82	97%	100%	97%	100%
HA-3	484	74	97%	100%	97%	100%
HA-4	618	55	97%	100%	97%	100%
HA-5	769	40	98%	100%	98%	100%
HA-6	360	25	99%	100%	100%	100%

Table 6-13. Comparison of the Model Calculated Citywide/Open Waters Waterbodies 10-Year Baseline and No NYC CSO Loads Fecal Coliform Maximum Monthly GM and Attainment of Existing WQ for Fecal Coliform Bacteria

	Maximum Monthly GMs (Annual - cfu/100mL)		% Attainment - Annual (GM<200 cfu/100mL)		% Attainment – Recreational Season(1) (GM<200 cfu/100mL)	
Description	**Baseline**	**No NYC CSO Loads**	**Baseline**	**No NYC CSO Loads**	**Baseline**	**No NYC CSO Loads**
East River, Battery to Whitestone Bridge (Class I)						
EA-6	134	13	100%	100%	100%	100%
EA-7	178	16	100%	100%	100%	100%
EA-8	162	16	100%	100%	100%	100%
EA-9	182	21	100%	100%	100%	100%
EA-10	215	27	99%	100%	100%	100%
EA-11	206	30	99%	100%	100%	100%
EA-12	193	32	100%	100%	100%	100%
EA-13	194	41	100%	100%	100%	100%
EA-14	196	44	100%	100%	100%	100%
EA-15	193	49	100%	100%	100%	100%
Arthur Kill, Raritan Bay to Outerbridge Crossing (Class I)						
K5	340	339	93%	93%	100%	100%
Arthur Kill, Outerbridge Crossing to Kill Van Kull (Class SD)						
K3	650	619	60%	63%	90%	90%
K4	520	479	77%	79%	98%	98%
Kill Van Kull (Class SD)						
KK-1	255	202	95%	99%	100%	100%
KK-2	251	199	96%	100%	100%	100%
KK-3	168	104	100%	100%	100%	100%

Note:

(1) The recreational season is from May 1st through October 31st.

The mosaics of the percent attainment with the *Enterococci* 30-day GM and STV criteria for the No NYC CSO Loads 10-year simulation within the applicable Coastal Primary Contact Recreational waters are presented in Figure 6-31 to Figure 6-34. As indicated in these figures, the mosaics showing attainment with the *Enterococci* 30-day GM are identical to the Baseline Conditions mosaics shown above, as all the model cells in those waterbodies achieve greater than 95 percent attainment with the criteria. Within the applicable Coastal Primary Contact Recreational waters of Long Island Sound, the mosaic of attainment with the *Enterococci* 30-day STV criterion under No NYC CSO Loads was also identical to the mosaic for Baseline Conditions, with all model cells showing greater than 95 percent attainment with the criterion. Within the applicable Coastal Primary Contact Recreational waters of New York Bay, the 100% control simulation resulted in an improvement in the attainment with the *Enterococci* 30-day STV criterion.

Table 6-14 presents a comparison of Baseline Conditions versus No NYC CSO Loads for the maximum 30-day rolling geometric mean *Enterococci* concentration, the maximum 30-day 90th percentile STV *Enterococci* value, and the percent attainment with the *Enterococci* WQ Criteria for LTCP sampling locations in the Class SB Coastal Primary Contact Recreational Citywide/Open Waters waterbodies.

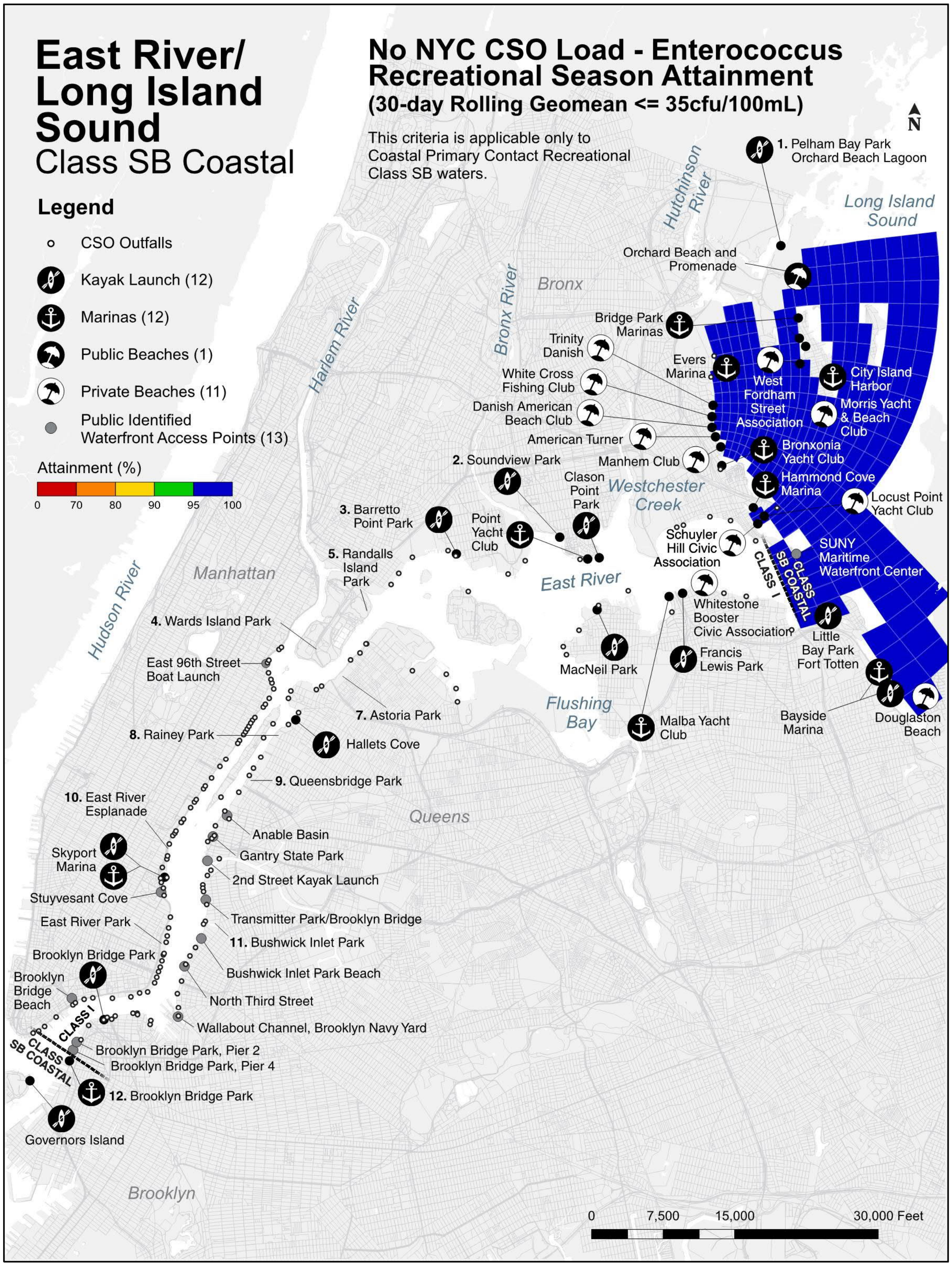

Figure 6-31. East River/Long Island Sound Enterococcus 30-Day Geometric Mean Recreational Season Attainment, No NYC CSO Loads, 10-Year Simulation

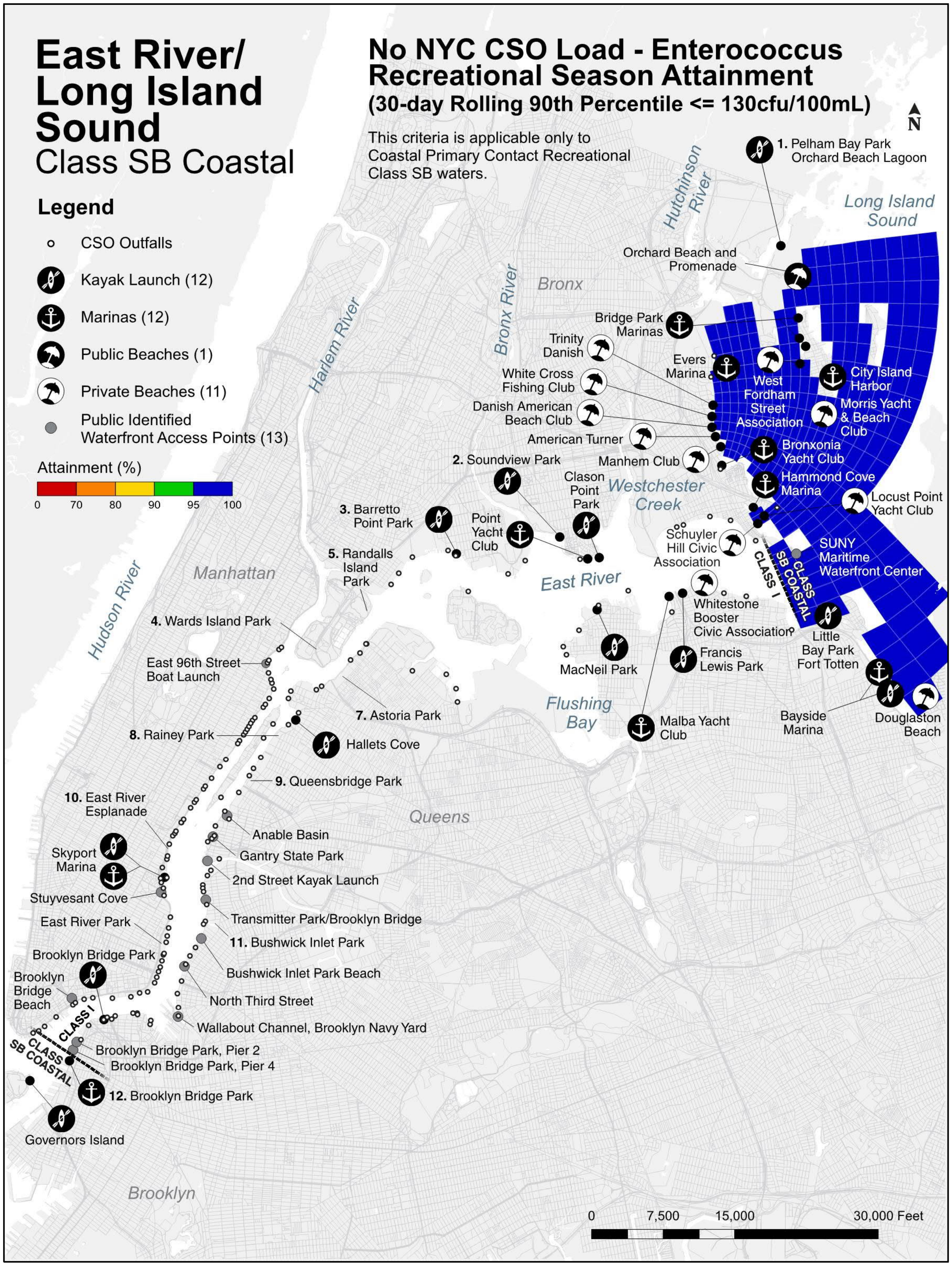

Figure 6-32. East River/Long Island Sound Enterococcus 30-Day STV Recreational Season Attainment, No NYC CSO Loads, 10-Year Simulation

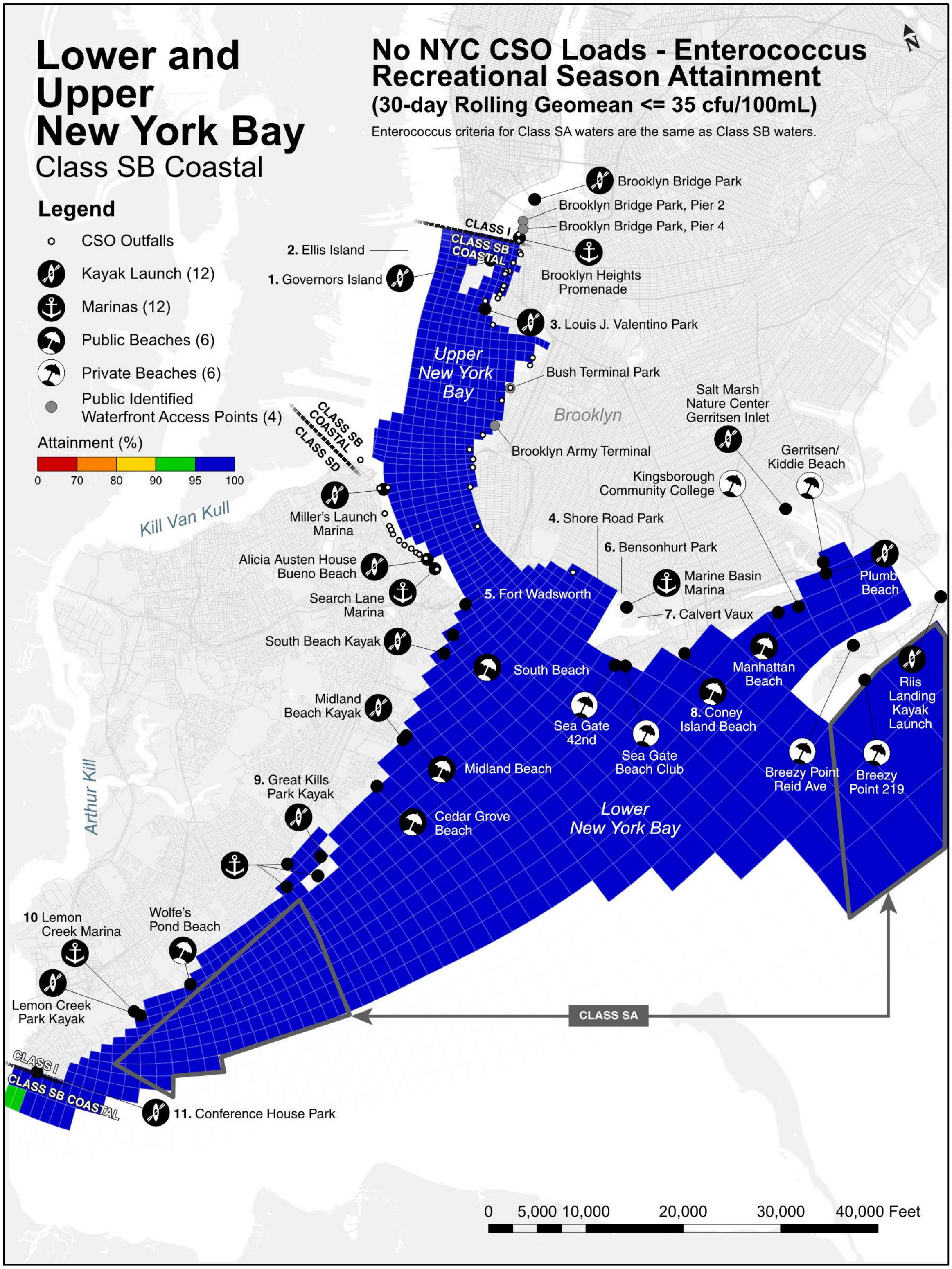

Figure 6-33. New York Bay Enterococcus 30-Day Geometric Mean Recreational Season Attainment, No NYC CSO Loads, 10-Year Simulation

AECOM with Hazen

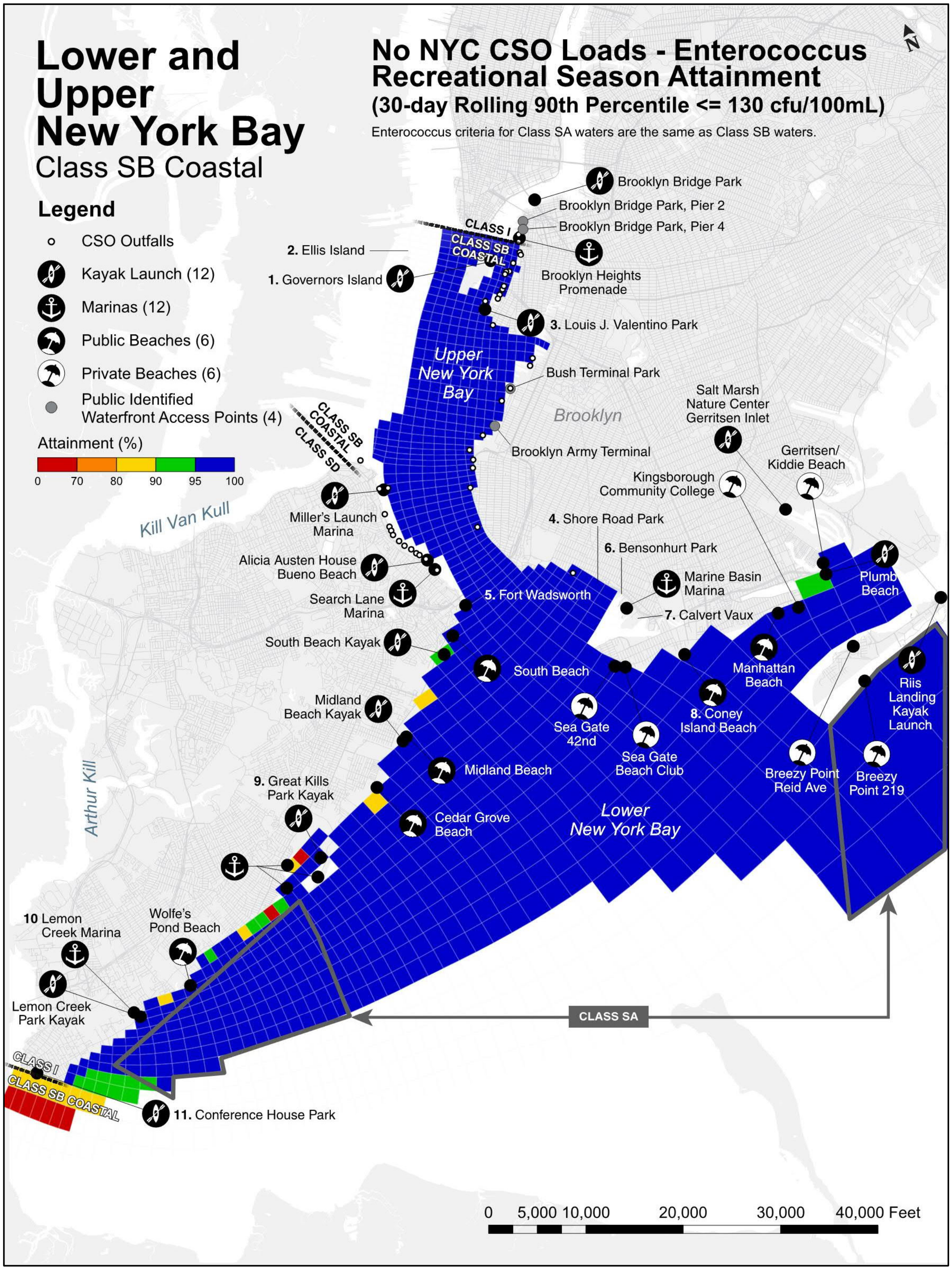

Figure 6-34. New York Bay Enterococcus 30-Day STV Recreational Season Attainment, No NYC CSO Loads, 10-Year Simulation

AECOM with Hazen

Table 6-14. Maximum *Enterococci* Values and Percent Attainment with *Enterococci* Criteria, Baseline Conditions Versus No NYC CSO Loads

	Baseline Conditions				No NYC CSO Loads			
	Maximum Recreational Season(1) 30-day *Enterococci* (cfu/100mL)		% Attainment Recreational Season(1)		Maximum Recreational Season(1) 30-day *Enterococci* (cfu/100mL)		% Attainment Recreational Season(1)	
Description	GM	90th Percentile STV	GM ≤ 35 cfu/100mL	90th Percentile STV ≤ 130 cfu/100mL	GM	90th Percentile STV	GM ≤ 35 cfu/100mL	90th Percentile STV ≤ 130 cfu/100mL
Long Island Sound East of Throgs Neck Bridge (Class SB Coastal Primary Contact Recreational)								
EA-1	7	238	100%	99%	3	68	100%	100%
EA-2	7	50	100%	100%	2	8	100%	100%
EA-3	14	114	100%	100%	2	11	100%	100%
Upper and Lower New York Bay (Class SB Coastal Primary Contact Recreational)								
NB-1	43	640	99.6%	84%	11	54	100%	100%
NB-2	37	498	99.8%	89%	12	76	100%	100%
NB-3	42	745	99.7%	82%	12	72	100%	100%
NB-4	42	779	99.6%	83%	11	65	100%	100%
NB-5	35	390	100%	94%	14	104	100%	100%
NB-6	35	343	100%	94%	17	154	100%	98%
NB-7	40	815	99.7%	82%	12	81	100%	100%
NB-8	30	309	100%	97%	14	117	100%	100%
NB-9	57	4,475	99%	50%	8	67	100%	100%
NB-10	10	152	100%	99%	4	26	100%	100%
NB-11	14	168	100%	98%	7	82	100%	100%
NB-12	13	131	100%	99%	8	88	100%	100%
Raritan Bay (Class SB Coastal Primary Contact Recreational)								
K5A	119	1,417	97%	68%	117	1,417	97%	67%

Table 6-14. Maximum *Enterococci* Values and Percent Attainment with *Enterococci* Criteria, Baseline Conditions Versus No NYC CSO Loads

	Baseline Conditions				No NYC CSO Loads			
	Maximum Recreational Season(1) 30-day *Enterococci* (cfu/100mL)		% Attainment Recreational Season(1)		Maximum Recreational Season(1) 30-day *Enterococci* (cfu/100mL)		% Attainment Recreational Season(1)	
Description	**GM**	**90th Percentile STV**	**GM ≤ 35 cfu/100mL**	**90th Percentile STV ≤ 130 cfu/100mL**	**GM**	**90th Percentile STV**	**GM ≤ 35 cfu/100mL**	**90th Percentile STV ≤ 130 cfu/100mL**
Rockaway Inlet (Class SB Coastal Primary Contact Recreational)								
J11	7	226	100%	91%	6	211	100%	91%
N9A	3	25	100%	100%	2	11	100%	100%

Note:
(1) The recreational season is from May 1st through October 31st.

2008 Annual Rainfall Simulation – Dissolved Oxygen

Figure 6-35 to Figure 6-40 present mosaics of the average annual attainment of applicable DO criteria for the Citywide/Open Waters waterbodies based on the water quality model simulation for the 2008 typical year under Baseline Conditions. Figure 6-41 to Figure 6-46 present mosaics of the average annual attainment of applicable DO criteria for the Citywide/Open Waters waterbodies based on the water quality model simulation for the 2008 typical year for No NYC CSO Loads. Values for the average annual attainment of DO criteria at LTCP sampling locations for the 2008 typical year under baseline conditions and with No NYC CSO Loads are presented in Table 6-15 for the Class SB Citywide/Open Waters waterbodies, Table 6-16 for the Class I waterbodies, and Table 6-17 for the Class SD waterbodies. The average annual attainment is calculated by averaging the calculated attainment in each of 10 modeled depth layers, comprising the entire water column with all stations except for K5A and K5 greater than 95 percent attainment, and most stations greater than 99 percent attainment for the 2008 Typical Year conditions.

As indicated in the mosaics and in these tables, when assessing the water column in its entirety, attainment of the applicable DO criteria is generally very high, and the model indicates virtually no difference in attainment between baseline conditions and No NYC CSO Loads. In particular, the non-attainment of the applicable DO criteria shown in the mosaics in the lower Arthur Kill and in Raritan Bay off the southwest corner of Staten Island, and at stations K5A and K5 remain under the No NYC CSO Loads scenario, indicating that the non-attainment is due to sources other than NYC CSOs. In summary, NYC CSO loads are not the controlling factor for DO concentrations and CSO controls will not change the level of attainment with the applicable DO criteria.

Figure 6-35. Harlem River Dissolved Oxygen Annual Attainment, Baseline Conditions, 2008 Typical Year Simulation

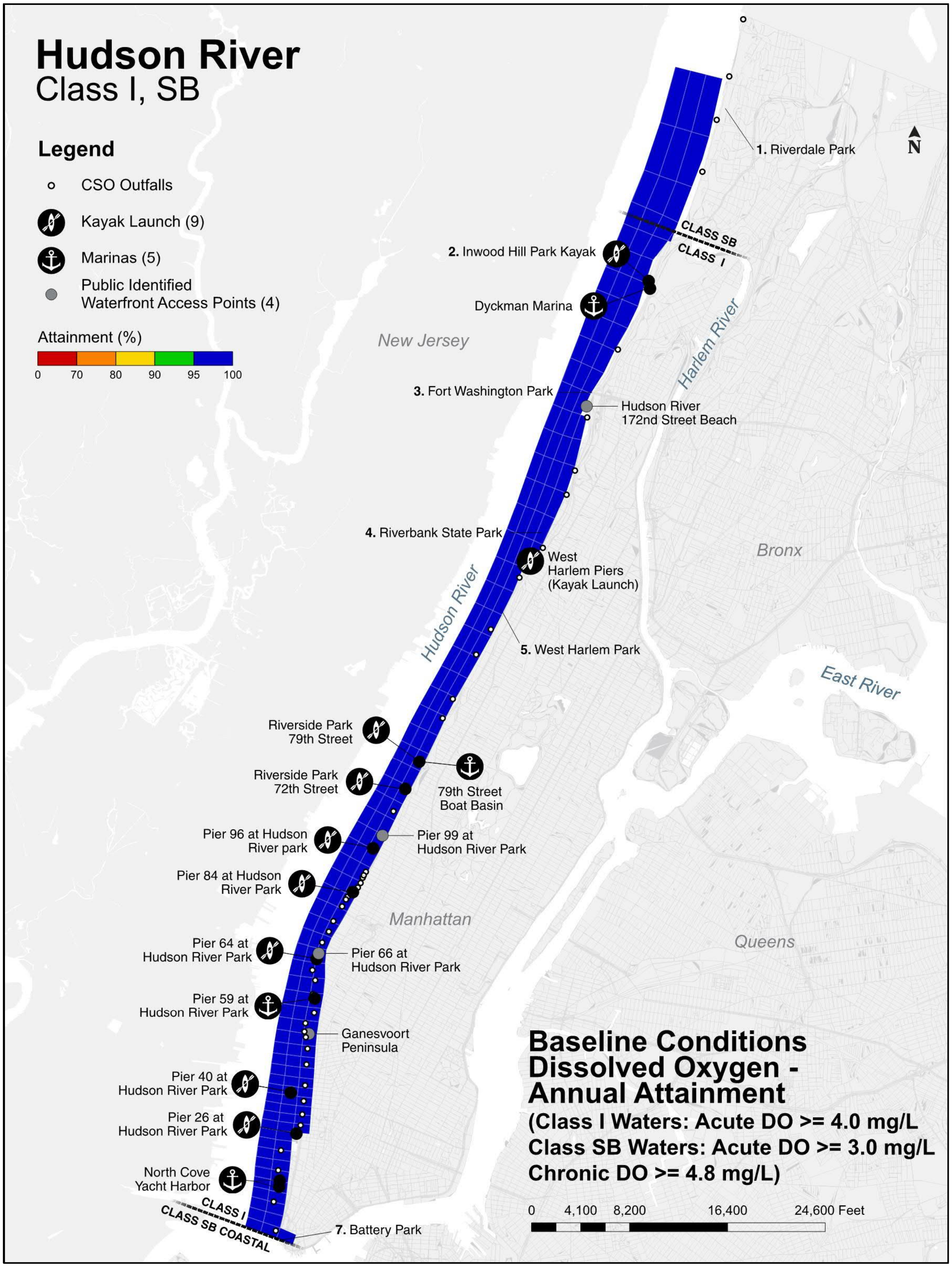

Figure 6-36. Hudson River Dissolved Oxygen Annual Attainment, Baseline Conditions, 2008 Typical Year Simulation

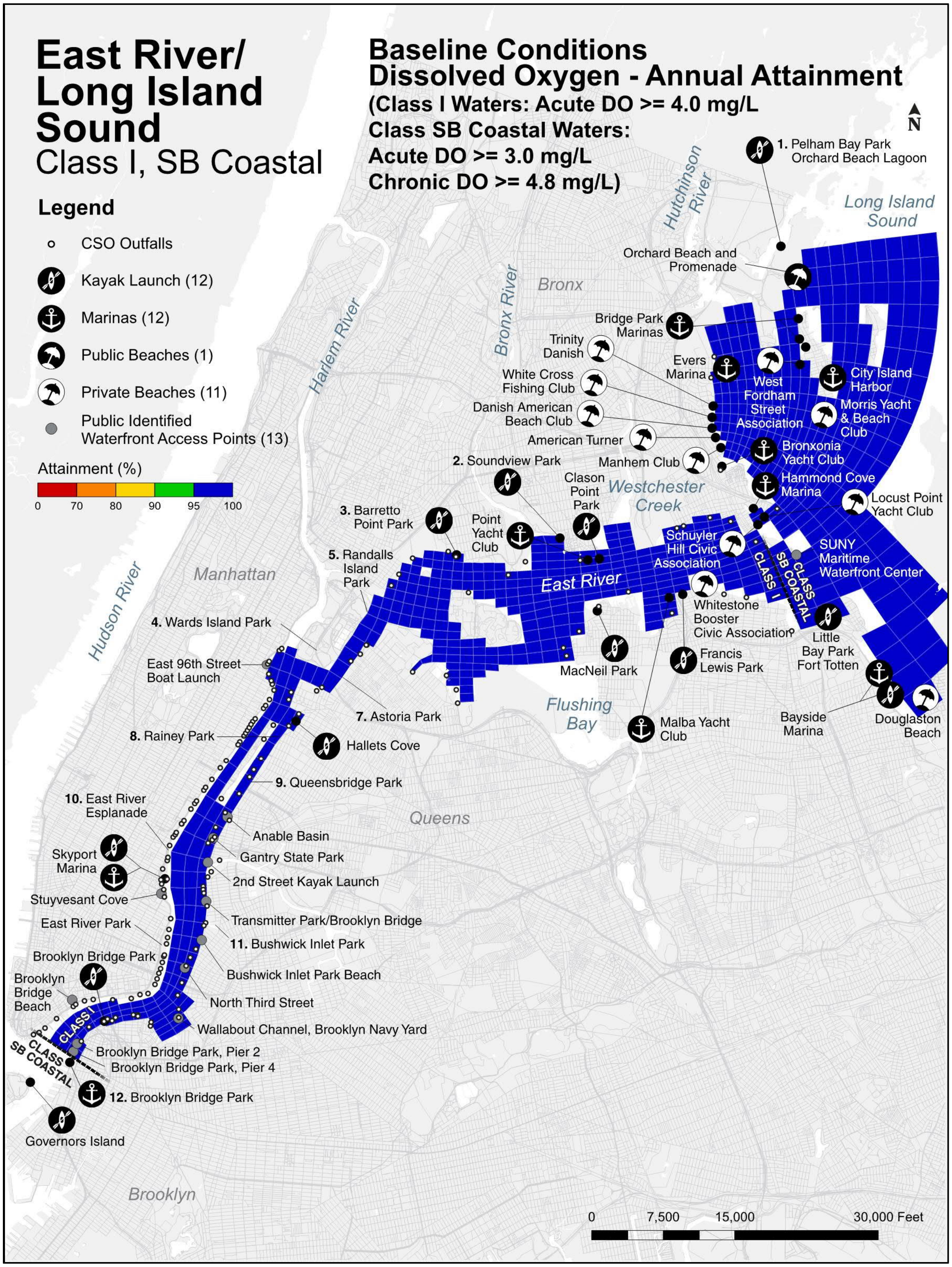

Figure 6-37. East River/Long Island Sound Dissolved Oxygen Annual Attainment, Baseline Conditions, 2008 Typical Year Simulation

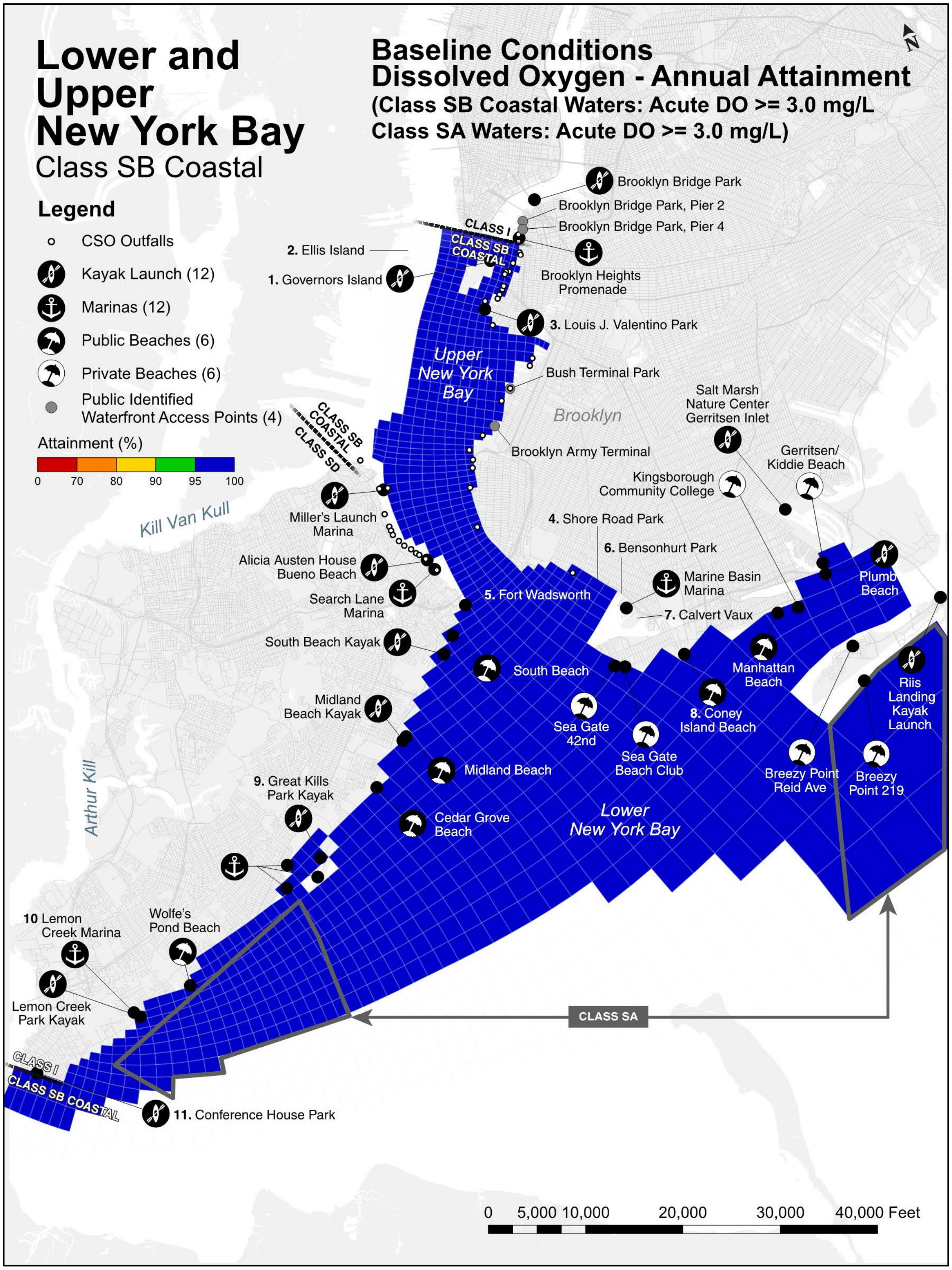

Figure 6-38. New York Bay Dissolved Oxygen Annual Acute Attainment, Baseline Conditions, 2008 Typical Year Simulation

AECOM with Hazen

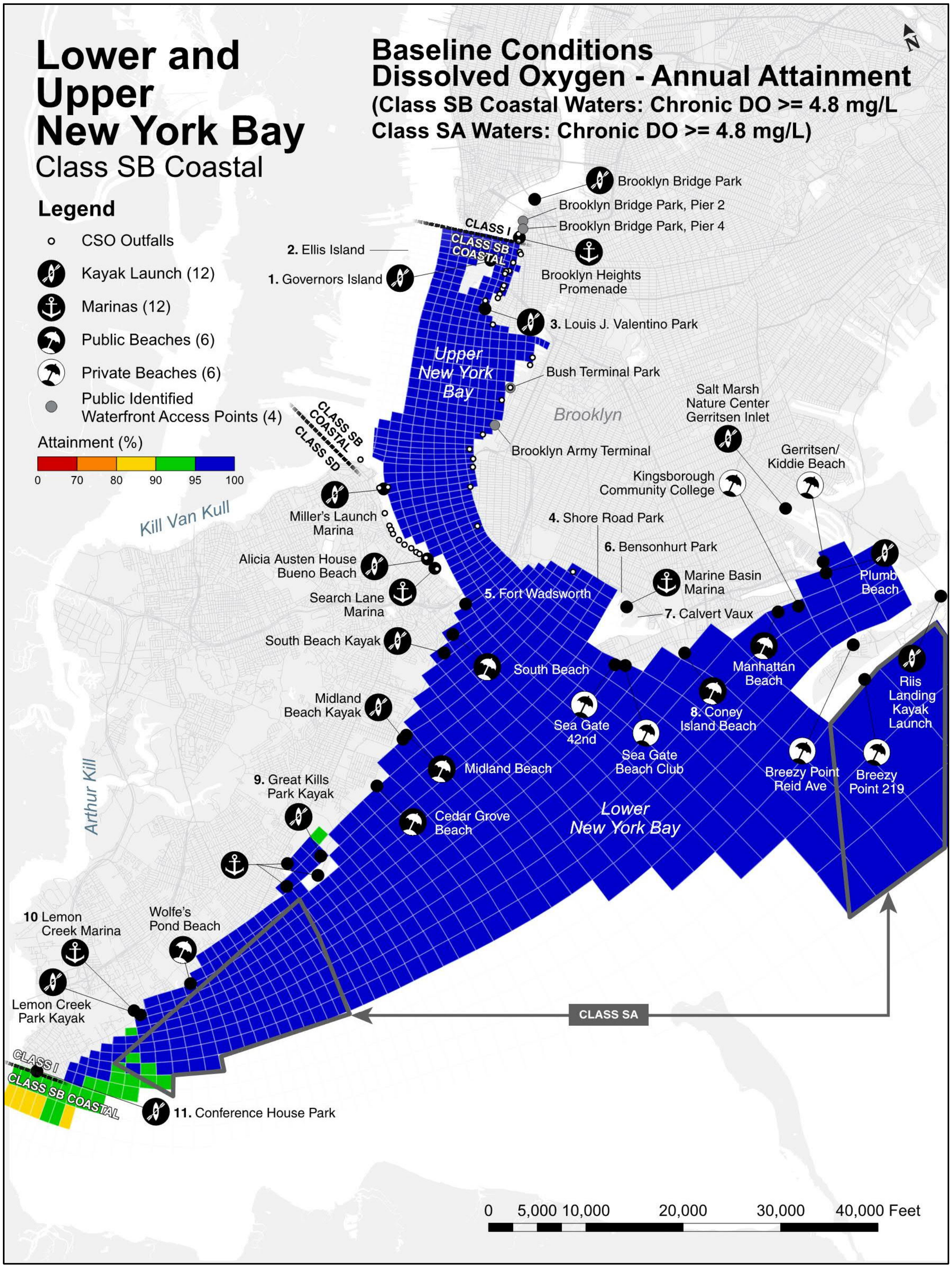

Figure 6-39. New York Bay Dissolved Oxygen Annual Chronic Attainment, Baseline Conditions, 2008 Typical Year Simulation

AECOM with Hazen

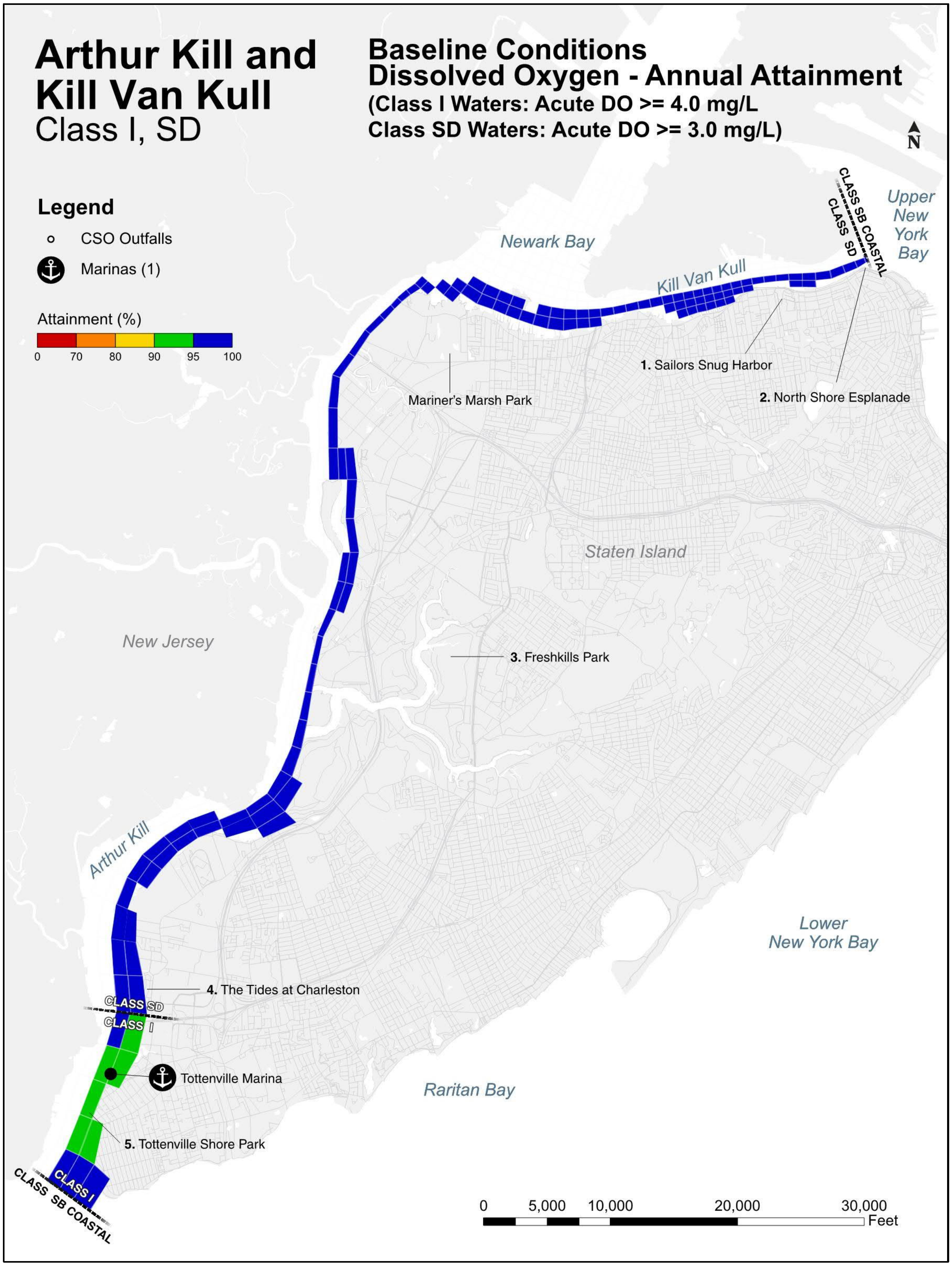

Figure 6-40. Arthur Kill/Kill Van Kull Dissolved Oxygen Annual Attainment, Baseline Conditions, 2008 Typical Year Simulation

Figure 6-41. Harlem River Dissolved Oxygen Annual Attainment, No NYC CSO Loads, 2008 Typical Year Simulation

Figure 6-42. Hudson River Dissolved Oxygen Annual Attainment, No NYC CSO Loads, 2008 Typical Year Simulation

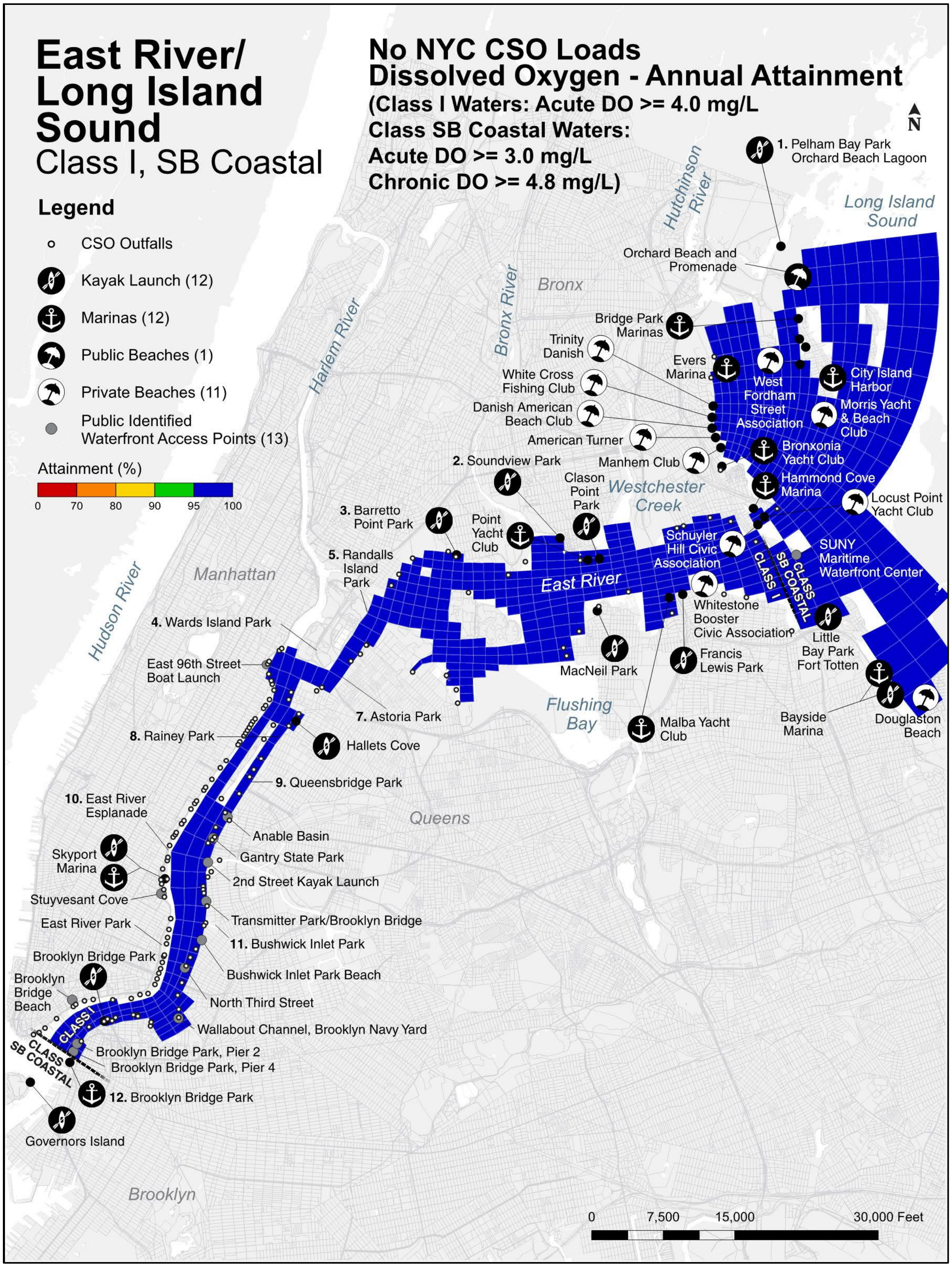

Figure 6-43. East River/Long Island Sound Dissolved Oxygen Annual Attainment, No NYC CSO Loads, 2008 Typical Year Simulation

AECOM with Hazen

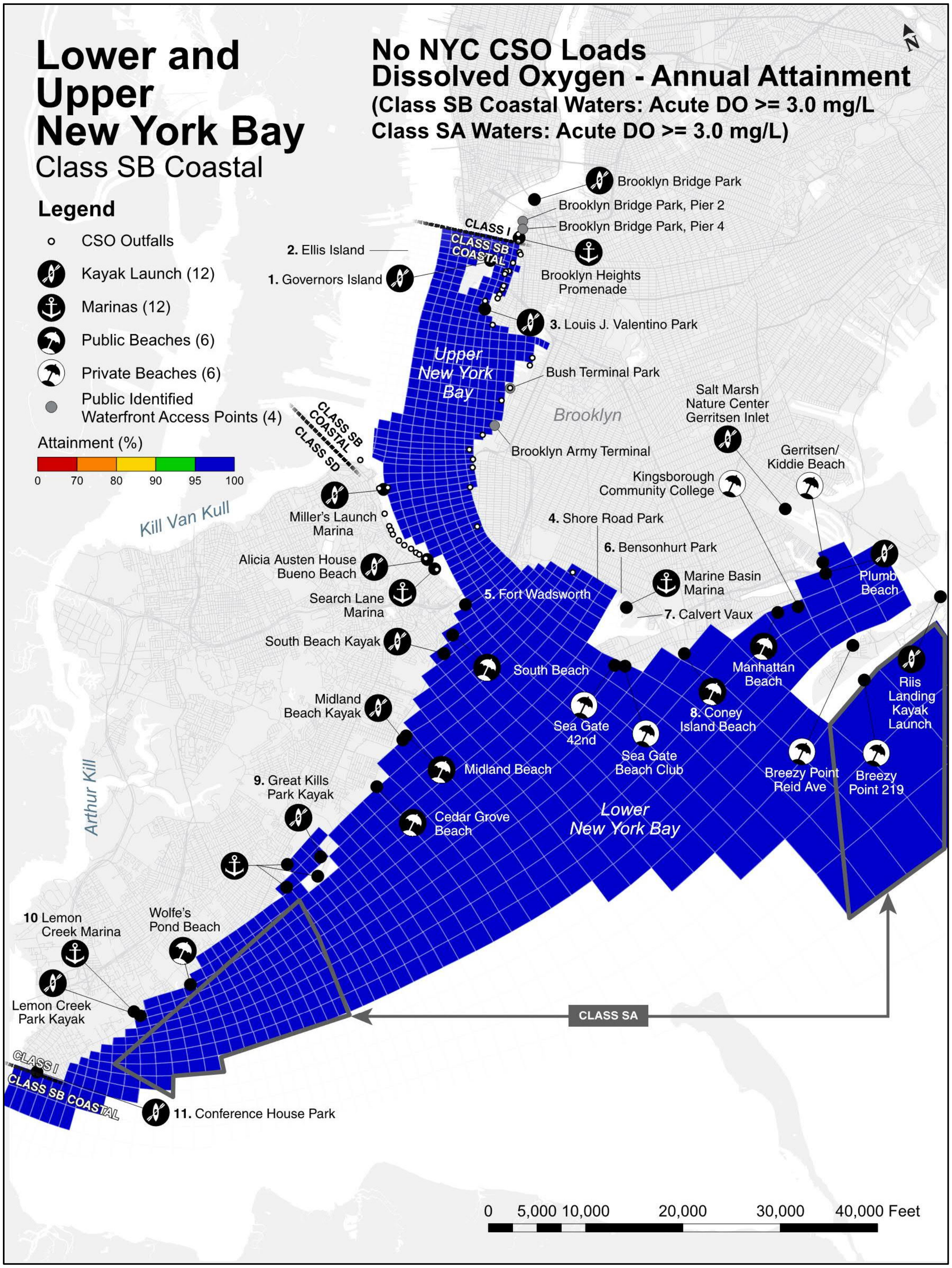

Figure 6-44. New York Bay Dissolved Oxygen Annual Acute Attainment, No NYC CSO Loads, 2008 Typical Year Simulation

AECOM with Hazen

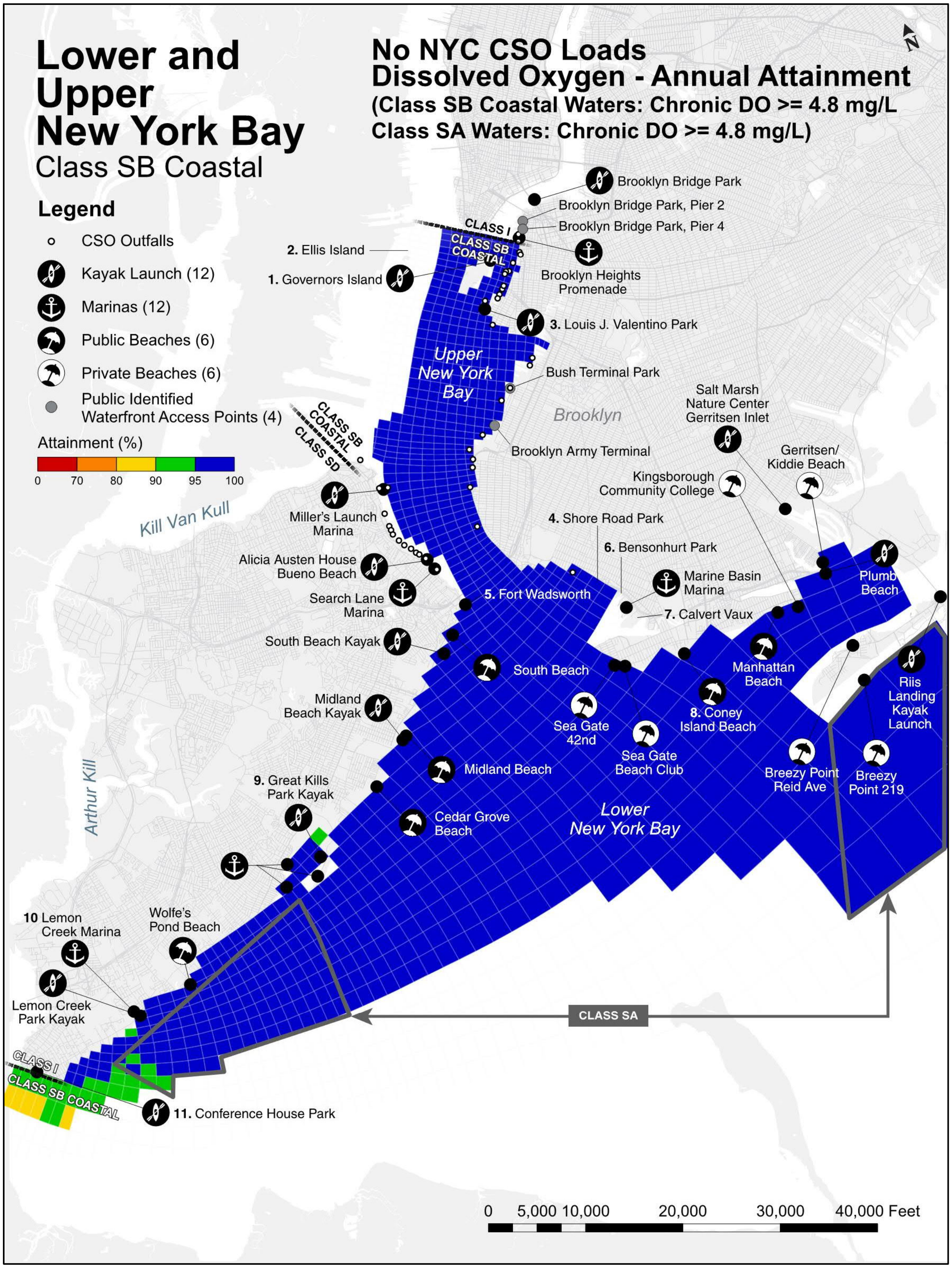

Figure 6-45. New York Bay Dissolved Oxygen Annual Chronic Attainment, No NYC CSO Loads, 2008 Typical Year Simulation

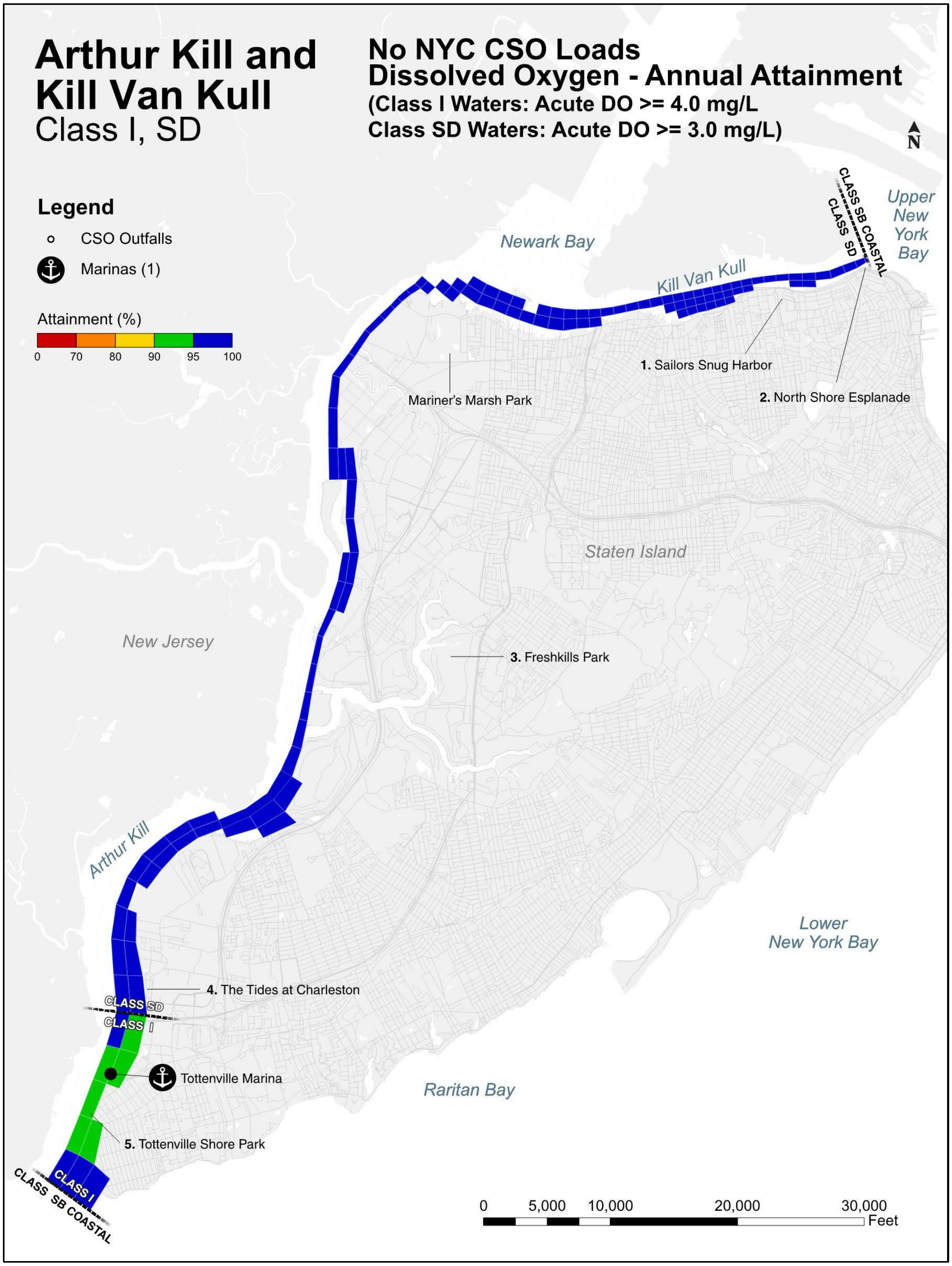

Figure 6-46. Arthur Kill/Kill Van Kull Dissolved Oxygen Annual Attainment, No NYC CSO Loads, 2008 Typical Year Simulation

Table 6-15. 2008 Baseline Conditions and No NYC CSO Loads Annual DO Attainment for Class SB Waterbodies

Station	Baseline		No NYC CSO Loads	
	Class SB Annual Attainment (%) (Entire Water Column)		Class SB Annual Attainment (%) (Entire Water Column)	
	Instantaneous (≥3.0 mg/L)	Daily Ave. (≥4.8 mg/L)	Instantaneous (≥3.0 mg/L)	Daily Ave. (≥4.8 mg/L)
Long Island Sound east of Throgs Neck Bridge				
EA-1	100%	100%	100%	100%
EA-2	100%	100%	100%	100%
EA-3	100%	100%	100%	100%
East River between Whitestone Bridge and Throgs Neck Bridge				
EA-4	100%	100%	100%	100%
EA-5	100%	100%	100%	100%
Hudson River, North of Harlem River				
HU-1	100%	95%	100%	95%
Upper and Lower New York Bay				
NB-1	100%	100%	100%	100%
NB-2	100%	100%	100%	100%
NB-3	100%	100%	100%	100%
NB-4	100%	100%	100%	100%
NB-5	100%	100%	100%	100%
NB-6	100%	100%	100%	100%
NB-7	100%	100%	100%	100%
NB-8	100%	100%	100%	100%
NB-9	100%	100%	100%	100%
NB-10	100%	100%	100%	100%
NB-11	100%	100%	100%	100%
NB-12	100%	99%	100%	99%

Table 6-15. 2008 Baseline Conditions and No NYC CSO Loads Annual DO Attainment for Class SB Waterbodies

Station	Baseline		No NYC CSO Loads	
	Class SB Annual Attainment (%) (Entire Water Column)		Class SB Annual Attainment (%) (Entire Water Column)	
	Instantaneous (≥3.0 mg/L)	Daily Ave. (≥4.8 mg/L)	Instantaneous (≥3.0 mg/L)	Daily Ave. (≥4.8 mg/L)
Raritan Bay				
K5A	98%	89%	98%	89%
Rockaway Inlet				
J11	100%	100%	100%	100%
N9A	100%	100%	100%	100%

Table 6-16. 2008 Baseline Conditions and No NYC CSO Loads Annual DO Attainment for Class I Waterbodies

Annual Attainment (%) (Entire Water Column)		
Class I Annual Attainment (%) Instantaneous (≥4.0 mg/L, Entire Water Column)		
Station	**Baseline**	**No NYC CSO Loads**
Hudson River, Harlem River to Battery		
HU-2	100%	100%
HU-3	100%	100%
HU-4	100%	100%
HU-5	100%	100%
HU-6	100%	100%
HU-7	100%	100%
HU-8	100%	100%
HU-9	100%	100%
HU-10	100%	100%
Harlem River		
HA-1	100%	100%
HA-2	100%	100%
HA-3	100%	100%
HA-4	100%	100%
HA-5	100%	100%
HA-6	100%	100%
East River, Whitestone Bridge to Battery		
EA-6	100%	100%
EA-7	100%	100%
EA-8	100%	100%
EA-9	100%	100%
EA-10	100%	100%
EA-11	100%	100%
EA-12	100%	100%
EA-13	100%	100%
EA-14	100%	100%
EA-15	100%	100%
Arthur Kill, Outerbridge Crossing to Raritan Bay		
K-5	92%	92%

Table 6-17. 2008 Baseline Conditions and No NYC CSO Loads Annual DO Attainment for Class SD Waterbodies

Annual Attainment (%) (Entire Water Column)		
Class SD Annual Attainment (%) Instantaneous (≥3.0 mg/L, Entire Water Column)		
Station	**Baseline**	**No NYC CSO Loads**
Kill Van Kull		
K2	100%	100%
KK-2	100%	100%
KK-3	100%	100%
Arthur Kill, Outerbridge Crossing to Kill Van Kull		
K-3	100%	100%
K-4	99%	99%

6.3.b Load Source Component Analysis

A load source component analysis was conducted for the 2008 baseline condition using JFK Airport rainfall data, to provide a better understanding of how each source type contributes to bacteria concentrations in the Citywide/Open Waters waterbodies. The source types include CSOs, MS4 stormwater, non-MS4 stormwater, WRRF discharges, loadings from outside of NYC, and boundary conditions (Hudson River at Troy, NY boundary, Bronx River at the dam north of East 180th Street, open ocean boundaries). The analysis included the calculation of fecal coliform and *Enterococci* bacteria GMs in total and from each component. For fecal coliform, a maximum winter month (December) was analyzed because the decay rate is lower in winter, resulting in generally higher fecal coliform concentrations. *Enterococci* was evaluated on a maximum recreational season (May 1st through October 31st) 30-day GM basis. The 30-day period chosen for the *Enterococci* component analysis included both the maximum 30-day period and the 30-day period where the maximum contribution of CSOs to the GM was observed. CSO, stormwater, and other loadings that discharge directly into the tributaries to the Open Waters waterbodies are accounted for in the component values.

Table 6-18 summarizes the fecal coliform and *Enterococci* component analysis at selected water quality stations. The source component analysis for the stations in Arthur Kill and Kill Van Kull support the conclusion noted above that non-attainment of the WQ Criteria for fecal coliform in those waterbodies is driven by loads from outside of NYC.

Table 6-18. Fecal Coliform and *Enterococci* GM 2008 Source Components

Source	Station	Fecal Coliform Contribution (cfu/100mL)	*Enterococci* Contribution (cfu/100mL)
		Annual Worst Month December Monthly GM	30-day GM at time of Overall Max.
Long Island Sound east of Throgs Neck Bridge (Class SB Coastal Primary Contact Recreational)			
Open Boundary Conditions	EA-1	1.0	1.0
NYC Stormwater (Except MS4)		0.7	0.3
NYC MS4 Stormwater		0.7	0.2
NYC CSOs		23.5	0.5
Total		**25.9**	**2**
Open Boundary Conditions	EA-2	1.0	1.0
NYC Stormwater (Except MS4)		0.6	0.1
NYC MS4 Stormwater		0.5	0
NYC CSOs		26.4	0.6
Total		**28.5**	**1.7**
Open Boundary Conditions	EA-3	1.0	1
Sources outside of NYC		0.1	0
Hudson River and Bronx River		0.3	0
NYC WRRF		0.1	0
NYC Stormwater (Except MS4)		1.5	0.2
NYC MS4 Stormwater		1.1	0.1
NYC CSOs		58.3	1.5
Total		**62.4**	**2.8**
Upper and Lower New York Bay (Class SB Coastal Primary Contact Recreational)			
Open Boundary Conditions	NB-1	1.0	1
Sources outside of NYC		15.5	0.7
Hudson River and Bronx River		17.4	0.1
NYC WRRF		0.6	0
NYC Stormwater (Except MS4)		1.4	0.4
NYC MS4 Stormwater		0.4	0.1
NYC CSOs		140.7	6.3
Total		**177.0**	**8.6**
Open Boundary Conditions	NB-3	1.0	1
Sources outside of NYC		17.6	0.7
Hudson River and Bronx River		20.3	0.1
NYC WRRF		0.3	0
NYC Stormwater (Except MS4)		1.3	0.3
NYC MS4 Stormwater		0.3	0.1

Table 6-18. Fecal Coliform and *Enterococci* GM 2008 Source Components

Source	Station	Fecal Coliform Contribution (cfu/100mL)	*Enterococci* Contribution (cfu/100mL)
		Annual Worst Month December Monthly GM	30-day GM at time of Overall Max.
NYC CSOs		124.0	4.9
Total		**164.8**	**7.1**
Open Boundary Conditions	NB-5	1.0	1
Sources outside of NYC		19.6	1.2
Hudson River and Bronx River		24.9	0
NYC WRRF		0.3	0
NYC Stormwater (Except MS4)		1.1	0.4
NYC MS4 Stormwater		0.3	0
NYC CSOs		110.3	3.9
Total		**157.5**	**6.5**
Open Boundary Conditions	NB-7	1.0	1
Sources outside of NYC		17.7	0.8
Hudson River and Bronx River		19.3	0
NYC WRRF		0.2	0
NYC Stormwater (Except MS4)		1.3	0.3
NYC MS4 Stormwater		0.4	0.1
NYC CSOs		116.4	5.5
Total		**156.3**	**7.7**
Open Boundary Conditions	NB-10	1.0	1
Sources outside of NYC		6.7	0
Hudson River and Bronx River		4.2	0
NYC WRRF		0.2	0
NYC Stormwater (Except MS4)		0.8	0.1
NYC MS4 Stormwater		1.0	0.1
NYC CSOs		55.5	1.3
Total		69.4	2.5
Open Boundary Conditions	NB-11	1.0	1
Sources outside of NYC		11.4	0.1
Hudson River and Bronx River		6.2	0
NYC WRRF		0.2	0
NYC Stormwater (Except MS4)		6.5	1.1
NYC MS4 Stormwater		0.2	0
NYC CSOs		46.4	1
Total		**71.9**	**3.2**
Open Boundary Conditions	Manhattan Beach	1	1
Sources outside of NYC		3.3	0

Table 6-18. Fecal Coliform and *Enterococci* GM 2008 Source Components

Source	Station	Fecal Coliform Contribution (cfu/100mL)	*Enterococci* Contribution (cfu/100mL)
		Annual Worst Month December Monthly GM	30-day GM at time of Overall Max.
Hudson River and Bronx River		1.5	0
NYC WRRF		0.2	0
NYC Stormwater (Except MS4)		1.5	0.2
NYC MS4 Stormwater		3	0.6
NYC CSOs		31.4	0.6
Total		**41.9**	**2.4**
Raritan Bay (Class SB Coastal Primary Contact Recreational)			
Open Boundary Conditions	K5A	1	1
Sources outside of NYC		219	10.3
Hudson River and Bronx River		1	0
NYC WRRF		0	0
NYC Stormwater (Except MS4)		7.9	0.6
NYC MS4 Stormwater		1.1	0
NYC CSOs		9.3	0
Total		239.3	11.9
Hudson River, NYC Boundary to Harlem River (Class SB)(1)			
Open Boundary Conditions	HU-1	1.0	1
Sources outside of NYC		1.3	1.1
Hudson River and Bronx River		76.7	16.9
NYC Stormwater (Except MS4)		0.1	0.1
NYC CSOs		22.2	4
Total		**101.3**	**23.1**
East River, between Whitestone Bridge and Throgs Neck Bridge (Class SB)(1)			
Open Boundary Conditions	EA-5	1	1
Sources outside of NYC		0.5	0
Hudson River and Bronx River		0.4	0
NYC WRRF		0.3	0
NYC Stormwater (Except MS4)		2.1	0.3
NYC MS4 Stormwater		1.1	0.1
NYC CSOs		78.2	2.4
Total		**83.6**	**3.8**
Hudson River, Battery to Harlem River (Class I)(1)			
Open Boundary Conditions	HU-3	1.0	1
Sources outside of NYC		6.1	2.6
Hudson River and Bronx River		61.2	5.1
NYC WRRF		0.1	0

Table 6-18. Fecal Coliform and *Enterococci* GM 2008 Source Components

Source	Station	Fecal Coliform Contribution (cfu/100mL)	*Enterococci* Contribution (cfu/100mL)
		Annual Worst Month December Monthly GM	30-day GM at time of Overall Max.
NYC Stormwater (Except MS4)		0.3	0.3
NYC MS4 Stormwater		0.1	0
NYC CSOs		120.1	20.3
Total		**188.9**	**29.3**
Open Boundary Conditions	HU-7	1.0	1
Sources outside of NYC		10.2	2.9
Hudson River and Bronx River		58.6	2.1
NYC WRRF		0.1	0
NYC Stormwater (Except MS4)		0.6	0.1
NYC CSOs		132.8	12.9
Total		**203.3**	**19**
Open Boundary Conditions	HU-9	1.0	1
Sources outside of NYC		14.7	2.8
Hudson River and Bronx River		48.6	0.8
NYC WRRF		0.2	0
NYC Stormwater (Except MS4)		0.6	0.2
NYC MS4 Stormwater		0.1	0
NYC CSOs		140.6	9.3
Total		**205.8**	**14.1**
Harlem River (Class I)(1)			
Open Boundary Conditions	HA-2	1.0	1
Sources outside of NYC		3.2	1.2
Hudson River and Bronx River		47.6	5.6
NYC WRRF		0.1	0
NYC Stormwater (Except MS4)		2.1	1.8
NYC MS4 Stormwater		0.1	0.1
NYC CSOs		390.4	107.4
Total		**444.5**	**117.1**
Open Boundary Conditions	HA-4	1.0	1
Sources outside of NYC		4.9	0.7
Hudson River and Bronx River		32.8	2.2
NYC WRRF		0.6	0

Table 6-18. Fecal Coliform and *Enterococci* GM 2008 Source Components

Source	Station	Fecal Coliform Contribution (cfu/100mL)	*Enterococci* Contribution (cfu/100mL)
		Annual Worst Month December Monthly GM	30-day GM at time of Overall Max.
NYC Stormwater (Except MS4)		4.5	2.2
NYC MS4 Stormwater		0.5	0.1
NYC CSOs		573.4	105.6
Total		**617.7**	**111.8**
Open Boundary Conditions	HA-5	1.0	1
Sources outside of NYC		5.6	0.4
Hudson River and Bronx River		21.3	0.8
NYC WRRF		0.9	0
NYC Stormwater (Except MS4)		6.1	2.2
NYC MS4 Stormwater		0.7	0.1
NYC CSOs		733.2	108.1
Total		**768.8**	**112.6**
East River, Battery to Whitestone Bridge (Class I)(1)			
Open Boundary Conditions	EA-6	1.0	1
Sources outside of NYC		1.3	0
Hudson River and Bronx River		1.1	0
NYC WRRF		0.6	0
NYC Stormwater (Except MS4)		4.7	0.8
NYC MS4 Stormwater		1.8	0.3
NYC CSOs		115.9	4
Total		**126.4**	**6.1**
Open Boundary Conditions	EA-9	1.0	1
Sources outside of NYC		5.0	0.2
Hudson River and Bronx River		4.5	0
NYC WRRF		1.4	0
NYC Stormwater (Except MS4)		3.9	0.6
NYC MS4 Stormwater		1.2	0.1
NYC CSOs		164.7	6.6
Total		**181.7**	**8.5**
Open Boundary Conditions	EA-11	1.0	1
Sources outside of NYC		8.5	0.4
Hudson River and Bronx River		8.9	0
NYC WRRF		1.3	0
NYC Stormwater (Except MS4)		3.2	0.6
NYC MS4 Stormwater		1.0	0.1
NYC CSOs		182.0	7.7

AECOM with Hazen

Table 6-18. Fecal Coliform and *Enterococci* GM 2008 Source Components

Source	Station	Fecal Coliform Contribution (cfu/100mL)	*Enterococci* Contribution (cfu/100mL)
		Annual Worst Month December Monthly GM	30-day GM at time of Overall Max.
Total		205.9	9.8
Open Boundary Conditions	EA-12	1.0	1
Sources outside of NYC		9.6	0.5
Hudson River and Bronx River		10.0	0
NYC WRRF		1.2	0.1
NYC Stormwater (Except MS4)		2.9	0.5
NYC MS4 Stormwater		1.0	0
NYC CSOs		167.5	7
Total		193.2	9.1
Open Boundary Conditions	EA-14	1.0	1
Sources outside of NYC		13.6	0.9
Hudson River and Bronx River		17.4	0.1
NYC WRRF		0.9	0
NYC Stormwater (Except MS4)		2.0	0.5
NYC MS4 Stormwater		0.6	0
NYC CSOs		160.0	7.2
Total		195.5	9.7
Arthur Kill, Raritan Bay to Outerbridge Crossing (Class I)(1)			
Open Boundary Conditions	Conference House Park	1	1
Sources outside of NYC		260.4	7.7
Hudson River and Bronx River		1.4	0
NYC Stormwater (Except MS4)		15.5	1.7
NYC MS4 Stormwater		2.1	0.1
NYC CSOs		11.8	0
Total		292.2	10.5
Arthur Kill, Outerbridge Crossing to Kill Van Kull (Class SD)(1)			
Open Boundary Conditions	K3	1	1
Sources outside of NYC		561.5	62.5
Hudson River and Bronx River		6.6	0
NYC WRRF		0.1	0
NYC Stormwater (Except MS4)		1.6	0.4
NYC MS4 Stormwater		1.1	0.1
NYC CSOs		39.2	0.2
Total		611.1	64.2
Open Boundary Conditions	K4	1.0	1
Sources outside of NYC		371.4	19.1

Table 6-18. Fecal Coliform and *Enterococci* GM 2008 Source Components

Source	Station	Fecal Coliform Contribution (cfu/100mL) Annual Worst Month December Monthly GM	*Enterococci* Contribution (cfu/100mL) 30-day GM at time of Overall Max.
Hudson River and Bronx River		3.9	0
NYC WRRF		0.1	0
NYC Stormwater (Except MS4)		31.8	7.3
NYC MS4 Stormwater		5.5	0.7
NYC CSOs		24.0	0
Total		437.7	28.1
Kill Van Kull (Class SD)(1)			
Open Boundary Conditions	KK-2	1.0	1
Sources outside of NYC		135.8	7.1
Hudson River and Bronx River		20.3	0
NYC WRRF		0.2	0
NYC Stormwater (Except MS4)		1.5	0.3
NYC MS4 Stormwater		1.1	0.3
NYC CSOs		69.2	1.3
Total		229.1	10

Note:
(1) *Enterococci* criteria do not apply to non-coastal, non-primary contact recreational waters, and are shown for informational purposes for those waterbodies.

6.3.c Time to Recovery

The analyses provided above focused on the long term impacts of wet-weather sources, as is required by Existing WQ Criteria (monthly or 30-day GMs). Shorter-term impacts are not evaluated using these regulatory criteria. Therefore, to gain insight to the shorter-term impacts of wet-weather sources of bacteria, DEP has reviewed the DOH guidelines relative to single sample maximum bacteria concentrations that DOH believes “constitute a potential hazard to health if used for bathing.” The presumption is that if the bacteria concentrations are lower than these levels, then the waterbodies do not pose potential hazards if used for primary contact activities.

DOH considers fecal coliform concentrations that exceed 1,000 cfu/100mL to be potential hazards to bathing. Water quality modeling analyses were conducted to assess the amount of time following the end of rainfall required for the Citywide/Open Waters waterbodies to recover and return to concentrations of less than 1,000 cfu/100mL. Note that this analysis was conducted for informational purposes, and that Primary Contact Recreation is not a designated use in the Class I and Class SD Citywide/Open Waters waterbodies.

The approach to developing a “Time to Recovery” began with an analysis of JFK Airport rainfall data for the period of 2002-2011. The Synoptic Surface Plotting (SYNOP) model was used to identify each

From NYS DOH

https://www.health.ny.gov/regulations/nycrr/title_10/part_6/subpart_6-2.htm

Operation and Supervision

6-2.15 Water quality monitoring
(a) No bathing beach shall be maintained … to constitute a potential hazard to health if used for bathing. To determine if the water quality constitutes a potential hazard … shall consider one or a combination of any of the following items: results of a sanitary survey; historical water quality model for rainfall and other factors; verified spill or discharge of contaminants affecting the bathing area; and water quality indicator levels specified in this section.

(1) Based on a single sample, the upper value for the density of bacteria shall be: (i) 1,000 fecal coliform bacteria per 100 ml; or …(iii) 104 enterococci per 100 ml for marine water; ….

individual storm and calculate the storm volume, duration, and start and end times. Rainfall periods separated by four hours or more were considered separate storms. Statistical analysis of the individual rainfall events for the recreational seasons (May 1st through October 31st) of the 10-year period resulted in a 90th percentile rainfall event of 1.09 inches.

For the Citywide/Open Waters waterbodies, the JFK Airport rainfall data was compared against water quality model bacteria results for the 10 recreational seasons to determine how long it took for the water column concentration to return to target threshold concentrations from the end of the rain event. The chosen target threshold concentration was 1,000 cfu/100mL for fecal coliform. The various rainfall events were then placed into rain event size "bins" ranging from less than 0.1 inch to greater than 1.5 inches. Only rain events that reached the target threshold concentrations before the beginning of the next storm were included. The median time to recovery for each bin at each water quality station was calculated. Table 6-19 presents the time to recovery for the baseline condition and the No NYC CSO Loads scenario for the Citywide/Open Waters waterbodies, for the greater than 1.0 to 1.5 inch rainfall bin. This rainfall bin includes the 90th percentile event.

DEC has advised that it seeks to have a time to recovery of less than 24 hours. As indicated in Table 6-19, under the baseline conditions, none of the stations assessed had a median time to recovery greater than 24 hours, and most of the stations had median time to recovery of zero, indicating that the average fecal coliform concentrations across the water column did not exceed 1,000 cfu/100mL for more than half of the storms within the 1-to-1.5 inch rainfall bin assessed. With removal of NYC CSOs from the Citywide/Open Waters waterbodies (No NYC CSO Loads), the median time to recovery at all of the stations assessed was zero.

Table 6-19. Time to Recovery – Fecal Coliform

Location	Median Time to Recovery (hours) Fecal Coliform Threshold (1,000 cfu/100mL)(1)	
	Baseline	No NYC CSO Loads
Long Island Sound East of Throgs Neck Bridge (Class SB Coastal Primary Contact Recreational)		
EA-1	0(2)	0
EA-2	0	0
EA-3	0	0
Upper and Lower New York Bay (Class SB Coastal Primary Contact Recreational)		
NB-1	2	0
NB-2	0	0
NB-3	2	0
NB-4	2	0
NB-5	0	0
NB-6	0	0
NB-7	4	0
NB-8	0	0
NB-9	9	0
NB-10	0	0
NB-11	0	0
NB-12	0	0
Raritan Bay (Class SB Coastal Primary Contact Recreational)		
K5A	0	0
Rockaway Inlet (Class SB Coastal Primary Contact Recreational)		
J11	0	0
N9A	0	0
East River between Whitestone Bridge and Throgs Neck Bridge (Class SB)		
EA-4	0	0
EA-5	0	0
Hudson River north of Harlem River (Class SB)		
HU-1	0	0
Hudson River, Battery to Harlem River (Class I)		
HU-2	0	0
HU-3	0	0
HU-4	0	0
HU-5	0	0
HU-6	0	0
HU-7	0	0
HU-8	0	0

Table 6-19. Time to Recovery – Fecal Coliform

Location	Median Time to Recovery (hours) Fecal Coliform Threshold (1,000 cfu/100mL)(1)	
	Baseline	No NYC CSO Loads
HU-9	2	0
HU-10	0	0
Harlem River (Class I)		
HA-1	2	0
HA-2	3	0
HA-3	4	0
HA-4	6.5	0
HA-5	6	0
HA-6	0	0
East River, Whitestone Bridge to Battery (Class I)		
EA-6	0	0
EA-7	0	0
EA-8	0	0
EA-9	0	0
EA-10	0	0
EA-11	0	0
EA-12	0	0
EA-13	0	0
EA-14	0	0
EA-15	0	0
Arthur Kill, Raritan Bay to Outerbridge Crossing (Class I)		
K5	0	0
Arthur Kill, Outerbridge Crossing to Kill Van Kull (Class SD)		
K3	2	2
K4	0	0
Kill Van Kull (Class SD)		
K2	0	0
KK-2	0	0
KK-3	0	0

Notes:

(1) Median time to recovery values presented for storms from the 10-year simulation, recreational seasons, in the size range of >1.0 to 1.5-inches of rainfall, which includes the 90th percentile rain event.

(2) Median time to recovery of “0” means that the average concentration across the water column never reached the 1,000 cfu/100mL threshold at the referenced station for more than half of the storms within the 1-to-1.5 inch rainfall bin assessed.

A similar analysis was conducted to assess time to recovery to an *Enterococci* concentration of 130 cfu/100mL, corresponding to the STV criterion for Class SB Coastal Primary Contact Recreational waters. The results of that analysis for Baseline Conditions and 100% CSO control are presented in Table 6-20. As indicated in Table 6-20, under the baseline conditions, none of the stations assessed had a median time to recovery greater than 24 hours, and many of the stations had zero time to recovery, indicating that the average *Enterococci* concentrations across the water column at those locations did not exceed 130 cfu/100mL for more than half of the storms within the 1-to-1.5 inch rainfall bin assessed. With removal of NYC CSOs from the Citywide/Open Waters waterbodies (No NYC CSO Loads), the median time to recovery was zero at all of the stations assessed except for Station J11, where the time to recovery remained at 2 hours.

Table 6-20. Time to Recovery – *Enterococci*

Location	Median Time to Recovery (hours) *Enterococci* Threshold (130 cfu/100mL)(1)	
	Baseline	No NYC CSO Loads
Long Island Sound east of Throgs Neck Bridge (Class SB Coastal Primary Contact Recreational)		
EA-1	0(2)	0
EA-2	0	0
EA-3	0	0
Upper and Lower New York Bay (Class SB Coastal Primary Contact Recreational)		
NB-1	7	0
NB-2	8	0
NB-3	9	0
NB-4	7.5	0
NB-5	0	0
NB-6	0	0
NB-7	11	0
NB-8	0	0
NB-9	12.5	0
NB-10	0	0
NB-11	0	0
NB-12	0	0
Raritan Bay (Class SB Coastal Primary Contact Recreational)		
K5A	0	0

Table 6-20. Time to Recovery – *Enterococci*

Location	Median Time to Recovery (hours) *Enterococci* Threshold (130 cfu/100mL)(1)	
	Baseline	No NYC CSO Loads
Rockaway Inlet (Class SB Coastal Primary Contact Recreational)		
J11	2	2
N9A	0	0

Notes:

(1) Median time to recovery values presented for storms from the 10-year simulation, recreational seasons, in the size range of >1.0 to 1.5-inches of rainfall, which includes the 90th percentile rain event.

(2) Median time to recovery of "0" means that the average concentration across the water column never reached the 130 cfu/100mL threshold at the referenced station for more than half of the storms within the 1-to-1.5 inch rainfall bin assessed.

7.0 PUBLIC PARTICIPATION AND AGENCY COORDINATION

DEP is committed to a proactive and robust program to inform the public about the development of watershed-specific and citywide LTCPs. Public outreach and public participation are important aspects of the plans, which are designed to reduce CSO-related impacts to achieve waterbody-specific water quality standards (WQS), consistent with the Federal CSO Control Policy and the CWA, and in accordance with EPA and DEC mandates.

DEP's public participation programing uses various tools and activities to inform, involve, and engage a diverse group of stakeholders and the broader public throughout the LTCP process. The purpose of public participation is to create a framework for communicating with and soliciting input from interested stakeholders and the broader public concerning water quality and the challenges and opportunities for CSO controls. DEP strategically and systematically implements activities that meet the public's information needs and critical milestones in the overall LTCP schedule outlined in the CSO Order.

As part of the CSO Quarterly Reports, DEP reports to DEC on the public participation activities implemented for the LTCP.

7.1 Public Participation for the Citywide/Open Waters LTCP

Public participation for the Long Term Control Plans has evolved since the first kickoff meeting in 2012. Over the years DEP has worked to incorporate public feedback as it relates to venue locations, presentation content, educational materials, and meeting advertising. DEP has also worked to incorporate public feedback as it relates to public comments on the Recommended Plan. For the LTCPs submitted between 2013 and 2017, DEP conducted two public meetings per LTCP before the final LTCP was submitted to DEC: a kickoff meeting and an alternatives meeting. A third final meeting on the Recommended Plan would not occur until after it had already been submitted to DEC. The public submitted multiple comments asking for the opportunity to review and provide feedback on the final recommendations before the LTCP was submitted to DEC. In response, DEP worked with DEC to develop a compromise for the Jamaica Bay and Citywide & East River/Open Waters LTCP that would give the public an opportunity to review the substance of the recommendation (proposed projects, costs, benefits) without further delaying LTCP submittal deadlines. As described below, DEP held additional public meetings and offered additional public comment response opportunities.

DEP also introduced new public-friendly documents that presented technical information in a more user friendly way to make it easier for the public to review and provide comments. The LTCP Retained Alternatives Summary and the LTCP Recommended Plan Summary were written in plain language and included helpful info-graphs, photos, and maps. These documents were introduced in response to public feedback about the technical nature of the LTCPs, and the difficulty the general public faced while reviewing them.

7.2 Summaries of Stakeholder Meetings

DEP held eight public meetings to aid in the development and execution of the LTCP. The objectives of the public meetings and summaries of the discussions are presented below.

Public Meetings

- <u>Public Meeting #1: Harlem River/Hudson River Focused Kickoff Meeting (January 31, 2018)</u>

  Objectives: Provide overview of Harlem River/Hudson River watershed characteristics, sampling program results and LTCP development process.

  DEP hosted a public Kickoff Meeting to initiate the water quality planning process for the Citywide/Open Waters LTCP. Given the wide area covered by the Citywide/Open Waters LTCP, the water quality sampling program was divided into three phases: Harlem and Hudson Rivers, East River, and New York Bay/Arthur Kill/Kill Van Kull. The first public meeting on the Citywide/Open Waters LTCP focused on the Harlem and Hudson Rivers. The two-hour event was held at the Manhattan College Leo Engineering building in the Bronx. Public Meetings for the two other phases will be held separately. The Kickoff Meeting for Harlem and Hudson Rivers provided stakeholders with information about DEP's LTCP Program, Harlem and Hudson River's watershed characteristics, results from the water quality sampling program, and the status of waterbody improvement projects. DEP also described additional opportunities for public input and outreach.

  Approximately 70 stakeholders from different non-profit, community, planning, environmental, economic development, governmental organizations, and the broader public attended the event, as well as representatives from the DEP, the DEC, Community Board 8, and the City Council. Information presented included:

  - Harlem and Hudson River watershed and land uses;
  - Harlem and Hudson River CSO outfalls and annual volumes;
  - Harlem and Hudson River water quality standard classification;
  - Harlem and Hudson River sampling program and results;
  - Existing Grey Infrastructure projects in vicinity of Harlem and Hudson River;
  - Green Infrastructure opportunities;
  - Water Quality Modeling and CSO Control evaluation process; and
  - Harlem and Hudson River CSO mitigation options.

  The presentation, along with video of the public meeting, are posted to DEP's LTCP Program website (http://www.nyc.gov/dep/ltcp).

- <u>Public Meeting #2: Kill Van Kull/Arthur Kill/New York Bay Kickoff Meeting (March 27, 2018)</u>

  Objectives: Provide overview of Kill Van Kull/Arthur Kill/New York Bay watershed characteristics, sampling program results and LTCP development process.

  DEP hosted a second public Kickoff Meeting on the Citywide/Open Waters LTCP water quality planning process, focusing on Kill Van Kull, Arthur Kill, and New York Bay. The two-hour event was held at St. John's University in Staten Island. The Kickoff Meeting provided stakeholders with information about DEP's LTCP Program, watershed characteristics, results from the water quality sampling program, and the status of waterbody improvement projects. DEP also described additional opportunities for public input and outreach.

Approximately 18 stakeholders from different non-profit, community, planning, environmental, economic development, and governmental organizations, and the broader public attended the event, as well as representatives from the DEP, the DEC, and Staten Island Community Boards 1, 2, and 3. Information presented on Kill Van Kull, Arthur Kill, and New York Bay included:

- Kill Van Kull, Arthur Kill, New York Bay watershed and land uses;
- Kill Van Kull, Arthur Kill, New York Bay CSO outfalls and annual volumes;
- Kill Van Kull, Arthur Kill, New York Bay water quality standard classification;
- Kill Van Kull, Arthur Kill, New York Bay sampling program and results;
- Existing Grey Infrastructure projects in vicinity of Kill Van Kull, Arthur Kill, and New York Bay;
- Green Infrastructure opportunities;
- Water Quality Modeling and CSO Control evaluation process; and
- Kill Van Kull, Arthur Kill, New York Bay CSO mitigation options.

The meeting presentation is posted to DEP's LTCP Program website (http://www.nyc.gov/dep/ltcp).

- Public Meeting #3: East River/Long Island Sound focused Kickoff Meeting (May 10, 2018)

Objectives: Provide overview of East River/Long Island Sound watershed characteristics, sampling program results and LTCP development process.

DEP hosted a third public Kickoff Meeting on the Citywide/Open Waters LTCP water quality planning process, focusing on the East River and Long Island Sound. The two-hour event was held at the Newtown Creek Visitor Center in Brooklyn. The Kickoff Meeting provided stakeholders with information about DEP's LTCP Program, East River, and Long Island Sound watershed characteristics, results from the water quality sampling program, and the status of waterbody improvement projects. DEP also described additional opportunities for public input and outreach.

Approximately 20 stakeholders from different non-profit, community, planning, environmental, economic development, and governmental organizations, and the broader public attended the event as well as representatives from the DEP, the DEC, and Community Board 2. Information presented on the East River and Long Island Sound included:

- East River and Long Island Sound CSO watershed and land uses;
- East River and Long Island Sound CSO outfalls and annual volumes;
- East River and Long Island Sound water quality standard classification;
- East River and Long Island Sound sampling program and results;
- Existing Grey Infrastructure projects in vicinity of East River and Long Island Sound;
- Green Infrastructure opportunities;
- Water Quality Modeling and CSO Control evaluation process; and
- East River and Long Island Sound CSO mitigation options.

The meeting presentation is posted on DEP's website (http://www.nyc.gov/dep/ltcp).

- Public Meeting #4: Citywide/Open Waters LTCP Stakeholder Meeting (April 16, 2019)

  Objectives: Provide an update on the Development of the Citywide/Open Waters LTCP.

  DEP hosted a fourth public meeting on April 16, 2019 to provide an update on the Citywide/ Open Waters LTCP. Over 50 stakeholders from different non-profit, community, planning, environmental, economic development, and governmental organizations and the broader public attended the event, as did representatives from DEP, the DEC, and Community Boards from Brooklyn, Queens, and the Bronx. The two--hour event, held at the CUNY Law School in Long Island City, provided stakeholders with information on the following topics:

  - Overview of LTCP Program and Citywide/Open Waters LTCP;
  - LTCP Milestone Status;
  - Public Outreach Update;
  - Update on Citywide/Open Waters Schedule;
  - Outline of the Citywide/Open Waters LTCP Executive Summary; and
  - Overview of the Citywide/Open Waters LTCP Progress.

  DEP presented a general update on the LTCP Program and public outreach, and an outline for the Citywide/Open Waters LTCP Executive Summary, as well as an overview of the Citywide/Open Waters LTCP Progress including an update on DEC WQS revisions, BMP regulator flow monitoring, collection system and water quality modeling, WQS attainment, and preliminary alternatives evaluations.

  During the meeting, the public was given until May 17, 2019 to provide comments on the public meeting. DEP received the following comments:

  1. Stormwater Infrastructure Matters (SWIM) Coalition, April 15, 2019. Re: Questions for Citywide/Open Waters LTCP Stakeholder Meeting.

  2. NYC Water Trail Association, April 17, 2019. Re: Citywide/Open Waters LTCP Stakeholder Meeting.

  3. Bronx Council for Environmental Quality, May 15, 2019. Re: 2019 Stakeholder Meeting CSO LTCP Citywide/Open Waters John Abbatangelo of GHD, October 3, 2019. Citywide/Open Waters public meeting follow up questions.

  DEP responses to the comments received were distributed to the public prior to the October 15, 2020 Retained Alternatives Meeting. The presentation, meeting summary and public comment response summary are posted on DEP's website (http://www.nyc.gov/dep/ltcp).

- Public Meeting #5: Public Meeting for Harlem River and Tibbetts Brook (October 2, 2019)

  Objectives: Review Citywide/Open Waters LTCP Retained Alternatives focusing on the Harlem River and Tibbetts Brook.

  DEP hosted a fifth Citywide/Open Waters LTCP public meeting on October 2, 2019 to provide an update on the alternatives for Harlem River and Tibbetts Brook. The two-hour event was held at the Van Cortland Lake House in the Bronx, New York City. Approximately 35 stakeholders from different non-profit, community, planning, environmental, economic development, governmental organizations, and the broader public attended the event, as well as representatives from the DEP, the DEC, and Community Board 8. Information presented included:

  - Summary of Harlem River water quality;
  - Harlem River baseline grey infrastructure projects;
  - Harlem River baseline green infrastructure projects;
  - Overview of Demand Management and Tibbetts Brook Daylighting Projects; and
  - Next steps for the Citywide/Open Waters CSO LTCP.

  The meeting presentation is posted on DEP's website (http://www.nyc.gov/dep/ltcp).

- Public Meeting #6: Public Meeting for Citywide/Open Waters LTCP Retained Alternatives (October 15, 2019)

  Objectives: Review the Citywide/Open Waters LTCP Retained Alternatives.

  DEP hosted a sixth Citywide/Open Waters LTCP public meeting on October 15, 2019 to provide an update on the open waters retained alternatives. The two-hour event was held at the CUNY School of Law in Queens. Approximately 55 stakeholders from different non-profit, community, planning, environmental, economic development, governmental organizations, and the broader public attended the event, as well as representatives from the DEP and the DEC. Information presented included:

  - Overview of Baseline Projects (Green Infrastructure, Demand Management and Tibbetts Brook Daylighting Projects);
  - Summary of Floatable Control Approach;
  - Water Quality Standards and Gap Analysis;
  - Alternatives Analysis Approach and Overview of Retained Alternatives; and
  - Next steps for the Citywide/Open Waters LTCP.

  At the meeting, DEP released the Citywide/Open Waters LTCP Retained Alternatives Summary for public review and comments. The public was given until December 2, 2019 to provide comments on the public meeting and the Retained Alternatives Summary. DEP received the following comments:

  1. John Abbatangelo of GHD, October 3, 2019. Re: Citywide/Open Waters public meeting follow up questions.

  2. Van Cortlandt Park Alliance (VCPA), November 25, 2019. Re: Comments on NYC DEP's Fall Update to the Citywide/Open Water Long Term Control Plan (Citywide LTCP).

3. NYC H2O, November 29, 2019. Re: Comments on Department of Environmental Protection's Retained Alternatives Summary for the Citywide/Open Waters CSO Long Term Control Plan.

4. Bronx Council for Environmental Quality (BCEQ), December 2, 2019. Re: Comments on the 2019 Citywide LTCP.

5. Newtown Creek Alliance (NCA), December 2, 2019. Re: Comments on Department of Environmental Protection's Retained Alternatives Summary for the Citywide/Open Waters CSO Long Term Control Plan.

6. Guardians of Flushing Bay (GoFB), December 2, 2019. Re: Comments on Department of Environmental Protection's Retained Alternatives Summary for the Citywide/Open Waters CSO Long Term Control Plan.

7. New York City Water Trail Association, December 2, 2019. Re: Comments on the Retained Alternatives Summary for the Citywide/Open Waters Combined Sewer Overflow Long Term Control Plan.

8. Stormwater Infrastructure Matters ("SWIM") Coalition, December 2, 2019. Re: Comments on Department of Environmental Protection's Retained Alternatives Summary for the Citywide/Open Waters CSO Long Term Control Plan.

9. Bronx Community Board 8, December 2, 2019. Re: LTCP Letter December 2019.

10. Gregory O'Mullan of Queens College, December 2, 2019. Re: Open Water CSO Long Term Control Plan public comment.

11. Linda Cohen (lindashoob@aol.com).

12. John Doyle (doylejc1@gmail.com).

13. Roy Fischman (ropaf@aol.com).

14. Janet McKee (McKee@sullcrom.com).

15. Coalition for the Daylighting of Tibbetts Brook.

16. Stormwater Infrastructure Matters ("SWIM") Coalition, December 16, 2019. Re: Addendum to Comments on Department of Environmental Protection's Retained Alternatives Summary for the Citywide/Open Waters CSO Long Term Control Plan

17. NYC Department of Parks and Recreation (DPR), December 12, 2019. Re: Comments on Citywide/Open Water LTCP Retained Alternatives Summary submitted via email to ltcp@dep.ny.gov. *(Due to ongoing coordination between DPR and DEP at that time, responses to this letter were deferred until the Final LTCP submittal.)*

DEP's responses to the comments received were distributed to the public prior to the January 29, 2020 Recommended Plan Meeting.The meeting presentation and public comment response summary are posted on DEP's website (http://www.nyc.gov/dep/ltcp).

- Public Meeting #7: Staten Island Retained Alternatives Public Meeting (November 6, 2019)

  Objectives: Review Citywide/Open Waters LTCP Retained Alternatives focusing on Staten Island.

  In consultation with local Staten Island Stakeholders, DEP attended the Staten Island Borough Board meeting to present on the retained alternatives. The presentation covered the same material as Public Meeting #6 and included more information on the Hannah Street Pumping Station retained alternative.

- Public Meeting #8: Recommended Plan Public Meeting (January 29, 2020)

  Objectives: Review Citywide/Open Waters LTCP Recommended Plan.

  DEP hosted an eighth Citywide/Open Waters LTCP public meeting on January 29, 2020 to present the Recommended Plan for the Citywide/Open Waters LTCP. The two-hour event was held at the CUNY School of Law in Queens. Approximately 90 stakeholders from different non-profit, community, planning, environmental, economic development, governmental organizations, and the broader public attended the event, as well as representatives from the DEP, the DEC, and the City Council. Information presented included:

  - Overview of DEP investments and spending priorities;
  - Overview of Baseline Projects (Green Infrastructure, Demand Management and Tibbetts Brook Daylighting Projects);
  - Overview of Recommended Plan; and
  - Next steps for the Citywide/Open Waters LTCP.

  At the meeting, DEP released the Citywide/Open Waters LTCP Recommended Plan Summary for public review and comments. The public was given until March 2, 2020 to provide comments on the public meeting and the Recommended Plan Summary. DEP received the following comments:

  1. Karen Argenti of Bronx Council for Environmental Quality (BCEQ), March 2, 2020. Re: NYCDEP Proposed Recommendations for the Citywide/Open Waters CSO LTCP.

  2. Rob Buchanan (avironvoile@gmail.com) of New York City Water Trail Association (NYCWTA) March 3, 2020. Re: NYCWTA comments on the proposed East River/Open Waters LTCP

  3. Linda Cohen (lindashoob@aol.com), March 3, 2020. Re: NYC Department of Environmental Protection Proposed Recommendations for the Citywide/Open Waters CSO Long Term Control Plan.

  4. Pro Bono Water Quality Associates (PBWQA), March 2, 2020. Re: Comments NYCDEP Citywide and Open Waters CSO LTCP (water quality modeling)

5. Amy Motzny of Gowanus Canal ConserVancy (GCC), March 2, 2020. Re: NYC Department of Environmental Protection Proposed Recommendations for the Citywide/Open Waters CSO Long Term Control Plan.

6. Roger Reynolds of Save the Sound (STS), March 2, 2020. Re: Comments on DEP's Combined Sewer Overflow (CSO) Long Term Control Plan (LTCP) for Citywide/Open Waters Recommended Plan Summary.

7. Kalra Raji, Bronx River Alliance (BRA), March 2, 2020. Re: NYC Department of Environmental Protection Proposed Recommendations for the Citywide/Open Waters CSO Long Term Control Plan.

8. Bob Alpern, January 30, 2020. Re: Citywide/Open Waters LTCP.

9. Kate Mc Letchie of Waterfront Alliance (WA), January 17, 2020. Re: Citywide and East River/Open Waters Recommended Plan Meeting.

10. Kellan Stanner of Lower East Side Ecology (LESEC), March 2, 2020. Re: NYC Department of Environmental Protection Proposed Recommendations for the Citywide/Open Waters CSO Long Term Control Plan.

11. Alan P. Berger of Alliance for a Human Scale City, February 24, 2020, Re: NYC Department of Environmental Protection Proposed Recommendations for the Citywide/Open Waters CSO Long Term Control Plan.

12. Vasos Panagiotopoulos, February 12, 2020, Re: Flushing River (Creek)

13. Ira Gershenhorn (ira@gershenhorn.com), February 3, 2020, Re: Citywide/Open Waters CSO Long Term Control Plan.

14. National Resource Defense Council (NRDC), March 2, 2020, Re: Citywide/Open Waters CSO Long Term Control Plan (form letter submitted by 1,670 additional individuals).

15. Riverkeeper, February 25, 2020, Re: DEP's "Citywide/Open Waters CSO Long Term Control Plan" must go further to protect public health (form letter submitted by 282 additional individuals).

16. NYC Department of Parks and Recreation (DPR), December 12, 2019. Re: Comments on Citywide/Open Water LTCP Retained Alternatives Summary submitted via email to ltcp@dep.ny.gov.

DEP's responses to the comments received are included in Appendix B, Public Participation Materials.

The presentation, along with video of the public meeting, are posted on DEP's website (http://www.nyc.gov/dep/ltcp.

7.3 Internet Accessible Information Outreach and Inquiries

Both traditional and electronic outreach tools are important elements of DEP's overall communication effort. DEP will ensure that outreach tools are accurate, informative, up-to-date, and consistent, and are widely distributed and easily accessible. Table 7-1 presents a summary of Citywide/Open Waters LTCP public participation activities.

Table 7-1. Summary of Citywide/Open Waters LTCP Public Participation Activities Performed

Category	Mechanisms Utilized	Dates (if applicable) and Comments
Regional LTCP Participation	Citywide LTCP Kickoff Meeting and Open House	• June 26, 2012
	Annual Citywide LTCP Meeting – Modeling Meeting	• February 28, 2013
	Annual Citywide LTCP Meeting #3	• December 11, 2014
	Annual Citywide LTCP Meeting #4	• January 12, 2016
	Annual Citywide LTCP Meeting #5	• November 15, 2017
	Annual Citywide LTCP Meeting #6	• December 5, 2018
Waterbody-specific Community Outreach	Public Meetings	• Kickoff Meeting #1: January 31, 2018 • Kickoff Meeting #2: March 27, 2018 • Kickoff Meeting #3: May 10, 2018 • Stakeholder Meeting: April 16, 2019 • Harlem River Retained Alternatives Meeting: October 2, 2019 • Retained Alternatives Meeting: October 15, 2019 • Staten Island Retained Alternatives Meeting: November 6, 2019 • Recommended Plan Meeting: January 29, 2020
Data Collection and Planning	Establish Online Comment Area and Process for Responding to Comments	• Comment area added to website on October 1, 2012 • Online comments receive response within two weeks of receipt
	Update Mailing List Database	• DEP updates master stakeholder database (1,300+ stakeholders) before each meeting
Communication Tools	Program Website or Dedicated Page	• LTCP Program website launched June 26, 2012 and frequently updated • DEP website revamped in late 2019
	Social Media	• Facebook and Twitter announcements of meetings
	FAQs	• LTCP FAQs developed and disseminated beginning June 2014 via website, meetings, and email

Table 7-1. Summary of Citywide/Open Waters LTCP Public Participation Activities Performed

Category	Mechanisms Utilized	Dates (if applicable) and Comments
Communication Tools	Print Materials	• LTCP FAQs: June 11, 2014 • LTCP Goal Statement: June 26, 2012 • LTCP Public Participation Plan: June 26, 2012 • LTCP Program Brochure: Updated December 2018 • Glossary of Modeling Terms: February 28, 2013 • Citywide LTCP Sampling Program • Meeting advertisements, agendas, and presentations • Meeting summaries and responses to comments • Quarterly Reports • WWFPs • Retained Alternatives Summary • Recommended Plan Summary
Student Education	Participate in Ongoing Education Events	• DEP has robust and ongoing education programs in local schools
	Provide Specific Green and Grey Infrastructure Educational Modules	• DEP has robust and ongoing education programs in local schools

DEP launched its LTCP Program website on June 26, 2012 (http://www.nyc.gov/dep/ltcp). The website provides links to documents related to the LTCP Program, including the CSO Order and any modifications, approved WWFPs, CSO Quarterly Reports, links to related programs, such as the GI Plan and Annual Report, and handouts and poster boards distributed and displayed at public meetings and open houses. A LTCP feedback email account was also created to receive LTCP-related feedback, and stakeholders can sign-up to receive LTCP Program announcements via email. In general, DEP's LTCP Program Website:

- Describes the LTCP process, CSO-related information, and citywide water quality improvement programs to-date;
- Describes waterbody-specific information including historical and existing conditions;
- Provides the public and stakeholders with timely updates and relevant information during the LTCP process, including meeting announcements;
- Broadens DEP's outreach campaign to further engage and educate the public on the LTCP process and related issues; and
- Provides an online portal for submission of comments, letters, suggestions, and other feedback.

A dedicated Citywide/Open Waters LTCP webpage was created on October 1, 2015 and includes the following information:

- Citywide/Open Waters public participation and education materials
  - Citywide LTCP Sampling Program Map and Data
  - Citywide/Open Waters Retained Alternatives Summary
  - Citywide/Open Waters Recommended Plan Summary
  - Citywide/Open Waters Response to Comments
- Citywide/Open Waters LTCP Meeting Announcements
- Citywide/Open Waters Meeting #1 Meeting Documents – January 31, 2018
  - Meeting Presentation
  - Video of Public Meeting
- Citywide/Open Waters Meeting #2 Meeting Documents – March 27, 2018
  - Meeting Presentation
- Citywide/Open Waters Meeting #3 Meeting Documents – May 10, 2018
  - Meeting Presentation
- Citywide/Open Waters Meeting #4 Meeting Documents – April 16, 2019
  - Meeting Presentation
  - Meeting Summary
  - Public Comment Response Summary
- Citywide/Open Waters Meeting #5 Meeting Documents – October 2, 2019
  - Meeting Presentation
- Citywide/Open Waters Meeting #6 Meeting Documents – October 15, 2019
  - Meeting Presentation
  - Public Comment Response Summary
- Citywide/Open Waters Meeting #7 Meeting Documents – November 6, 2019
  - Meeting Presentation
- Citywide/Open Waters Meeting #8 Meeting Documents – January 29, 2020
  - Meeting Presentation
  - Public Comment Response Summary
  - Video of Public Meeting

8.0 EVALUATION OF ALTERNATIVES

This section describes the development and evaluation of CSO control measures and watershed-wide alternatives. A CSO control measure is defined as a technology (e.g., treatment or storage), practice (e.g., NMC or BMP), or other method (e.g., source control or GI) of abating CSO discharges or the effects of such discharges on the environment. Alternatives evaluated are comprised of a single CSO control measure or a group of control measures that will collectively address the water quality objectives for the Citywide/Open Waters waterbodies.

This section contains the following information:

- Process for developing and evaluating CSO control alternatives that reduce CSO discharges and improves water quality (Section 8.1).
- CSO control alternatives and initial screening applicable to all of the five Citywide/Open Waters waterbodies (Section 8.2).
- CSO control alternatives development and evaluation for each of the five Citywide/Open Waters waterbodies (Sections 0 to 8.7). Within each of these sections, information is presented related to:
    - Initial evaluation of alternatives and identification of alternatives retained for more detailed cost/performance analysis
    - Estimated costs and CSO reductions achieved by the retained alternatives
    - Cost-performance relationships and level of attainment of water quality standards for the retained alternatives
    - Selection of the preferred alternative for each waterbody
- Summary of the overall Recommended Plan for the Citywide/Open Waters waterbodies (Section 8.8)

The water quality standards applicable to the Citywide/Open Waters waterbodies vary with the waterbody classifications, which include coastal primary recreational Class SB, non-coastal Class SB, Class I, and Class SD. As presented in Section 6.3, Table 6-11, all waterbodies were assessed for attainment with fecal coliform bacteria criteria. *Enterococcus* criteria are applicable only to the Class SB coastal recreational waters and were therefore assessed only for those waterbodies. The level of attainment with DO criteria associated with the appropriate waterbody classification was also assessed.

8.1 Considerations for LTCP Alternatives under the Federal CSO Control Policy

This LTCP addresses the water quality objectives of the CWA and the New York State Environmental Conservation Law. As required by the 2012 CSO Order, when the proposed alternative set forth in the LTCP will not achieve Existing WQ Criteria or the Section 101(a)(2) goals, a Use Attainability Analysis (UAA) must be prepared. A UAA is the mechanism to examine whether applicable waterbody classifications, criteria, or standards should be adjusted by the State. If deemed necessary, the UAA would assess compliance with the next higher classification that the State would consider in adjusting WQS and developing waterbody-specific criteria. The remainder of Section 8.1 presents general considerations for developing the LTCP in accordance with the CSO Control Policy, and a description of the process for evaluating the alternatives.

8.1.a Performance

To determine the influence of control of NYC CSOs on the attainment of WQ Criteria, a Performance Gap Analysis was performed. For this analysis, NYC CSO loads were modeled as eliminated, but all other sources of discharge to the waterbodies remained, including NYC stormwater discharges, and loadings from outside of NYC reflective of current conditions. The results of the analysis for each of the Citywide/Open Waters waterbodies are summarized in Section 6.3, and below in Table 8.1-1. As indicated in Table 8.1-1, the Hudson, Harlem and East Rivers, and New York Bay are all in attainment with the fecal coliform Water Quality Criteria under Baseline Conditions, so no attainment gap exists between Baseline Conditions and the condition with No NYC CSO Loads. For Kill Van Kull and the Class SD reach of Arthur Kill north of the Outerbridge Crossing Bridge, annual attainment of the fecal coliform criteria ranges from approximately 60 to 100 percent under Baseline Conditions, and 63 to 100 percent with No NYC CSO Loads. For the Class I section of Arthur Kill south of the Outerbridge Crossing Bridge, annual attainment of the fecal coliform criteria at Station K5 was 93 percent under both Baseline Conditions and No NYC CSO Loads. Thus, control of NYC CSOs has no impact on the attainment of the fecal coliform Water Quality Criteria in Arthur Kill or Kill Van Kull, indicating that impairments to water quality are due to sources other than NYC CSOs.

The Class SB coastal recreational waters of Long Island Sound east of the Throgs Neck Bridge are in attainment with the applicable *Enterococcus* Water Quality Criteria under Baseline Conditions, indicating no attainment gap. The Upper and Lower New York Bay are in attainment with the 30-day geomean *Enterococcus* criteria under Baseline Conditions, but portions of the Bay along the Brooklyn shoreline are not in attainment with the 90th Percentile STV *Enterococcus* criteria under Baseline Conditions. Attainment with the 90th Percentile STV *Enterococcus* criteria in that area ranges from 50 to 100 percent under Baseline Conditions. With No NYC CSO Loads, the Brooklyn shoreline of New York Bay is generally in compliance with the 30-day STV *Enterococcus* criteria. The area around Station K5A, near the southwestern tip of Staten Island, remains under 70 percent attainment with the 30-day STV *Enterococcus* criteria under the No NYC CSO Loads modeling scenario, indicating that the non-attainment in that area is driven by sources other than NYC CSOs.

Water Quality Criteria for dissolved oxygen are attained on an annual average basis in each of the Citywide Open Waters with the exception of the Class I portion of Arthur Kill and in an area of New York Bay off the southwest corner of Staten Island, where no NYC CSO discharges exist. For the Class I reach of Arthur Kill south of the Outerbridge Crossing, attainment of the DO criteria at Station K5 was 93 percent for both Baseline Conditions and No NYC CSO Loads. Similarly, attainment of the Class SB daily average criteria at Station K5A of the southwest corner of Staten Island was 89 percent for both Baseline Conditions and No NYC CSO Loads. Thus, control of NYC CSOs has no impact on the attainment of the dissolved oxygen Water Quality Criteria in Arthur Kill or New York Bay near Station K5A, indicating that impairments to water quality in those areas are due to sources other than NYC CSOs.

Table 8.1-1. Summary of Water Quality Gap Analysis

Waterbody	WQS Classification	Attainment with Criteria[1]							
		Fecal Coliform Monthly GM≤200 CFU/100mL[2]		*Enterococcus* 30-day GM≤35 cfu/100mL[3]		*Enterococcus* 30-day STV≤130 cfu/100mL[3]		DO Annual Average Attainment[4]	
		Baseline	No NYC CSO Loads	Baseline	No NYC CSO Loads	Baseline	No NYC CSO Loads	Baseline	No NYC CSO Loads
Harlem River	Class I	Yes	Yes	N/A	N/A	N/A	N/A	Yes	Yes
Hudson River (North of Harlem River)	Class SB	Yes	Yes	N/A	N/A	N/A	N/A	Yes	Yes
Hudson River (South of Harlem River)	Class I	Yes	Yes	N/A	N/A	N/A	N/A	Yes	Yes
Long Island Sound (East of Throgs Neck Bridge)	Class SB Coastal Primary Recreational	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
East River (between Whitestone Bridge and Throgs Neck Bridge)	Class SB	Yes	Yes	N/A	N/A	N/A	N/A	Yes	Yes
East River (West of Whitestone Bridge)	Class I	Yes	Yes	N/A	N/A	N/A	N/A	Yes	Yes
New York Bay	Class SB Coastal Primary Recreational	Yes	Yes	Yes	Yes	No	Yes[5]	No[6]	No[6]
Arthur Kill/Kill Van Kull (South of Outerbridge Crossing Bridge)	Class I	No[6]	No[6]	N/A	N/A	N/A	N/A	No[6]	No[6]

Table 8.1-1. Summary of Water Quality Gap Analysis

Waterbody	WQS Classification	Attainment with Criteria(1)							
		Fecal Coliform Monthly GM≤200 CFU/100mL(2)		*Enterococcus* 30-day GM≤35 cfu/100mL(3)		*Enterococcus* 30-day STV≤130 cfu/100mL(3)		DO Annual Average Attainment(4)	
		Baseline	No NYC CSO Loads	Baseline	No NYC CSO Loads	Baseline	No NYC CSO Loads	Baseline	No NYC CSO Loads
Arthur Kill (North of Outerbridge Crossing Bridge)	Class SD	**No(6)**	**No(6)**	N/A	N/A	N/A	N/A	**Yes**	**Yes**
Kill Van Kull	Class SD	**No(6)**	**No(6)**	N/A	N/A	N/A	N/A	**Yes**	**Yes**

Notes:

* *Enterococcus* criteria are not applicable to these waterbodies. Attainment with criteria is presented for informational purposes

(1) "**Yes**" means ≥95% attainment with the criteria. "**No**" means <95% attainment with the criteria. Attainment based on 10-year model simulation.

(2) Assessed on an annual basis.

(3) Assessed on a recreational season (May 1st through October 31st) basis. *Enterococcus* criteria apply only to coastal primary recreational waters. N/A = Not applicable.

(4) DO criteria:
   a. Class SB acute ≥3 mg/L; chronic ≥ range of 3 to 4.8 mg/L (see Section 6 for more details on Class SB chronic criteria)
   b. Class I ≥4 mg/L
   c. Class SD ≥3 mg/L

(5) All but a few shoreline grid cells and the area around Station K5A off the southwest end of Staten Island are in compliance with the 30-day STV *Enterococcus* criteria. None of these locations are near NYC CSOs.

(6) The load component analysis in Section 6 demonstrated that the non-attainment is driven by sources from outside of NYC.

The evaluations concluded that for the Hudson River, Harlem River, and East River/Long Island Sound, the waterbodies are in attainment with the applicable bacteria and DO Water Quality Criteria under Baseline Conditions, and thus no further CSO control would be needed to meet WQS. For Arthur Kill and Kill Van Kull, a condition of No NYC CSOs would not be sufficient to meet the applicable bacteria Water Quality Criteria, in part because Arthur Kill already has no direct NYC CSO discharges, but also indicative that other sources are driving the non-attainment of WQS. A model run was conducted for Baseline Conditions with all pollutant loads from outside of NYC zeroed out. This run indicated that with only CSO and stormwater discharges from NYC, Arthur Kill, and Kill Van Kull would be in full attainment with the Existing WQ Criteria for bacteria (fecal coliform). Thus, the remaining NYC CSO loads would not preclude attainment of the WQ Criteria for bacteria if the other sources were controlled.

For the Upper and Lower New York Bay, the applicable fecal coliform monthly GM criteria are met on an annual basis and the *Enterococcus* 30-day GM criteria are achieved on a recreational season basis under Baseline Conditions. However, attainment with the *Enterococcus* 30-day STV criteria is less than 95 percent during the recreation season. The modeled condition with No NYC CSO Loads would bring the *Enterococcus* 30-day STV criteria attainment to greater than 95 percent, indicating that the non-attainment with the STV element of the *Enterococcus* criteria under Baseline Conditions is driven by NYC CSO sources.

As a result of the generally high level of attainment with applicable WQ Criteria under Baseline Conditions, the CSO control alternatives evaluations focused primarily on system optimization measures. These optimization measures prioritized high-frequency CSO discharges and CSOs located near public access points along the waterbodies. The alternatives evaluations also considered the level of CSO control necessary to achieve the DEC goal for a time to recovery of less than 24 hours after a wet-weather event. Consistent with the CSO Control Policy, alternatives to provide a range of 25, 50, 75, and 100 percent CSO control (based on the 2008 typical year rainfall) were also evaluated. Given the extremely high cost of these CSO control alternatives and the limited potential benefit in terms of improvement in attainment of WQS, these alternatives were only developed to a conceptual level, sufficient to assess general dimensions and order-of-magnitude costs.

Table 8.1-2 provides a summary of the storage volume required to achieve 25, 50, 75, and 100 percent CSO capture in the 2008 typical year for each of the Citywide/Open Waters waterbodies. For each case, the percent CSO control was estimated based upon the 2008 Typical Year.

Table 8.1-2. Summary of Storage Volume Required for 25, 50, 75, and 100 Percent CSO Control for Citywide/Open Waters Waterbodies

Waterbody	Storage Volume Required (MG)			
	25% CSO Control(1)	50% CSO Control(1)	75% CSO Control(1)	100% CSO Control(1)
Harlem River	21	130	197	277
Hudson River	14	79	114	142
East River/Long Island Sound	52	367	526	740
Upper/Lower New York Bay	22	156	253	361
Kill Van Kull	2.5	6.8	15	30
Total	**112**	**739**	**1,105**	**1,550**

Note:
(1) Level of CSO control based on 2008 typical year rainfall.

Figure 8.1-1 shows a plot of the required volumes for the Citywide/Open Waters waterbodies for 50, 75, and 100 percent CSO control for the 2008 typical year.

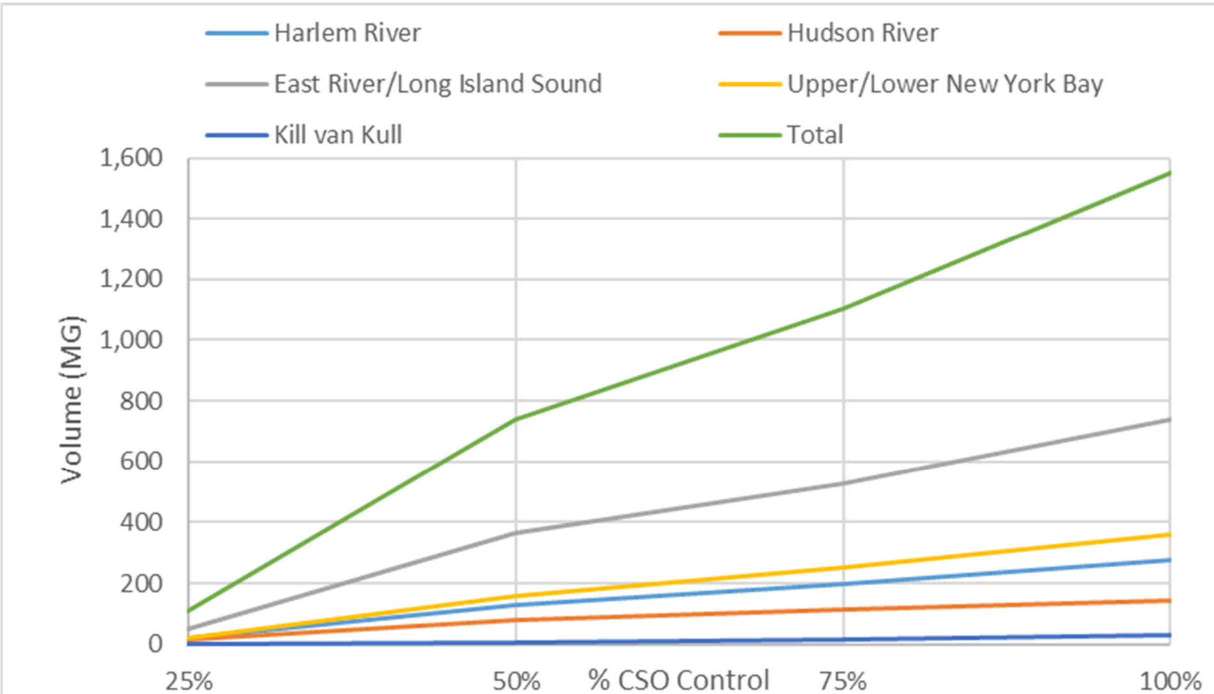

Figure 8.1-1. Required Storage Volume for 25, 50, 75 and 100 Percent CSO Control for each of the Citywide/Open Waters Waterbodies

8.1.b Impact on Sensitive Areas

In developing LTCP alternatives, special effort is made to minimize the impact of construction, to protect existing sensitive areas, and to enhance water quality in sensitive areas. As described in Section 2.0, sensitive areas as defined by the CSO Control Policy within the Citywide/Open Waters waterbodies included the Class SB waters of Hudson River north of the Harlem River, East River/Long Island Sound east of the Whitestone Bridge, and New York Bay. Each of the Citywide/Open Waters waterbodies was also identified as "waters with threatened or endangered species and their habitat."

8.1.c Cost

Cost estimates for the alternatives were computed using a costing tool based on parametric costing data. This approach provides an AACE Class 5 estimate (accuracy range of minus 20 to 50 percent to plus 30 to 100 percent), which is typical and appropriate for this type of planning evaluation. For the purpose of this LTCP, all costs are in 2019 dollars.

For the LTCP alternatives, Probable Bid Cost (PBC) was used as the estimate of the construction cost. Annual operation and maintenance costs were then used to calculate the total or net present worth (NPW) over the projected useful life of the project. In general, a lifecycle of 100 years and an interest rate of 3.0 percent were assumed resulting in a Present Worth Factor of 31.599.

To quantify costs and benefits, alternatives were compared based on reductions of both CSO discharge volume and bacteria loading against the total cost of the alternative. These costs were then used to plot the performance and attainment curves. A pronounced inflection point appearing in the resulting graphs, the so-called knee-of-the-curve point, suggests a potential cost-effective alternative for further consideration. In theory, this would reflect the alternative that achieves the greatest appreciable water quality improvements per unit of cost. However, cost/performance or cost/attainment curves do not always identify a distinct "knee," and if an alternative does fall on a distinct "knee," it may not necessarily be the preferred alternative. The final, or preferred, alternative must be capable of improving water quality in a fiscally responsible and affordable manner to properly allocate resources across the overall citywide LTCP program and DEP's larger capital improvement program (see Section 9 for discussion of affordability analysis). These monetary considerations also must be balanced with non-monetary factors, such as construction impacts, environmental benefits, technical feasibility, and operability, which are discussed below.

8.1.d Technical Feasibility

Several factors were considered when evaluating technical feasibility, including:

- Effectiveness for controlling CSO
- Reliability
- Constructability

The effectiveness of CSO control measures was assessed based on their ability to reduce CSO frequency, volume and load. Reliability is an important operational consideration and can have an impact on overall effectiveness of a CSO control measure. Therefore, reliability and proven history were used to assess the technical feasibility of a CSO control measure.

Several site-specific factors were considered to evaluate an alternative's constructability, including available space, neighborhood assimilation, impact on parks and green space, and overall practicality of installing and maintaining CSO controls. In addition, the method of construction was factored into the final selection. Some technologies require specialized construction methods that typically incur additional impacts as well as costs.

8.1.e Cost-Effective Expansion

All alternatives evaluated were sized to handle the CSO volumes based on the 2008 typical year rainfall and 2040 design year dry-weather flows, with the understanding that the predicted and actual flows may differ. To help mitigate the difference between predicted and actual flows, adaptive management was considered for those CSO technologies that could be expanded in the future to capture or treat additional CSO flows or volumes, should it be needed. In some cases, this may have affected where the facility would be constructed or gave preference to a facility that could be expanded at a later date with minimal cost and disruption of operation.

Breaking construction into segments allows adjustment of the design of future phases based on the performance of already-constructed phases. Lessons learned during operation of current facilities can be incorporated into the design of future facilities. However, phased construction also exposes the local community to a longer construction period. Where applicable, for those alternatives that could be expanded, the LTCP took into account the ease of expansion, what additional infrastructure may be required, and if additional land acquisition would be needed.

As regulatory requirements change, other water quality improvements may be required. The ability of a CSO control technology to be retrofitted to address additional pollutant parameters or more stringent discharge limits strengthens the case for application of that technology.

8.1.f Long Term Phased Implementation

Recommended LTCP implementation steps associated with the preferred alternative are typically structured in a way that makes them adaptable to change by expansion and modification resulting from possible new regulatory and/or local drivers at the time of implementation of the LTCP alternative. If applicable, the project(s) would be implemented over a multi-year schedule. Because of this, permitting and approval requirements must be identified prior to selection of the alternative. With the exception of GI, which is assumed to occur on both private and public property, most of the CSO grey technologies target municipally owned property and right-of-way-acquisitions. DEP will work closely with other NYC agencies and, as necessary, with NYS, to provide proper coordination with other government entities.

8.1.g Other Environmental Considerations

DEP has considered minimizing impacts on the environment and surrounding neighborhoods during construction. These impacts could potentially include traffic, site access issues, park and wetland disruption, noise pollution, air quality, and odor emissions. Potential environmental impacts will be identified with the selection of the preferred plan and communicated to the public. The specific details on mitigation of the identified concerns and/or impacts, such as erosion control measures and the re-routing of traffic, would be addressed later as part of a pre-construction environmental assessment.

8.1.h Community Acceptance

As described in Section 7, DEP is committed to involving the public, regulators, and other stakeholders throughout the planning process. Community acceptance of the Recommended Plan is essential to its success. As such, DEP uses the LTCP public participation process to present the scope of the LTCP, background, newly collected data, WQS and the development and evaluation of alternatives to the public and to solicit its support and feedback. The Citywide/Open Waters LTCP is intended to improve water quality, and public health and safety are its priorities. The goal of raising awareness of and access to waterbodies was also considered throughout the alternative analysis. Several CSO control measures, such as GI, have been shown to enhance communities while increasing local property values. As such, the benefits of GI were considered in the formation of the baseline and the final Recommended Plan.

8.1.i Methodology for Ranking Alternatives

The multi-step evaluation process DEP used to develop the Citywide/Open Waters LTCP included the following:

1. Evaluated benchmarking scenarios, including baseline and 100 percent CSO control, to establish a range of CSO controls within the Citywide/Open Waters sewersheds for consideration. The results of this step were described in Section 6.
2. Used baseline conditions to prioritize the CSO outfalls for possible controls.
3. Developed a list of promising CSO control measures for further evaluation based in part on the prioritized CSO list.

4. Established levels of intermediate CSO control that provide a range between baseline and 100 percent CSO control for the receiving water quality simulations that were conducted.
5. Conducted a series of workshops with DEP staff from April through June 2019, to work through the evaluation of system optimization measures using the Optimizer software and the InfoWorks model.
6. Held meetings with DEP and DEC staff on February 26, June 28 (conference call), and August 8, 2019, to review progress on the development and evaluation of CSO control alternatives.
7. Conducted a meeting with DEP staff on July 22, 2019, to prepare for the Inter-Bureau Alternatives Workshop.
8. Conducted an Inter-Bureau Alternatives Workshop at DEP on July 25, 2019, to solicit input on the alternatives under consideration, and to select a shortlist of retained alternatives.
9. Conducted a workshop with DEP Bureau of Wastewater Treatment staff on November 20, 2019, to review the retained optimization alternatives.
10. Held meeting with DEP and DEC staff on December 3, 2019, to review the retained alternatives.

Consistent with the approach used for the previous LTCPs submitted to DEC under this program, the alternatives development and evaluation process started with a range of different potential CSO control technologies. This initial "toolbox" was organized into categories that included Source Control, System Optimization, CSO Relocation, Water Quality/Ecological Enhancement, Treatment and Storage. Specific CSO control measures considered under each category were as follows:

Source Control

- Additional Green Infrastructure
- High Level Storm Sewers

System Optimization

- Regulator Modification
- Parallel Interceptor/Sewer
- Bending Weirs or Control Gates
- Pumping Station Expansion/Optimization

CSO Relocation

- Gravity Flow Redirection to Other Watersheds
- Pumping Station Modification
- Flow Redirection with Conduit/Tunnel and Pumping

Water Quality/Ecological Enhancement

- Floatables Control
- Environmental Dredging
- Wetland Restoration and Daylighting

Treatment

- Outfall Disinfection
- Retention Treatment Basin
- High-Rate Clarification
- WRRF Expansion

Storage

- In-System/Outfall
- Tank
- Tunnel

As noted above, due to the generally high level of attainment with applicable WQ Criteria under Baseline Conditions, the CSO control alternatives evaluations focused primarily on system optimization measures. In addition, consistent with the CSO Control Policy, alternatives to provide a range of 25, 50, 75, and 100 percent CSO control (in the 2008 typical year) were also evaluated. However, each of the technologies listed above was initially considered for potential applicability to the Citywide/Open Waters waterbodies. Some of the technologies could be screened out for all waterbodies without further evaluation, based on general system knowledge. Other technologies required varying levels of analysis to assess feasibility before getting screened out. The screening process was iterative and was conducted in coordination with DEP staff through the various workshops described above.

Figure 8.1-2 presents a graphical representation of the CSO control alternatives toolbox. This figure shows all of the technologies listed above, color-coded to indicate whether the technology was considered for ongoing implementation under other programs, was screened out based on various levels of evaluation, or was carried forward as a retained alternative for evaluation using the cost/performance curves. Further discussion of the technologies within each of these categories is presented below.

Source Control	**Green Infrastructure**		**Storm Sewers**		
System Optimization	**Regulator Modifications**	**Parallel Interceptor / Sewer**	**Bending Weirs Control Gates**	Pump Station Optimization	Pump Station Expansion
CSO Relocation	**Gravity Flow Redirection to Other Watersheds**	Pumping Station Modification	Flow Redirection with Conduit/Tunnel and Pumping		
Water Quality / Ecological Enhancement	**Floatables Control**	Environmental Dredging	**Wetland Restoration & Daylighting**		
Satellite Treatment	Outfall Disinfection	Retention Treatment Basin (RTB)		**High-Rate Clarification (HRC)**	
Centralized Treatment	WRRF Expansion				
Storage	In-System		**Tank**	**Tunnel**	

Ongoing Projects | Evaluated but Screened Out | **Retained Alternatives**

Figure 8.1-2. Matrix of CSO Control Measures for Citywide Open Waters

8.1.i.1 Ongoing Projects

Technologies under this category are not specifically recommended as part of this LTCP, but may continue to be implemented in parts of the Citywide/Open Waters sewersheds as part of other DEP programs and initiatives.

- *Additional Green Infrastructure (GI):* As noted in Section 5, the planned and implemented GI in the Citywide/Open Waters sewersheds included in the Citywide/Open Waters Baseline Conditions is projected to result in a CSO volume reduction of approximately 912 MGY, based on the 2008 typical rainfall year. The GI assets generally consist of right-of-way (ROW) practices, public property retrofits, and GI implementation on private properties. DEP is also developing a new stormwater program which is expected to provide additional CSO and stormwater load reductions in Open Waters above and beyond the GI baseline conditions and timeframe. More details on the program development and associated proposed legislation are included in Section *5*.

- *High Level Storm Sewers:* DEP has typically employed high level storm sewers (HLSS) – i.e., the removal of public right-of-way runoff from streets and sidewalks – only where localized flooding problems have occurred, rather than as a CSO control measure. While HLSS can reduce CSO volumes, the resultant increase in stormwater discharge can negate the benefit of the CSO reduction in terms of attainment of WQS. In addition, construction of HLSS is relatively expensive, and results in extensive construction-period disruptions and impacts in the location of the work. For these reasons, HLSS was not carried forward as a retained alternative. However, as localized drainage level-of-service issues arise, DEP will continue to evaluate HLSS as a means of improving drainage level-of-service on a site-specific basis.

8.1.i.2 Technologies Evaluated but Screened Out

Technologies under this category were not carried forward as retained alternatives. The reasons for screening these technologies out are summarized below.

- *Pumping Station Optimization/Expansion/Modification:* The system optimization evaluations described further below identified pumping stations that could potentially impact CSO discharges to the Citywide/Open Waters waterbodies, and where appropriate, evaluated the impact of potential changes to the pump station operation/capacity on CSOs. Previously submitted LTCPs evaluated the impacts of pumping station modifications on CSOs that discharge to the various tributary waterbodies. In the Port Richmond system, construction of needed renovations to the Hannah Street Pumping Station is expected to commence in 2021, and expansion of the pumping station had been evaluated in the East River/Open Waters WWFP. In addition, the Hannah Street Bypass alternative described further below would maximize the capacity of the downstream interceptor and reduce flow to the Hannah Street Pumping Station. Potential modifications to other pumping stations were not found to significantly improve CSO performance and were therefore not evaluated further.

- *Flow Redirection with Conduit/Tunnel and Pumping.* The concept behind this technology is to relocate CSO flow to a less-sensitive receiving water, using a combination of tunnels and/or near-surface conduits and pumping. This approach would typically be considered where a CSO outfall is located upstream along a confined tributary, and the CSO could potentially be relocated to a larger, less-sensitive waterbody where the CSO loads could be more readily diluted and dispersed. Since this LTCP addresses the larger waterbodies where strong currents and rapid dilution already takes place, and adjacent waterbodies were not considered to be "less sensitive," this technology was not considered further.

- *Environmental Dredging*: This technology would typically be considered in locations were solids deposition at the end of a CSO outfall creates adverse aesthetic conditions in the waterbody. No such locations were identified for the Citywide/Open Waters CSOs, and therefore environmental dredging was not considered further.
- *Outfall Disinfection*: This technology would be considered in locations where a relatively long, large-diameter outfall exists, and CSO bacteria loads are contributing to non-attainment of WQS. For the Citywide/Open Waters sewersheds, the interceptor systems tend to run adjacent to the shorelines, resulting in relatively short distances between the CSO regulators and the ends of the outfall pipes. In addition, as described above, the gap analysis indicated that the only location where NYC CSOs were clearly tied to non-attainment of WQS was along the Brooklyn shoreline in New York Bay, where the 30-day STV *Enterococcus* criteria are not met under Baseline Conditions (although the 30-day Enterococcus geometric mean criteria are met). None of the outfalls downstream of the CSO regulators along the Brooklyn shoreline are long enough to make outfall disinfection practical. For these reasons, outfall disinfection was not considered further.
- *Retention/treatment Basin*: Retention/treatment basins are tanks that store CSO volume up to the capacity of the tank, then provide sedimentation and disinfection treatment for volumes in excess of the storage capacity. Given the size of the major outfalls discharging to the Citywide/Open Waters waterbodies, a single retention/treatment basin would likely require at least two acres of land and would cost in the hundreds of millions of dollars to construct. Multiple retention/treatment basins would be required to provide even 50 percent capture for the waterbodies. As described further below, tunnel storage is being assessed as a means to provide 25, 50, 75, and 100 percent capture of the CSOs to the Citywide/Open Waters waterbodies in the 2008 typical year. Therefore, retention/treatment basins were not considered further.
- *WRRF Expansion*: For each of the WRRFs in the Citywide/Open Waters sewersheds, modeling evaluations were conducted to assess the impact on CSO reduction of increasing the capacity of the WRRFs by 25, 50, 75, and 100 percent. This initial screening assessment was intended to identify if further investigation into the siting needs and costs for such expansion would be beneficial from the perspective of CSO reduction. In many cases, the benefit of expanding the WRRF capacity would be limited by the capacity of the collection system to convey additional wet-weather flow to the plant. In addition, significant space constraints at the WRRF sites limit the ability to expand existing plant processes. For these reasons, WRRF expansion was not evaluated further.
- *In-System Storage*: As noted above, most of the Open Waters outfalls were relatively short, so opportunities for significant storage in existing outfalls were limited.

The evaluation of retained CSO control measures applicable to all of the Open Waters waterbodies is described in Section 8.2, while the subsequent subsections present the evaluation of retained alternatives specific to each of the individual Open Waters waterbodies.

8.2 CSO Control Alternatives Applicable to All of the Citywide/Open Waters Waterbodies

Of the CSO control technologies indicated as "Retained" in the Toolbox presented in Figure 8.1-2 above, DEP's programmatic approach to floatables control would be considered similarly applicable in each of the Open Waters waterbodies.

Stormwater runoff can transport trash and debris from urban areas into local waterbodies. Once waterborne, these materials are referred to as "floatables." The City relies on many existing programs to control trash and debris stemming from its combined and storm sewers. Public education, outreach, involvement and participation are important parts of the City's efforts to control floatables. A variety of programs encourage the public to help manage trash and debris, including a suite of stewardship programs (e.g., Parks Community Clean-ups) and 311, which enables New Yorkers to report to the City dirty conditions they observe. Other key programs include street sweeping, catch basin hooding and maintenance, catch basin inspection and cleaning, and booming and netting to catch materials that could potentially discharge via an outfall.

The components of the existing program include the following:

Rules and Regulations Enforcement – The Department of Sanitation of New York (DSNY) patrols all areas including commercial, industrial, manufacturing, and residential blocks daily and issues notices of violation for failure of property owners to maintain their properties in conformance with the applicable rules and regulations for littering and illegal dumping.

Public Education, Outreach, and Stewardship – The City has multiple education and outreach programs that target litter and floatables. Table 8.2-1 summarizes these programs.

Table 8.2-1. Summary of Litter and Floatables Education, Outreach, and Stewardship Programs

Controls	Responsible Agencies	Description
Adopt-a-Bluebelt	DEP	DEP invites local organizations to keep their catch basins clear of debris.
Adopt-a-Catch Basin	DEP	DEP invites local organizations to keep their catch basins clear of debris.
Shoreline and Bluebelt Clean-ups	DEP	DEP organizes, supports, and sponsors various shoreline cleanup events throughout NYC.
NYC Park Stewardship	DPR	DPR coordinates volunteer opportunities that enable volunteers to help restore natural areas, care for street trees, clean and beautify parks, and monitor wildlife. These activities can include the care and restoration of natural areas through removal of invasive plants and floatable debris along coastlines.
Adopt-a-Highway/Greenway	DOT	DOT invites sponsors to adopt highway or greenway segments to perform litter removal and beautification.
Adopt-a-Basket	DSNY	DSNY invites local businesses or community groups to monitor and maintain local litter baskets.
Community Clean-ups	DSNY	DSNY supports local community groups and block associations in their volunteer efforts to keep their

Table 8.2-1. Summary of Litter and Floatables Education, Outreach, and Stewardship Programs

Controls	Responsible Agencies	Description
		neighborhoods clean through local block and street area clean-ups by offering free loans of cleanup tools and equipment.
311	Various Agencies	311 enables the public to report issues, such as heavily littered streets or clogged catch basins, which are referred to the appropriate agency for inspection and follow-up.
Agency Websites and Social Media	Various Agencies	Various agencies provide educational information on webpages and through outreach campaigns which aim to improve cleanliness and aesthetics of City streets, beaches and the harbor.
Clean Streets = Clean Beaches	DEP, DSNY	The City distributes educational literature, places posters, and conducts events to raise awareness of litter and floatables issues.

DEP Catch Basin Hooding, Inspection, and Maintenance Program – DEP administers a catch basin inspection, hooding, and maintenance program, which helps prevent trash and debris from reaching waterbodies. DEP is responsible for approximately 148,000 catch basins, which are regularly inspected, and if necessary, cleaned and repaired, in both the combined sewer and MS4 areas.

Catch Basin Marking – Catch basins are marked with a medallion or stamp to inform the public that the catch basin drains directly to local waterbodies and that nothing should be dumped into them.

End-of-Pipe and In-Water Containment Systems – DEP operates and maintains a number of end-of-pipe/in-water controls that intercept floatables from combined and separate sewer systems. DEP also operates specialized skimmer vessels (Figure 8.2-1) that collect floatables from these booms and/or form surface waters.

DEP Bluebelt Program – This program preserves natural drainage corridors such as streams and ponds and optimizes them through the design and construction of stormwater controls to filter stormwater before it empties into the New York Harbor.

Public Litter Baskets – DSNY services over 23,500 litter baskets to encourage pedestrians to properly dispose of trash. Through the Adopt-A-Basket Program, DSNY invites local businesses or community groups to monitor local litter baskets and replace bags when they are nearly full to minimize the risk of overflow between scheduled pickups.

Street Sweeping – DSNY utilizes about 435 mechanical broom trucks (Figure 8.2-1) and 185 mechanical brooms to remove street litter before it can enter the sewer system. Each week, the boom trucks cover about 9,700 miles of roadway along their scheduled routes.

Figure 8.2-1. Examples of Mechanical Broom Truck and Skimmer Vessel

SAFE Disposal Events and Special Waste Drop-off Sites – DSNY hosts SAFE (Solvents, Automotive, Flammables, and Electronics) Disposal Events throughout the year in all five boroughs to help residents properly dispose of waste that cannot be thrown out with regular household waste.

Zero Waste – In 2015, the City released OneNYC which includes commitments to sustainability and sending zero waste to landfills by 2030. The initiatives to reduce waste all serve to reduce the sources of floatables.

Business Improvement Districts (BIDs) – BIDs are geographical areas where local stakeholders oversee and fund the maintenance, improvement, and promotion of their commercial district which often includes supplemental sanitation services such as litter removal and litter basket maintenance. In 2017, there were more than 70 BIDs in operation, providing sanitation services to 4,000 block faces and servicing nearly 6,000 waste receptacles.

Park Maintenance – DPR works closely with several groups to promote park stewardship, including litter removal from parks and other DPR properties. Each year it organizes numerous events including beach clean-ups, community garden maintenance, and regular litter removal activities.

Media Campaigns – From 2015 to 2018, the City implemented three public education media campaigns. The BYO (Bring Your Own) Campaign encourages New Yorkers to live a less disposable lifestyle by using reusable bags, mugs, and bottles. The Don't Trash Our Waters Campaign was launched to raise public awareness of the connection between trash, litter and water quality. DSNY partnered with DPR and the New York Knicks for #TalkTrashNewYork, an anti-litter campaign promoting clean streets, sidewalks, beaches, and parks across NYC.

The City also made recent progress on item bans and fees that can reduce the prevalence and persistence of floatables.

Styrofoam Ban. As of January 1, 2019, New York City stores, food service establishments, and mobile food commissaries were no longer permitted to offer, sell, or possess single-use foam food containers. Enforcement of this ban began July 1, 2019.

Executive Order on Single-Use Plastic. In April 2019, Mayor de Blasio signed an Executive Order (EO) that ended the direct City purchase of unnecessary single-use plastics in favor of compostable or recyclable alternatives. This EO is expected to reduce NYC carbon emissions, decrease plastic pollution, and reduce risks to wildlife.

Paper Bag Fee. In 2019 New York State passed the Bag Waste Reduction Law making New York State one of eight States in the country to implement a plastic-bag ban. In 2019, the New York City Council approved a five-cent paper bag fee to complement the ban. Three cents of the fee will go to the State Environmental Protection Fund and the other two cents will go toward the production of reusable bags. The fee and ban encourage New Yorkers to use reusable bags, reducing the number of single-use bags that might end up in the environment. The New York State ban follows the City's 2016 NYC Carryout Bag Law, which sought to impose a fee of at least five cents on all carryout merchandise bags.

Evaluation of Existing Programs

As part of past initiatives to reduce floatables citywide, DEP has assessed many floatables control technologies and estimated the efficiency of those used in NYC. Additionally, the City continually evaluates litter and floatables conditions in NYC through several ongoing monitoring programs.

DEP has conducted various field studies to estimate the removal efficiency of various floatables controls as part of its previous Citywide Comprehensive Floatables Facility Planning Project. Based on these studies, DEP developed estimates of the removal rates for current practices, including street sweeping, catch basin hooding, end-of-pipe netting, booming and skimming operations, and combined-sewage treatment capture at WRRFs. The total capture efficiency is approximately 96 percent for citywide floatables originating from street litter. In addition to the past studies that evaluated the efficiency of various controls, the City has several ongoing monitoring programs to help assess trash and debris conditions. The Street Cleanliness Program visually monitors trends in street and sidewalk litter, on a monthly basis throughout the City. In tandem, DEP monitors floatables in waterbodies and on beaches citywide through its Floatables Monitoring Program which utilizes visual ratings to document floatables levels at monitoring sites throughout NYC (Figure 8.2-2). Visual ratings collected by DEP staff through the Harbor Survey Program are supplemented by citizen scientists who conduct similar inspections through the Volunteer Survey Program.

Figure 8.2-2. Floatables Monitoring Program Sites

DEP also monitors the volume of floatable materials recovered through booms, nets, and open water skimming. This information is reported in the Annual CSO BMP Report and is summarized in Figure 8.2-3. The quantity of floatables reaching the in-water containment system has decreased by about 75% over the last decade.

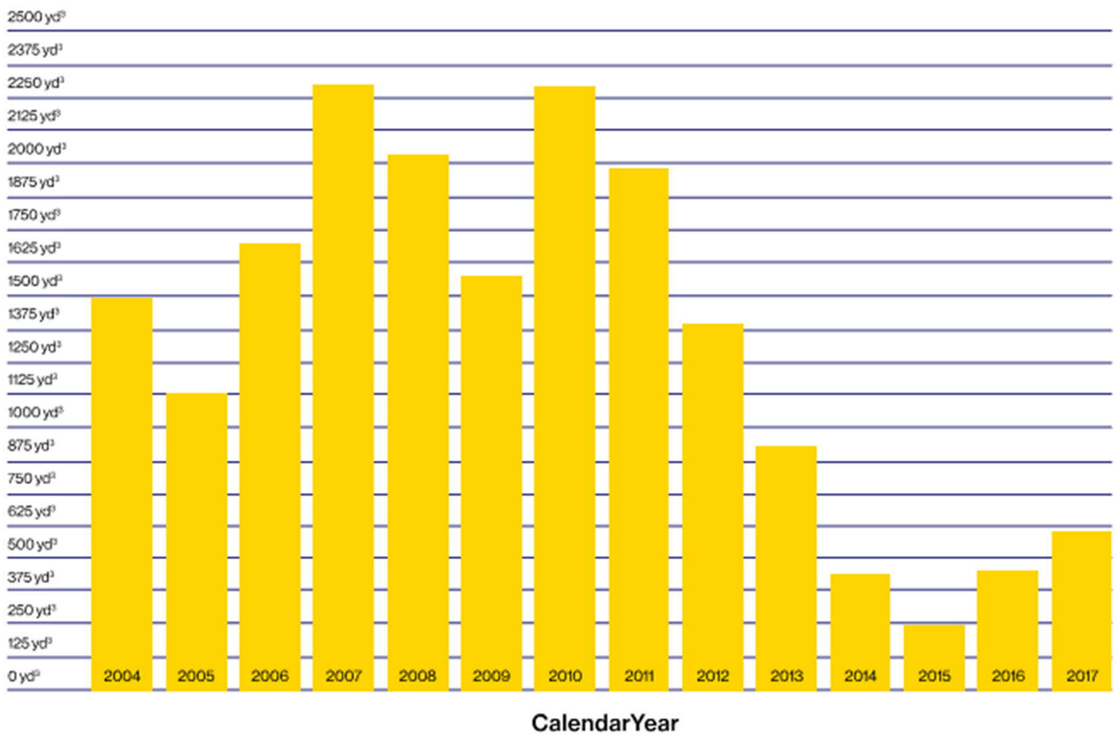

Figure 8.2-3. Total Floatables Collected by Boom and Skim Program

Measurable Goals and Program Assessment

The City has established measurable goals and utilizes these measures to detail the status of each goal through their annual reporting. The City's MS4 Permit requires an Annual Effectiveness Assessment in each Annual Report. The City is continuing to refine and update the measurable goals to allow for better quantification and accurate representation of the effectiveness of each measure.

The City's litter and floatables control programs are highly effective in preventing litter, trash, and floatable materials from entering surrounding waterbodies. The City continues to evaluate technologies and approaches to further improve upon its current successes and document performance in their annual CSO and MS4 BMP reports.

8.3 CSO Control Alternatives for Harlem River

As shown in Section 6, WQS for bacteria and dissolved oxygen are met in the Harlem River under Baseline Conditions. Therefore, attainment of WQS was not a factor in evaluating CSO control alternatives for the Harlem River. Rather, the focus was on evaluating alternatives for cost-effective reduction of CSO activations and volume. The CSO control alternatives that passed the initial screening phase and were retained for the Harlem River generally fell within the categories of system optimization and tunnel storage. System optimization alternatives covered the categories of fixed weirs, parallel interceptor/sewer, bending weirs or control gates, and gravity flow redirection to other watersheds. The storage tunnel alternatives, used to assess 25, 50, 75 and 100 percent CSO capture in the 2008 typical year, also included high-rate clarification for the dewatering flows from the tunnels. Storage tanks were not evaluated due to the number of outfalls to be captured and the general lack of available sites of sufficient size for storage tanks. Each CSO control measure was initially evaluated on three of the key considerations described in Section 8.1: (1) benefits, as expressed by level of CSO control and WQS attainment; (2) costs; and (3) challenges, such as siting and operations. Using this methodology, the retained CSO control measures listed in Section 8.1 were evaluated on a cost-performance basis and used to develop the basin-wide alternatives.

As described in Section 5 above, the Tibbetts Brook Daylighting project is included in the LTCP Baseline Conditions. The system optimization and storage tunnel alternatives were evaluated assuming the CSO reduction and system hydraulic benefits derived from the Tibbetts Brook Daylighting project would be in place. The Citywide/Open Waters Baseline Conditions also include implementation of the Recommended Plans from the LTCPs for the tributary waterbodies previously submitted to DEC under this program, as well as other grey infrastructure projects implemented as part of earlier planning programs. Those projects are summarized in Section 4.

The following sections present the evaluations of the system optimization and tunnel storage alternatives for the Harlem River.

8.3.a System Optimization Alternatives

The approach to the initial identification and evaluation of system optimization alternatives for the Harlem River using the Optimatics Optimizer software was presented in Section 3. As described in Section 3, the Optimizer software was configured to prioritize monitored regulators discharging outside the period of critical wet-weather events, high-discharge frequency regulators, and regulators discharging in proximity to official and publicly-identified public access points (kayak launches/marinas).

The optimization alternatives for outfalls to the Harlem River associated with the North River WRRF collection system were evaluated independently from the outfalls associated with the Wards Island WRRF collection system, as the two systems are hydraulically independent. However, the North River WRRF system also includes combined sewer outfalls discharging to the Hudson River, and the Wards Island WRRF includes outfalls that discharge to the Hudson River, Bronx Kill, and East River. Thus, the Harlem River optimization alternatives associated with the North River WRRF system needed to be considered in conjunction with alternatives for the Hudson River outfalls associated with the North River WRRF system, and Harlem River optimization alternatives associated with the Wards Island WRRF system needed to be considered in conjunction with alternatives for the Hudson River, Bronx Kill and East River outfalls associated with the Wards Island WRRF system.

The sections below present the evaluations of Harlem River optimization alternatives associated with the North River and Wards Island WRRF collections systems, respectively.

8.3.a.1 System Optimization for Harlem River Outfalls in the North River WRRF System

Table 8.3-1 summarizes the CSO outfalls and associated regulators tributary to the Harlem River from the North River WRRF system that were the initial focus of the optimization evaluations. The locations of these outfalls/regulators are shown in Figure 8.3-1. Table 8.3-2 identifies the annual CSO volume and activation frequency under Baseline Conditions, and whether the outfall/regulator falls within one or more of the following categories:

- One of the 100 monitored regulators listed in the WRRF SPDES permits (“BMP Regulator”)
- A “Key Regulator” as identified in the WRRF SPDES permits
- An outfall in proximity to (typically within 500 feet of) a public access location
- Regulators that activated more than average for the waterbody

Table 8.3-1. Harlem River CSO Outfalls/Regulators Associated with the North River WRRF

Outfall	Regulator	Baseline Conditions		BMP Regulator	Key Regulator	Outfall in Proximity to Public Access	Higher Frequency Regulator
		Annual CSO Volume (MG)	Annual CSO Activations				
NR-008	N-14	19.2	34				✓
NR-009	N-13	1.7	20				✓
NR-010	N-10, N-11, N-12	9.3	18				✓
NR-016	N-4	1.1	6			✓	
NR-017	N-3	25.5	17	✓			✓
NR-018	N-1	0.1	1			✓	
NR-007	N-15	0.9	10			✓	

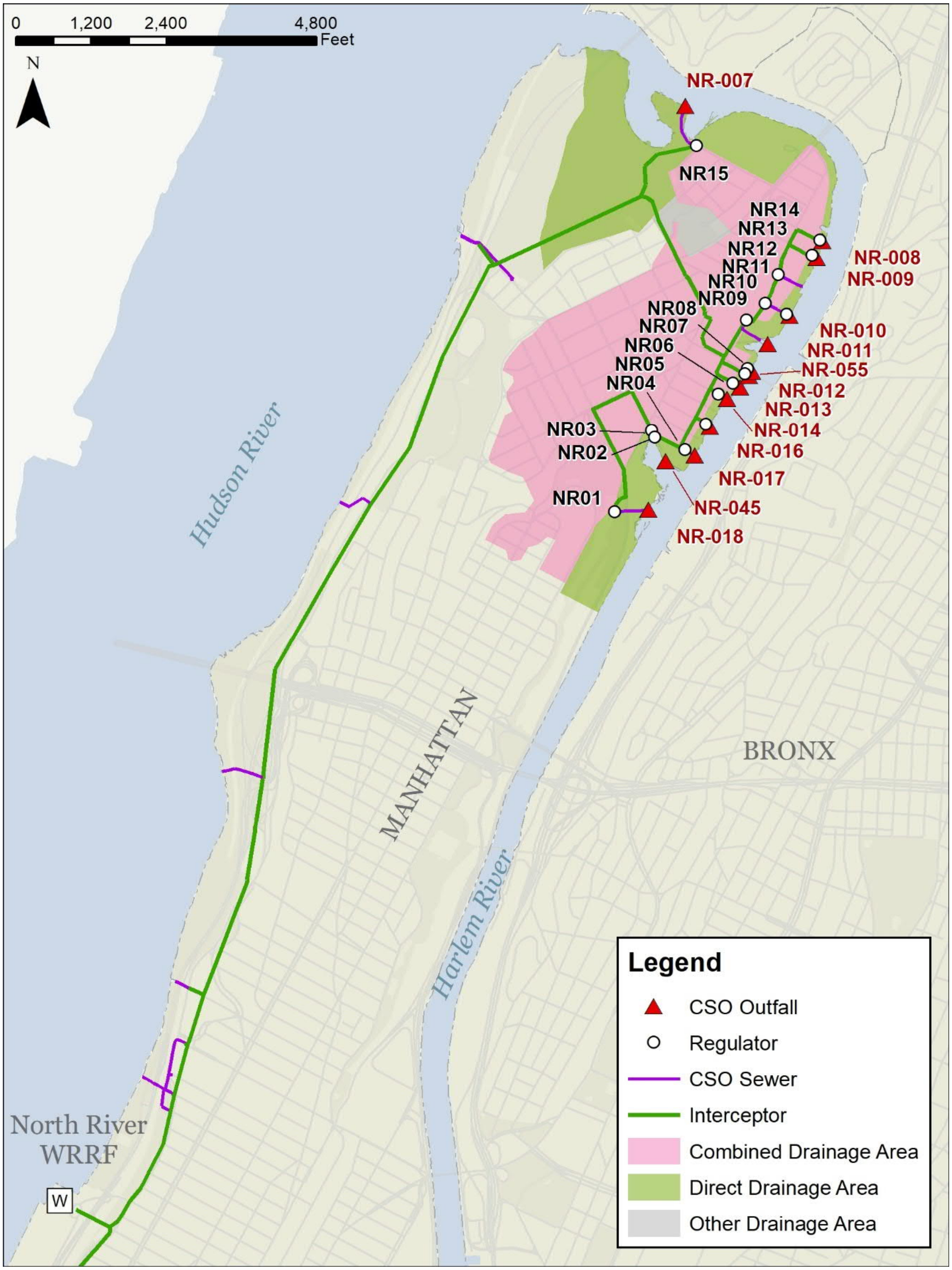

Figure 8.3-1. CSO Outfalls/Regulators Tributary to Harlem River from the North River WRRF System

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<u>Findings/Observations from Optimizer Evaluations</u>

The Optimizer evaluations served as an initial screening step to identify potentially promising optimization alternatives to be further evaluated using the full North River WRRF InfoWorks model. These evaluations included the assessment of the impacts to CSO volume, activation and peak hydraulic grade line (hydraulic grade line) elevations relative to Baseline Conditions, as well as other general system conditions. General collection system information and findings of the initial Optimizer evaluations included the following:

- The North River WRRF is located along the Henry Hudson Parkway south of Hudson Riverbank State Park. The collection system primarily serves the western shoreline and northern tip of Manhattan. The southern interceptor begins at West 12th Street generally follows Route 9A and Riverside Boulevard in a northerly direction towards the WRRF. The northern interceptor sewer parallels the Harlem River at its upstream end, crosses Manhattan along Isham Street and then bends to the south along the Henry Hudson Parkway (Route 9A) to the WRRF. A total of 55 regulators divert flow to the interceptors with 51 outfalls discharging to the Hudson River (38 CSOs) and Harlem River (13 CSOs).

- The WRRF collection system is relatively shallow (<10 feet of cover) at the upstream end of the interceptor, but ranges from 15 to 25 feet of cover for most of the interceptor paralleling the Harlem River.

- Regulators contributing to CSO outfalls discharging to the Harlem River generally activate between 6 to 34 times during the typical year with a total average annual overflow volume (AAOV) of 75 MGY.

- Freeboard for the 5-year design storm and many of the larger storms during the typical year is generally less than 10 feet from the ground surface indicating that the portion of the system along the Harlem River is highly sensitive to hydraulic grade line impacts.

- The Optimizer modeling identified multiple alternatives that included modifications to the regulators located along the Harlem River resulting in varying degrees of improved capture and hydraulic performance. The most optimal alternatives from the Optimizer modeling were evaluated in more detail using InfoWorks runs for the 2008 typical year. AAOV reductions of approximately 20 percent and activation frequency reductions of approximately 40 percent were predicted for the better performing alternatives.

- The strong performance improvement was a result of the components of the alternatives that included up-sizing of interceptor and branch interceptor connections. These modifications allowed more flow to be conveyed to the WRRF without adversely affecting the peak hydraulic grade line.

- While CSO volume and activations increased at two regulators downstream of the system optimization, the reductions at other regulators associated with the system optimization measures resulted in a net reduction in CSO discharge volume and frequency of activation to the Harlem River.

Another consideration for assessing the optimization of the North River outfalls tributary to the Harlem River was the planned up-zoning throughout Inwood north of Thayer Street. The re-zoning was enacted for the purposes of promoting development of thousands of affordable housing units, encourage economic development that benefits the local community and development of additional open space to improve community access to the Harlem River. As projects develop and advance, traffic, sewer and water improvements will be performed throughout the sewershed. In addition to the re-zoning, DEP is evaluating alternatives for the elimination of Regulators NR-09, 10, and 12 associated with Outfalls NR-010 and 011. These regulators and associated outfalls are located within the MTA's 207th Street Train Yard Facility and are difficult to access for performance of routine inspections and maintenance.

Sewer modifications planned for both of these projects are in the early planning stages and routing is not currently available. For the purposes of simulating the proposed up-zoning in the optimization evaluations, re-routing of the main interceptor and up-sizing the branch interceptors serving Regulators NR-14 (CSO-008) and NR-13 (CSO-009) were included in the Optimizer model. In addition, installation of a new regulator to replace Regulator NR-10 and re-routing of the branch interceptor along 10th Avenue was included in the Optimizer model to simulate elimination of regulators associated with CSOs NR-010 and NR-011. The assumed interceptor modifications associated with these planned projects are illustrated in Figure 8.3-2.

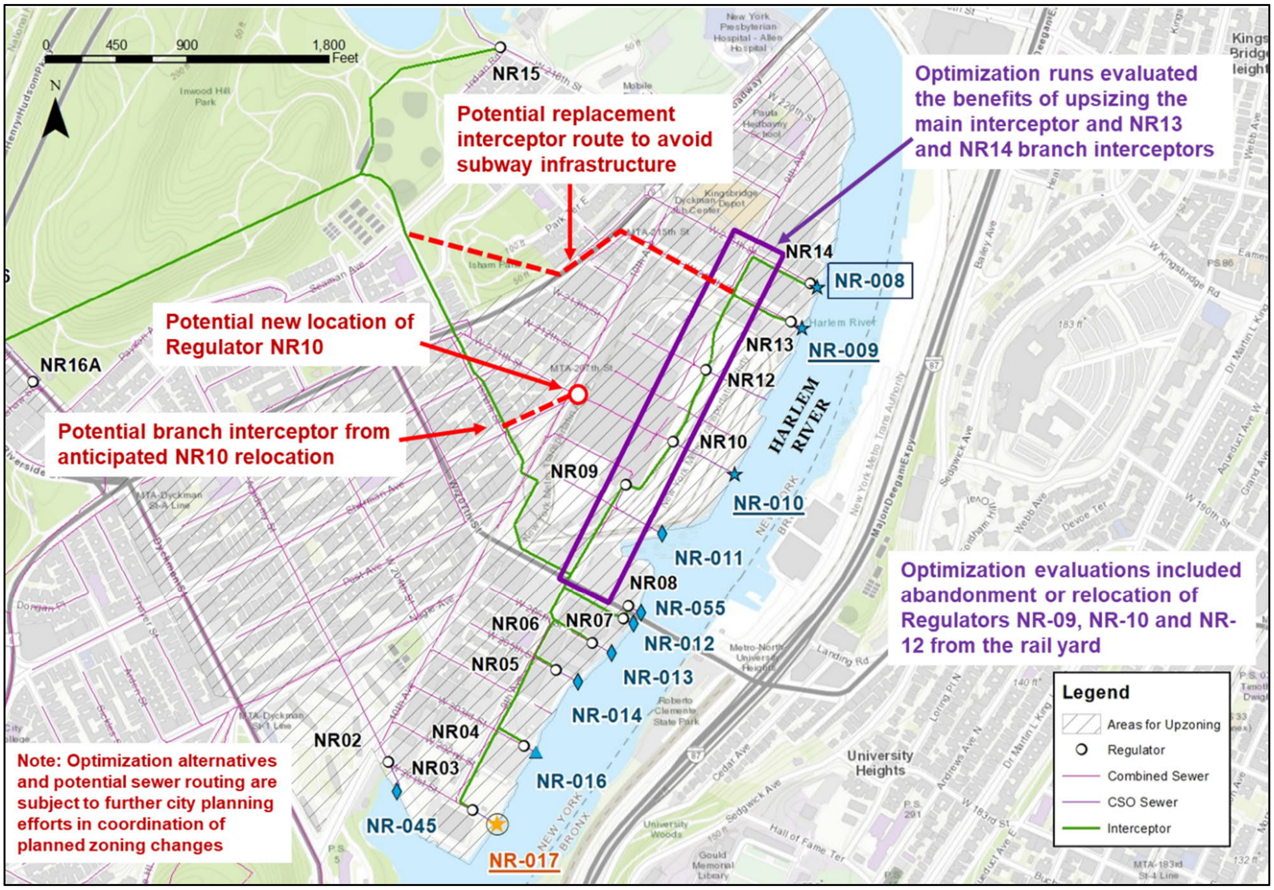

Figure 8.3-2. Potential Interceptor Upgrades Assumed for Optimization Evaluations

<u>Follow-up Evaluations Based on Full InfoWorks Model</u>

The most promising optimization alternatives coming out of the Optimizer evaluations are summarized in Table 8.3-2. These alternatives were further analyzed in more detail using the full North River WRRF system InfoWorks model. The resulting impacts of Alternatives HAR-1 and HAR-2 on peak hydraulic grade line in the 5-year storm are summarized in Figure 8.3-3 and Figure 8.3-4, respectively. The annual CSO volume and frequency for these optimization alternatives are summarized in Table 8.3-3 and estimated probable bid costs and construction/implementation considerations are summarized in Table 8.3-4.

Table 8.3-2. Harlem River Optimization Components for Retained Alternatives

Outfall	Regulator	Components	
		HAR-1	HAR-2
NR-007	NR-15		
NR-008	NR-14		
NR-009	NR-13		
NR-017	NR-03		
AAOV Reduction		16 MGY	15 MGY
Probable Bid Cost		$ 36M	$ 31M

<u>KEY</u>

Increase Orifice Size

Raise Weir

Replace Branch Interceptor

Upsize Main Interceptor

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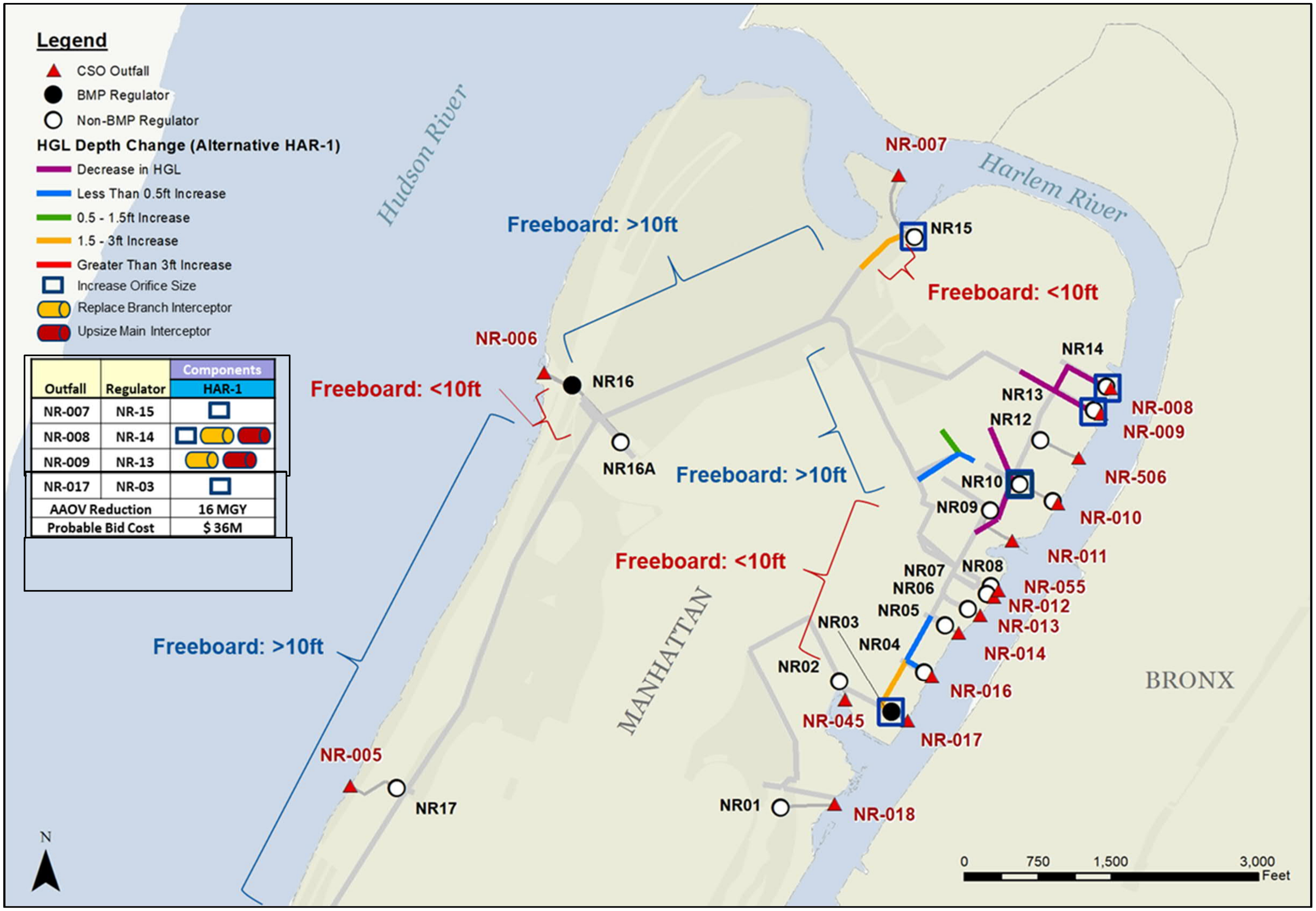

Figure 8.3-3. Hydraulic Grade Line Impacts of Alternative HAR-1 vs. Baseline Conditions, 5-Year Storm

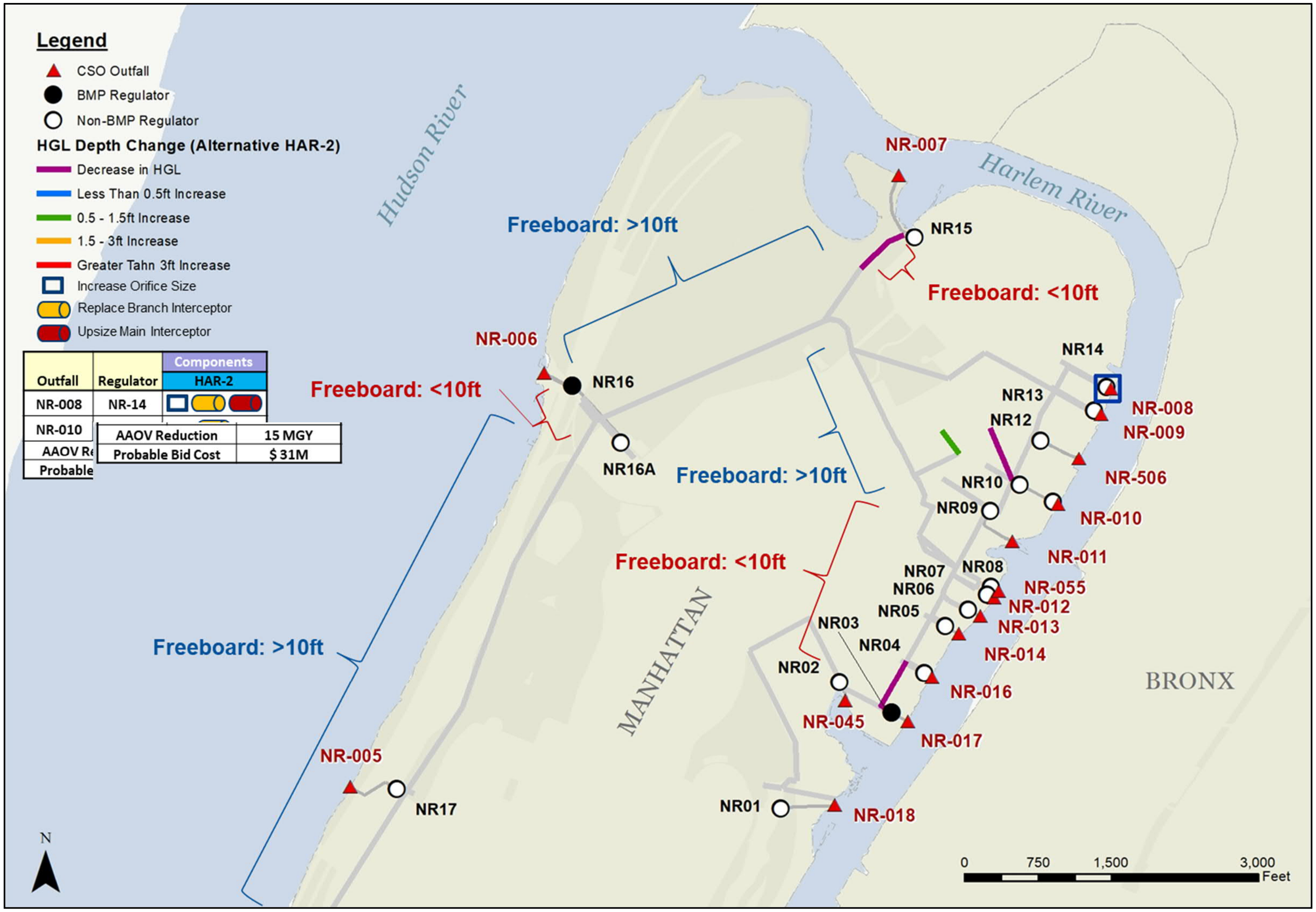

Figure 8.3-4. Hydraulic Grade Line Impacts of Alternative HAR-2 vs. Baseline Conditions, 5-Year Storm

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Table 8.3-3. Summary of Performance of North River Optimization Alternatives for Harlem River

Outfall[1]	Regulator	Baseline Conditions Typical Year		Alternative HAR-1[2]		Alternative HAR-2[3]	
		Annual CSO Volume (MG)	Annual CSO Activations	Annual CSO Volume (MG)	Annual CSO Activations	Annual CSO Volume (MG)	Annual CSO Activations
NR-008	N-14	19.2	34	7.0	11	7.2	10
NR-009	N-13	1.7	20	1.3	6	0.6	6
NR-010	N-10,11,12	9.3	18	4.2	7	4.1	7
NR-016	N-4	1.1	6	1.3	8	1.1	7
NR-017	N-3	25.5	17	24	15	26.3	18
NR-045	N-2	12.5	15	11.8	12	12.5	15
NR-018	N-1	0.1	1	0.1	1	0.1	1
NR-007	N-15	0.9	10	0.5	7	0.9	10
Total		74.9	152	55.2	100	57.5	104

Notes:

(1) Outfalls and regulators with negligible impacts to Annual CSO Volume and Activations are not included in this table.

(2) HAR-1 reduces CSO volume to the Harlem River by 20 MGY, but increases CSO volume to the Hudson River by 5 MGY, resulting in a net reduction of 15 MGY. Total activations of Harlem River CSOs are reduced by 52 per year, while Hudson River CSO activations are increased by 1 per year.

(3) HAR-2 reduces CSO volume to the Harlem River by 17 MGY, but increases CSO volume to the Hudson River by 4 MGY, resulting in a net reduction of 13 MGY. Total activations of Harlem River CSOs are reduced by 48 per year, while Hudson River CSO activations are not impacted.

Table 8.3-4. Summary of Cost and Implementation Considerations for North River Optimization Alternatives for Harlem River

Alternative	Probable Bid Cost ($M)	Implementation Considerations
HAR-1	$36M	• Net reduction in CSO is 15 MGY. • Projected to reduce CSO by 20 MGY to the Harlem River with a 5 MGY increase in CSO to the Hudson River.
HAR-2	$31M	• Net reduction in CSO is 13 MGY. • Projected to reduce CSO by 17 MGY to the Harlem River with a 4 MGY increase in CSO to the Hudson River.

Given the potential reduction in CSO activation frequency and volume associated with the relatively modest costs for Alternatives HAR-1 and HAR-2, both alternatives were retained for further consideration.

8.3.a.2 System Optimization for Harlem River Outfalls in the Wards Island WRRF System

Table 8.3-5 summarizes the CSO outfalls and associated regulators tributary to the Harlem River (including the Bronx Kill) from the Wards Island WRRF system that were the initial focus of the optimization evaluations. The locations of these outfalls/regulators are shown in Figure 8.3-5. Table 8.3-5 identifies the annual CSO volume and activation frequency under Baseline Conditions, and whether the outfall/regulator falls within one or more of the following categories:

- One of the 100 monitored regulators listed in the WRRF SPDES permits (“BMP Regulator”)
- A “Key Regulator” as identified in the WRRF SPDES permits
- An outfall in proximity to (typically within 500 feet of) a public access location
- Regulators that activated more than average for the waterbody

Another consideration for assessing the optimization of the Wards Island outfalls tributary to the Harlem River was the planned up-zoning in East Harlem to accommodate the Department of City Planning’s Mandatory Inclusionary Housing (MIH) Program would be applied. The zoning changes allows for greater density on Park Avenue, Lexington Avenue, Third Avenue, Second Avenue and East 116th Street to provide income restricted housing for a portion of the units in any new development. The increase in zoning densities is located between regulators WIM-24 through WIM-30 near the point at which the interceptor crosses under the Harlem River from Manhattan to Randall’s Island. While dry-weather flows are anticipated with the up-zoning, impacts to wet-weather flow are expected to be negligible and have no impact on the optimization evaluations.

<u>Findings/Observations from Optimizer Evaluations</u>

The Optimizer evaluations served as an initial screening step to identify potentially promising optimization alternatives to be further evaluated using the full Wards Island WRRF InfoWorks model. These evaluations included the assessment of the impacts to CSO volume, activation and peak hydraulic grade line elevations relative to Baseline Conditions, as well as other general system conditions. General collection system information and findings of the initial Optimizer evaluations included the following:

- The Wards Island WRRF collection system serves the east side of Manhattan and western Bronx. The Manhattan interceptor parallels the Harlem River Drive, while the Bronx Interceptor generally follows the Major Deegan Expressway. A total of 75 regulators divert flow to the interceptors. During wet-weather, flow in excess of the interceptor capacity can overflow to CSO outfalls discharging to the Hudson River (3 CSOs), Harlem River (50 CSOs), Bronx Kill (3 CSOs), and East River (19 CSOs). The interceptor sewers convey flow to the Wards Island WRRF located to the south and east of Randall's Island Park.

- The WRRF collection system is relatively shallow (<10 feet of cover) at the upstream ends of each interceptor, but ranges from 15 to 25 feet of cover for most of the interceptor paralleling the Harlem River.

- Baseline Conditions include daylighting of Tibbetts Brook which is projected to reduce CSO discharges to the Harlem River by 228 MGY.

- Regulators contributing to CSO outfalls discharging to the Harlem River activate between 16 to 58 times during the typical year with a total average annual overflow volume (AAOV) of 1,824 MGY.

- Freeboard for the 5-year design storm and many of the larger storms during the typical year is generally less than 10 feet from the ground surface indicating the system is highly sensitive to hydraulic grade line impacts.

- The Optimizer modeling identified multiple alternatives that included modifications to as many as 25 regulators that resulted in varying degrees of improved capture and hydraulic performance. The most optimal alternatives from the Optimizer modeling were evaluated in more detail using InfoWorks runs for the 2008 typical year. However, these runs indicated that limited reductions in AAOV (<1.5%) and activation frequency (<2.5%) were predicted for the better performing alternatives.

- The limited performance improvement was a result of a combination of hydraulic grade line sensitivities and hydraulic balancing. In this system, increasing flow to the interceptor system tended to create adverse impacts on the hydraulic grade line, potentially increasing the risk of flooding. Also, since the system was generally running full during wet-weather, alternatives that reduced CSO at one location tended to result in offsetting increases at other locations.

Table 8.3-5. Harlem River CSO Outfalls/Regulators Associated with the Wards Island WRRF

Outfall	Regulator	Baseline Conditions		BMP Regulator	Key Regulator	Outfall in Proximity to Public Access	Higher Frequency Regulator
		Annual CSO Volume (MG)	Annual CSO Activations				
WIM-038	WI-38	11.0	29	✓			
WIM-045	WI-45	34.1	37	✓			✓
WIM-046	WI-46	123.0	43	✓		✓	✓
WIM-047	WI-47	18.3	47				✓
WIM-048	WI-48	11.1	48				✓
WIM-050	WI-50	15.7	41				✓
WIM-051	WI-51	21.7	37	✓			✓
WIM-052	WI-52	44.5	45	✓			✓
WIB-056	WI-67	582.0	44	✓	✓		✓
WIB-057	WI-66	124.0	41	✓		✓	✓
WIB-058	WI-65	31.3	29				✓
WIB-060	WI-62	285.4	35	✓			✓
WIB-062	WI-60A	147.0	38	✓		✓	✓
WIB-065	WI-57	0.2	28			✓	
WIB-068	WI-53	17.2	5	✓	✓		
WIB-075	WI-58	68.0	27	✓			
WIB-076	WI-76	58.5	42				✓
WIB-077	WI-75	81.2	38				✓
WIB-078	WI-74	34.5	41				✓

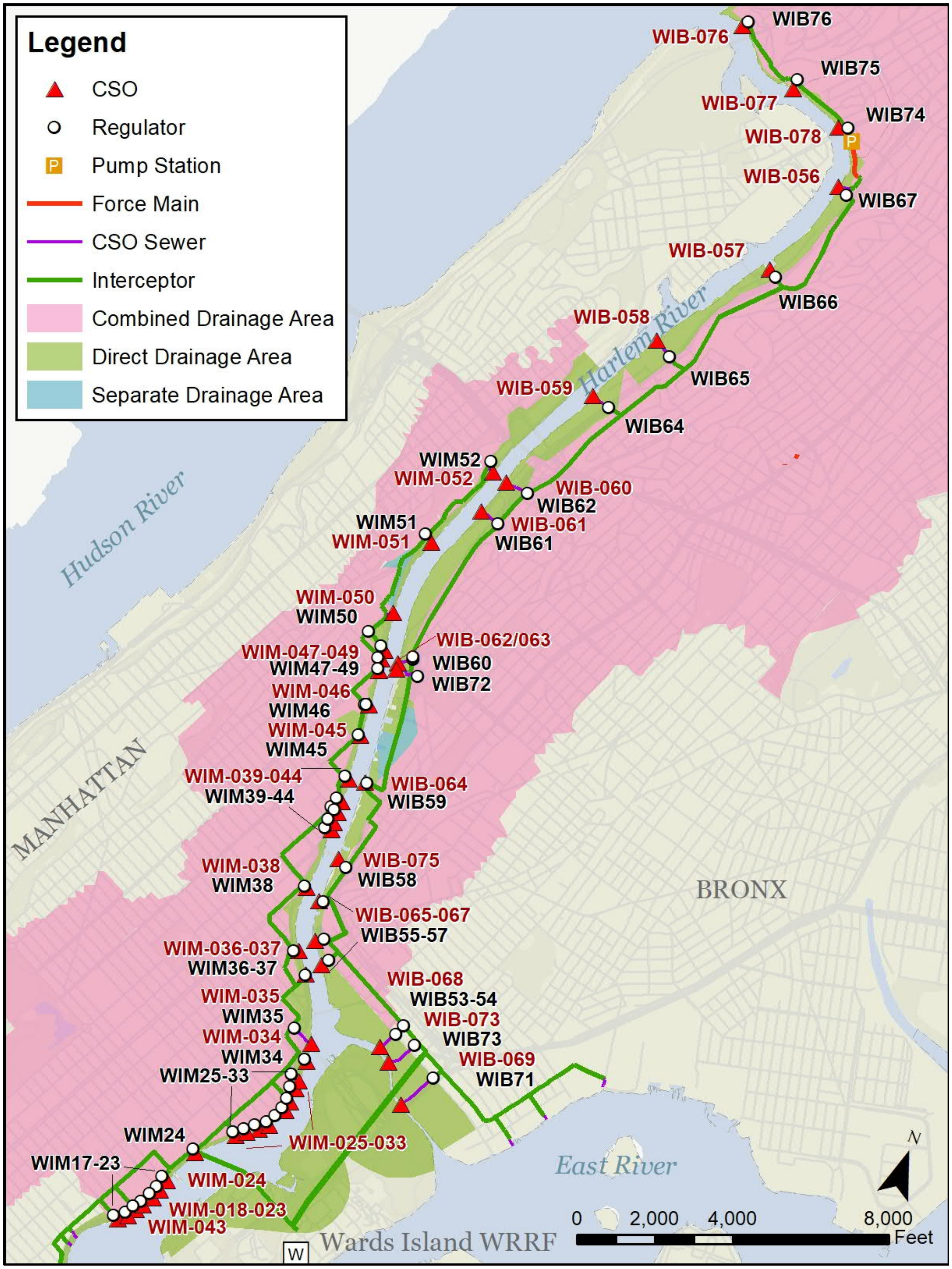


Figure 8.3-5. CSO Outfalls/Regulators Tributary to Harlem River from the Wards Island WRRF System

Follow-up Evaluations Based on Full InfoWorks Model

No retained alternatives were identified from the initial Optimization runs due to hydraulic grade line impacts that increased the potential risk of flooding, while providing negligible reductions in CSO volume and activations along the Harlem River. In an effort to reduce the hydraulic grade line impacts associated with system optimization, an evaluation of bending weirs was performed for select regulator sites using the InfoWorks model. The results of the evaluation are summarized in Table 8.3-6.

Initial evaluations reviewed regulator sites for suitability based upon manufacturer installation and operational constraints. Mean high tide elevations were reviewed in comparison to the existing weir crest to identify regulator sites where installation of a bending weir would be suitable based upon weir submergence limitations set by the manufacturers. Two sites within the Wards Island collection system were identified where the mean high tide did not exceed an elevation of the existing regulator weir crest. InfoWorks model runs were then performed to determine whether the 5-year design storm hydraulic grade line for Baseline Conditions could be matched to achieve DEP design criteria. Available record drawings were reviewed for each regulator site to assess constructability.

Installation of a bending weir is not recommended at Regulator WI-62 as it was found to increase the hydraulic grade line of the upstream collector sewer as much as 72 inches during a 5-year design storm. Constructability issues were also identified. The existing regulator weir is located within a tunnel that was constructed within bedrock. Stairway access to the weir is provided within an adjacent shaft. Insufficient space is available within the existing access shaft to accommodate the bending weir counter-weight system, requiring an additional chamber to be constructed to a depth of 70 feet within bedrock adjacent to the existing tunnel. The depth of the tunnel would require special provisions to address confined space entry requirements for the frequent access necessary for proper operation and maintenance of the bending weir mechanical systems. In addition, construction next to adjacent structures in bedrock can be very risky and require costly measures to protect existing structures from being damaged during excavation. In consideration of the hydraulic performance and constructability risks, installation of a bending weir at this site is not recommended.

Regulator WI-60A is located adjacent to an exit ramp from the Major Deegan Expressway north of the Macombs Dam Bridge. The regulator chamber is about 23 feet deep and located in relatively steeply sloped right-of-way green space to the west of the exit ramp. There is space adjacent to the existing regulator to accommodate the counter-weight chamber. InfoWorks modeling projects a 7 MGY reduction in CSO volume with hydraulic grade line impacts in excess of 12 inches during the 5-year design storm along collector sewers upstream of the regulator. In consideration of the relatively small CSO reductions, hydraulic grade line impacts and accessibility for maintenance, installation of a bending weir at Regulator WI-60A was not retained for further consideration.

Table 8.3-6. Summary of Bending Weir Evaluations

Outfall	Regulator	Mean High Tide Below Weir Crest	Achieves 5-year Design Storm hydraulic grade line Criteria	Constructability and O&M Concerns	Retained Alternative
WIB-060	WI-62	✓	Increases of 12” to 72”	Bedrock, deep, access limitations	Not recommended
WIB-061	WI-60A	✓	Increases of 6” to 15”	✓	Not recommended

8.3.b Storage Tunnel Alternatives for 25/50/75/100 Percent CSO Control

Conceptual storage tunnel alternatives were developed to model potential 25, 50, 75, and 100 percent control of the annual CSO volume discharged to the Harlem River in the 2008 Typical Year. The approach to sizing and layout of the storage tunnel alternatives was as follows:

- For the 50-percent CSO control tunnel, the Typical Year annual overflow volume of each CSO outfall to the Harlem River was reviewed and combinations of outfalls were identified where capture of 100 percent of the CSO from those outfalls would approximately match 50 percent of the total CSO volume from all outfalls to the Harlem River.
- The locations of these outfalls were then assessed in relation to the length and diameter of tunnel needed to capture the outfalls.
- Based on DEP expertise, a combination of outfalls was selected that provided reasonable tunnel length/diameter to provide 50-percent volume capture.
- A similar approach was taken for the 75-percent CSO control tunnel.
- For the 25-percent CSO control tunnel, the 50-percent CSO tunnel was downsized until the volume of storage provided would result in approximately 25-percent CSO control.
- For the 100-percent CSO control tunnel, it was assumed that every CSO outfall to the Harlem River that was predicted to be active in the 2008 Typical Year would be tied into the tunnel. Where multiple outfalls were located in close proximity to each other, it was assumed that a near-surface consolidation conduit would be provided to a single drop shaft.
- For each storage tunnel alternative, the dewatering rate required to dewater the storage tunnel within 24 hours was compared to the available dry-weather flow capacity in the WRRF closest to the downstream end of the tunnel. If insufficient dry-weather flow capacity was available at the

WRRF to accept the additional dewatering flows, a high-rate clarification wet-weather flow treatment system with disinfection was added to the alternative to treat the dewatered flow.

- A detailed siting assessment was not conducted, so the specific locations of various features of the tunnel alternatives (mining shaft, TBM removal shaft, drop shafts, dewatering pump station, dewatered flow treatment facility, near-surface diversion structures/connection conduits) were not identified.

The main features of the 25, 50, 75, and 100-percent CSO control storage tunnels modeling scenarios for the Harlem River are summarized in Table 8.3-7. Figure 8.3-6 to Figure 8.3-8 present conceptual layouts of the storage tunnel alternatives.

Table 8.3-7. Summary of 25, 50, 75, and 100-Percent CSO Control Alternatives for Harlem River

Alternative	HAR-3	HAR-4	HAR-5	HAR-6
Level of CSO Control[(1)]	**25%**	**50%**	**75%**	**100%**
Length (mi.)	5.4	5.4	6.0	6.0
Diameter (ft.)	11	28	32	39
Volume (MG)	20	130	190	269
Outfalls Captured	• WIB-056 • WIB-057 • WIB-060	• WIB-056 • WIB-057 • WIB-060	• WIM-046 • WIB-056 • WIB-057 • WIB-060 • WIB-062 • WIB-068 • WIB-075 • WIB-076 • WIB-077	All CSO Outfalls to Harlem River (62 Total)
Net CSO Volume Reduction (MGY)	476	991	1,486	1,899
Wet Weather Flow Treatment Facility Capacity for Dewatering Flow (MGD)	20	130	190	269
Estimated Probable Bid Cost[(2)]	$800M	$1,900M	$3,200M	$8,000M

Notes:
(1) Modeled annual percent CSO reduction based on the 2008 Typical Year.
(2) 2019 dollars.

The 25 percent and 50 percent capture tunnels would start from a mining shaft located in the vicinity of the Wards Island WRRF, and run generally under or along the shoreline of the Harlem River north to a TBM retrieval shaft/drop shaft in the vicinity of Outfall WIB-056 (Figure 8.3-6). Additional drop shafts would be provided in the vicinity of Outfalls WIB-057 and WIB-060. The 75 percent capture tunnel would follow a similar route, but would extend further north in the vicinity of outfalls WIB-076 and WIB-077, and would capture the additional outfalls listed in Table 8.3-7 (Figure 8.3-7). The 100 percent CSO control tunnel would run along a route similar to the 75 percent capture tunnel. Multiple near-surface consolidation conduits would be provided to convey flow from adjacent outfalls to common drop shafts, and the tunnels would capture all of the CSO from all of the Harlem River CSO outfalls in the 2008 typical year (Figure 8.3-8).

The closest WRRF to the mining shaft for the tunnel storage alternatives would be the Wards Island WRRF. However, a dedicated wet-weather high-rate treatment facility would be necessary for the treatment of the CSO retained in the storage tunnel.

While these alternatives provide relatively high levels of CSO control, the significant challenges to implementation include:

- Very high implementation cost
- Limited siting availability for shafts, dewatering pumping station, dewatering flow treatment facility
- Long implementation period
- Significant and prolonged construction impacts (truck traffic, noise, dust) for surface consolidation sewers due to the large number of drop shafts necessary to divert CSO to the tunnel
- Negligible improvement in the annual attainment of applicable water quality standards
- Construction impacts and likelihood of utility conflicts for near-surface diversion structures and connecting conduits

Despite these challenges, these alternatives were retained in order to provide an assessment of a range of levels of CSO control for the Harlem River, in accordance with the CSO Control Policy and the Clean Water Act guidance.

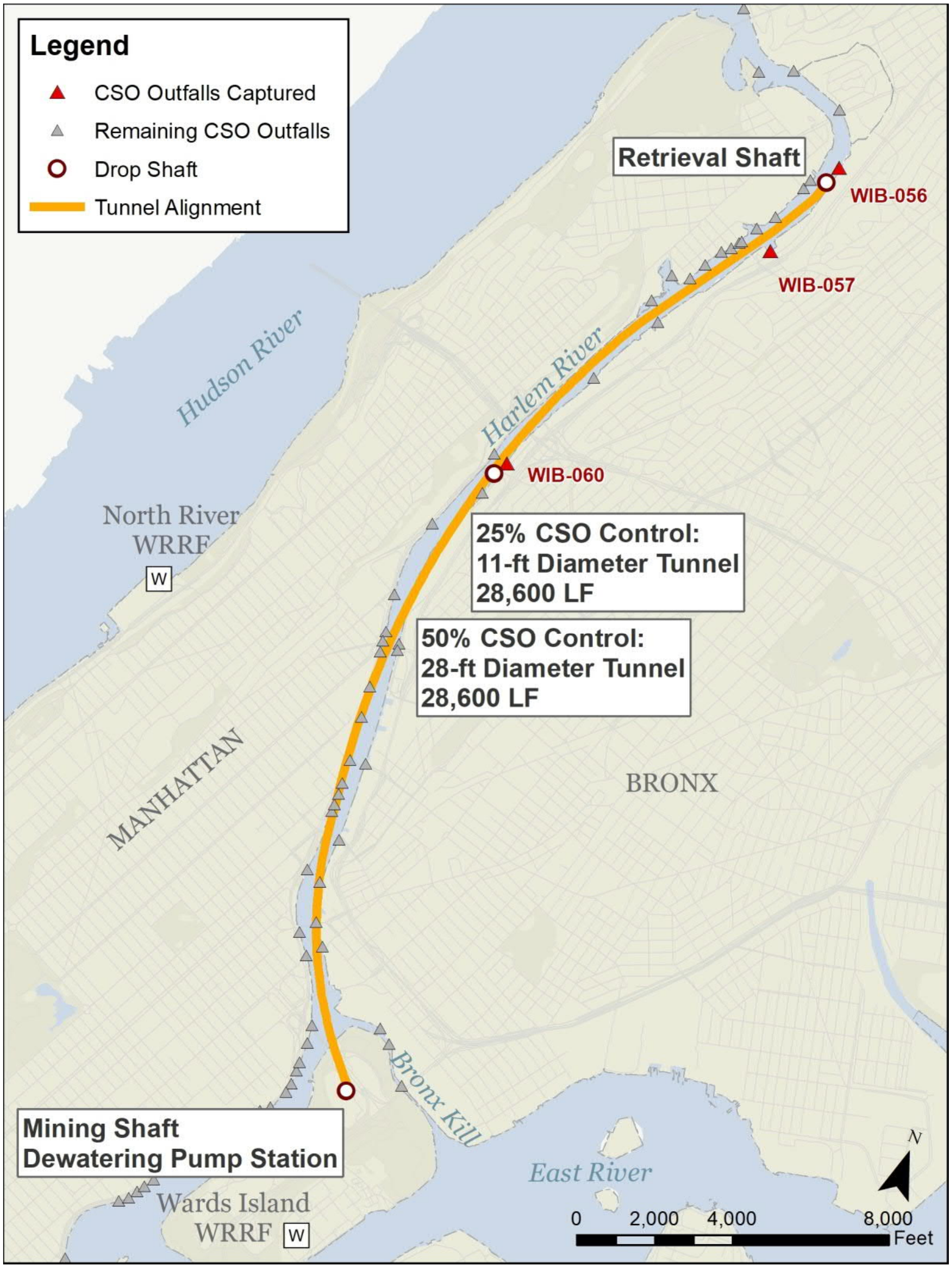


Figure 8.3-6. Conceptual Layout for 25% and 50% Control Storage Tunnels for Harlem River

Figure 8.3-7. Conceptual Layout for 75% Control Storage Tunnel for Harlem River

Figure 8.3-8. Conceptual Layout for 100% Control Storage Tunnel for Harlem River

8.3.c Summary of Retained Alternatives for Harlem River

The goal of the previous evaluations was to develop a list of retained CSO control measures for the Harlem River. These CSO control measures, whether individually or in combination, form the basis of basin-wide alternatives to be assessed using more rigorous cost-performance and cost-attainment analyses. Table 8.3-8 lists all of the CSO control measures originally identified in the "Alternatives Toolbox" shown above in Figure 8.1-2, and identifies whether the CSO control measure was retained for further analysis. The reasons for excluding the non-retained CSO control measures from further consideration are also noted in the table.

Table 8.3-8. Summary of CSO Control Measure Screening for Harlem River

Control Measure	Category	Retained for Further Analysis?	Remarks
Additional GI Build-out	Source Control	NO(1)	Planned GI build-out in the watershed is included in the baseline. It is unlikely that additional sites will be identified due to site constraints in publicly owned properties.
High Level Storm Sewers	Source Control	NO(1)	No cost-effective opportunities identified
Regulator Modifications	System Optimization	YES	Incorporated into optimization alternatives HAR-1, HAR-2
Parallel Interceptor Sewer	System Optimization	YES	Incorporated into optimization alternatives HAR-1, HAR-2.
Bending Weirs/Control Gates	System Optimization	NO	Only two potentially feasible locations were predicted to have adverse hydraulic grade line impacts.
Pumping Station Optimization	System Optimization	NO	Limited benefit in terms of CSO reduction.
Pumping Station Expansion	System Optimization	NO	Limited benefit in terms of CSO reduction.
Gravity Flow Redirection to Other Watersheds	CSO Relocation	YES	Optimization Alternatives HAR-1 and HAR-2 shift some CSO volume between Harlem and Hudson River
Pumping Station Modification	CSO Relocation	NO	No cost-effective opportunities identified.
Flow Redirection with Conduit and Pumping	CSO Relocation	NO	No cost-effective opportunities identified.
Floatables Control	Floatables Control	YES	Programmatic floatables control will be applied and expanded citywide.
Environmental Dredging	Water Quality/ Ecological Enhancement	NO	No specific locations of CSO sediment mounding identified.
Wetland Restoration and Daylighting	Water Quality/ Ecological Enhancement	NO(2)	Tibbetts Brook Daylighting project is included in the baseline conditions. No additional daylighting opportunities were identified.
Outfall Disinfection	Treatment: Satellite	NO	Not feasible due to short length of outfalls.

Table 8.3-8. Summary of CSO Control Measure Screening for Harlem River

Control Measure	Category	Retained for Further Analysis?	Remarks
Retention/Treatment Basins	Treatment: Satellite	NO	Significant siting constraints and very high costs. Tunnel storage covers 25/50/75/100 percent CSO control alternatives.
High-Rate Clarification	Treatment: Satellite	YES	Incorporated into the storage tunnel alternatives for treatment of captured CSO during tunnel dewatering.
WRRF Expansion	Centralized Treatment	NO	Insufficient space available. Limited benefit compared to potential cost.
In-System Storage (Outfalls)	Storage	NO	Negligible levels of CSO control due to short outfalls.
Off-line Storage (Tanks)	Storage	NO	Significant siting constraints and very high costs. Tunnel storage covers 50/75/100 percent CSO control alternatives.
Off-line Storage (Tunnels)	Storage	YES	Tunnel storage alternatives HAR-3, HAR-4 and HAR-5 cover 25/50/75/100 percent CSO control.

Notes:

(1) Additional GI and HLSS are considered to be ongoing programs that will continue to be implemented system-wide outside of the LTCP program.

(2) Tibbetts Brook daylighting was evaluated, but the project has been incorporated into the baseline conditions.

As shown, the retained CSO control measures include system optimization measures, tunnel storage (with high-rate clarification for dewatering flows), and programmatic floatables control. Wetland restoration and daylighting were evaluated as part of the Tibbetts Brook project, which is incorporated into the baseline conditions.

8.3.d CSO Volume and Loading Reductions for Retained Alternatives for Harlem River

Table 8.3-9 summarizes the projected performance of the retained Harlem River alternatives in terms of annual CSO volume and fecal coliform load reduction, based on the 2008 Typical Year. These data are plotted on Figure 8.3-9. In all cases, the predicted reductions shown are relative to the baseline conditions using 2008 JFK rainfall as described in Section 6. The baseline assumptions were described in detail in Section 6 and include the implementation of the grey infrastructure projects from the approved WWFPs, the Recommended Plans from the previously submitted LTCPs, and the projected level of GI identified in Section 5.

Table 8.3-9. Summary of Model Predicted Performance for Retained Harlem River Alternatives

Alternative	Annual Performance Based on 2008 Typical Year				
	Remaining CSO Volume (MGY) (1)	Frequency of Overflow (2)	Additional CSO Volume to Other Waterbodies (MGY) (3)	Net CSO Volume Reduction (%)	Net Fecal Coliform Reduction (%)
Baseline Conditions	1,899	58	-	-	-
HAR-1. Optimization of Regulators Associated with Outfalls NR-007, 008, 009, 010 and 017	1,880	58	4	<1	<1
HAR-2. Optimization of Regulators Associated with Outfalls NR-008, and 010	1,882	58	4	<1	<1
HAR-3. Tunnel Storage for 25% CSO Control (20 MG Capacity)	1,423	58	0	25	25
HAR-4. Tunnel Storage for 50% CSO Control (130 MG Capacity)	908	58	0	52	52
HAR-5. Tunnel Storage for 75% CSO Control (190 MG Capacity)	413	58	0	78	78
HAR-6. Tunnel Storage for 100% CSO Control (269 MG Capacity)	0	0	0	100	100

Notes:

(1) Remaining CSO includes all discharges to the Harlem River and Bronx Kill from the North River and Wards Island WRRF Collection Systems.
(2) Frequency of overflow is based upon the most frequently active CSO outfall.
(3) Additional CSO volume to other waterbodies accounts for increases at other CSO outfalls in response to the implementation of a CSO control alternative. Net CSO volume reduction and net fecal coliform reduction account for any additional CSO discharge to other waterbodies.

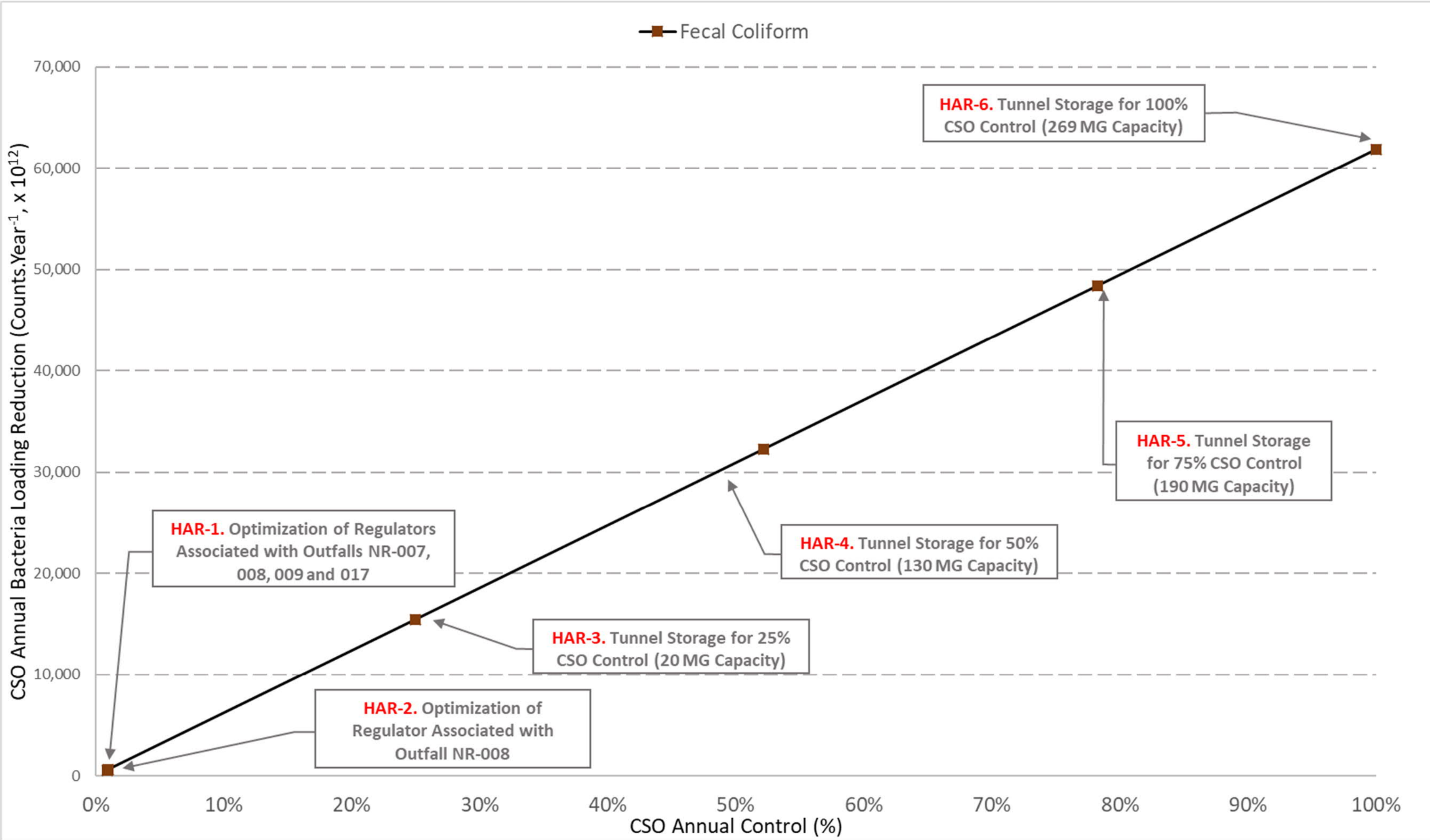


Figure 8.3-9. Untreated CSO Volume Reductions (as Percent CSO Annual Control) vs. Annual CSO Bacteria Loading Reduction (2008 Typical Year)

Because the retained alternatives for the Harlem River provide volume reduction and not treatment, the predicted bacteria loading reductions of the alternatives are very closely aligned with their projected CSO volume reductions.

8.3.e Cost Estimates for Harlem River Retained Alternatives

Evaluation of the retained alternatives requires cost estimation. The methodology for developing these costs is dependent upon the type of technology and its O&M requirements. The construction costs were developed as PBC and the total NPW costs were determined by adding the estimated PBC to the NPW of the projected annual O&M costs at an assumed interest rate of 3 percent over a 100-year life cycle. Design, construction management, and land acquisition costs are not included in the cost estimates. All costs are in 2019 dollars and are considered Level 5 cost estimates by AACE International with an accuracy of -50 percent to +100 percent.

8.3.e.1 Alternative HAR-1. Optimization of Regulators Associated With Outfalls NR-007, 008, 009, and 017.

Costs for Alternative HAR-1 include planning-level estimates of the costs to optimize the performance of Regulators NR-15, NR-14, NR-13 and NR-03 associated with Outfalls NR-007, NR-008, NR-009, and NR-017 respectively. A description of the optimization components is provided in Section 8.3.a.1 and summarized in Table 8.3-2. Site acquisition costs are not included. The total cost, expressed as NPW, for Alternative HAR-1 is $37M as shown in Table 8.3-10.

Table 8.3-10. Estimated Costs for Alternative HAR-1

Item	2019 Cost ($ Million)
Probable Bid Cost	$36
Annual O&M Cost	$1
Net Present Worth	$37

8.3.e.2 Alternative HAR-2. Optimization of Regulators Associated With Outfall NR-008.

Costs for Alternative HAR-2 include planning-level estimates of the costs to optimize the performance of Regulator NR-14 associated with Outfall NR-008. A description of the optimization components is provided in Section 8.3.a.1 and summarized in Table 8.3-2. Site acquisition costs are not included. The total cost, expressed as NPW, for Alternative HAR-2 is $32M as shown in Table 8.3-11.

Table 8.3-11. Estimated Costs for Alternative HAR-2

Item	2019 Cost ($ Million)
Probable Bid Cost	$31
Annual O&M Cost	$1
Net Present Worth	$32

8.3.e.3 Alternative HAR-3. Tunnel Storage for 25 Percent CSO Control

Costs for Alternative HAR-3 include planning-level estimates of the costs for a CSO storage tunnel sized for 25 percent CSO control in the 2008 typical year. A description of the tunnel alternative components is provided in Section 8.3.b and summarized in Table 8.3-7. Site acquisition costs are not included. The total cost, expressed as NPW, for Alternative HAR-3 is $1,000M as shown in Table 8.3-12.

Table 8.3-12. Estimated Costs for Alternative HAR-3

Item	2019 Cost ($ Million)
Probable Bid Cost	$800
Annual O&M Cost	$5
Net Present Worth	$1,000

8.3.e.4 Alternative HAR-4. Tunnel Storage for 50 Percent CSO Control

Costs for Alternative HAR-4 include planning-level estimates of the costs for a CSO storage tunnel sized for 50 percent CSO control in the 2008 typical year. A description of the optimization components is provided in Section 8.3.b and summarized in Table 8.3-7. Site acquisition costs are not included. The total cost, expressed as NPW, for Alternative HAR-4 is $2,200M as shown in Table 8.3-13.

Table 8.3-13. Estimated Costs for Alternative HAR-4

Item	2019 Cost ($ Million)
Probable Bid Cost	$1,900
Annual O&M Cost	$9
Net Present Worth	$2,200

8.3.e.5 Alternative HAR-5. Tunnel Storage for 75 Percent CSO Control

Costs for Alternative HAR-5 include planning-level estimates of the costs for a CSO storage tunnel sized for 75 percent CSO control in the 2008 typical year. A description of the optimization components is provided in Section 8.3.b and summarized in Table 8.3-7. Site acquisition costs are not included. The total cost, expressed as NPW, for Alternative HAR-5 is $3,500M as shown in Table 8.3-14.

Table 8.3-14. Estimated Costs for Alternative HAR-5

Item	2019 Cost ($ Million)
Probable Bid Cost	$3,200
Annual O&M Cost	$11
Net Present Worth	$3,500

8.3.e.6 Alternative HAR-6. Tunnel Storage for 100 Percent CSO Control.

Costs for Alternative HAR-6 include planning-level estimates of the costs for a CSO storage tunnel sized for 100 percent CSO control in the 2008 typical year. A description of the optimization components is provided in Section 8.3.b and summarized in Table 8.3-7. Site acquisition costs are not included. The total cost, expressed as NPW, for Alternative HAR-6 is $8,400M as shown in Table 8.3-15.

Table 8.3-15. Estimated Costs for Alternative HAR-6

Item	2019 Cost ($ Million)
Probable Bid Cost	$8,000
Annual O&M Cost	$14
Net Present Worth	$8,400

The cost estimates of these retained alternatives are summarized below in Table 8.3-16 and are then used in the development of the cost-performance and cost-attainment plots presented in Section 8.3.f.

Table 8.3-16. Estimated Costs of Retained Alternatives

Alternative	PBC(1) ($ Million)	Annual O&M Cost ($ Million/Year)	Total Net Present Worth(2) ($ Million)
HAR-1. Optimization of Regulators Associated with Outfalls NR-007, 008, 009 and 017	$36	$1	$37
HAR-2. Optimization of Regulator Associated with Outfall NR-008	$31	$1	$32
HAR-3. Tunnel Storage for 25% CSO Control (21 MG Capacity)	$800	$5	$1,000
HAR-4. Tunnel Storage for 50% CSO Control (132 MG Capacity)	$1,900	$9	$2,200
HAR-5. Tunnel Storage for 75% CSO Control (202 MG Capacity)	$3,200	$11	$3,500
HAR-6. Tunnel Storage for 100% CSO Control (291 MG Capacity)	$8,000	$14	$8,400

Notes:
(1) The Probable Bid Cost (PBC) for the construction contract based upon 2019 dollars.
(2) The Net Present Worth (NPW) is based upon a 100-year service life for tunnels and is calculated by multiplying the annual O&M cost by a present worth of 31.599 and adding this value to the PBC.

8.3.f Cost-Benefit Curves for Retained Alternatives

The final step of the analysis is to evaluate the cost-effectiveness of the basin-wide retained alternatives based on their NPW and projected impact on CSO loadings and attainment of applicable WQS. Section 8.3.f.1 below presents plots of cost versus CSO volume and bacteria load reduction (Cost-Performance

Curves), and Section 8.3.g.2 below presents plots of cost versus percent attainment with WQS for selected points along the Harlem River (Cost-Attainment Curves).

8.3.f.1 Cost-Performance Curves

Cost-performance curves were developed by plotting the costs of the retained alternatives against their predicted level of CSO control, both in terms of CSO volume reduction, and in bacteria load reduction. In each case, a best-fit cost curve was developed based on those alternatives judged most cost-effective for a defined level of CSO control as estimated by IW modeling for the 2008 typical year rainfall. Figure 8.3-10 presents a plot of CSO volume reduction versus NPW for the retained alternatives, while Figure 8.3-11 plots the cost of the alternatives against fecal coliform loading reductions.

8.3.g Cost-Attainment Curves

This section evaluates the relationship of the costs of the retained alternatives versus their expected level of attainment of bacteria Primary Contact WQ Criteria as modeled using the LTCPRM water quality model for the 2008 Typical Year simulation. As indicated in Section 6, based on the 10-year WQ simulations for the Harlem River, the Existing WQ Criteria (Class I) for fecal coliform are met at least 95 percent of the time under baseline conditions. As a result, implementation of any of the retained alternatives described above, including the 100 percent CSO capture tunnel, results in nominal improvement in the percent attainment of Existing WQ Criteria (Class I) for fecal coliform. Cost-attainment plots are presented below for two locations along the Harlem River: LTCP sampling Station HA-2, near the northern end of the Harlem River (Figure 8.3-12), and LTCP sampling Station HA-4, located approximately midway between the northern and southern ends of the Harlem River (Figure 8.3-13). The locations of these stations are shown in Figure 8.3-17 below. The plots show NPW versus percent attainment with the Existing WQ Criteria (Class I) for fecal coliform on both an annual and recreational season (May 1st through October 31st) basis. Cost-attainment plots for any other WQ modeling cell along the Harlem River would look similar to Figure 8.3-12 and Figure 8.3-13.

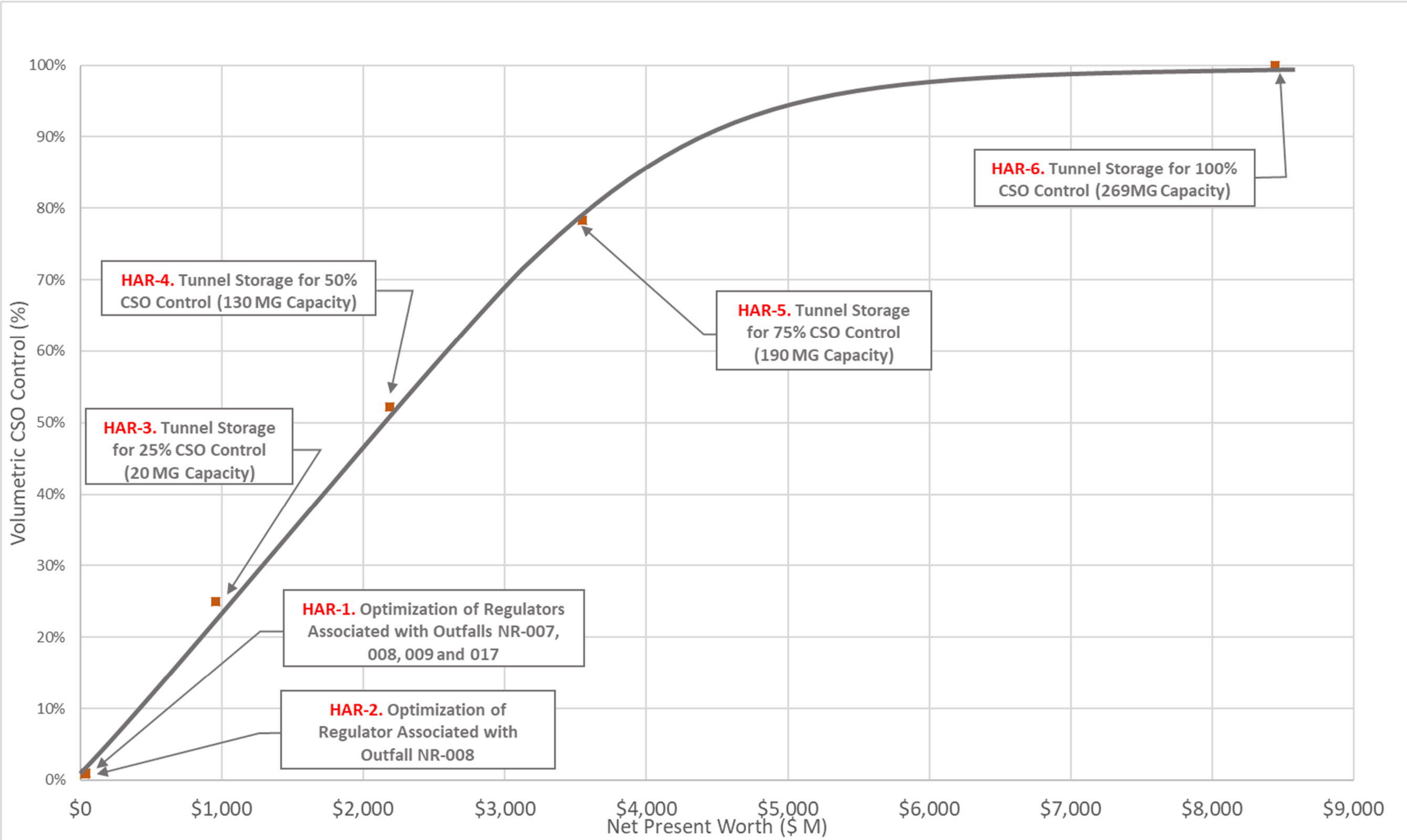


Figure 8.3-10. Cost vs. CSO Control (2008 Typical Year)

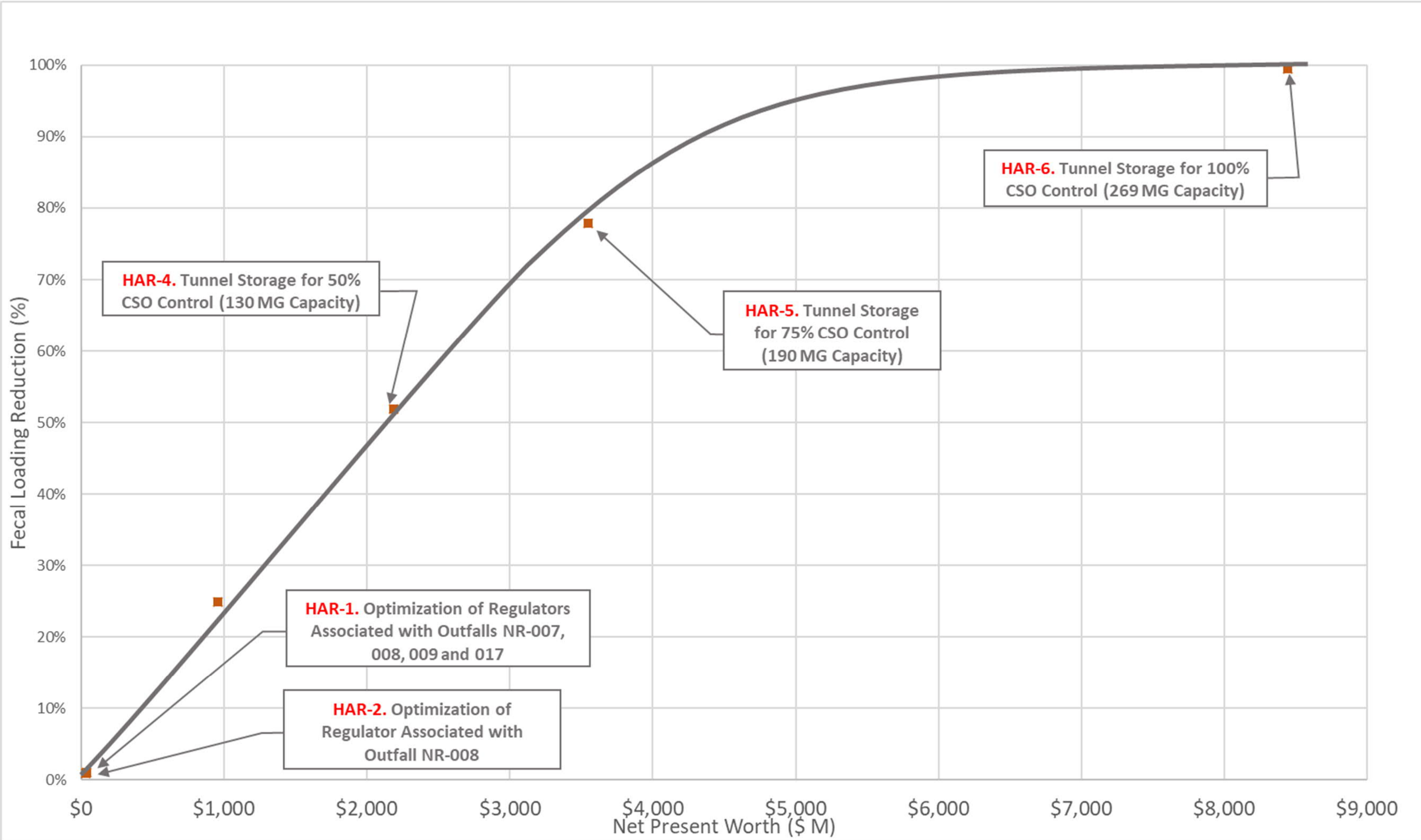


Figure 8.3-11. Cost vs. Fecal Coliform Loading Reduction (2008 Typical Year)

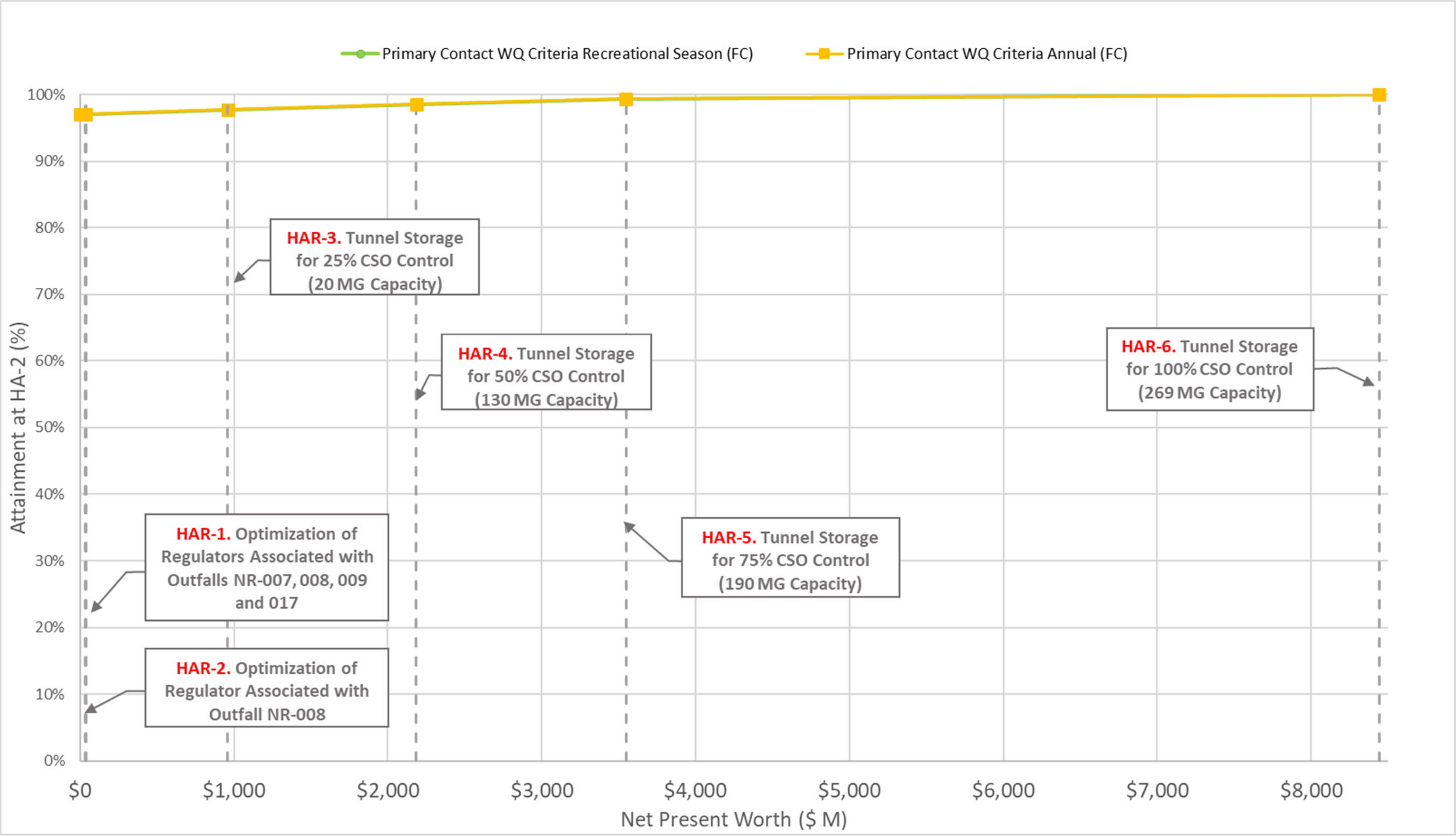


Figure 8.3-12. Cost vs. Bacteria Attainment at Station HA-2

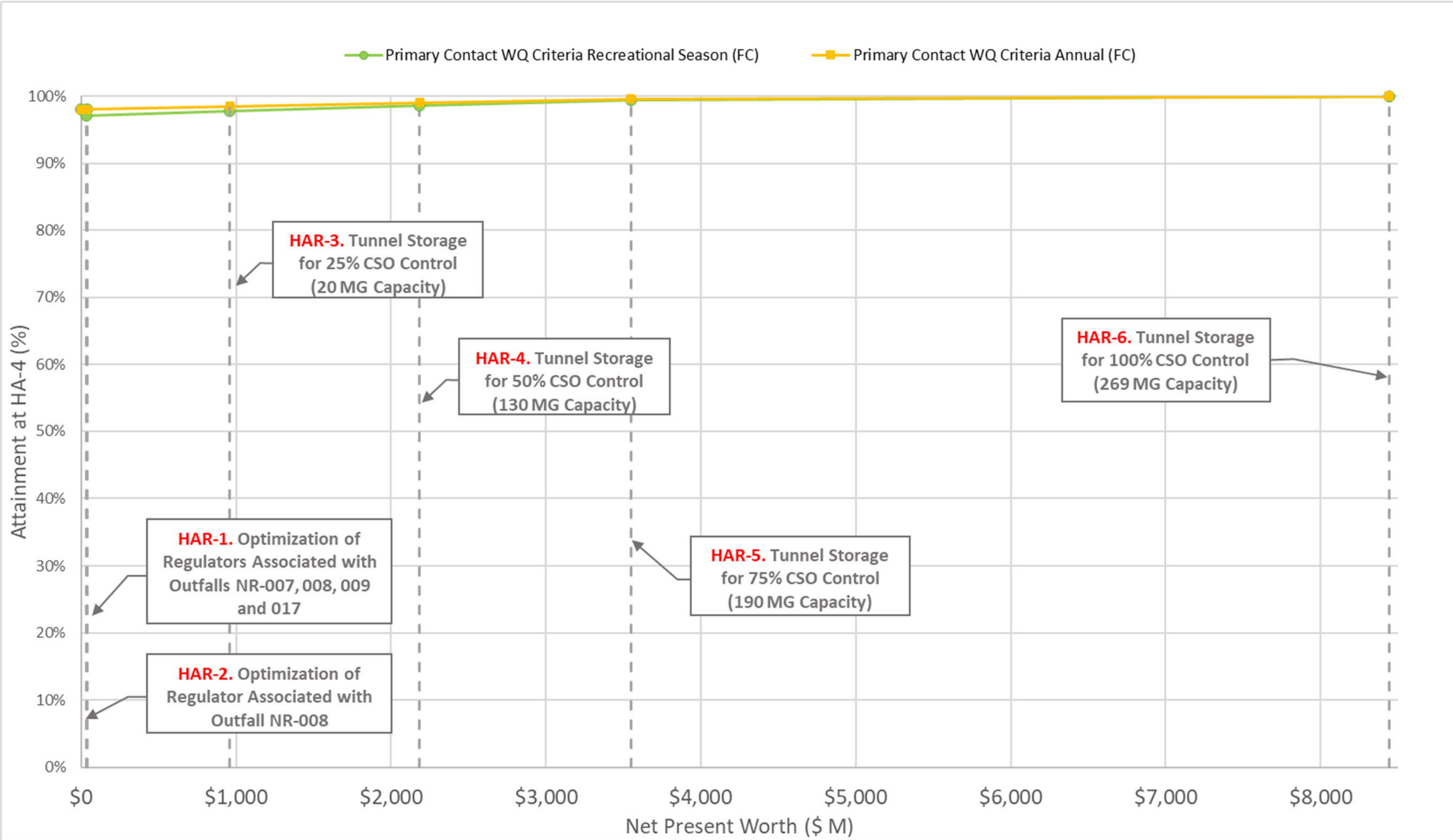


Figure 8.3-13. Cost vs. Bacteria Attainment at Station HA-4

8.3.h Conclusion on Preferred Alternative

The selection of the preferred alternative for the Harlem River is based on multiple considerations including public input, environmental and water quality benefits, and projected costs. The two optimization alternatives described above, HAR-1 and HAR-2, would provide a nominal reduction in CSO volume to the Harlem River for a cost of $36M and $31M, respectively. These alternatives, however, are contingent on the re-routing of the branch interceptor along 10th Avenue that is being considered as part of up-zoning modifications in the Inwood area. Since the timing and configuration of this work is uncertain, and the costs associated with Alternatives HAR-1 and HAR-2 are high relative to the net volume of CSO reduced, these optimization alternatives are not recommended. These alternatives could potentially be re-considered in the future as part of the overall improvements being considered for the Inwood area.

The CSO storage tunnel alternatives would provide a range of levels of CSO reduction to the Harlem River, but the costs associated with those alternatives are very high. Since the level of attainment with the Existing WQ Criteria for bacteria is greater than 95 percent at all WQ model cells in the Harlem River (see Figure 6-2 in Section 6), the high costs associated with the storage tunnel alternatives would not significantly change the already-high level of attainment with the WQ Criteria. Section 9 presents affordability issues and impacts on disadvantaged communities that would come into play if the CSO program costs were to further significantly increase. For these reasons, the CSO storage tunnel alternatives are not recommended.

As described in Section 5, the Tibbetts Brook Daylighting project to be implemented under the GI program will reduce CSO volume to the Harlem River by 228 MGY. Although this project is considered to be part of the Baseline Conditions, the volume reduction is significant, regardless of which program the projected is counted under. This project will also reduce energy consumption at the Wards Island WRRF by reducing dry-weather pumping and treatment requirements as a result of diverting the dry-weather brook flow direction to the Harlem River.

In summary, no new CSO projects are recommended for the Harlem River. Water quality improvements will continue to be achieved through implementation of the Tibbetts Brook Daylighting projects under the GI program, as well as other GI projects and ongoing programmatic floatables control activities. While the annual volume of CSO remaining in the Harlem River is acknowledged to remain relatively high, the time-to-recovery analysis presented further below demonstrates that the duration of impact of the remaining CSOs is relatively low.

Figure 8.3-14 presents a mosaic of the level of attainment with the Existing WQ Criteria for bacteria in the Harlem River on an annual basis, and Figure 8.3-15 shows the level of attainment for the recreational season (May 1st through October 31st). Figure 8.3-16 presents the level of attainment with the Existing WQ Criteria for DO on an average annual basis.

Table 8.3-17 presents the highest calculated monthly fecal coliform GM at LTCP sampling locations and waterbody access locations in the Harlem River during the 10-year period on an annual basis and during the recreational season (May 1st through October 31st), for the Recommended Plan. Table 8.3-17 also presents the percent of time that the fecal coliform monthly GM criterion of 200 cfu/100mL would be attained over the 10-year simulation period. The locations of the stations and supplemental model output locations listed in Table 8.3-17 are shown on Figure 8.3-17.

Figure 8.3-14. Harlem River Fecal Coliform Annual Attainment, Recommended Plan, 10-Year Simulation

Figure 8.3-15. Harlem River Fecal Coliform Recreational Season Attainment, Recommended Plan, 10-Year Simulation

Figure 8.3-16. Harlem River DO Annual Attainment, Recommended Plan, 2008 Typical Year Simulation

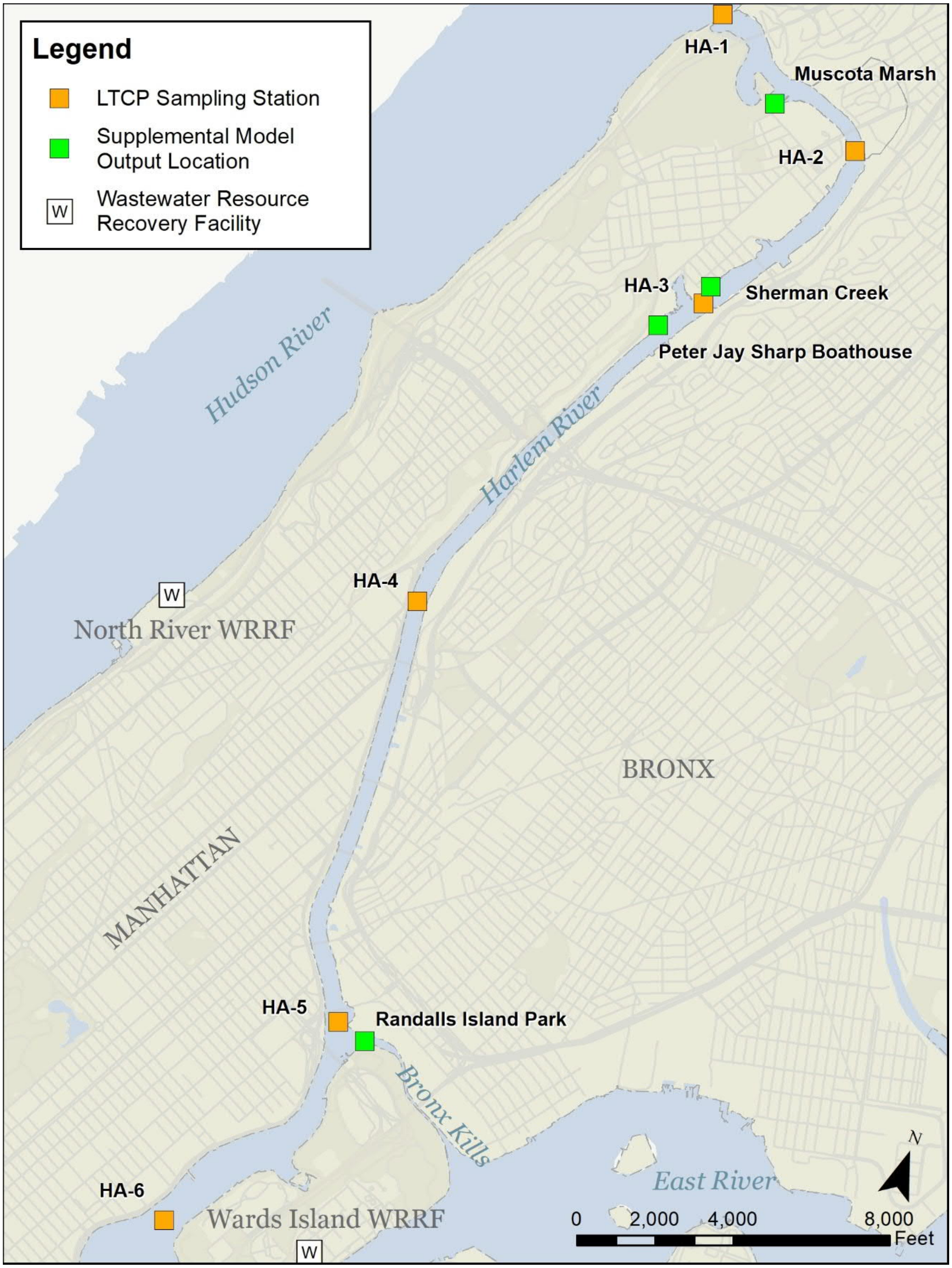


Figure 8.3-17. Sampling Stations and Supplemental Model Output Locations on the Harlem River

Table 8.3-17. Model Calculated 10-Year Baseline Fecal Coliform Maximum Monthly GM and Percent Attainment of WQ Criteria for Harlem River Recommended Plan

Description	Maximum Monthly Fecal Coliform GMs (cfu/100mL)		% Attainment (GM ≤200 cfu/100mL)	
	Annual	Recreational Season(1)	Annual	Recreational Season(1)
Harlem River (Class I)				
HAR-1	280	196	98%	100%
HAR-2	445	303	97%	97%
HAR-3	484	296	97%	97%
HAR-4	618	308	97%	97%
HAR-5	769	326	98%	98%
HAR-6	360	150	99%	100%
Muscota Marsh	363	243	98%	98%
Sherman Creek	480	295	97%	97%
Sharp Boathouse	526	312	97%	97%
Randall's Island Park	503	451	97%	97%

Note:
(1) The recreational season is from May 1st through October 31st.

Table 8.3-18 presents the average annual attainment of DO criteria for the 2008 typical year for the Recommended Plan at LTCP sampling locations in the Harlem River.

Table 8.3-18. 2008 Annual Average DO Attainment for Harlem River, Recommended Plan

Class I 2008 Annual Attainment (%) (Entire Water Column)	
Station	**Instantaneous (≥4.0 mg/L)**
Harlem River	
HAR-1	99.9%
HAR-2	100%
HAR-3	100%
HAR-4	100%
HAR-5	100%
HAR-6	100%

AECOM with Hazen

8.3.i Use Attainability Analysis

The CSO Order requires that a UAA be included in an LTCP "where existing WQS do not meet the Section 101(a)(2) goals of the CWA, or where the proposed alternative set forth in the LTCP will not achieve existing WQS or the Section 101(a)(2) goals." The UAA shall "examine whether applicable waterbody classifications, criteria, or standards should be adjusted by the State." The UAA process specifies that States can remove a designated use that is not an existing use if the scientific assessment can demonstrate that attaining the designated use is not feasible for at least one of six reasons:

1. Naturally occurring loading concentrations prevent the attainment of the use; or
2. Natural, ephemeral, intermittent or low flow conditions or water levels prevent the attainment of the use, unless these conditions may be compensated for by the discharge of sufficient volume of effluent discharges without violating State water conservation requirements to enable uses to be met; or
3. Human caused conditions or sources of pollution prevent the attainment of the use and cannot be remedied or would cause more environmental damage to correct than to leave in place; or
4. Dams, diversions or other types of hydrologic modifications preclude the attainment of the use, and it is not feasible to restore the waterbody to its original condition or to operate such modification in a way that would result in the attainment of the use; or
5. Physical conditions related to the natural features of the waterbody, such as the lack of a proper substrate, cover, flow, depth, pools, riffles, and the like, unrelated to water quality, preclude attainment of aquatic life protection uses; or
6. Controls more stringent than those required by Sections 301(b) and 306 of the Act would result in substantial and widespread economic and social impact.

As part of the LTCP, elements of a UAA, including the six conditions presented above, will be used to determine if changes to the designated use are warranted, considering a potential adjustment to the designated use classification as appropriate.

As noted in previous sections, with the implementation of the preferred alternative, the Harlem River is predicted to meet the Existing WQ fecal coliform bacteria criterion of 200 cfu/100mL on an annual basis based on both the 2008 Typical Year rainfall and the 10-year continuous simulation. The Class I DO criteria are also predicted to be achieved for the preferred alternative. Therefore, a Use Attainability Analysis is not needed for the Harlem River.

8.3.j Time to Recovery

As noted above, the Harlem River is a Class I waterbody, with best uses identified as secondary contact recreation and fishing, and the applicable Water Quality Criteria for fecal coliform bacteria are based on a monthly geometric mean. However, to gain insight into the shorter-term impacts of wet-weather sources of bacteria, DEP has performed an analysis to assess the amount of time following the end of a rainfall event required for the Harlem River to recover and return to fecal coliform concentrations less than 1,000 cfu/100mL.

The analyses consisted of examining the WQ model-calculated bacteria concentrations in the Harlem River for recreational periods (May 1st through October 31st) abstracted from 10 years of model simulations. For the Harlem River, the JFK Airport rainfall data was compared against water quality model bacteria results for the 10 recreational seasons to determine how long it took for the water column concentration to return to target threshold concentrations from the end of the rain event. The chosen target threshold concentration was 1,000 cfu/100mL for fecal coliform. The various rainfall events were then placed into rain event size "bins" ranging from less than 0.1 inch to greater than 1.5 inches. Only rain events that reached the target threshold concentrations before the beginning of the next storm were included. The median time to recovery for each bin at each water quality station was calculated.

Table 8.3-19 presents the median time to recovery for the Recommended Plan for the Harlem River, for the storms in the greater than 1.0 to 1.5 inch rainfall bin, which includes the 90th percentile event. In other words, this rainfall bin covers approximately 90 percent of the rain events that would occur in an average year. Values are presented at the LTCP sampling stations, and the waterbody access locations.

DEC has advised that it seeks to have a time to recovery of less than 24 hours, and this target has been consistent in the previously approved LTCPs. As indicated in Table 8.3-19, under the Recommended Plan, none of the stations assessed had a median time to recovery greater than ten hours, and six of the ten locations had median times to recovery of 4 hours or less, indicating a quick recovery following greater than 90 percent of the storms.

Table 8.3-19. Harlem River Time to Recovery, Fecal Coliform, Recommended Plan

Location	Median Time to Recovery (hours) Fecal Coliform Threshold (1,000 cfu/100mL)(1)
HAR-1	2
HAR-2	3
HAR-3	4
HAR-4	6.5
HAR-5	6
HAR-6	0(2)
Muscota Marsh	2
Sherman Creek	4
Sharp Boathouse	5
Randall's Island Park	9.5

Notes:

(1) Median time-to-recovery values presented for storms from the 10-year simulation, recreational seasons, in the size range of >1.0 to 1.5-inches of rainfall, which includes the 90th percentile rain event.

(2) Median time to recovery of "0" means that the average concentration across the water column never reached the 1,000 cfu/100mL threshold at the referenced station for more than half of the storms within the 1 to-1.5 inch rainfall bin assessed.

8.3.k Recommended LTCP Elements to Meet Water Quality Goals for Harlem River

The actions identified in this LTCP include:

- DEP will continue to implement the Green Infrastructure Program, including the Tibbetts Brook Daylighting project, and programmatic floatables control activities for the Harlem River.
- The Recommended Plan is predicted to achieve compliance with the Current WQ Criteria for bacteria on an annual basis based on both the 2008 Typical Year rainfall and the 10-year continuous simulation. The Class I DO criteria are also predicted to be achieved on an annual average basis for the Recommended Plan. As a result, a UAA is not required as part of this LTCP.
- DEP will establish with the DOHMH through public notification a wet-weather advisory during the recreational season (May 1st through October 31st), informing the public which recreational activities are not recommended in the Harlem River at that time. The LTCP includes a recovery time analysis that can be used to establish the duration of the wet-weather advisory for public notification.

DEP is committed to improving water quality in this waterbody, which will be advanced by the improvements and actions identified in this LTCP. These identified actions have been balanced with input from the public and awareness of the cost to the residents of NYC.

8.4 CSO Control Alternatives for Hudson River

As shown in Section 6, WQS for bacteria and dissolved oxygen are met in the Hudson River under Baseline Conditions. Therefore, attainment of WQS was not a factor in evaluating CSO control alternatives for the Hudson River. Rather, the focus was on evaluating alternatives for cost-effective reduction of CSO activations and volume. The CSO control alternatives that passed the initial screening phase and were retained for the Hudson River generally fell within the categories of system optimization and tunnel storage. System optimization alternatives covered the categories of fixed weirs, parallel interceptor/sewer, bending weirs or control gates, and gravity flow redirection to other watersheds. The storage tunnel alternatives, used to assess 25, 50, 75, and 100 percent CSO capture in the typical year, also included high-rate clarification for the dewatering flows from the tunnels. Storage tanks were not evaluated due to the number of outfalls and the general lack of available sites of sufficient size for storage tanks. Each control measure was initially evaluated on three of the key considerations described in Section 8.1: (1) benefits, as expressed by level of CSO control and WQS attainment; (2) costs; and (3) challenges, such as siting and operations. Using this methodology, the retained control measures listed in Section 8.1 were evaluated on a cost-performance basis and used to develop the basin-wide alternatives.

The Citywide/Open Waters Baseline Conditions include implementation of the Recommended Plans from the LTCPs for the tributary waterbodies previously submitted to DEC under this program, as well as other grey infrastructure projects implemented as part of earlier planning programs. Those projects are summarized in Section 4.

The following sections present the evaluations of the system optimization and tunnel storage alternatives for the Hudson River.

8.4.a System Optimization Alternatives

The approach to the initial identification and evaluation of system optimization alternatives for the Hudson River using the Optimatics Optimizer software was presented in Section 3. As described in Section 3, the Optimizer software was configured to prioritize monitored regulators discharging outside the period of critical wet -weather events, high-discharge frequency regulators, and regulators discharging in proximity to official and publicly-identified public access points (kayak launches/marinas).

The optimization alternatives for outfalls to the Hudson River associated with the Wards Island, North River, and Newtown Creek WRRF collection systems were evaluated independently, as the three systems are hydraulically independent. However, the Wards Island WRRF includes: combined sewer outfalls that discharge to the Harlem River, Bronx Kill, and East River; the North River WRRF system also includes combined sewer outfalls discharging to the Harlem River; and the Newtown Creek WRRF system includes combined sewer outfalls that discharge to the East River. Thus, the Hudson River optimization alternatives associated with the North River WRRF system need to be considered in conjunction with alternatives for the Harlem River outfalls associated with the North River WRRF system. Hudson River optimization alternatives associated with the Wards Island WRRF system need to be considered in conjunction with alternatives for the Harlem River, Bronx Kill, and East River outfalls associated with the Wards Island WRRF systems. Hudson River optimization alternatives associated with the Newtown Creek WRRF system need to be considered in conjunction with alternatives for the East River.

The sections below present the evaluations of Hudson River optimization alternatives associated with the Wards Island, North River and Newtown Creek WRRF collections systems, respectively.

8.4.a.1 System Optimization for Hudson River Outfalls in the North River WRRF System

Table 8.4-1 summarizes the CSO outfalls and associated regulators tributary to the Hudson River from the North River WRRF system that were the initial focus of the optimization evaluations. The locations of these outfalls/regulators are shown in Figure 8.4-1. Table 8.4-1 identifies the annual CSO volume and activation frequency under Baseline Conditions, and whether the outfall/regulator falls within one or more of the following categories:

- One of the 100 monitored regulators listed in the WRRF SPDES permits ("BMP Regulator")
- A "Key Regulator" as identified in the WRRF SPDES permits
- An outfall in proximity to (typically within 500 feet of) a public access location
- Regulators that activated more than average for the waterbody

<u>Findings/Observations from Optimizer Evaluations</u>

The Optimizer evaluations served as an initial screening step to identify potentially promising optimization alternatives to be further evaluated using the full North River WRRF InfoWorks model. These evaluations included the assessment of the impacts to CSO volume, activation and peak hydraulic grade line elevations relative to Baseline Conditions, as well as other general system conditions. General collection system information and findings of the initial Optimizer evaluations included the following:

- The North River WRRF is located along the Henry Hudson Parkway south of Hudson Riverbank State Park. The collection system primarily serves the western shoreline and northern tip of Manhattan. The southern interceptor begins at West 12th Street generally following Route 9A and Riverside Boulevard in a northerly direction towards the WRRF. The northern interceptor sewer parallels the Harlem River at its upstream end, crosses Manhattan along Isham Street and then bends to the south along the Henry Hudson Parkway (Route 9A) to the WRRF. A total of 55 regulators divert flow to the interceptors with 52 outfalls discharging to the Hudson River (39 CSOs) and Harlem River (13 CSOs).
- The WRRF collection system is relatively shallow (<10 feet of cover) at the upstream ends of each interceptor, but ranges from 15 to 25 feet of cover for most of the interceptor paralleling the Hudson River.
- Regulators contributing to CSO outfalls discharging to the Hudson River generally activate between 1 to 21 times during the typical year with a total average annual overflow volume (AAOV) of 366 MGY.
- Freeboard for the 5-year design storm and many of the larger storms during the typical year is generally less than 10 feet from the ground surface near the southern end of the interceptor, indicating that it is highly sensitive to hydraulic grade line impacts. However, the balance of the interceptor sewer along the Hudson River reaches depths over 100 feet in some areas with freeboard greater than 25 feet. These deeper sections provide opportunities to store and convey additional flow from optimized regulators and branch interceptors.
- The Optimizer modeling identified multiple alternatives that included modifications to as many as 10 regulators resulting in varying degrees of improved capture and hydraulic performance. Upon

performing InfoWorks runs for the 2008 typical year, limited reductions in AAOV (approximately 1-2%) and activation frequency (approximately 4-8%) were predicted for the better performing alternatives.

- The relatively limited performance improvement was a result of a combination of hydraulic grade line sensitivities and hydraulic balancing. In this system, increasing flow to the interceptor system tended to create adverse impacts on the hydraulic grade line, potentially increasing the risk of flooding. Also, since the system was generally running full during wet-weather, alternatives that reduced CSO at one location tended to result in offsetting increases at other locations. While the interceptor has available storage capacity during smaller storms, the rise in grade line during the 5-year storm in the shallower upstream reaches of the interceptor exceeds the level of acceptable risk.

Table 8.4-1. Hudson River CSO Outfalls/Regulators Associated with the North River WRRF

Outfall	Regulator	Baseline Conditions Typical Year		BMP Regulator	Key Regulator	Outfall in Proximity to Public Access	Higher Frequency Regulator
		Annual CSO Volume (MG)	Annual CSO Activations				
NR-006	N-16	35.7	18	✓	✓	✓	
NR-004	N-18	4.9	10	✓	✓		
NR-043	N-23	45.4	10	✓	✓		
NR-040	N-26A	44.7	21	✓			✓
NR-038	N-28	5.6	8	✓		✓	
NR-037	N-29	0.9	4			✓	
NR-046	N-29A	7.4	12	✓			
NR-035	N-31	6.5	18			✓	
NR-033	N-33	19.4	10	✓	✓		
NR-032	N-36	0.7	6			✓	
NR-031	N-38	2.1	8			✓	
NR-030	N-39, 40	4.9	12			✓	
NR-027	N-45	69.8	11	✓			
NR-026	N-46	13.9	19			✓	✓
NR-023	N-50	20.1	10	✓		✓	
NR-022	N-51	6.5	10			✓	

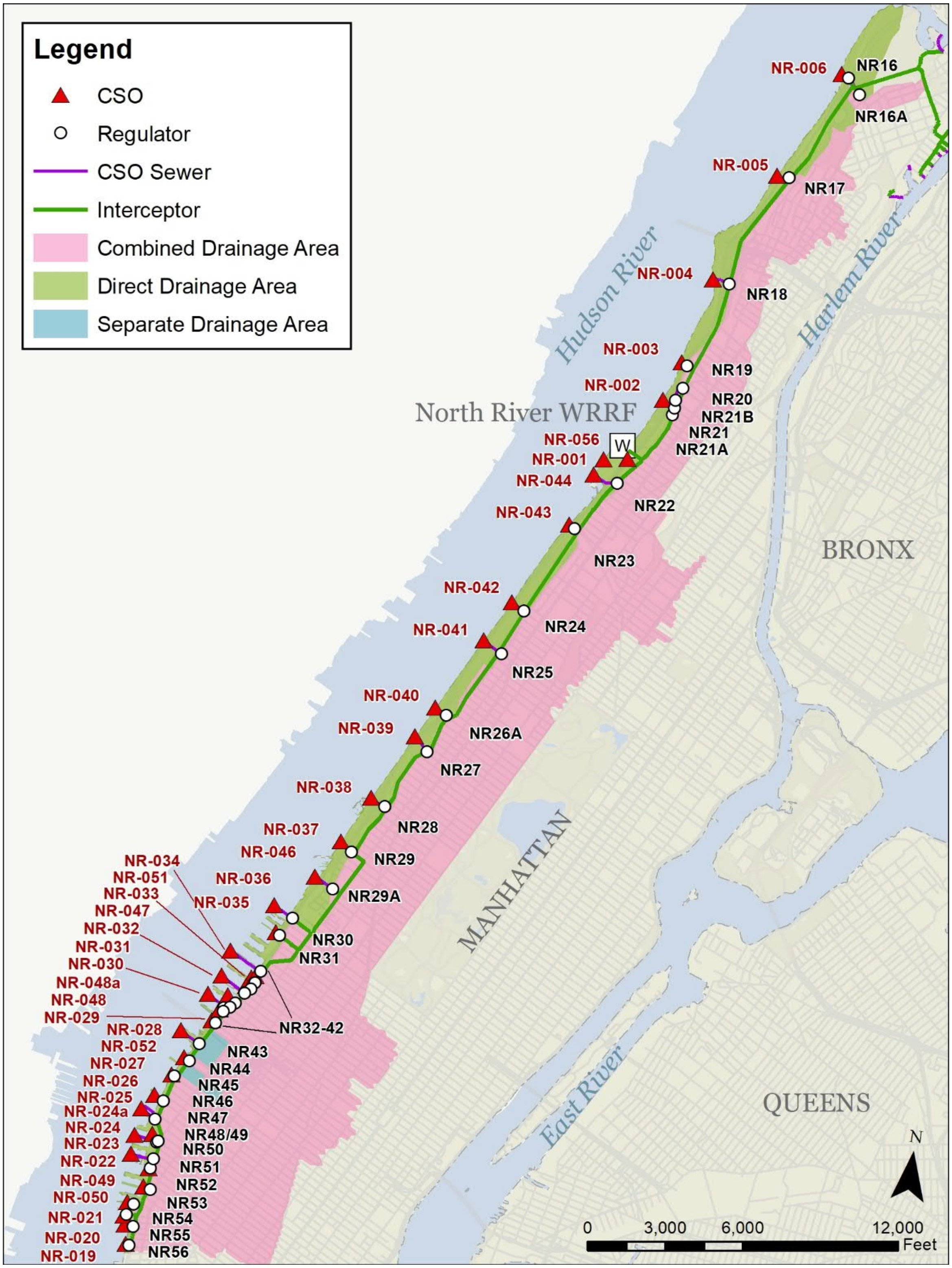


Figure 8.4-1. CSO Outfalls/Regulators Tributary to Hudson River from the North River WRRF System

<u>Follow-up Evaluations Based on Full InfoWorks Model</u>

The most promising optimization alternatives coming out of the Optimizer evaluations are summarized in Table 8.4-2:

Table 8.4-2. Hudson River Optimization Components for Retained Alternatives

Outfall	Regulator	Components HUD-1	Components HUD-2
NR-040	NR-26A	□	□
NR-038	NR-28	□	□
NR-046	NR-029A	□	□
NR-035	NR-31	□ ⬭	
NR-032	NR-36	□ ⬭	
NR-031	NR-38	□ ⬭	
NR-027	NR-45	□	
NR-026	NR-46	□	
NR-023	NR-50	□	
NR-022	NR-051	□	
AAOV Reduction		12 MGY	10 MGY
Probable Bid Cost		$ 19M	$ 3M

<u>KEY</u>

Increase Orifice Size

Raise Weir

Replace Branch Interceptor

Upsize Main Interceptor

These alternatives were further analyzed in more detail using the full North River WRRF system InfoWorks model. The resulting impacts of Alternatives HUD-1 and HUD-2 on peak hydraulic grade line in the 5-year storm are summarized in Figure 8.4-2 and Figure 8.4-3, respectively. The annual CSO volume and frequency for these optimization alternatives are summarized in Table 8.4-3 and estimated probable bid costs and construction/implementation considerations are summarized in Table 8.4-4.

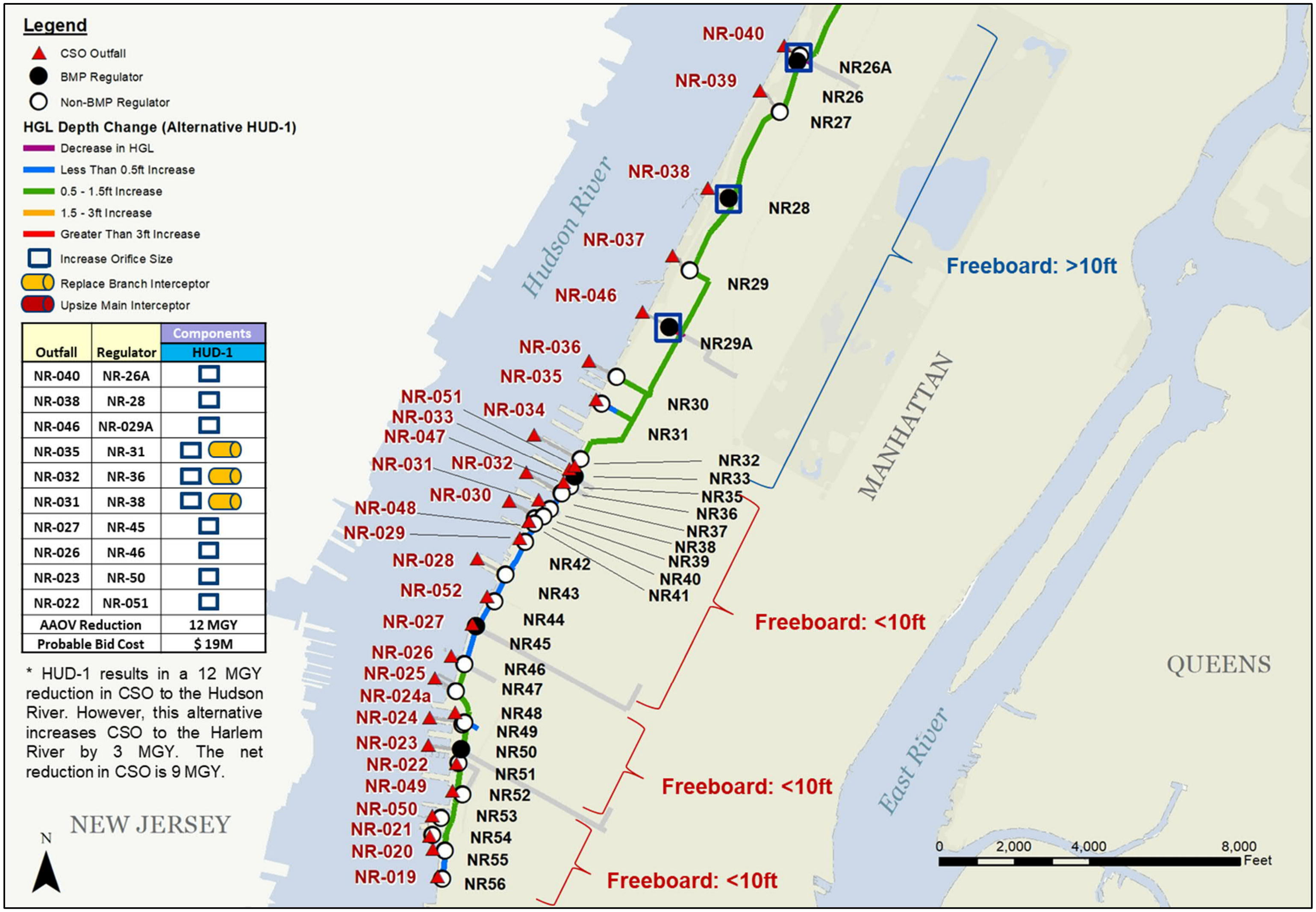


Figure 8.4-2. Hydraulic Grade Line Impacts of Alternative HUD-1 vs. Baseline Conditions, 5-Year

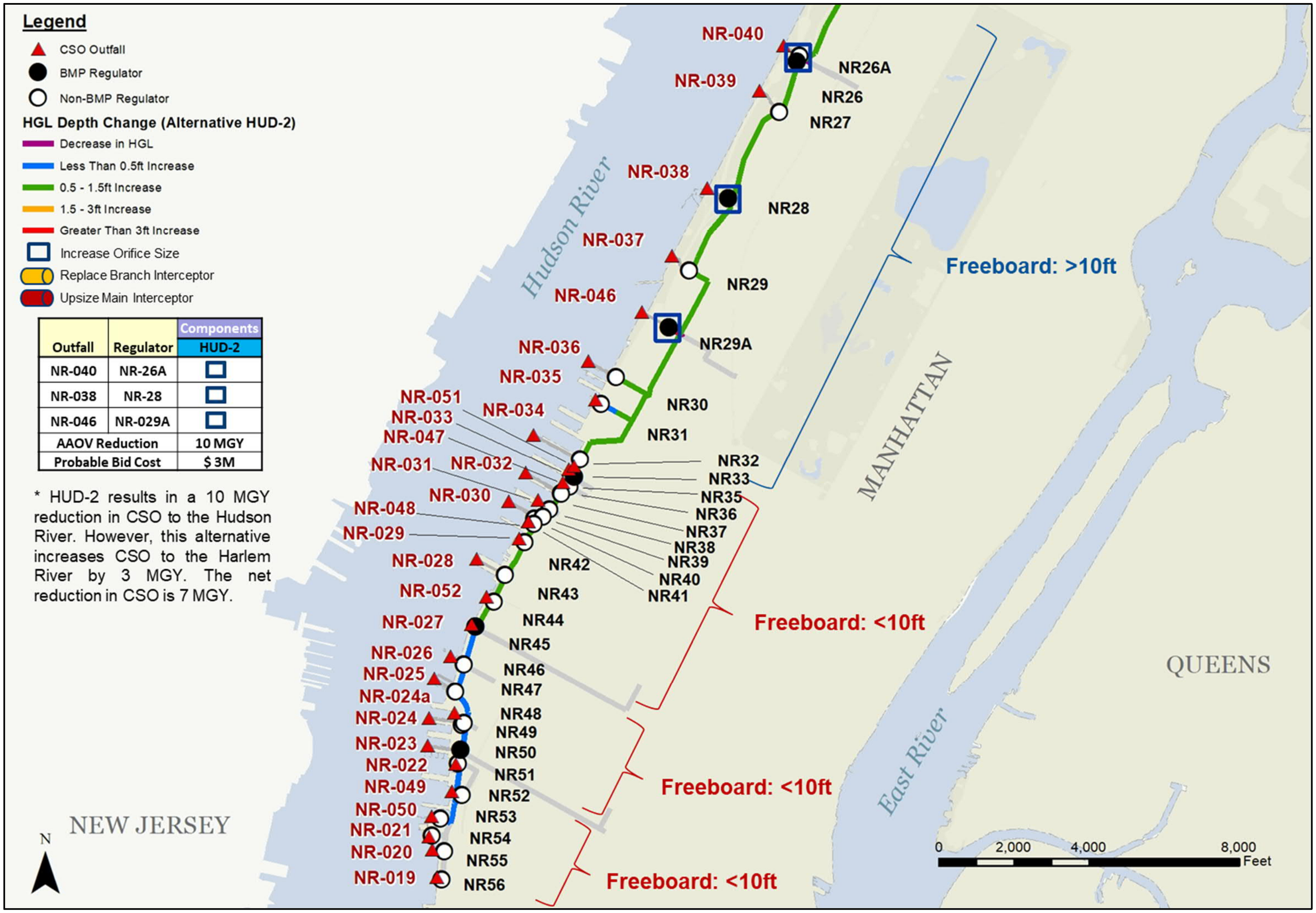


Figure 8.4-3. Hydraulic Grade Line Impacts of Alternative HUD-2 vs. Baseline Conditions, 5-Year Storm

Table 8.4-3. Summary of Performance of North River Optimization Alternatives for Hudson River

Outfall(1)	Regulator	Baseline Conditions Typical Year		Alternative HUD-1(2)		Alternative HUD-2(3)	
		Annual CSO Volume (MG)	Annual CSO Activations	Annual CSO Volume (MG)	Annual CSO Activations	Annual CSO Volume (MG)	Annual CSO Activations
NR-006	N-16	35.7	18	38.6	18	38.3	18
NR-004	N-18	4.9	10	4.9	10	4.9	10
NR-043	N-23	45.4	10	51.0	11	50.7	11
NR-040	N-26A	44.7	21	32.1	12	12.8	9
NR-038	N-28	5.6	8	2.4	3	2.4	3
NR-037	N-29	0.9	4	1.1	5	1.1	5
NR-046	N-29A	7.4	12	0.6	1	0.6	1
NR-035	N-31	6.5	18	5.3	6	7.0	18
NR-033	N-33	19.4	10	21.2	10	21.7	10
NR-032	N-36	0.7	6	1.8	6	1.1	6
NR-031	N-38	2.1	8	3.8	6	2.5	8
NR-030	N-39, 40	4.9	12	5.5	12	5.5	12
NR-027	N-45	69.8	11	83.6	10	77.2	11
NR-026	N-46	13.9	19	9.3	10	14.9	19
NR-023	N-50	20.1	10	18.5	9	23.1	11
NR-022	N-51	6.5	10	6.9	10	7.4	12
Total		**366**	**400**	**354**	**363**	**356**	**385**

Notes:
(1) Outfalls and regulators with negligible impacts to Annual CSO Volume and Activations are not included in this table.
(2) HUD-1 reduces CSO volume to the Hudson River by 12 MGY, but increases CSO volume to the Harlem River by 3 MGY, resulting in a net reduction of 9 MGY. Total activations of Hudson River CSOs are reduced by 37 per year, while Harlem River CSO activations are increased by 5 per year.
(3) HUD-2 reduces CSO volume to the Hudson River by 10 MGY, but increases CSO volume to the Harlem River by 3 MGY, resulting in a net reduction of 7 MGY. Total activations of Hudson River CSOs are reduced by 15 per year, while Harlem River CSO activations are increased by 4 per year.

Table 8.4-4. Summary of Cost and Implementation Considerations for North River Optimization Alternatives for Hudson River

Alternative	Probable Bid Cost ($M)	Implementation Considerations
HUD-1	$19M	Net reduction in CSO is 9 MGY. Projected to reduce CSO by 12 MGY to the Hudson River with a 3 MGY increase in CSO to the Harlem River.
HUD-2	$3M	Net reduction in CSO is 7 MGY. Projected to reduce CSO by 10 MGY to the Hudson River with a 3 MGY increase in CSO to the Harlem River.

Given the relatively cost-effective potential reduction in CSO activation frequency and volume for Alternatives HUD-1 and HUD-2, both alternatives were retained for further consideration.

8.4.a.2 System Optimization for Hudson River Outfalls in the Wards Island WRRF System

Table 8.4-5 lists the CSO outfalls and associated regulators tributary to the Hudson River from the Wards Island WRRF system that were the initial focus of the optimization evaluations. The locations of these outfalls/regulators are shown in Figure 8.4-4. Table 8.4-5 identifies the annual CSO volume and activation frequency under Baseline Conditions, and whether the outfall/regulator falls within one or more of the following categories:

- One of the 100 monitored regulators listed in the WRRF SPDES permits (“BMP Regulator”)
- A “key regulator” as identified in the WRRF SPDES permits
- An outfall in proximity to (typically within 500 feet of) a public access location
- Regulators that activated more than average for the waterbody

Table 8.4-5. Hudson River CSO Outfalls/Regulators Associated with the Wards Island WRRF

Outfall	Regulator	Baseline Conditions		BMP Regulator	Key Regulator	Outfall in Proximity to Public Access	Higher Frequency Regulator
		Annual CSO Volume (MG)	Annual CSO Activations				
WIB-053	WI-79	46.3	50				✓
WIB-054	WI-78	31.7	39				✓
WIB-055	WI-77	19.5	54				✓

Findings/Observations from Optimizer Evaluations

The Optimizer evaluations served as an initial screening step to identify potentially promising optimization alternatives to be further evaluated using the full Wards Island WRRF InfoWorks model. These evaluations included the assessment of the impacts to CSO volume, activation and peak hydraulic grade line elevations relative to Baseline Conditions, as well as other general system conditions. General collection system information and findings of the initial Optimizer evaluations included the following:

- The Wards Island WRRF collection system serves the northeast side of Manhattan and western Bronx. The Manhattan interceptor parallels the Harlem River Drive, while the Bronx Interceptor initially parallels the Hudson River along Palisades Avenue, then bends eastward along the Harlem River and then to the south generally following the Major Deegan Expressway. A total of 75 regulators divert flow to the interceptors. During wet-weather, flow in excess of the interceptor capacity can overflow to CSO outfalls discharging to the Hudson River (3 CSOs), Harlem River (50 CSOs), Bronx Kill (3 CSOs) and East River (19 CSOs). The interceptor sewers convey flow to the Wards Island WRRF located to the south and east of Randall's Island Park.
- The topography at the north end of the WRRF collection system is undulating and is served by three pumping stations (West 254th Street PS, West 248th Street PS and West 235th Street PS). A regulator is also located at each pumping station to control the peak wet-weather flows diverted to each pumping station.
- The sewers tributary to each regulator are relatively steep due to the topography. Depth of cover on the gravity sewers varies, ranging from relatively shallow (<10 feet of cover) to about 40 feet.
- Regulators contributing to CSO outfalls discharging to the Hudson River activate between 39 to 54 times during the typical year with a total AAOV of 98 MGY.
- Freeboard for the 5-year design storm and many of the larger storms during the typical year is generally less than 10 feet from the ground surface, indicating the system is highly sensitive to hydraulic grade line impacts.
- The Optimizer modeling identified multiple alternatives that included modifications to as many as 25 regulators throughout the WRRF collection system that resulted in varying degrees of improved capture and hydraulic performance. However, upon performing InfoWorks runs for the 2008 typical year, limited reductions in AAOV (<1.5%) and activation frequency (<2.5%) were predicted for the better performing alternatives.
- The limited performance improvement was a result of the hydraulic grade line sensitivities and the capacity of each pumping station.

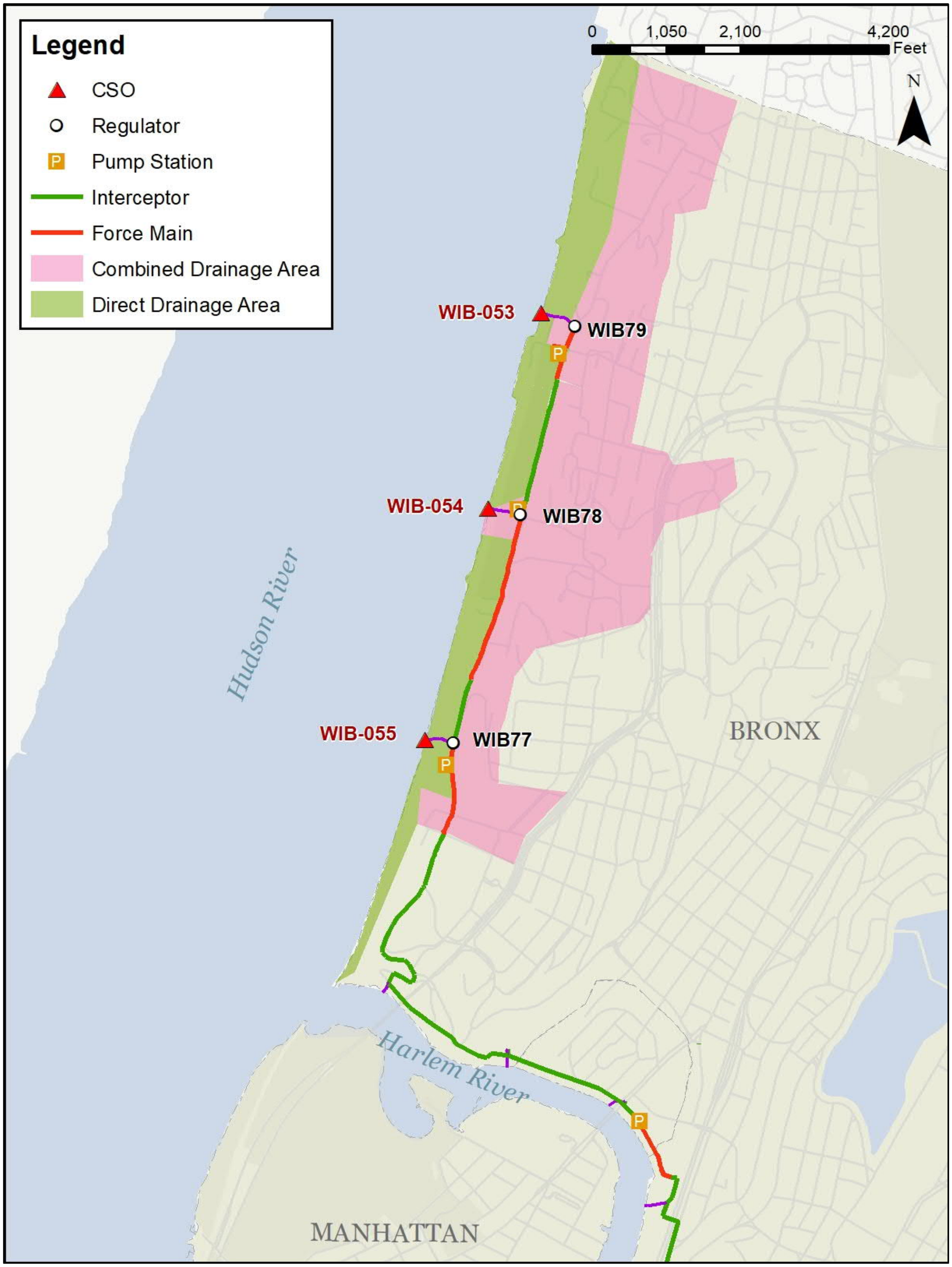


Figure 8.4-4. CSO Outfalls/Regulators Tributary to Hudson River from the Wards Island WRRF System

AECOM with Hazen

Follow-up Evaluations Based on Full InfoWorks Model

InfoWorks model runs were performed to evaluate the pumping station capacity upgrades necessary to reduce CSO volume and activation at each of the three pumping stations. Pumping station capacities were increased in 50-percent increments up to two times the existing pumping station capacity. Results of the analysis are summarized in Table 8.4-6. While volumes and frequencies were reduced at each of the outfalls associated with these pumping stations, the volumes and frequencies of overflow at downstream outfalls increased. The re-balancing of wet-weather flow within the interceptor system resulted in a transfer of CSO discharges from the Hudson River to the Harlem River. Upon looking at the total volume of CSO discharged during the 2008 typical year for each of these scenarios, the volumes were found to increase as the pumping station capacities were increased. As these alternatives produced no net reduction in CSO volume, they were eliminated from further consideration.

Table 8.4-6. Summary of Pumping Station Capacity Upgrade Evaluation for Wards Island WRRF System

Outfall	Regulator	Baseline Conditions		1.5X PS Capacity Increase		2.0X PS Capacity Increase	
		Annual CSO Volume (MG)	Annual CSO Activations	Annual CSO Volume (MG)	Annual CSO Activations	Annual CSO Volume (MG)	Annual CSO Activations
W. 254th St. PS		**1.0 MGD**		**1.5 MGD**		**2.0 MGD**	
WI-053	WI-79	46.3	50	39.8	47	34.8	42
W. 248th St. PS		**2.9 MGD**		**4.3 MGD**		**5.8 MGD**	
WI-054	WI-78	31.7	39	24.3	34	19.2	29
W. 235th St. PS		**3.5 MGD**		**5.3 MGD**		**7.0 MGD**	
WI-055	WI-77	19.5	54	14.8	49	11.7	38
Total Hudson River		**97.5**	**143**	**78.9**	**130**	**65.7**	**109**
Impacted Downstream Regulators/Outfalls							
WI-076	WI-76	58.5	42	74.2	41	86.1	43
WI-077	WI-75	81.2	38	84.0	40	85.7	40
WI-078	WI-75	34.5	41	35.4	42	35.9	42
Total Harlem River		**174.2**	**121**	**193.6**	**123**	**207.7**	**125**
Total		**271.7**	**264**	**272.5**	**253**	**273.4**	**234**

8.4.a.3 System Optimization for Hudson River Outfalls in the Newtown Creek WRRF System

Table 8.4-7 summarizes the CSO outfalls and associated regulators tributary to the Hudson River from the Newtown Creek WRRF system that were the initial focus of the optimization evaluations. The locations of these outfalls/regulators are shown in Figure 8.4-5. Table 8.4-7 identifies the annual CSO volume and activation frequency under Baseline Conditions, and whether the outfall/regulator falls within one or more of the following categories:

- One of the 100 monitored regulators listed in the WRRF SPDES permits ("BMP Regulator")
- A "key regulator" as identified in the WRRF SPDES permits
- An outfall in proximity to (typically within 500 feet of) a public access location
- Regulators that activated more than average for the waterbody

Table 8.4-7. Hudson River CSO Outfalls/Regulators Associated with the Newtown Creek WRRF

Outfall	Regulator	Baseline Conditions		BMP Regulator	Key Regulator	Outfall in Proximity to Public Access	Higher Frequency Regulator
		Annual CSO Volume (MG)	Annual CSO Activations				
NCM-070	NCM-9	8.4	21				✓
NCM-071	NCM-6, 7	8.1	19				✓
NCM-072	NCM-5	9.2	12			✓	
NCM-074	NCM-3	10.9	15			✓	
NCM-075	NCM-2	77.8	21	✓		✓	✓
NCM-076	NCM-1	225.3	47	✓		✓	✓

Note:
(1) Outfalls and regulators with negligible impacts to Annual CSO Volume and Activations are not included in this table.

Findings/Observations from Optimizer Evaluations

The Optimizer evaluations served as an initial screening step to identify potentially promising optimization alternatives to be further evaluated using the full Newtown Creek WRRF InfoWorks model. These evaluations included the assessment of the impacts to CSO volume, activation and peak hydraulic grade line elevations relative to Baseline Conditions, as well as other general system conditions. General collection system information and findings of the initial Optimizer evaluations included the following:

- The Manhattan part of the Newtown Creek WRRF collection system serves the southern end of Manhattan. The southern branch of the Manhattan interceptor starts in the vicinity of Outfall NCM-081, and runs south parallel to the Hudson River shoreline. The interceptor continues around the southern tip of Manhattan, then runs north parallel to the East River, to the Manhattan Pumping Station. The northern branch of the Manhattan Interceptor runs south from approximately East 71st Street, parallel to the East River shoreline, to the Manhattan Pumping Station. A total of 63 regulators divert flow to the interceptors. During wet-weather, flow in excess of the interceptor capacity can overflow to CSO outfalls discharging to the Hudson River (9 CSOs), and East River (49 CSOs). The interceptor sewers convey flow to the Manhattan Pumping Station, where flow is pumped across the East River to the Newtown Creek WRRF.
- Depth of cover on the interceptor varies, ranging from relatively shallow (<10 feet of cover) at the upstream end to greater than 20 feet.
- Regulators contributing to CSO outfalls discharging to the Hudson River activate between 6 to 47 times during the typical year with a total AAOV of 370 MGY.
- Freeboard for the 5-year design storm and many of the larger storms during the typical year is generally less than 10 feet from the ground surface indicating the system is highly sensitive to hydraulic grade line impacts.
- The Optimizer modeling identified multiple alternatives that included modifications to as many as 11 regulators throughout the Manhattan side of the WRRF collection system that resulted in varying degrees of improved capture and hydraulic performance. However, upon performing InfoWorks runs for the 2008 typical year, limited reductions in AAOV (<3%) and activation frequency (<2%) were predicted for the better performing alternatives.
- The relatively limited performance improvement was a result of a combination of hydraulic grade line sensitivities and hydraulic balancing. In this system, increasing flow to the interceptor system tended to create adverse impacts on the hydraulic grade line, potentially increasing the risk of flooding. Also, since the system was generally running full during wet-weather, alternatives that reduced CSO at one location tended to result in offsetting increases at other locations. While the interceptor has available storage capacity during smaller storms, the rise in grade line during the 5-year storm into the shallower upstream reaches of the interceptor exceeds the level of acceptable risk.

Figure 8.4-5. CSO Outfalls/Regulators Tributary to Hudson River from the Newtown Creek WRRF System

Follow-up Evaluations Based on Full InfoWorks Model

As noted above, the best-performing alternatives coming out of the Optimizer evaluations resulted in very limited improvement in either CSO volumes or activations. When these alternatives were evaluated using the full InfoWorks model, these alternatives resulted in unacceptable increases in the peak hydraulic grade line in the upstream end of the interceptor during the 5-year storm. Therefore, these alternatives were not retained for further evaluation.

8.4.b Storage Tunnel Alternatives for 25/50/75/100 Percent CSO Control

Conceptual storage tunnel alternatives were developed to model potential 25, 50, 75, and 100 percent control of the annual CSO volume discharged to the Hudson River in the 2008 Typical Year. The approach to sizing and layout of the storage tunnel alternatives was as follows:

- For the 50 percent CSO control tunnel, the Typical Year annual overflow volume of each CSO outfall to the Hudson River was reviewed and combinations of outfalls were identified where capture of 100 percent of the CSO from those outfalls would approximately match 50 percent of the total CSO volume from all outfalls to the Hudson River.
- The locations of these outfalls were then assessed in relation to the length and diameter of tunnel needed to capture the outfalls.
- Based on DEP expertise, a combination of outfalls was selected that provided reasonable tunnel length/diameter to provide 50 percent CSO volume capture.
- A similar approach was taken for the 75 percent CSO control tunnel.
- For the 25 percent CSO control tunnel, the 50 percent CSO tunnel was downsized until the volume of storage provided would result in approximately 25 percent CSO control.
- For the 100 percent CSO control tunnel, it was assumed that every CSO outfall to the Hudson River that was predicted to be active in the 2008 Typical Year would be tied into the tunnel. Where multiple outfalls were located in close proximity to each other, it was assumed that a near-surface consolidation conduit would be provided to a single drop shaft.
- For each of these alternatives, the dewatering rate required to dewater the storage tunnel within 24 hours was compared to the available dry-weather flow capacity in the WRRF closest to the downstream end of the tunnel. If insufficient dry-weather flow capacity was available at the WRRF to accept the additional dewatering flows, a high-rate clarification wet-weather flow treatment system with disinfection was added to the alternative to treat the dewatered flow.
- A detailed siting assessment was not conducted, so the specific locations of various features of the tunnel alternatives (mining shaft, TBM removal shaft, drop shafts, dewatering pumping station, dewatered flow treatment facility, near-surface diversion structures/connection conduits) were not identified.

The main features of the 25, 50, 75, and 100 percent CSO control storage tunnels modeling scenarios for the Hudson River are summarized in Table 8.4-8. Figure 8.4-6 to Figure 8.4-9 present conceptual layouts of the storage tunnel alternatives.

Table 8.4-8. Summary of 25, 50, 75 and 100 Percent CSO Control Alternatives for the Hudson River

Alternative	HUD-3	HUD-4	HUD-5	HUD-6
Level of CSO Control(1)	**25%**	**50%**	**75%**	**100%**
Length (mi.)	2.3	7.0	10.9	14.8
Diameter (ft.)	14	19	18	18
Volume (MG)	14	79	114	142
Outfalls Captured	• NCM-075 • NCM-076	• NCM-075 • NMC-076 • NR-023 • NR-027 • NR-043	2 NCM outfalls and 15 NR outfalls	All CSO Outfalls to Hudson River (52 Total)
Net CSO Volume Reduction (MGY)	209	438	613	833
Wet-Weather Flow Treatment Facility Capacity for Dewatering Flow (MGD)	14	79	114	142
Estimated Probable Bid Cost(2)	$600M	$1,500M	$2,900M	$5,200M

Notes:
(1) Modeled annual percent CSO reduction based on the 2008 Typical Year.
(2) 2019 dollars.

The 25 percent CSO capture tunnel would capture overflow from Outfalls NCM-075 and NCM-076 (Figure 8.4-6). The distance between those outfalls is relatively short (approximately 2,000 feet). Therefore, a tunnel to provide 25-percent CSO capture would likely start at a mining shaft some distance north of Outfall NCM-076, and terminate at an equipment removal/drop shaft at Outfall NCM-075. For this exercise, the tunnel length was assumed to be approximately 12,000 feet long, which would result in a diameter of 14 feet. A shorter tunnel with larger diameter or a longer tunnel with smaller diameter could also be considered. The 50 percent CSO capture tunnel would start from a mining shaft located in the vicinity of Outfall NR-043, south of the North River WRRF, and run generally under or along the shoreline of the Hudson River south to a TBM retrieval shaft/drop shaft in the vicinity of Outfall NCM-075 (Figure 8.4-7). Additional drop shafts would be provided in the vicinity of Outfalls NCM-076, NR-023, and NR-027. The 75 percent CSO capture tunnel would follow a similar route, but would extend further north to the vicinity of Outfall NR-006, and would capture the additional outfalls listed in Table 8.4-8 (Figure 8.4-8). The mining shaft for this tunnel could be located near Outfall NR-006, or could be located near the North River WRRF, with the tunnel bored in both directions from that mining shaft. The 100 percent CSO control tunnel would run along a route similar to the 75 percent CSO capture tunnel, but would extend to Outfall NCM-071 in the south, and to Outfall WIB-053, north of the Harlem River (Figure 8.4-9). Multiple near-surface consolidation conduits would be provided to convey flow from adjacent outfalls to common drop shafts, and the tunnel would capture all of the CSO from all of the Hudson River CSO outfalls in the 2008 typical year.

The closest WRRF to the mining shaft for the tunnel storage alternatives would be the North River WRRF. However, a dedicated wet-weather high-rate treatment facility would be necessary for the treatment of the CSO retained in the storage tunnel.

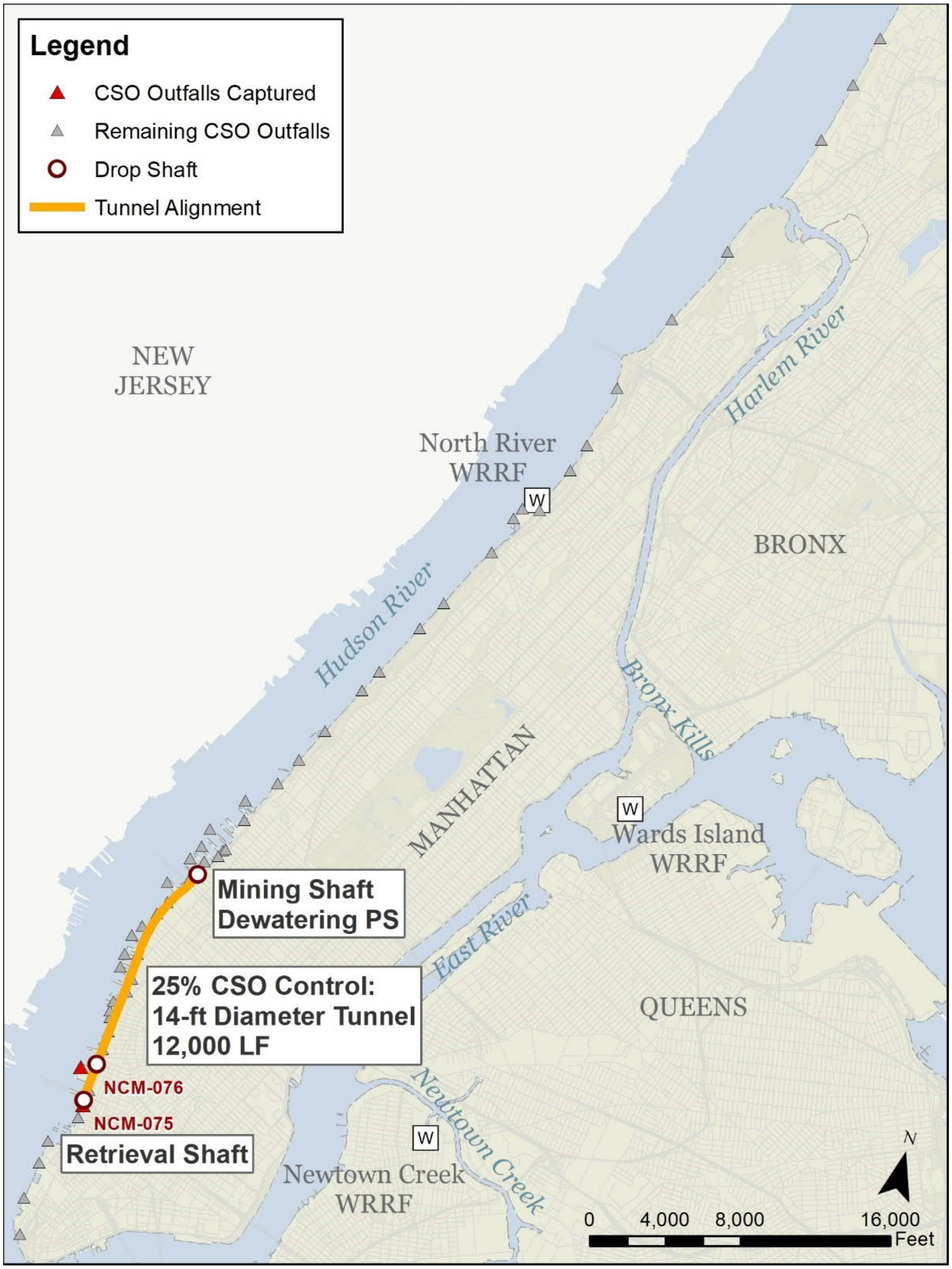


Figure 8.4-6. 25 Percent CSO Control Tunnel for Hudson River

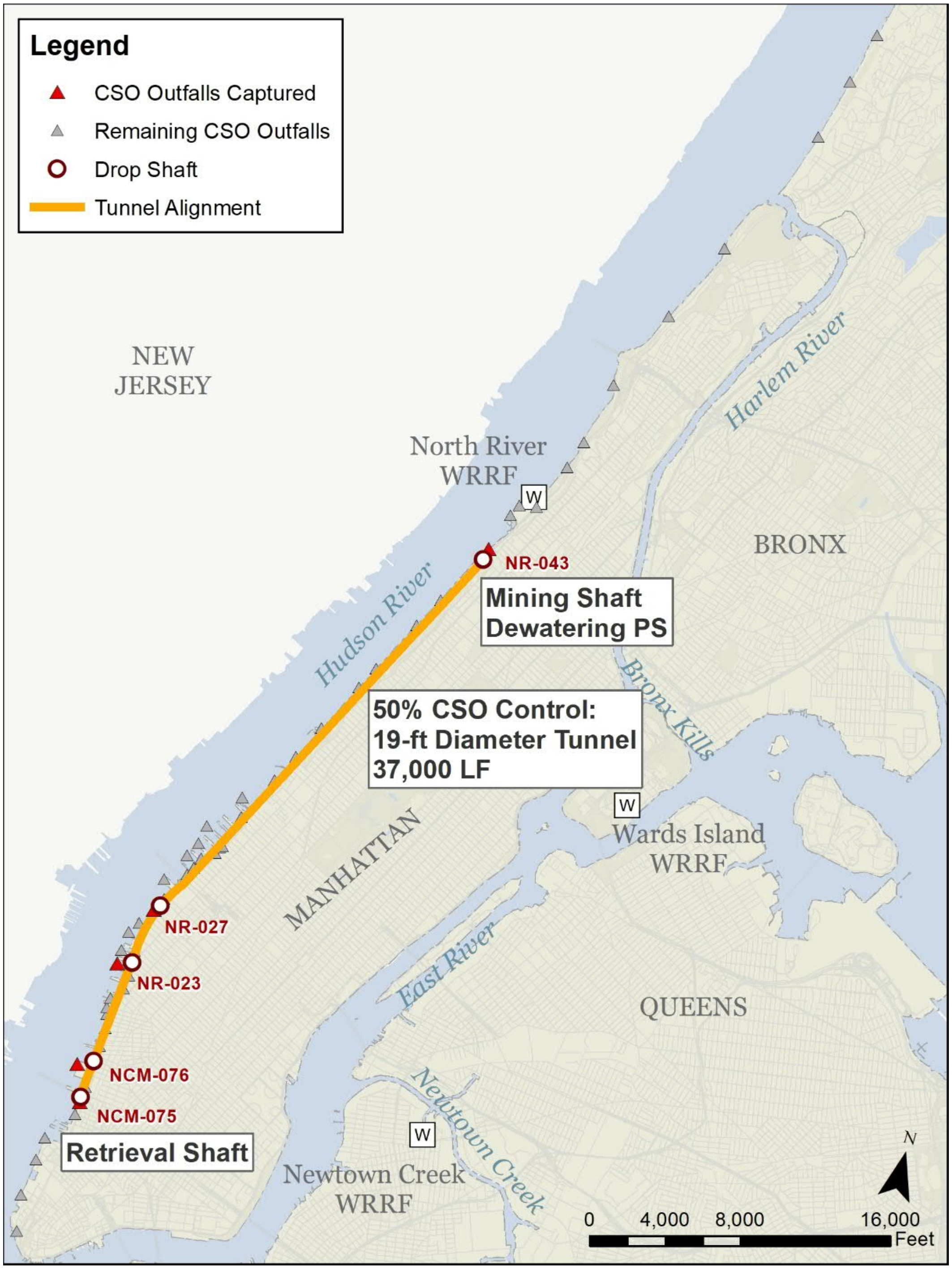


Figure 8.4-7. 50 Percent CSO Control Tunnel for Hudson River

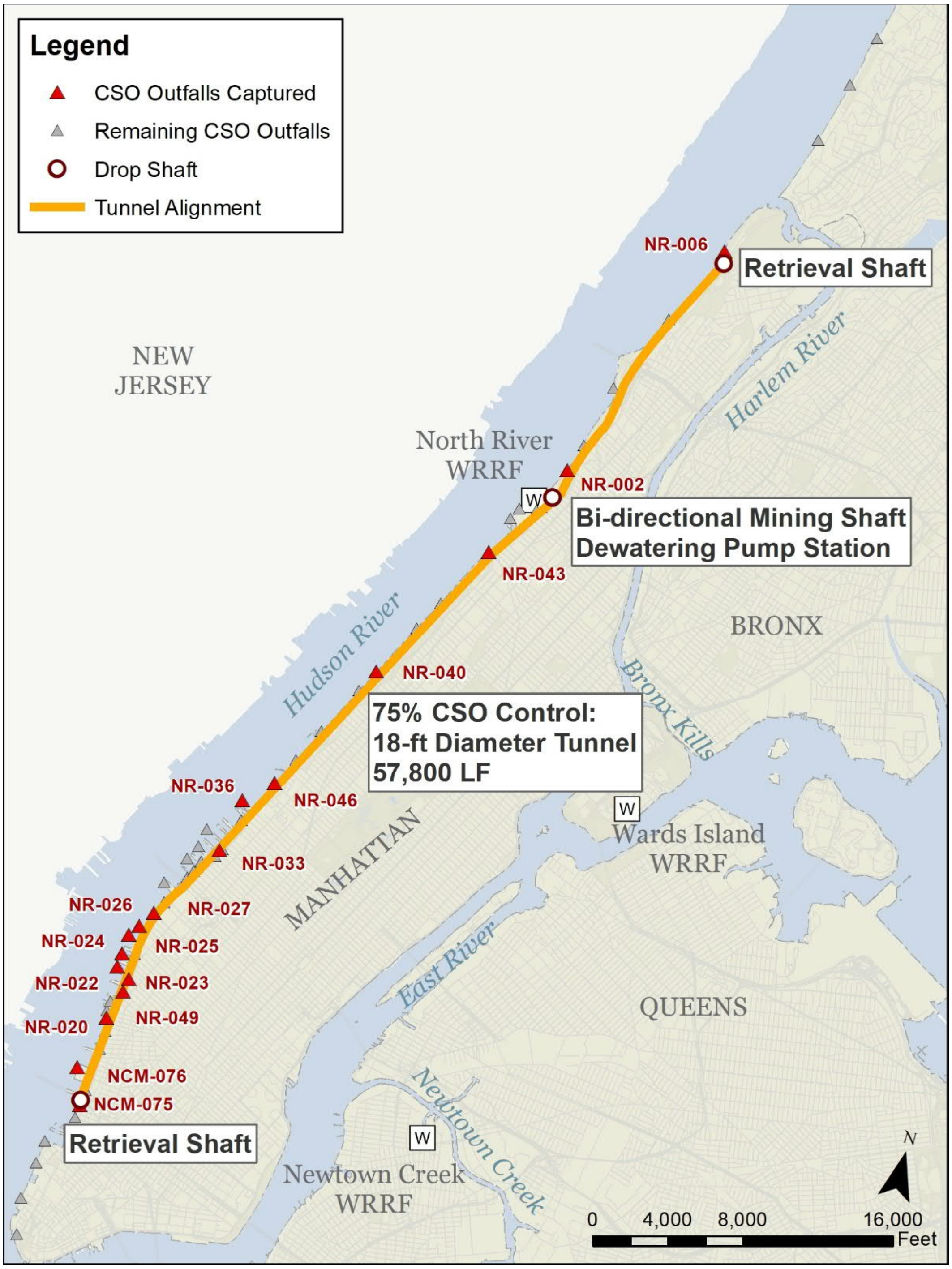


Figure 8.4-8. 75 Percent CSO Control Tunnel for Hudson River

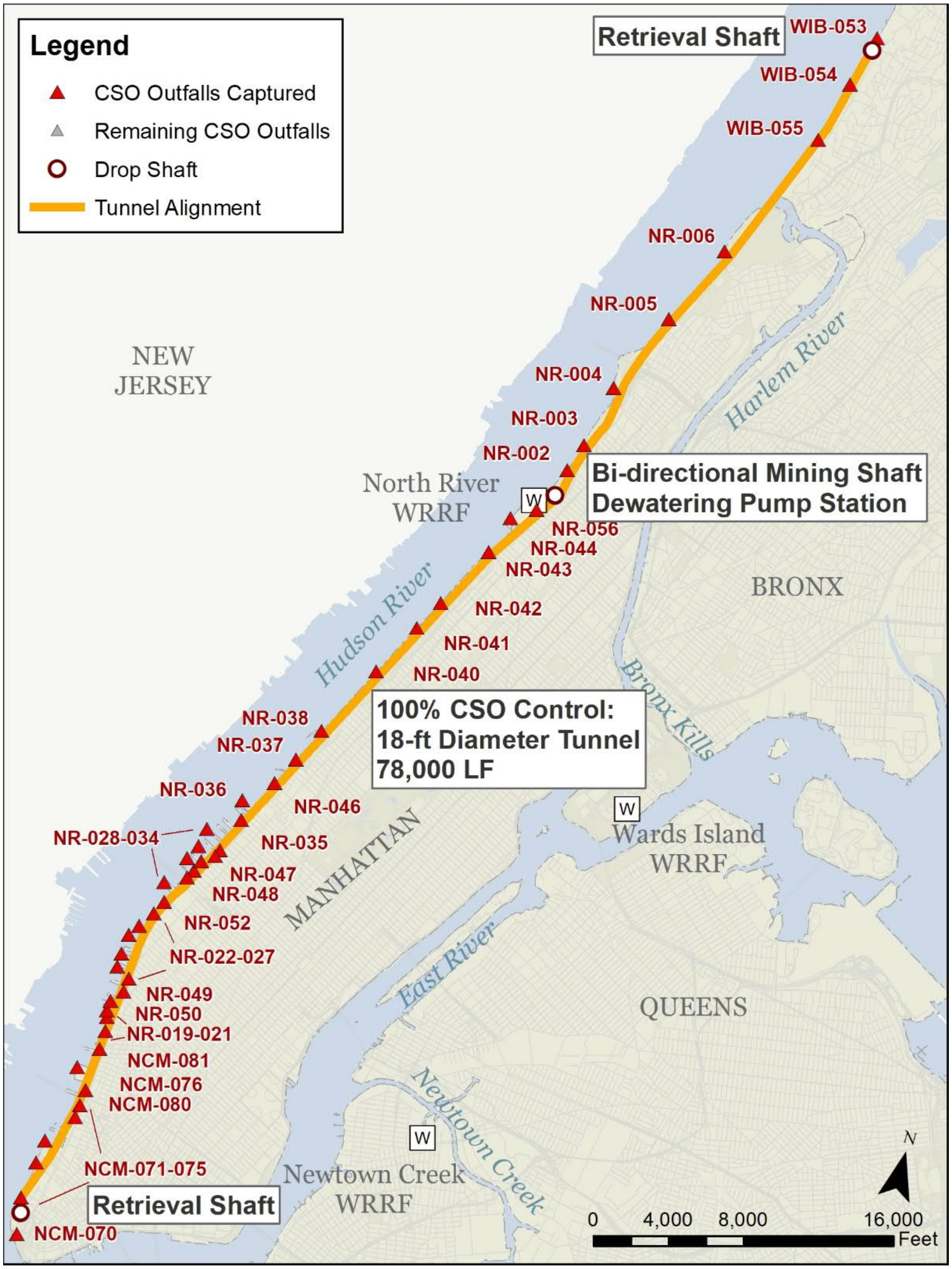


Figure 8.4-9. 100 Percent CSO Control Tunnel for Hudson River

Table 8.4-9. Summary of CSO Control Measure Screening for Hudson River

Control Measure	Category	Retained for Further Analysis?	Remarks
Additional GI Build-out	Source Control	NO(1)	Planned GI build-out in the watershed is included in the baseline. It is unlikely that additional sites will be identified due to site constraints in publicly owned properties.
High Level Storm Sewers	Source Control	NO(1)	No cost-effective opportunities identified
Regulator Modifications	System Optimization	YES	Incorporated into optimization alternatives HUD-1, HUD-2
Parallel Interceptor Sewer	System Optimization	YES	Incorporated into optimization alternatives HUD-1, HUD-2.
Bending Weirs/Control Gates	System Optimization	NO	No cost-effective or constructible site opportunities were identified
Pumping Station Optimization	System Optimization	NO	Limited benefit in terms of CSO reduction.
Pumping Station Expansion	System Optimization	NO	Limited benefit in terms of CSO reduction.
Gravity Flow Redirection to Other Watersheds	CSO Relocation	YES	Optimization Alternatives HUD-1 and HUD-2 shift some CSO volume between Harlem and Hudson River
Pumping Station Modification	CSO Relocation	NO	No cost-effective opportunities identified.
Flow Redirection with Conduit and Pumping	CSO Relocation	NO	No cost-effective opportunities identified.
Floatables Control	Floatables Control	YES	Programmatic floatables control will be applied and expanded Citywide
Environmental Dredging	Water Quality/ Ecological Enhancement	NO	No specific locations of CSO sediment mounding identified.
Wetland Restoration and Daylighting	Water Quality/ Ecological Enhancement	NO	No daylighting opportunities were identified.
Outfall Disinfection	Treatment: Satellite	NO	Not feasible due to short length of outfalls.
Retention/Treatment Basins	Treatment: Satellite	NO	Significant siting constraints and very high costs. Tunnel storage covers 25/50/75/100% CSO control alternatives.
High-Rate Clarification	Treatment: Satellite	YES	Incorporated into the storage tunnel alternatives for treatment of captured CSO during tunnel dewatering.
WRRF Expansion	Centralized Treatment	NO	Insufficient space available. Limited benefit compared to potential cost.
In-System Storage (Outfalls)	Storage	NO	Negligible levels of CSO control due to short outfalls.
Off-line Storage (Tanks)	Storage	NO	Significant siting constraints and very high costs. Tunnel storage covers 25/50/75/100% CSO control alternatives.
Off-line Storage (Tunnels)	Storage	YES	Tunnel storage alternatives HUD-3, HUD-4, HUD-5 and HUD-6 cover 25/50/75/100% CSO control.

Note:

(1) Additional GI and HLSS are considered to be ongoing programs that will continue to be implemented system-wide outside of the LTCP program.

While these alternatives provide relatively high levels of CSO control, the significant challenges to implementation include:

- Very high implementation cost
- Limited siting availability for shafts, dewatering pumping station, dewatering flow treatment facility
- Long implementation period
- Significant and prolonged construction impacts (truck traffic, noise, dust) for surface consolidation sewers due to the large number of drop shafts necessary to divert CSO to the tunnel
- Negligible improvement in the annual attainment of applicable water quality standards
- Construction impacts and likelihood of utility conflicts for near-surface diversion structures and connecting conduits

Despite these challenges, these alternatives were retained in order to provide an assessment of a range of levels of CSO control for the Hudson River, in accordance with the CSO Control Policy and the Clean Water Act guidance.

8.4.c Summary of Retained Alternatives for Hudson River

The goal of the previous evaluations was to develop a list of retained control measures for the Hudson River. These control measures, whether individually or in combination, form the basis of basin-wide alternatives to be assessed using more rigorous cost-performance and cost-attainment analyses. Table 8.4-8 lists all of the control measures originally identified in the "Alternatives Toolbox" shown above in Table 8.4-9, and identifies whether the control measure was retained for further analysis. The reasons for excluding the non-retained control measures from further consideration are also noted in the table.

As shown, the retained control measures include system optimization measures, tunnel storage (with high-rate clarification for dewatering flows), and programmatic floatables control.

8.4.d CSO Volume and Loading Reductions for Retained Alternatives for Hudson River

Table 8.4-10 summarizes the projected performance of the retained Hudson River alternatives in terms of annual CSO volume and fecal coliform load reduction, based on the 2008 Typical Year. These data are plotted on Figure 8.4-10. In all cases, the predicted reductions shown are relative to the Baseline Conditions using 2008 JFK rainfall as described in Section 6. The baseline assumptions were described in detail in Section 6 and include the implementation of the grey infrastructure projects from the approved WWFPs, the Recommended Plans from the previously-submitted LTCPs, and the projected level of GI identified in Section 5.

Table 8.4-10. Hudson River Retained Alternatives Performance Summary (2008)

Alternative	Annual Performance Based on 2008 Typical Year				
	Remaining CSO Volume (MGY) (1)	Frequency of Overflow (2)	Additional CSO Volume to Other Waterbodies (MGY) (3)	Net CSO Volume Reduction (%)	Net Fecal Coliform Reduction (%)
Baseline Conditions	833	54	-	-	-
HUD-1. Optimization of Regulators Associated with Outfalls NR-022, 023, 026, 027, 031, 032, 035, 038, 040	821	54	3	1	1
HUD-2. Optimization of Regulators Associated with Outfalls NR-038, 040 and 046	823	54	3	1	1
HUD-3. Tunnel Storage for 25% CSO Control (14 MG Capacity)	624	54	0	25	25
HUD-4. Tunnel Storage for 50% CSO Control (79 MG Capacity)	395	54	0	53	53
HUD-5. Tunnel Storage for 75% CSO Control (114 MG Capacity)	220	54	0	74	74
HUD-6. Tunnel Storage for 100% CSO Control (142 MG Capacity)	0	0	0	100	100

Notes:

(1) Remaining CSO includes all discharges to the Hudson River from the Newtown Creek, North River, and Wards Island WRRF Collection Systems.
(2) Frequency of overflow is based upon the most frequently active CSO outfall.
(3) Additional CSO volume to other waterbodies accounts for increases at other CSO outfalls in response to the implementation of a CSO control alternative. Net CSO volume reduction and net fecal coliform reduction account for any additional CSO discharge to other waterbodies.

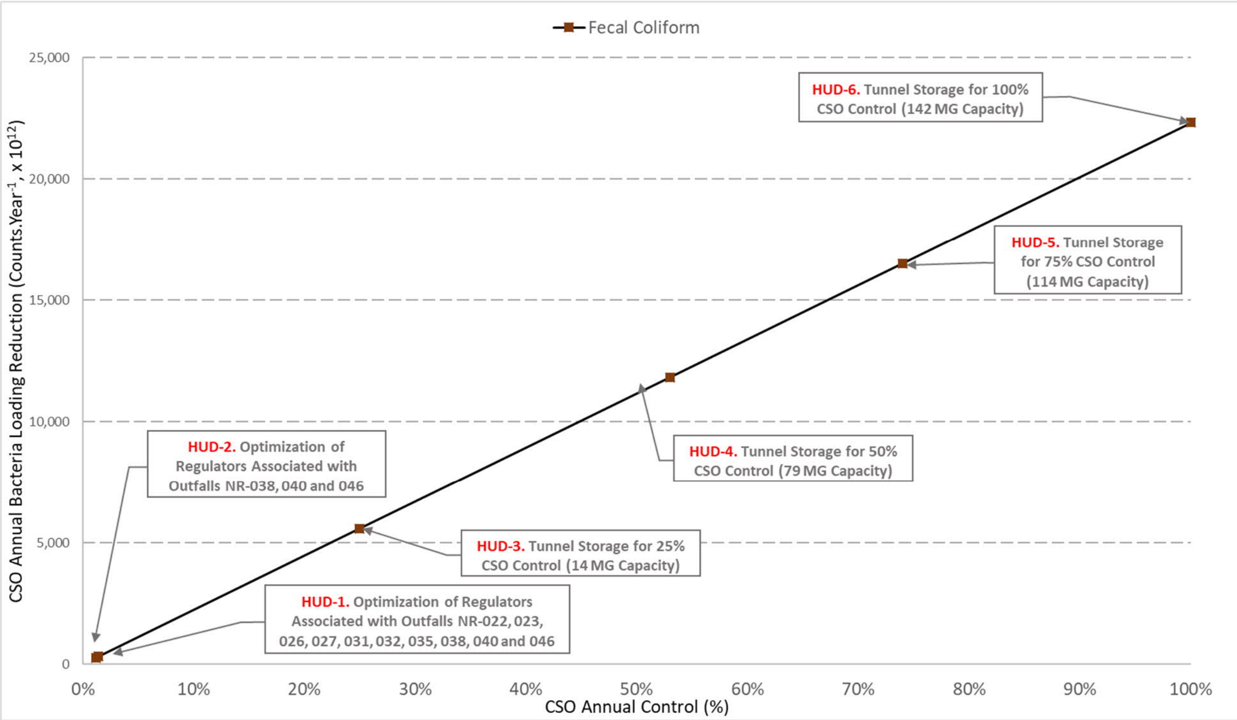


Figure 8.4-10. Untreated CSO Volume Reductions (as Percent CSO Annual Control) vs. Annual CSO Bacteria Loading Reduction (2008 Typical Year)

Because the retained alternatives for the Hudson River provide volume reduction and not treatment, the predicted bacteria loading reductions of the alternatives are very closely aligned with their projected CSO volume reductions.

8.4.e Cost Estimates for Hudson River Retained Alternatives

Evaluation of the retained alternatives requires cost estimation. The methodology for developing these costs is dependent upon the type of technology and its operation and maintenance (O&M) requirements. The construction costs were developed as Probable Bid Cost (PBC) and the total Net Present Worth (NPW) costs were determined by adding the estimated PBC to the NPW of the projected annual O&M costs at an assumed interest rate of 3 percent over a 100-year life cycle. Design, construction management, and land acquisition costs are not included in the cost estimates. All costs are in 2019 dollars and are considered Level 5 cost estimates by AACE International with an accuracy of -50 percent to +100 percent.

8.4.e.1 Alternative HUD-1. Optimization of Outfalls NR-022, NR-023, NR-026, NR-027, NR-031, NR-032, NR-035, NR-038, NR-040, NR-046.

Costs for Alternative HUD-1 include planning-level estimates of the costs to modify regulators associated with Outfalls NR-022, NR-023, NR-026, NR-027, NR-031, NR-032, NR-035, NR-038, NR-040, and NR-046 and reflect the description provided in Section 8.4.a. Site acquisition costs are not included. As this alternative is limited to modifications to regulator orifices and branch interceptor replacement, there is no impact to existing operation and maintenance costs. The total cost, expressed as NPW, for Alternative HUD-1 is $20M as shown in Table 8.4-11.

Table 8.4-11. Estimated Costs for Alternative HUD-1

Item	2019 Cost ($ Million)
Probable Bid Cost	$19
Annual O&M Cost	$0
Net Present Worth	$19

8.4.e.2 Alternative HUD-2. Optimization of Outfalls NR-038, NR-040, and NR-046.

Costs for Alternative HUD-2 include planning-level estimates of the costs to modify regulators associated with Outfalls NR-038, NR-040, and NR-046 and reflect the description provided in Section 8.4.a. Site acquisition costs are not included. As this alternative consists of modifications to the orifices in three existing regulators, there is no impact to existing operation and maintenance costs. The total cost, expressed as NPW, for Alternative HUD-2 is $3M as shown in Table 8.4-12.

Table 8.4-12. Estimated Costs for Alternative HUD-2

Item	2019 Cost ($ Million)
Probable Bid Cost	$3
Annual O&M Cost	$0
Net Present Worth	$3

8.4.e.3 Alternative HUD-3. Tunnel Storage for 25 Percent CSO Control

Costs for Alternative HUD-3 include planning-level estimates of the costs for a CSO storage tunnel sized for 25 percent CSO control. A description of the optimization components is provided in Section 8.4.b and illustrated in Table 8.4-9. Site acquisition costs are not included. The total cost, expressed as NPW, for Alternative HAR-3 is $700M as shown in Table 8.4-13.

Table 8.4-13. Estimated Costs for Alternative HUD-3

Item	2019 Cost ($ Million)
Probable Bid Cost	$600
Annual O&M Cost	$5
Net Present Worth	$700

8.4.e.4 Alternative HUD-4. Tunnel Storage for 50 Percent CSO Control

Costs for Alternative HUD-4 include planning-level estimates of the costs for a CSO storage tunnel sized for 50 percent CSO control. A description of the optimization components is provided in Section 8.4.b and illustrated in Table 8.4-9. Site acquisition costs are not included. The total cost, expressed as NPW, for Alternative HAR-3 is $1,700M as shown in Table 8.4-14.

Table 8.4-14. Estimated Costs for Alternative HUD-4

Item	2019 Cost ($ Million)
Probable Bid Cost	$1,500
Annual O&M Cost	$7
Net Present Worth	$1,700

8.4.e.5 Alternative HUD-5. Tunnel Storage for 75 Percent CSO Control

Costs for Alternative HUD-5 include planning-level estimates of the costs for a CSO storage tunnel sized for 75 percent CSO control. A description of the optimization components is provided in Section 8.4.b and illustrated in Table 8.4-9. Site acquisition costs are not included. The total cost, expressed as NPW, for Alternative HUD-4 is $3,200M as shown in Table 8.4-15.

Table 8.4-15. Estimated Costs for Alternative HUD-5

Item	2019 Cost ($ Million)
Probable Bid Cost	$2,900
Annual O&M Cost	$8
Net Present Worth	$3,200

8.4.e.6 Alternative HUD-6. Tunnel Storage for 100 Percent CSO Control.

Costs for Alternative HUD-6 include planning-level estimates of the costs for a CSO storage tunnel sized for 100 percent CSO control. A description of the optimization components is provided in Section 8.4.b and illustrated in Table 8.4-9. Site acquisition costs are not included. The total cost, expressed as NPW, for Alternative HUD-5 is $5,000M as shown in Table 8.4-16.

Table 8.4-16. Estimated Costs for Alternative HUD-6

Item	2019 Cost ($ Million)
Probable Bid Cost	$5,200
Annual O&M Cost	$9
Net Present Worth	$5,500

The cost estimates of these retained alternatives are summarized below in Table 8.4-17 and are then used in the development of the cost-performance and cost-attainment plots presented in Section 8.4.f.

Table 8.4-17. Estimated Cost of Retained Alternatives for Hudson River

Alternative	PBC(1) ($ Million)	Annual O&M Cost ($ Million/Year)	Total Net Present Worth(2) ($ Million)
HUD-1. Optimization of Regulators Associated with Outfalls NR-022, 023, 026, 027, 031, 032, 035, 038, 040 and 046	$19	$0	$19
HUD-2. Optimization of Regulators Associated with Outfalls NR-038, 040 and 046	$3	$0	$3
HUD-3. Tunnel Storage for 25% CSO Control (14 MG Capacity)	$600	$5	$700
HUD-4. Tunnel Storage for 50% CSO Control (79 MG Capacity)	$1,500	$7	$1,700
HUD-5. Tunnel Storage for 75% CSO Control (114 MG Capacity)	$2,200	$8	$3,200
HUD-6. Tunnel Storage for 100% CSO Control (142 MG Capacity)	$5,200	$9	$5,500

Notes:
(1) The Probable Bid Cost (PBC) for the construction contract based upon 2019 dollars.
(2) The Net Present Worth (NPW) is based upon a 100-year service life for tunnels and is calculated by multiplying the annual O&M cost by a present worth of 31.599 and adding this value to the PBC.

8.4.f Cost-Benefit Curves for Retained Alternatives

The final step of the analysis is to evaluate the cost-effectiveness of the basin-wide retained alternatives based on their NPW and projected impact on CSO loadings and attainment of applicable WQS. Section 8.4.f.1 below presents plots of cost versus CSO volume and bacteria load reduction (Cost-Performance Curves), and Section 8.4.g below presents plots of cost versus percent attainment with WQS for selected points along the Hudson River (Cost-Attainment Curves).

8.4.f.1 Cost-Performance Curves

Cost-performance curves were developed by plotting the costs of the retained alternatives against their predicted level of CSO control, both in terms of CSO volume reduction, and in bacteria load reduction. In each case, a best-fit cost curve was developed based on those alternatives judged most cost-effective for a defined level of CSO control as estimated by IW modeling for the typical year rainfall (2008).

Figure 8.4-11 presents a plot of CSO volume reduction versus NPW for the retained alternatives, while Figure 8.4-12 plots the cost of the alternatives against fecal coliform loading reductions.

8.4.g Cost-Attainment Curves

This section evaluates the relationship of the costs of the retained alternatives versus their expected level of attainment of bacteria Primary Contact WQ Criteria as modeled using the LTCPRM water quality model for the 2008 Typical Year simulation. As indicated in Section 6, based on the 10-year WQ simulations for the Harlem River, the Existing WQ Criteria (Class I) for fecal coliform are met 100 percent of the time under Baseline Conditions. As a result, implementation of any of the retained alternatives described above, including the 100 percent CSO capture tunnel, results in no improvement in the percent attainment of Existing WQ Criteria (Class I) for fecal coliform. Cost-attainment plots are presented below for two locations along the Hudson River: LTCP sampling Station HD-2, located in the northern half of the River (Figure 8.4-13), and LTCP sampling Station HD-7, located in the southern half of the River (Figure 8.4-14). The locations of these stations are shown in Figure 8.4-18 below. The plots show NPW versus percent attainment with the Existing WQ Criteria (Class I) for fecal coliform on both an annual and recreational season (May 1st through October 31st) basis. As indicated in the figures, attainment is 100 percent for all of the alternatives. Cost-attainment plots for any other WQ modeling cell along the Hudson River would look similar to Figure 8.4-14 and Figure 8.4-15.

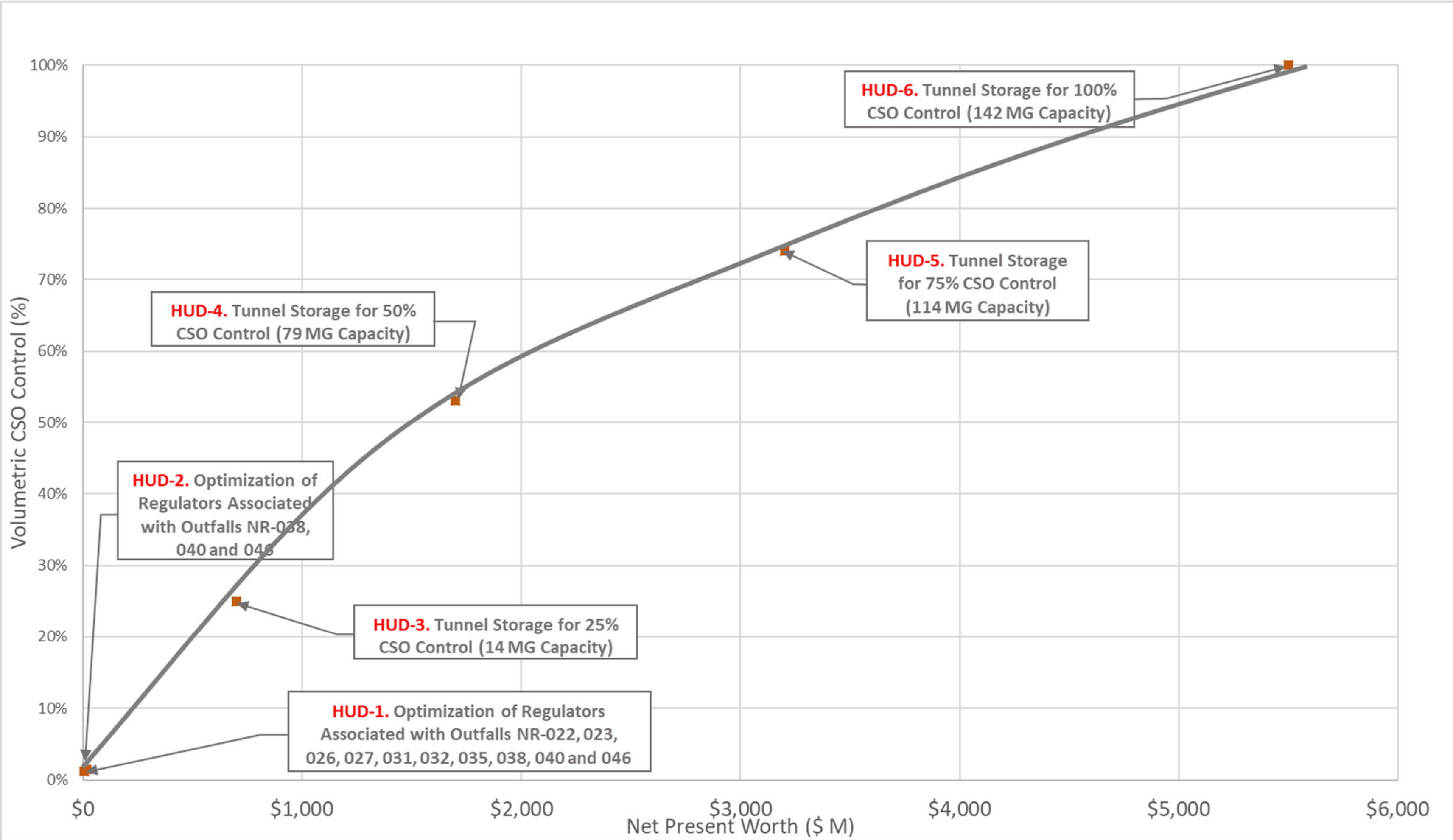


Figure 8.4-11. Cost vs. CSO Control (2008 Typical Year) for Hudson River

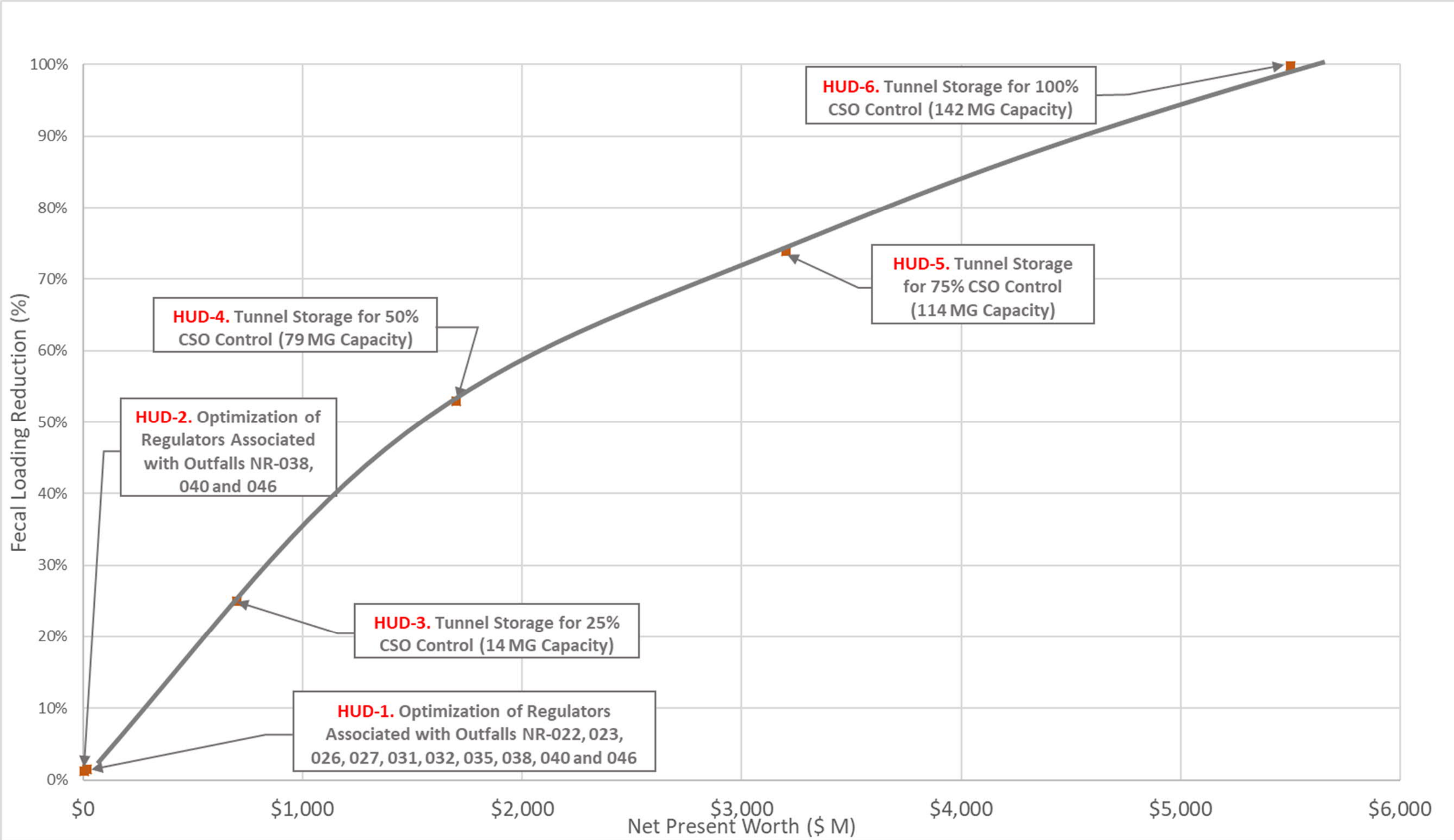


Figure 8.4-12. Cost vs. Fecal Coliform Loading Reduction (2008 Typical Year) for Hudson River

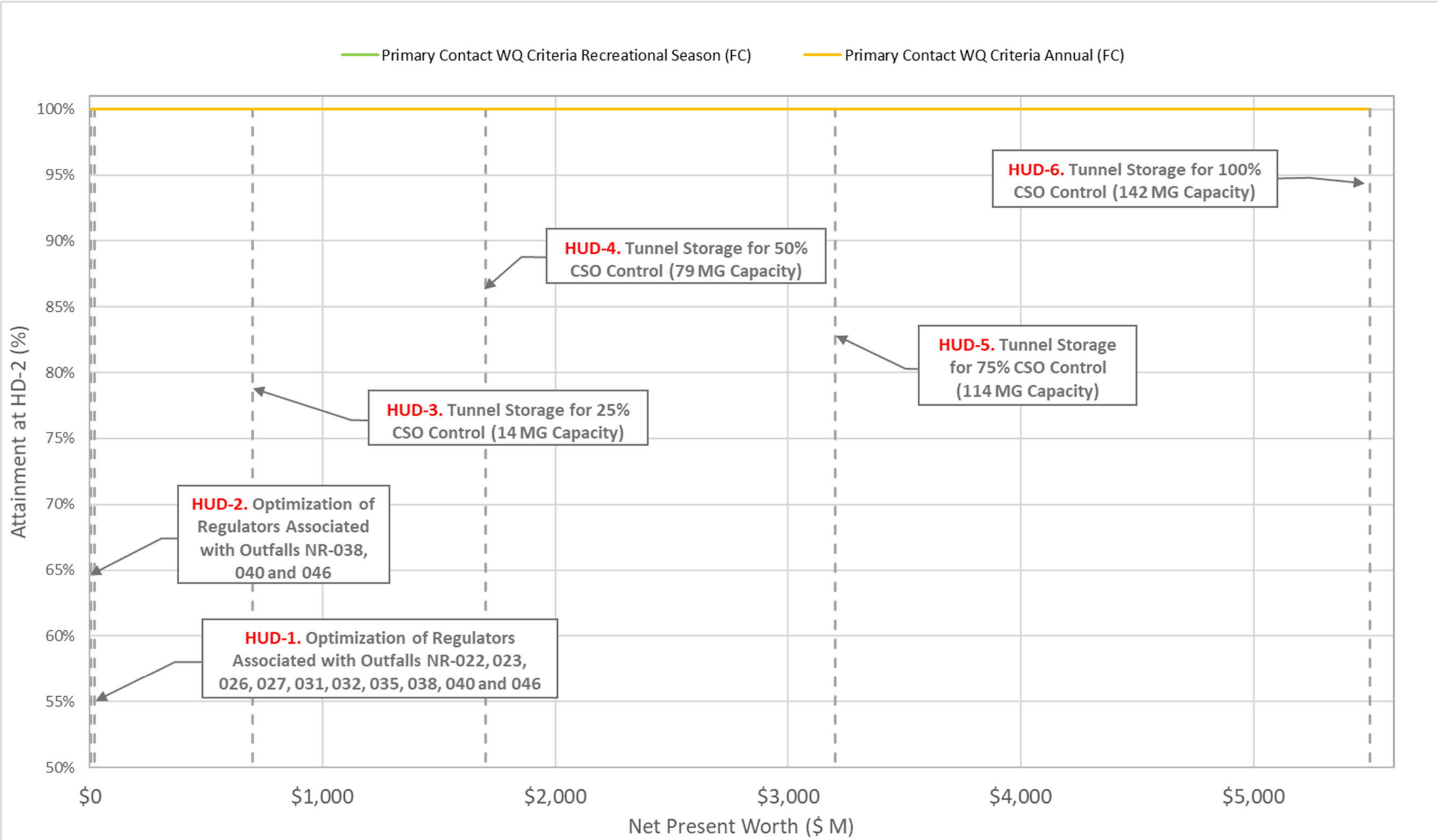


Figure 8.4-13. Cost vs. Bacteria Attainment at Station HD-2

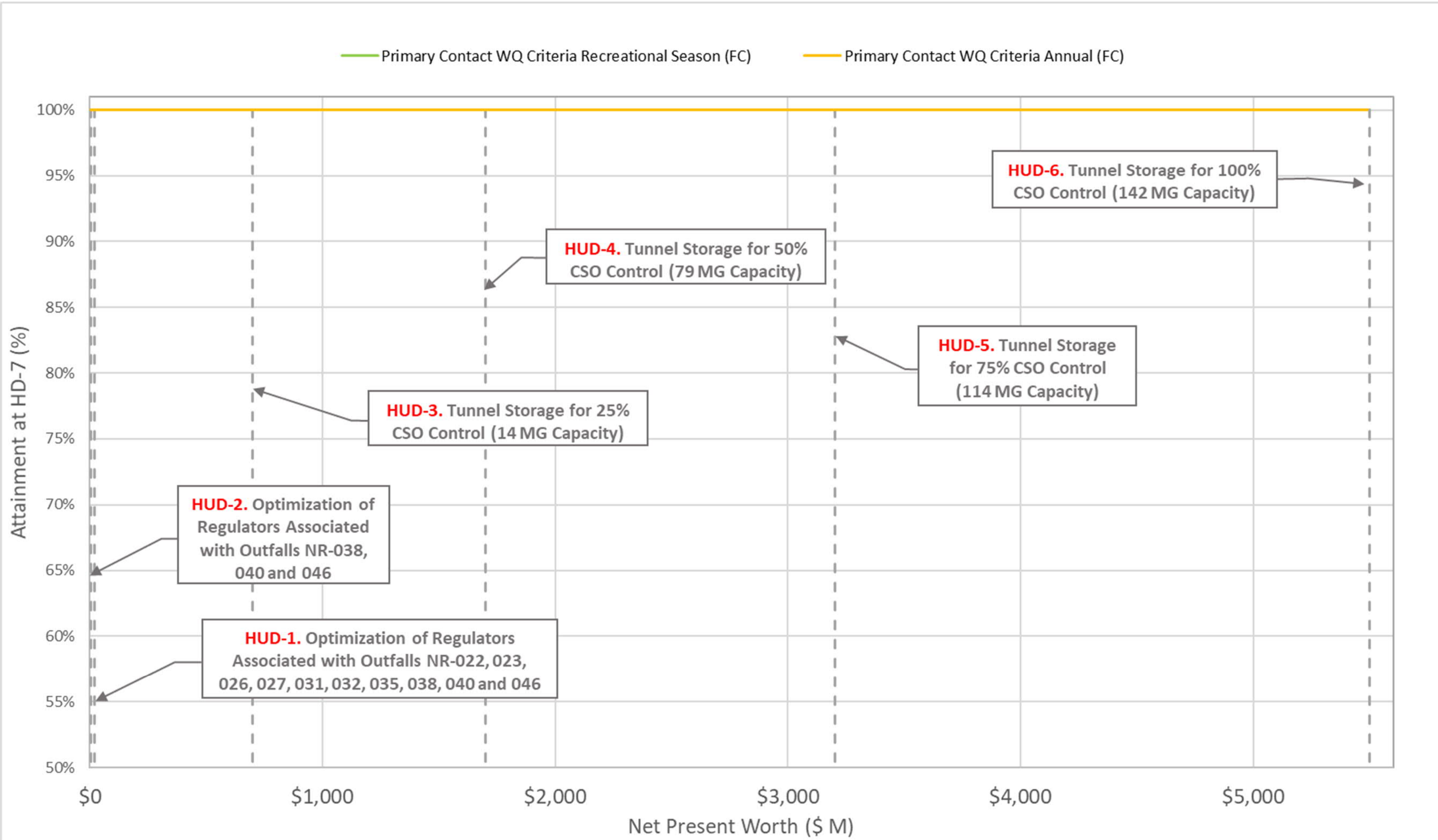


Figure 8.4-14. Cost vs. Bacteria Attainment at Station HD-7

8.4.h Conclusion on Preferred Alternative

The selection of the preferred alternative for the Hudson River is based on multiple considerations including public input, environmental and water quality benefits, and projected costs. A traditional knee-of-the-curve (KOTC) analysis is presented above. However, as described above and in Section 6, the Hudson River attains applicable water quality standards for fecal coliform and dissolved oxygen greater than 95 percent of the time under Baseline Conditions. The CSO storage tunnel alternatives would provide a range of levels of CSO reduction to the Hudson River, but the costs associated with those alternatives are very high, and those high-cost alternatives would not change the level of attainment of WQ criteria. Section 9 presents affordability issues and impacts on disadvantaged communities that would come into play if the CSO program costs were to further significantly increase. For these reasons, the CSO storage tunnel alternatives are not recommended.

Of the two optimization alternatives carried forward in the evaluation, HUD-2 was the more cost-effective based on CSO volume control, with a net CSO volume reduction of 7 MGY during the typical year and a PBC of $3M This cost does not include costs for land acquisition, design, and construction management. As this alternative consists of increasing the regulator orifice opening and involves no mechanical equipment, no additional operation and maintenance costs are associated with this alternative. Although Alternative HUD-1 had a slightly higher net CSO volume reduction (9 MGY), the PBC for HUD-1 was more than six times higher than the PBC for HUD-2. Therefore, HUD-2 was selected as the preferred alternative for inclusion in the Recommended Plan. While this project provides a relatively nominal reduction in CSO discharge, the project is consistent with DEP BMP practices for maximizing flow to the WRRF.

In summary, the following conclusions can be drawn from these analyses:

1. Under Baseline Conditions, fecal coliform standards attainment is projected to be 98 percent or greater at all Hudson River Stations annually and during the recreational season (May 31st through October 31st), while DO attainment is greater than 97 percent at all stations.
2. The most cost-effective alternative, based on the KOTC analysis approach, consistent with EPA's CSO Control Policy is Alternative HUD-2 which cost-effectively reduces CSO discharges with no impact to current collection system operation and maintenance practices.
3. The PCM will document the WQ improvements upon implementation of these projects.
4. While the annual volume of CSO remaining in the Hudson River is acknowledged to remain relatively high, the time to recovery analysis presented further below demonstrates that the duration of impact of the remaining CSOs is low.

Figure 8.4-15 presents a mosaic of the level of attainment with the Existing WQ Criteria for bacteria in the Hudson River on an annual basis, and Figure 8.4-16 presents the level of attainment for the recreational season (May 1st through October 31st). Figure 8.4-17 presents the level of attainment with the Existing WQ Criteria for DO on an average annual basis.

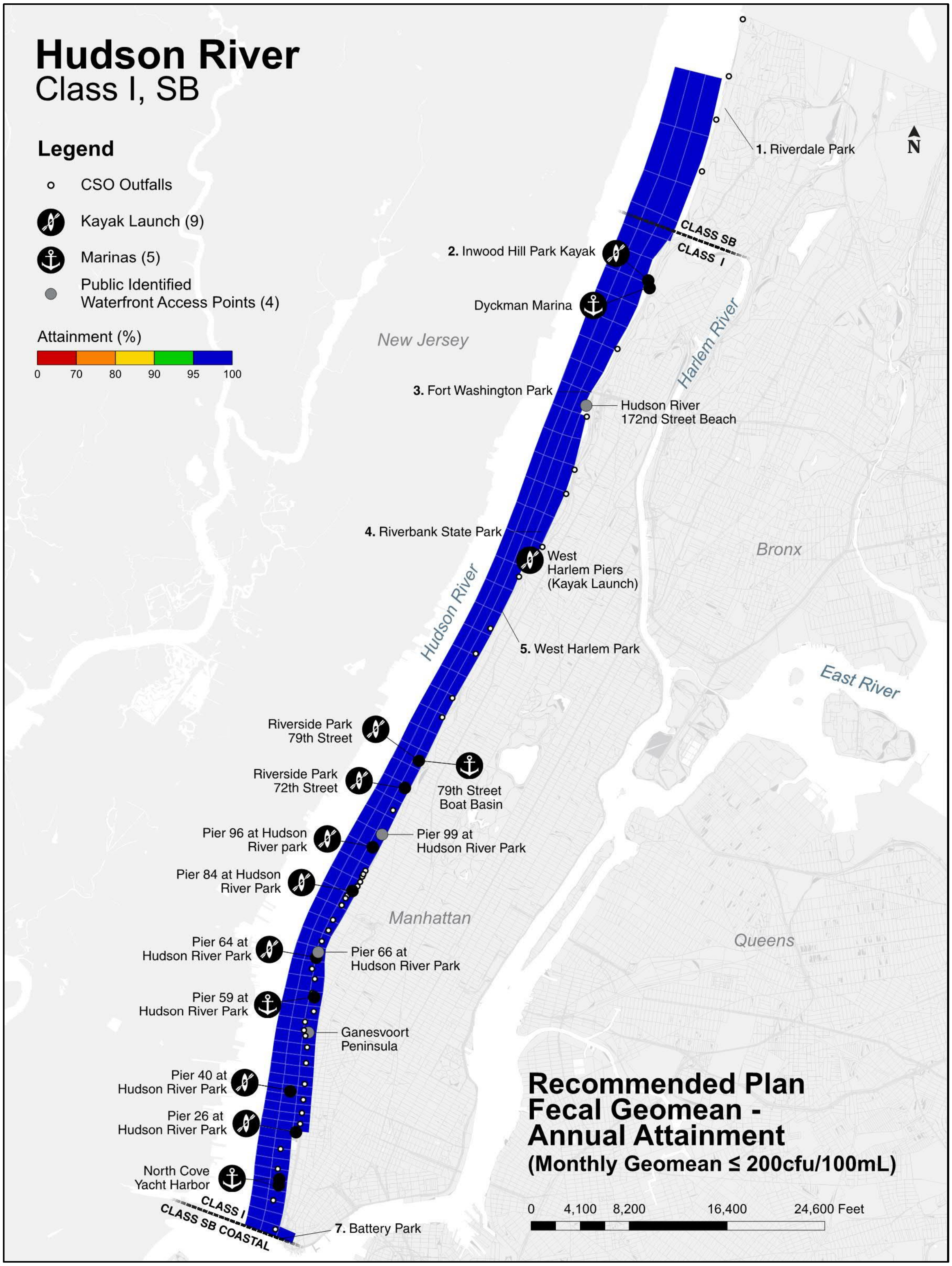


Figure 8.4-15. Hudson River Fecal Coliform – Recommended Plan Annual Attainment (10-year Runs)

Figure 8.4-16. Hudson River Fecal Coliform – Recommended Plan Recreational Season Attainment (10-year Runs)

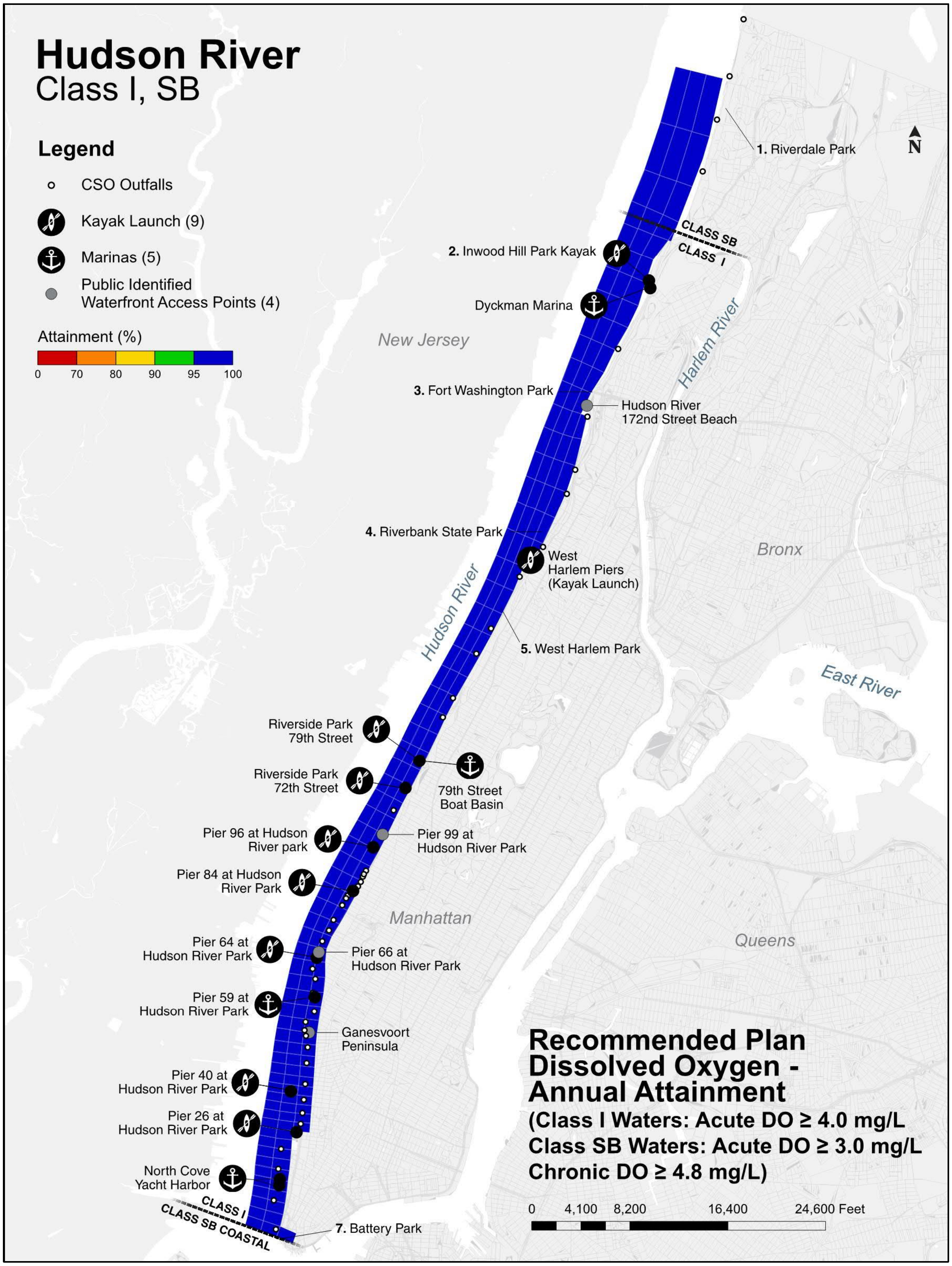


Figure 8.4-17. Hudson River Dissolved Oxygen – Recommended Plan Annual Attainment (2008 Typical Year)

Table 8.4-18 presents the fecal coliform maximum monthly geometric mean, and the percent of time that the fecal coliform monthly GM criterion of 200 cfu/100mL would be attained on an annual basis and for the recreational season (May 1st through October 31st), for the 10-year simulation period, with the Recommended Plan. The locations of the stations and supplemental model output locations listed in Table 8.4-18 are shown on Figure 8.4-18.

Table 8.4-18. Model Calculated 10-Year Fecal Coliform Maximum Monthly GM and Percent Attainment of Existing WQ Criteria for Hudson River Recommended Plan

Recommended Plan: HUD-2 Optimization of Regulators Associated with Outfalls NR-038, 040 and 046				
Station	**Maximum Monthly Fecal Coliform GMs (cfu/100mL)**		**10 Year % Attainment**	
	Annual	**Recreational Season(1)**	**Annual Monthly GM <200 cfu/100mL**	**Recreational Season(1) Monthly GM <200 cfu/100mL**
Hudson River (North of Harlem River) – Class SB				
HD-1	125	86	100%	100%
Riverdale Park	87	51	100%	100%
Hudson River (Harlem River to Battery) – Class I				
HD-2	157	96	100%	100%
HD-3	187	95	100%	100%
HD-4	194	98	100%	100%
HD-5	190	99	100%	100%
HD-6	201	96	99%	100%
HD-7	200	101	100%	100%
HD-8	189	102	100%	100%
HD-9	202	125	99%	100%
HD-10	181	98	100%	100%
Inwood Hill Park/Dyckman Marina	135	94	100%	100%
West Harlem Piers	187	94	100%	100%
Riverside Park 79th Street/79th Street Boat Basin	201	95	99%	100%
Riverside Park 72nd Street	201	94	99%	100%

Table 8.4-18. Model Calculated 10-Year Fecal Coliform Maximum Monthly GM and Percent Attainment of Existing WQ Criteria for Hudson River Recommended Plan

Recommended Plan: HUD-2 Optimization of Regulators Associated with Outfalls NR-038, 040 and 046				
Station	Maximum Monthly Fecal Coliform GMs (cfu/100mL)		10 Year % Attainment	
	Annual	Recreational Season(1)	Annual Monthly GM <200 cfu/100mL	Recreational Season(1) Monthly GM <200 cfu/100mL
Pier 96 at Hudson River Park	200	96	100%	100%
Pier 84 at Hudson River Park	198	99	100%	100%
Pier 64 at Hudson River Park	193	103	100%	100%
Pier 59 at Hudson River Park	190	101	100%	100%
Pier 40 at Hudson River Park	199	119	100%	100%
Pier 26 at Hudson River Park	195	115	100%	100%
North Cove Yacht Harbor	182	100	100%	100%

Note:
(1) Recreational Season is May 1st through October 31st.

The average annual attainment of the Existing WQ Criteria for DO (Class SB and I) for the entire water column is presented at LTCP sampling stations for the Recommended Plan in Table 8.4-19. As indicated in Table 8.4-19, the Existing WQ Criterion for DO (Class I) are predicted to be attained at all stations for the preferred alternative. DO attainment in the Class I portion of the Hudson River ranges from 96.9 to 99.9 percent for the preferred alternative.

As discussed in Section 6, analysis of attainment of Class SB DO criteria are complex because the standard allows for excursions from the daily average limit of 4.8 mg/L for a limited number of consecutive calendar days. To simplify the analysis, attainment was based solely upon attainment of the daily average without the allowed excursions. The results indicate 97.4 percent attainment of the acute criterion (never less than 3.0 mg/L) for the Recommended Plan. Attainment of the chronic criterion (greater than or equal to 4.8 mg/L) is 98.6 percent for the Recommended Plan.

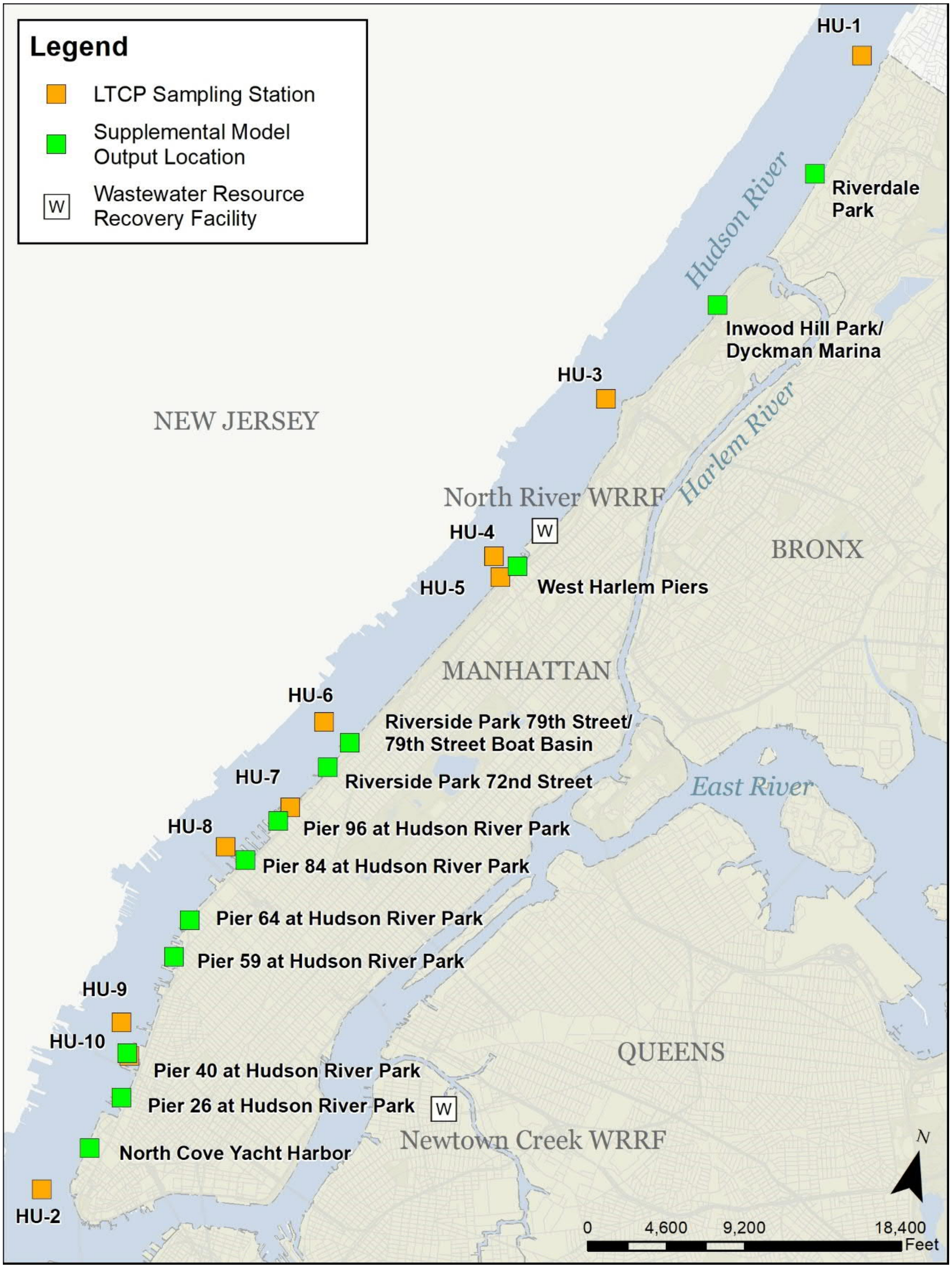


Figure 8.4-18. Sampling Stations and Supplemental Model Output Locations on the Hudson River

Table 8.4-19. Model Calculated (2008) DO Percent Attainment of Existing Class SB and I WQ Criteria for Hudson River, Recommended Plan

Recommended Plan: HUD-2 Optimization of Regulators Associated with Outfalls NR-038, 040 and 046		
Hudson River (North of Harlem River) - Class SB		
Station	**Acute (≥ 3.0 mg/L)**	**Chronic (≥ 4.8 mg/L)**
HD-1	100%	95%
Hudson River (Harlem River to Battery) – Class I		
Station	**Instantaneous (≥ 4.0 mg/L)**	
HD-2	100%	
HD-3	100%	
HD-4	100%	
HD-5	100%	
HD-6	100%	
HD-7	100%	
HD-8	100%	
HD-9	100%	
HD-10	100%	

The key components of the Recommended Plan include enlargement of regulator orifice openings at Regulators NR-26A, 28, and 29A associated with Outfalls NR-040, 038, and 046, respectively. The implementation of these elements is predicted to result in a net reduction of 7 MGY of CSO to the Hudson River, with a PBC of $3M. The proposed schedule for the implementation of the Recommended Plan is presented in Section 9.2.

8.4.i Use Attainability Analysis

The CSO Order requires that a UAA be included in an LTCP "where existing WQS do not meet the Section 101(a)(2) goals of the CWA, or where the proposed alternative set forth in the LTCP will not achieve existing WQS or the Section 101(a)(2) goals." The UAA shall "examine whether applicable waterbody classifications, criteria, or standards should be adjusted by the State." The UAA process specifies that States can remove a designated use that is not an existing use if the scientific assessment can demonstrate that attaining the designated use is not feasible for at least one of six reasons:

1. Naturally occurring loading concentrations prevent the attainment of the use; or

2. Natural, ephemeral, intermittent or low flow conditions or water levels prevent the attainment of the use, unless these conditions may be compensated for by the discharge of sufficient volume of effluent discharges without violating State water conservation requirements to enable uses to be met; or
3. Human caused conditions or sources of pollution prevent the attainment of the use and cannot be remedied or would cause more environmental damage to correct than to leave in place; or
4. Dams, diversions, or other types of hydrologic modifications preclude the attainment of the use, and it is not feasible to restore the waterbody to its original condition or to operate such modification in a way that would result in the attainment of the use; or
5. Physical conditions related to the natural features of the waterbody, such as the lack of a proper substrate, cover, flow, depth, pools, riffles, and the like, unrelated to water quality, preclude attainment of aquatic life protection uses; or
6. Controls more stringent than those required by Sections 301(b) and 306 of the Act would result in substantial and widespread economic and social impact.

As part of the LTCP, elements of a UAA, including the six conditions presented above, will be used to determine if changes to the designated use are warranted, considering a potential adjustment to the designated use classification as appropriate.

As noted in previous sections, with the implementation of the Recommended Plan, the Hudson River is predicted to meet the Existing WQ fecal coliform bacteria criterion of 200 cfu/100mL on both an annual and recreational season (May 1st through October 31st) basis for both the 2008 Typical Year rainfall and the 10-year continuous simulation. Class SB and I DO criteria are also predicted to be achieved for the Recommended Plan. Therefore, a Use Attainability Analysis is not needed for the Hudson River.

8.4.j Time to Recovery

As noted above, the Hudson River south of the Harlem River is a Class I waterbody, with best uses identified as secondary contact recreation and fishing, and the applicable Water Quality Criteria for fecal coliform bacteria are based on a monthly geometric mean. However, to gain insight into the shorter-term impacts of wet-weather sources of bacteria, DEP has performed an analysis to assess the amount of time following the end of a rainfall event required for the Hudson River to recover and return to fecal coliform concentrations less than 1,000 cfu/100mL.

The analyses consisted of examining the WQ model-calculated bacteria concentrations in the Hudson River for recreational periods (May 1st through October 31st) abstracted from 10 years of model simulations. For the Hudson River, the JFK Airport rainfall data was compared against water quality model bacteria results for the 10 recreational seasons to determine how long it took for the water column concentration to return to target threshold concentrations from the end of the rain event. The chosen target threshold concentration was 1,000 cfu/100mL for fecal coliform. The various rainfall events were then placed into rain event size “bins” ranging from less than 0.1 inch to greater than 1.5 inches. Only rain events that reached the target threshold concentrations before the beginning of the next storm were included. The median time to recovery for each bin at each water quality station was calculated.

Table 8.4-20 presents the median time to recovery for the Recommended Plan for the Hudson River, for the storms in the greater than 1.0 to 1.5 inch rainfall bin, which includes the 90th percentile event. In other words, this rainfall bin covers approximately 90 percent of the rain events that would occur in an average year. Values are presented at the LTCP sampling stations, and the waterbody access locations.

DEC has advised that it seeks to have a time to recovery of less than 24 hours, and this target has been consistent in the previously approved LTCPs. As indicated in Table 8.4-20, under the Recommended Plan, none of the locations assessed had a median time to recovery greater than 2 hours, and most locations had median times to recovery of 0 hours, indicating a quick recovery following greater than 90 percent of the storms.

Table 8.4-20. Hudson River Time to Recovery, Fecal Coliform, Recommended Plan

Location	Median Time to Recovery (hours) Fecal Coliform Threshold (1,000 cfu/100mL)[1]
HD-1	0[2]
HD-2	0
HD-3	0
HD-4	0
HD-5	0
HD-6	0
HD-7	0
HD-8	0
HD-9	2
HD-10	0
Riverdale Park	0
Inwood Hill Park/Dyckman Marina	0
West Harlem Piers	0
Riverside Park 79th Street/79th	0
Riverside Park 72nd Street	0
Pier 96 at Hudson River Park	0
Pier 84 at Hudson River Park	0
Pier 64 at Hudson River Park	0
Pier 59 at Hudson River Park	0
Pier 40 at Hudson River Park	0
Pier 26 at Hudson River Park	0
North Cove Yacht Harbor	0

Notes:

(1) Median time to recovery values presented for storms from the 10-year simulation, recreational seasons, in the size range of >1.0 to 1.5-inches of rainfall, which includes the 90th percentile rain event.

(2) Median time to recovery of "0" means that the average concentration across the water column never reached the 1,000 cfu/100mL threshold at the referenced station for more than half of the storms within the 1-to-1.5 inch rainfall bin assessed.

8.4.k Recommended LTCP Elements to Meet Water Quality Goals for Hudson River

The actions identified in this LTCP include:

- Enlargement of regulator orifice openings at Regulators NR-26A, 28, and 29A associated with Outfalls NR-040, 038, and 046, respectively.
- Costs (in 2019 dollars) for the recommended alternative are: NPW $3, PBC of $3M, and no annual O&M cost.
- Compliance with Primary Contact WQ Criteria on an annual basis for the 2008 Typical Year and based on a 10-year continuous simulation. As a result, a UAA is not required as part of this LTCP.
- DEP will establish with the DOHMH through public notification a wet-weather advisory during the recreational season (May 1st through October 31st), informing the public which recreational activities are not recommended in the Hudson River at that time. The LTCP includes a recovery time analysis that can be used to establish the duration of the wet-weather advisory for public notification.

DEP is committed to improving water quality in this waterbody, which will be advanced by the improvements and actions identified in this LTCP. These identified actions have been balanced with input from the public and awareness of the cost to the residents of NYC.

8.5 CSO Control Alternatives for East River/Long Island Sound

As shown in Section 6, WQS for bacteria and dissolved oxygen are met in the East River/Long Island Sound under Baseline Conditions. Therefore, attainment of WQS was not a factor in evaluating CSO control alternatives for the East River/Long Island Sound. Rather, the focus was on evaluating alternatives for cost-effective reduction of CSO activations and volume. The CSO control alternatives that passed the initial screening phase and were retained for the East River generally fell within the categories of system optimization and tunnel storage. System optimization alternatives covered the categories of fixed weirs, parallel interceptor/sewer, bending weirs or control gates, and gravity flow tipping to other watersheds. The storage tunnel alternatives, used to assess 25, 50, 75, and 100 percent CSO capture, also included high-rate clarification for the dewatering flows from the tunnels. Storage tanks were not evaluated due to the number of outfalls and the general lack of available sites of sufficient size for storage tanks. Each CSO control measure was initially evaluated on three of the key considerations described in Section 8.1: (1) benefits, as expressed by level of CSO control and WQS attainment; (2) costs; and (3) challenges, such as siting and operations. Using this methodology, the retained CSO control measures listed in Section 8.1 were evaluated on a cost-performance basis and used to develop the basin-wide alternatives.

The Citywide/Open Waters Baseline Conditions include implementation of the Recommended Plans from the LTCPs for the tributary waterbodies previously submitted to DEC under this program, as well as other grey infrastructure projects implemented as part of earlier planning programs. Those projects are summarized in Section 4.

The following sections present the evaluations of the system optimization and tunnel storage alternatives for the East River.

8.5.a System Optimization Alternatives

The approach to the initial identification and evaluation of system optimization alternatives for the East River using the Optimizer software was presented in Section 3. As described in Section 3, the Optimizer software was configured to prioritize monitored regulators discharging outside the period of critical wet--weather events, high-discharge frequency regulators, and regulators discharging in proximity to official and publicly-identified public access points (kayak launches/marinas).

The optimization alternatives for outfalls to the East River associated with the Tallman Island, Hunts Point, Bowery Bay, Wards Island, Newtown Creek and Red Hook WRRF collections systems were evaluated independently, as the six systems are hydraulically independent. However, each collection system also includes combined sewer outfalls discharging to the other waterbodies and thus, the East River optimization alternatives associated with each collection system need to be considered in conjunction with alternatives for those outfalls discharging to other tributary waterbodies. Table 8.5-1 summarizes the waterbodies impacted by WRRF effluent and CSO discharges from each of the respective collection systems.

The sections below present the evaluations of East River optimization alternatives associated with the Tallman Island, Hunts Point, Bowery Bay, Wards Island, Newtown Creek and Red Hook WRRF collection systems, respectively.

Table 8.5-1. Additional Waterbodies Receiving Discharges from East River WRRF Outfalls and Collection System CSO Outfalls

LTCP Open Waters and Tributary Waterbodies	WRRF & Associated Collection Systems					
	Tallman Island	Bowery Bay	Hunts Point	Wards Island	Red Hook	Newtown Creek
East River	✓	✓	✓	✓	✓	✓
Alley Creek	✓					
Flushing Creek	✓					
Flushing Bay		✓				
Hutchinson River			✓			
Westchester Creek			✓			
Bronx River			✓			
Harlem River/ Bronx Kill				✓		
Hudson River				✓		✓
Newtown Creek						✓
Gowanus Canal/Bay					✓	
New York Bay					✓	

8.5.a.1 System Optimization for East River Outfalls in the Tallman Island WRRF System

Table 8.5-2 summarizes the CSO outfalls and associated regulators tributary to the East River from the Tallman Island WRRF system that were the initial focus of the optimization evaluations. The locations of these outfalls/regulators are shown in Figure 8.5-1. Table 8.5-2 identifies the annual CSO volume and activation frequency under Baseline Conditions, and whether the outfall/regulator falls within one or more of the following categories:

- One of the 100 monitored regulators listed in the WRRF SPDES permits ("BMP Regulator")
- A "Key Regulator" as identified in the WRRF SPDES permits
- An outfall in proximity to a public access location (typically within 500 feet of an access location)
- Regulators that activated more than average for the waterbody

Table 8.5-2. East River CSO Outfalls/Regulators Associated with the Tallman Island WRRF

Outfall	Regulator	Baseline Conditions		BMP Regulator	Key Regulator	Outfall in Proximity to Public Access	Higher Frequency Regulator
		Annual CSO Volume (MG)	Annual CSO Activations				
TI-003	TI-10A	0	0	✓	✓		
	TI-10B	71.0	45				✓
TI-023	TI-13	259.6	45	✓		✓	✓

Findings/Observations from Optimizer Evaluations

The Optimizer evaluations served as an initial screening step to identify potentially promising optimization alternatives to be further evaluated using the full Tallman Island WRRF InfoWorks model. These evaluations included the assessment of the impacts to CSO volume, activation and peak hydraulic grade line elevations relative to Baseline Conditions, as well as other general system conditions. General collection system information and findings of the initial Optimizer evaluations included the following:

- The Tallman Island WRRF is located along the Powell Cove Boulevard immediately east of the College Point Yacht Club. The collection system primarily serves northern Queens and is bounded to the east by Little Neck Bay, to the south by Kissena Park to the west by Flushing Bay and north by the East River.
- The Tallman Island WRRF includes four principal interceptors: the Main Interceptor, the College Point Interceptor, the Flushing Interceptor, and the Whitestone Interceptor.
    - The Main Interceptor is a direct tributary to the Tallman Island WRRF and picks up flow from the College Point and Flushing interceptors.
    - The College Point Interceptor conveys flow from sewersheds along Flushing Bay to the west of the treatment plant, and discharges into the Powell's Cove Pumping Station, which discharges into the Main Interceptor within the WRRF premises.
    - The Flushing Interceptor is an extension of the Main Interceptor south of the Whitestone connection, and serves most of the areas to the south in the system. The Flushing Interceptor also receives flow from the southeast areas of the system, along the Kissena Corridor Interceptor (via trunk sewers upstream of the TI-R31 regulator), and from the Douglaston area. The Alley Creek sewershed drains to the Tallman Island WRRF via the Kissena Corridor Interceptor.
    - The Whitestone Interceptor conveys flow from the area east of the treatment plant along the East River. Until recently, the Whitestone Interceptor used to discharge to the Main Interceptor from the west side, just upstream of the College Point Interceptor connection, via gravity discharge. As proposed in the Flushing Creek WWFP, the Whitestone Interceptor was

extended and disconnected from the Flushing Interceptor. The new extension came on-line in mid-2014.

- The Tallman Island WRRF collection system is relatively shallow (<10 feet of cover) at the upstream ends of each interceptor, but ranges from 15 to 25 feet of cover as the interceptors approach the Tallman Island WRRF.
- Regulators contributing to CSO outfalls discharging to the East River generally activate between 16 to 45 times during the typical year with a total average annual overflow volume (AAOV) of 213 MGY.
- Freeboard for the 5-year design storm and many of the larger storms during the typical year is generally greater than 10 feet from the ground surface with the exception of the upstream end of the upstream end of the Kissena Corridor and Main Interceptor where freeboard is less than 10 feet from the ground surface.
- The Optimizer modeling identified alternatives that included modifications to two or three regulators resulting in varying degrees of improved capture and hydraulic performance. Upon performing InfoWorks runs for the 2008 typical year, limited reductions in AAOV (approximately 1-3%) and activation frequency (approximately 11-21%) were predicted for the better performing alternatives.
- The performance improvements were limited by hydraulic grade line sensitivities. While the interceptor has available storage capacity during smaller storms, the rise in grade line during the 5-year storm translates upstream during the 5-year design storm, affecting some of the shallower reaches of the interceptor beyond the level of acceptable risk.
- In addition, hydraulic balancing occurs, where CSO volume and activations increase at regulators/outfalls upstream or downstream of those regulators/outfalls where reductions were observed in response to the system optimization measures. Although the optimization alternatives produced a net reduction in CSO volume and activations for the typical rainfall year, the CSO volumes and activations increased to Outfalls TI-010 and TI-011, which are tributary to Flushing Creek. Although these outfalls are planned to be disinfected by facilities recommended in the approved Flushing Creek LTCP, it is not desirable to increase CSO discharges to Flushing Creek.

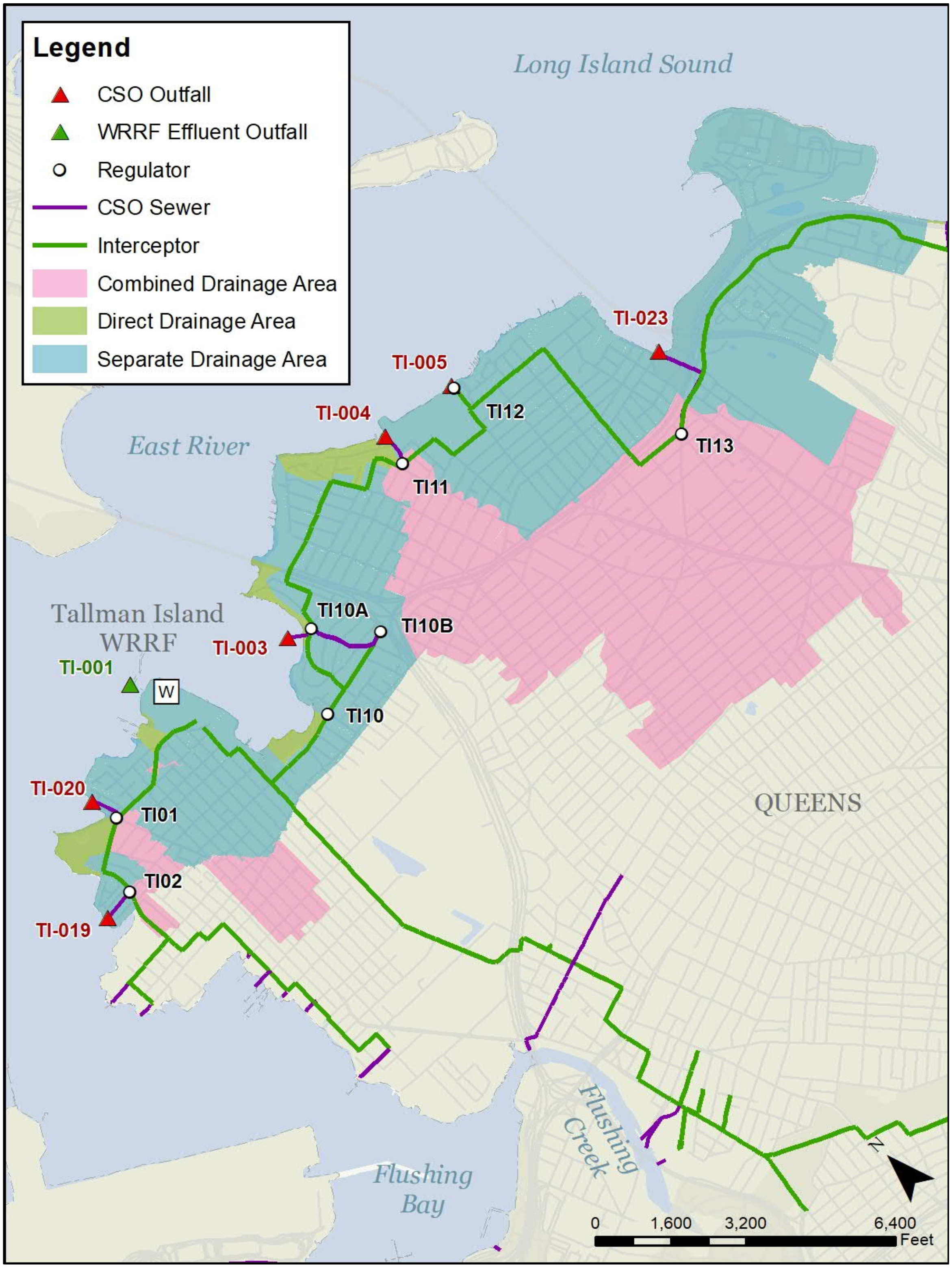
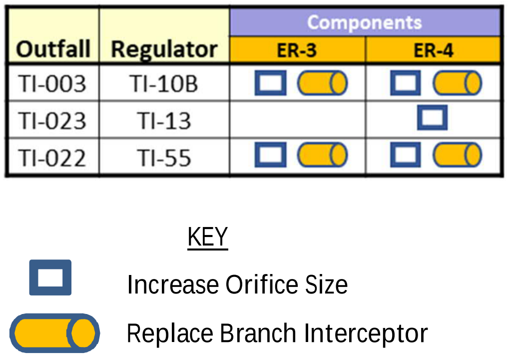


Figure 8.5-1. CSO Outfalls/Regulators Tributary to East River from the Tallman Island WRRF System

<u>Follow-up Evaluations Based on Full InfoWorks Model</u>

The most promising optimization alternatives coming out of the Optimizer evaluations are summarized in Table 8.5-3:

Table 8.5-3. Tallman Island Optimization Components for Retained Alternatives



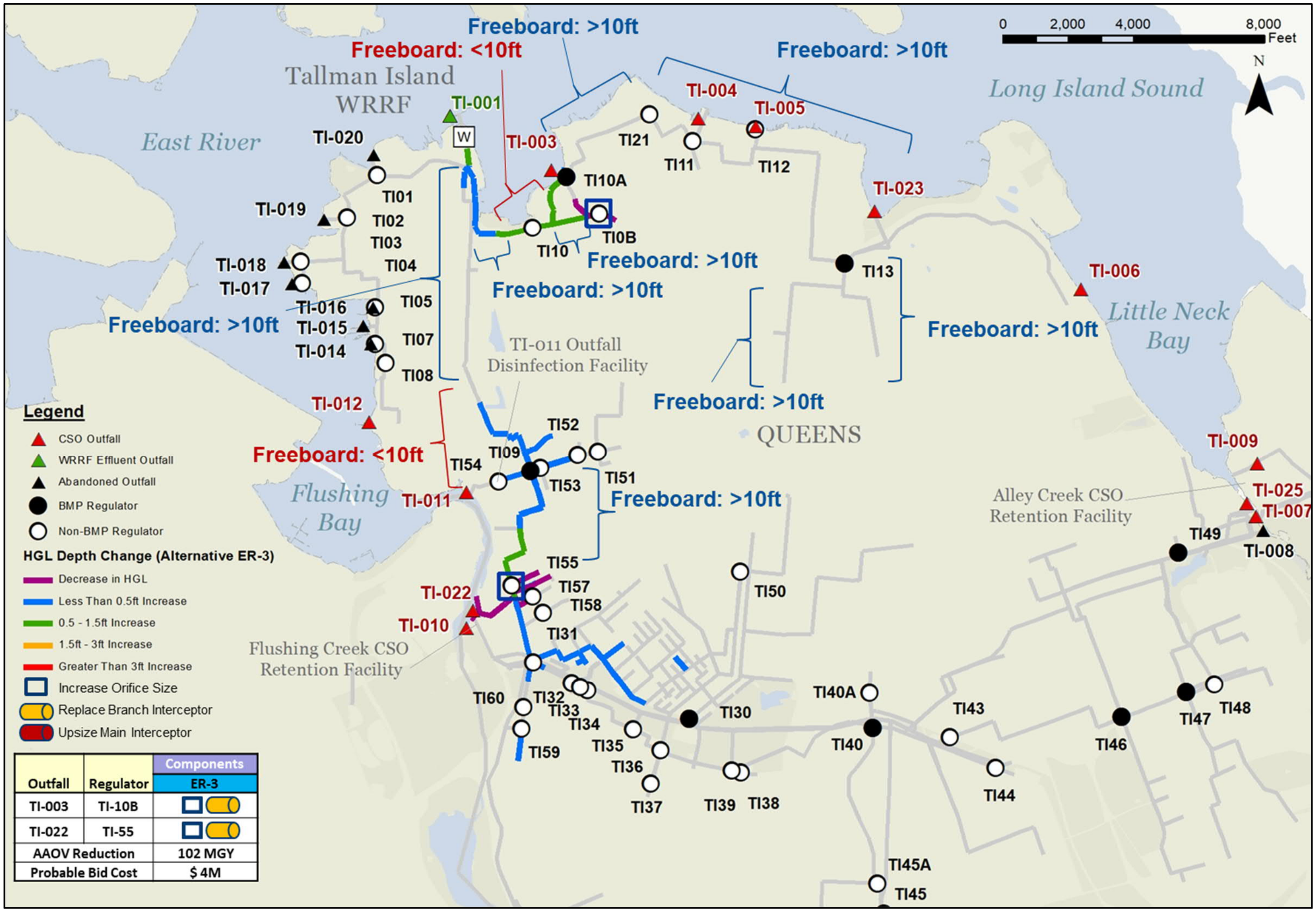
Outfall	Regulator	Components	
		ER-3	ER-4
TI-003	TI-10B		
TI-023	TI-13		
TI-022	TI-55		

KEY

Increase Orifice Size

Replace Branch Interceptor

These alternatives were further analyzed in more detail using the full Tallman Island WRRF system InfoWorks model. The resulting impacts of Alternatives ER-3 and ER-4 on peak hydraulic grade line in the 5-year storm are summarized in Figure 8.5-2 and Figure 8.5-3, respectively. The annual CSO volume and frequency for these optimization alternatives are summarized in Table 8.5-4, and estimated probable bid costs and construction/ implementation considerations are summarized in Table 8.5-5.



Outfall	Regulator	Components ER-3
TI-003	TI-10B	
TI-022	TI-55	
AAOV Reduction		102 MGY
Probable Bid Cost		$ 4M

Figure 8.5-2. Hydraulic Grade Line Impacts of Alternative ER-3 vs. Baseline Conditions (5-Year Storm)

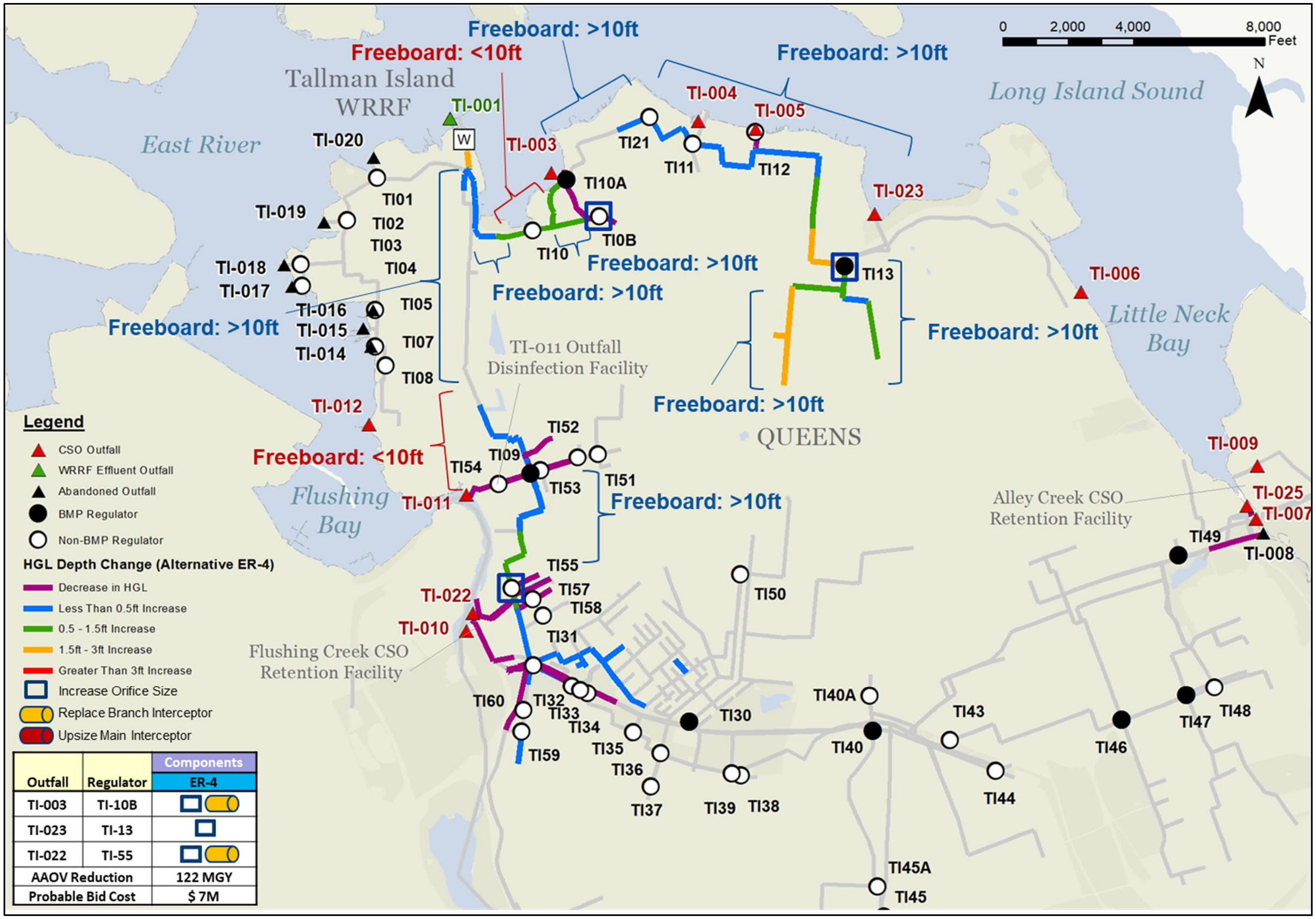


Figure 8.5-3. Hydraulic Grade Line Impacts of Alternative ER-4 vs. Baseline Conditions (5-Year Storm)

Table 8.5-4. Summary of Performance of Tallman Island Optimization Alternatives ER-3 and ER-4 for East River

Outfall(1)	Regulator	Baseline Conditions Typical Year		Alternative ER-3(2)		Alternative ER-4(3)	
		Annual CSO Volume (MG)	Annual CSO Activations	Annual CSO Volume (MG)	Annual CSO Activations	Annual CSO Volume (MG)	Annual CSO Activations
TI-003	TI-10B	71.0	45	26.7	26	26.7	26
TI-011	TI-09	259.6	45	279.6	45	286.0	45
	TI-51 to 54	130.6	50	130.4	50	130.8	50
TI-022	TI-55 to 58	89.5	59	31.9	25	22.1	22
TI-023	TI-13	138.4	39	138.4	39	127.6	33
Total		**1,590**	**59**	**1,522**	**50**	**1,513**	**50**

Notes:

(1) Outfalls and regulators with negligible impacts to Annual CSO Volume and Activations are not included in this table.

(2) ER-3 reduces CSO volume to the East River by 44 MGY and untreated CSO to Flushing Creek by 58 MGY for a total untreated CSO reduction of 102 MGY. This alternative results in an increase in treated CSO volume to Flushing Creek at TI-010 and TI-011 of 33 MGY.

(3) ER-4 reduces CSO volume to the East River by 55 MGY and untreated CSO to Flushing Creek by 68 MGY for a total untreated CSO reduction of 123 MGY. This alternative results in an increase in treated CSO volume to Flushing Creek at TI-010 and TI-011 of 45 MGY.

Table 8.5-5. Summary of Cost and Implementation Considerations for Tallman Island Optimization Alternatives ER-3 and ER-4 for East River

Alternative	Probable Bid Cost ($M)	Implementation Considerations
ER-3	$4M	• Reduction in CSO to the East River by 44 MGY • Reduction in untreated CSO to Flushing Creek of 58 MGY • Total reduction in untreated CSO of 102 MGY • Increases treated CSO to Flushing Creek by 33 MGY
ER-4	$7M	• Reduction in CSO to the East River by 55 MGY • Reduction in untreated CSO to Flushing Creek of 68 MGY • Total reduction in untreated CSO of 123 MGY • Increases treated CSO to Flushing Creek by 45 MGY

Due to the potential impacts to the hydraulic grade line in the 5-year design storm, and the predicted increase in CSO volume to Flushing Creek, Alternatives ER-3 and ER-4 were not carried forward for further evaluations. However, additional alternatives were evaluated using the InfoWorks model.

In consideration of historical hydraulic grade line sensitivities downstream of Regulator TI-13, a bending weir was evaluated at this site as Alternative ER-5. To improve upon the performance of Alternative ER-5, orifice and branch interceptor optimizations at Regulator TI-10B included in earlier alternatives were combined with the bending weir at Regulator TI-13 to create Alternative ER-6. Table 8.5-6 identifies the components that make up Alternatives ER-5 and ER-6.

Table 8.5-6. Tallman Island Optimization Components for Retained Alternatives

Outfall	Regulator	Components	
		ER-5	ER-6
TI-003	TI-10B		
TI-023	TI-13	BW	BW
TI-022	TI-55		

KEY

Increase Orifice Size

Replace Branch Interceptor

BW Bending Weir

The annual CSO volume and frequency for optimization Alternatives ER-5 and ER-6 are summarized in Table 8.5-7, and estimated probable bid costs and construction/implementation considerations are summarized in Table 8.5-8. As shown in Table 8.5-8, Alternative ER-5 reduced CSO volume by 41 MGY, while ER-6 reduced CSO volume by 86 MGY. Figure 8.5-4 and Figure 8.5-5 illustrate the hydraulic grade line impacts for Alternatives ER-5 and ER-6, respectively, for the 5-year design storm.

Given the potential reduction in CSO activation frequency and volume associated with the relatively modest cost, Alternatives ER-5 and ER-6 were retained for further consideration. Tunnel storage alternatives for Tallman Island WRRF outfalls tributary to the East River/Long Island Sound are evaluated later in this section.

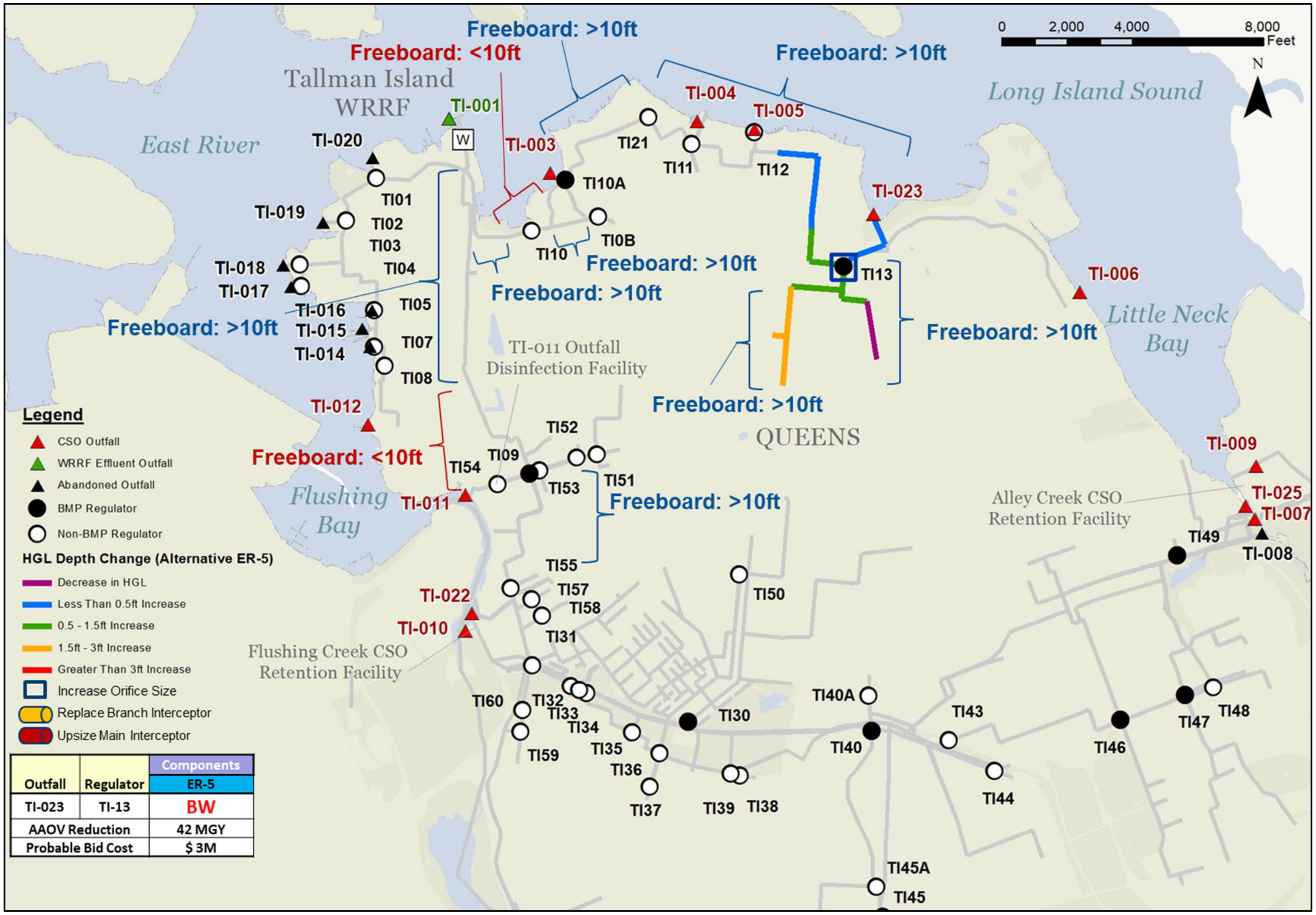
Table 8.5-7. Summary of Performance of Tallman Island Optimization Alternatives ER-5 and ER-6 for East River

Outfall[1]	Regulator	Baseline Conditions Typical Year		Alternative ER-5		Alternative ER-6	
		Annual CSO Volume (MG)	Annual CSO Activations	Annual CSO Volume (MG)	Annual CSO Activations	Annual CSO Volume (MG)	Annual CSO Activations
TI-003	TI-10B	71.0	45	71.0	45	26.7	26
TI-011	TI-09	260	45	260	45	260	45
	TI-51 to 54	131	50	131	50	130	50
TI-022	TI-55 to 58	89.5	59	89.5	59	89.4	59
TI-023	TI-13	138	39	96.5	24	96.1	24
Total		**1,590**	**59**	**1,549**	**59**	**1,504**	**59**

Note:
(1) Outfalls and regulators with negligible impacts to Annual CSO Volume and Activations are not included in this table.

Table 8.5-8. Summary of Cost and Implementation Considerations for Tallman Island Optimization Alternatives ER-5 and ER-6 for East River

Alternative	Probable Bid Cost ($M)	Implementation Considerations
ER-5	$3M	• Reduction in CSO to the East River by 42 MGY. • No impacts to CSOs along tributaries.
ER-6	$6M	• Reduction in CSO to the East River by 86 MGY. • No impacts to CSOs along tributaries.



Outfall	Regulator	Components ER-5
TI-023	TI-13	BW
AAOV Reduction		42 MGY
Probable Bid Cost		$ 3M

Figure 8.5-4. Hydraulic Grade Line Impacts of Alternative ER-5 vs. Baseline Conditions (5-Year Storm)

AECOM with Hazen

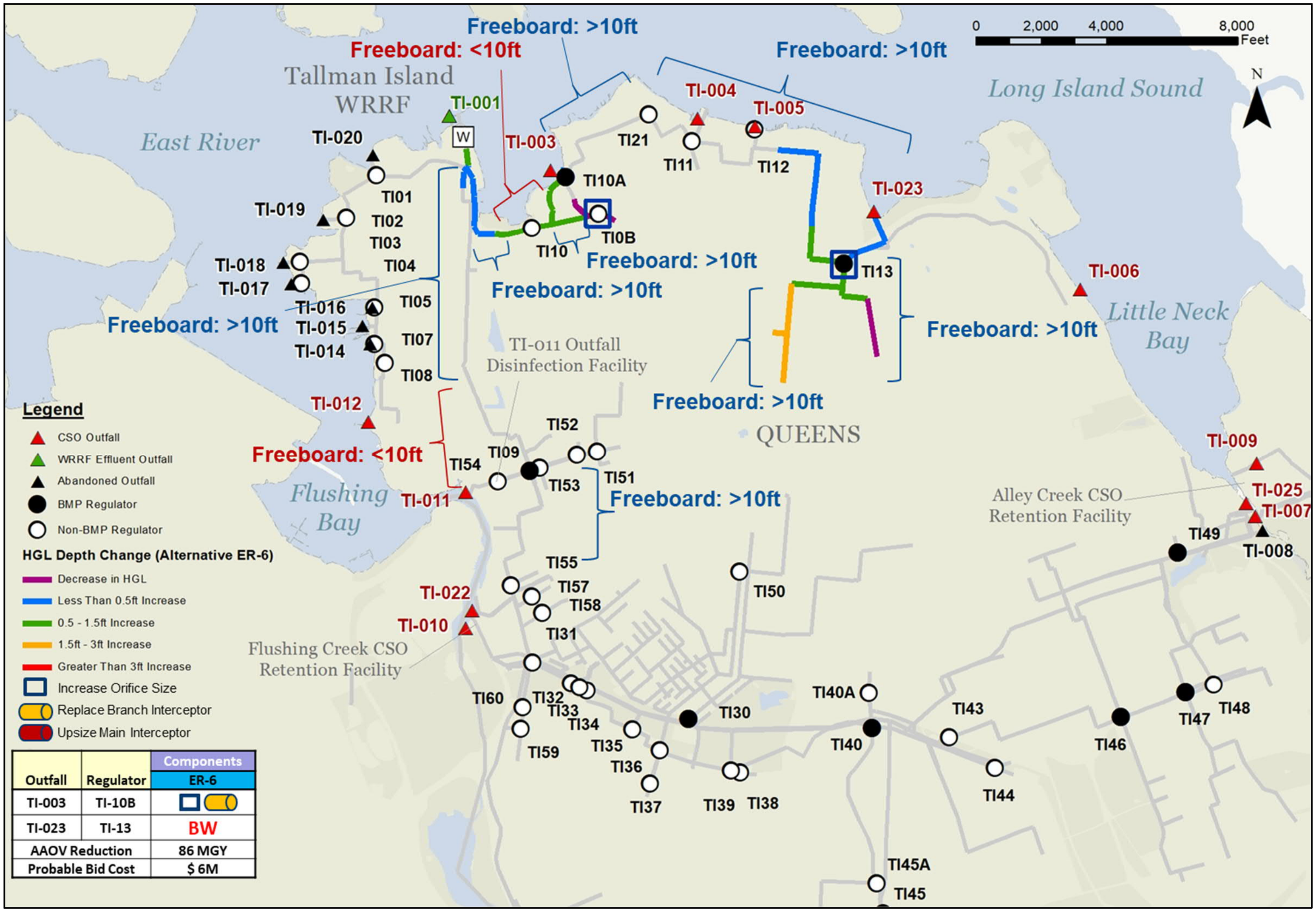


Figure 8.5-5. Hydraulic Grade Line Impacts of Alternative ER-6 vs. Baseline Conditions (5-Year Storm)

8.5.a.2 System Optimization for East River Outfalls in the Bowery Bay WRRF System

Table 8.5-9 lists the CSO outfalls and associated regulators tributary to the East River from the Bowery Bay WRRF system that were the initial focus of the optimization evaluations. The locations of these outfalls/regulators are shown in Figure 8.5-6. Table 8.5-9 identifies the annual CSO volume and activation frequency under Baseline Conditions, and whether the outfall/regulator falls within one or more of the following categories:

- One of the 100 monitored regulators listed in the WRRF SPDES permits ("BMP Regulator")
- A "key regulator" as identified in the WRRF SPDES permits
- An outfall in proximity to (typically within 500 feet) a public access location
- Regulators that activated more than average for the waterbody

Table 8.5-9. East River CSO Outfalls/Regulators Associated with the Bowery Bay WRRF

Outfall	Regulator	Baseline Conditions		BMP Regulator	Key Regulator	Outfall in Proximity to Public Access	Higher Frequency Regulator
		Annual CSO Volume (MG)	Annual CSO Activations				
BB-002	BBH-02	12.9	19	✓	✓		
BB-003	BBH-03	53.2	32	✓			✓
BB-005	24th Ave	597	35				✓
BB-028	BBL-21	317	43	✓		✓	✓
BB-029	BBL-22	89.6	29	✓	✓	✓	✓
BB-030	BBL-23	24.7	39	✓		✓	✓
BB-034	BBL-30	186	47	✓			✓
BB-021	BBL-15	20.9	30				✓
BB-025	BBL-19	10.0	27				✓
BB-033	BBL-27	5.5	28				✓
BB-035	BBL-31	3.8	31				✓
BB-036	BBL-32	8.4	29				✓
BB-041	BBL-01	85.0	61				✓
BB-046	BBL-26	6.6	30				✓

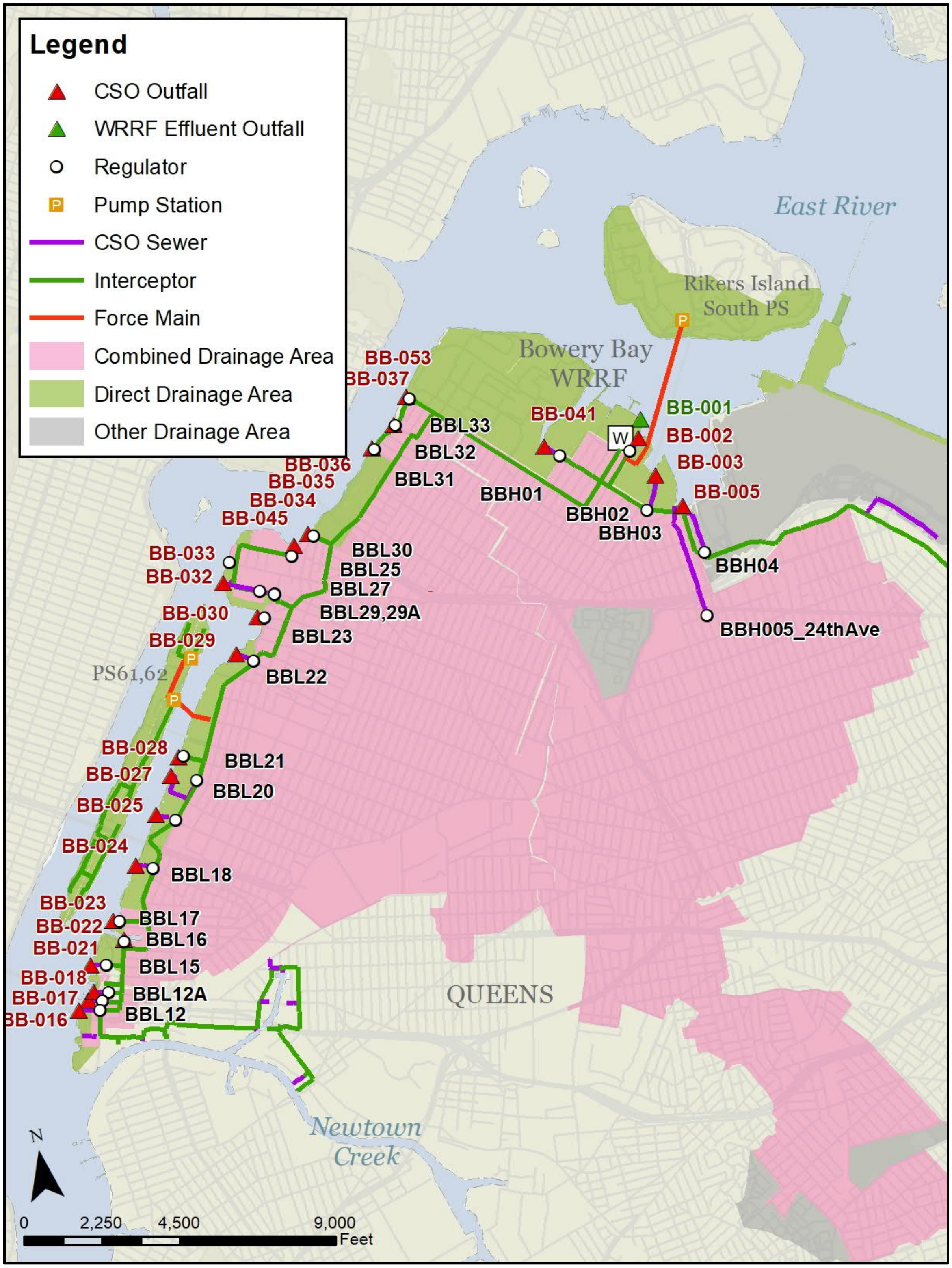


Figure 8.5-6. CSO Outfalls/Regulators Tributary to East River from the Bowery Bay WRRF System

Findings/Observations from Optimizer Evaluations

The Optimizer evaluations served as an initial screening step to identify potentially promising optimization alternatives to be further evaluated using the full Bowery Bay WRRF InfoWorks model. These evaluations included the assessment of the impacts to CSO volume, activation and peak hydraulic grade line elevations relative to Baseline Conditions, as well as other general system conditions. General collection system information and findings of the initial Optimizer evaluations included the following:

- The Bowery Bay WRRF collection system serves the northwestern side of Queens. The Low Level Interceptor (LLI) begins on 27th Street receiving flow from the Borden Avenue Pumping Station and running southward parallel to Newtown Creek towards the East River. At 2nd Street, the LLI bends and runs northerly paralleling the East River through Long Island City, Dutch Kills and Astoria. The LLI bends to the east in Steinway and runs along 20th Avenue to 43rd Street where it bends northward towards the Bowery Bay WRRF. The High Level Interceptor (HLI) generally follows 108th Street, running southward from Rego Park to East Elmhurst. The HLI bends to the west along Ditmars Boulevard, crossing the Grand Central Parkway and the southwestern corner of LaGuardia Airport before heading northward along 81st Street. The HLI bends westward along 19th Avenue and then northward to the Bowery Bay WRRF along 45th Street.
- A total of 43 regulators divert flow to the interceptors. During wet-weather, flow in excess of the interceptor capacity can overflow to CSO outfalls discharging to the Dutch Kills (6 CSOs), Newtown Creek (7 CSOs), East River (26 CSOs), and Flushing Bay (3 CSOs).
- The sewers tributary to each regulator are relatively flat due to the topography. Depth of cover on the gravity sewers varies, ranging from relatively shallow (<10 feet of cover) to about 40 feet.
- Regulators in the Bowery Bay WRRF system contributing to CSO outfalls discharging to the East River activate between 1 to 61 times during the typical year with a total average annual overflow volume (AAOV) of 1,621 MGY.
- Low Level Interceptor freeboard for the 5-year design storm and many of the larger storms during the typical year is generally less than 10 feet from the ground surface indicating the system is highly sensitive to hydraulic grade line impacts.
- The Optimizer modeling identified alternatives that included modifications to as many as nine regulators throughout the WRRF collection system that resulted in varying degrees of improved capture and hydraulic performance. However, upon performing InfoWorks runs for the 2008 typical year, limited AAOV (<3 percent) reductions were predicted for the better performing alternatives, and these alternatives resulted in approximately 5 percent increases in the total number of activations.
- The limited performance improvement is a result of the hydraulic grade line sensitivities along the entire stretch of the Low Level Interceptor and portions of the High Level Interceptor near the WRRF. Also, since the system was generally running full during wet-weather, alternatives that reduced CSO at one location tended to result in offsetting increases at other locations.

Follow-up Evaluations Based on Full InfoWorks Model

No retained alternatives were identified from the initial optimization runs due to:

- Hydraulic grade line impacts that increased the potential risk of flooding

- Negligible reductions in CSO volume to the East River, that were accompanied by increases in total numbers of activations of the CSO outfalls to the East River from the Bowery Bay system.

Figure 8.5-7 illustrates the hydraulic grade line (HGL) sensitivities where optimization alternatives increase the potential risk of street flooding and basement backups. Tunnel storage options for the outfalls to the East River from the Bowery Bay WRRF system are evaluated later in this section.

8.5.a.3 System Optimization for East River Outfalls in the Hunts Point WRRF System

Table 8.5-10 lists the CSO outfalls and associated regulators tributary to the East River from the Hunts Point WRRF system that were the initial focus of the optimization evaluations. The locations of these outfalls/regulators are shown in Figure 8.5-8. Table 8.5-10 identifies the annual CSO volume and activation frequency under Baseline Conditions, and whether the outfall/regulator falls within one or more of the following categories:

- One of the 100 monitored regulators listed in the WRRF SPDES permits ("BMP Regulator")
- A "key regulator" as identified in the WRRF SPDES permits
- An outfall in proximity to (typically within 500 feet) a public access location
- Regulators that activated more than average for the waterbody

<u>Findings/Observations from Optimizer Evaluations</u>

The Optimizer evaluations served as an initial screening step to identify potentially promising optimization alternatives to be further evaluated using the full Hunts Point WRRF InfoWorks model. These evaluations included the assessment of the impacts to CSO volume, activation and peak hydraulic grade line elevations relative to Baseline Conditions, as well as other general system conditions. General collection system information and findings of the initial Optimizer evaluations included the following:

- The Hunts Point WRRF collection system serves the majority of the Bronx, with the exception of a small portion to the west that is served by the Wards Island WRRF collection system. The eastern portion of the Bronx is served by a combined sewer that parallels Eastchester Bay. The combined sewer connects to an interceptor sewer that parallels the East River and then runs northwest to the Throgs Neck Pumping Station. The middle portion of the collection system is served by a combined sewer that generally parallels the west side of Westchester Creek. This sewer receives flow from the Throgs Neck Pumping Station before connecting to an interceptor sewer near the upstream end of Pugsley Creek. The western portion of the Bronx is served by collector sewers that primarily runs adjacent to the east and west side of the Bronx River. These sewers discharge to an interceptor sewer that generally parallels the East River receiving flow from other combined sewers before discharging to the Hunts Point WRRF.
- A total of 18 regulators, 15 CSO relief structures and 10 pumping stations divert flow to the collection system. During periods when wet-weather flow exceeds the collection system capacity, these facilities may overflow to CSO outfalls discharging to the Bronx River (5 CSOs), Westchester Creek (7 CSOs), Hutchinson River (5 CSOs), Eastchester Bay (3 CSOs), Long Island Sound (2 CSOs) and East River (12 CSOs).

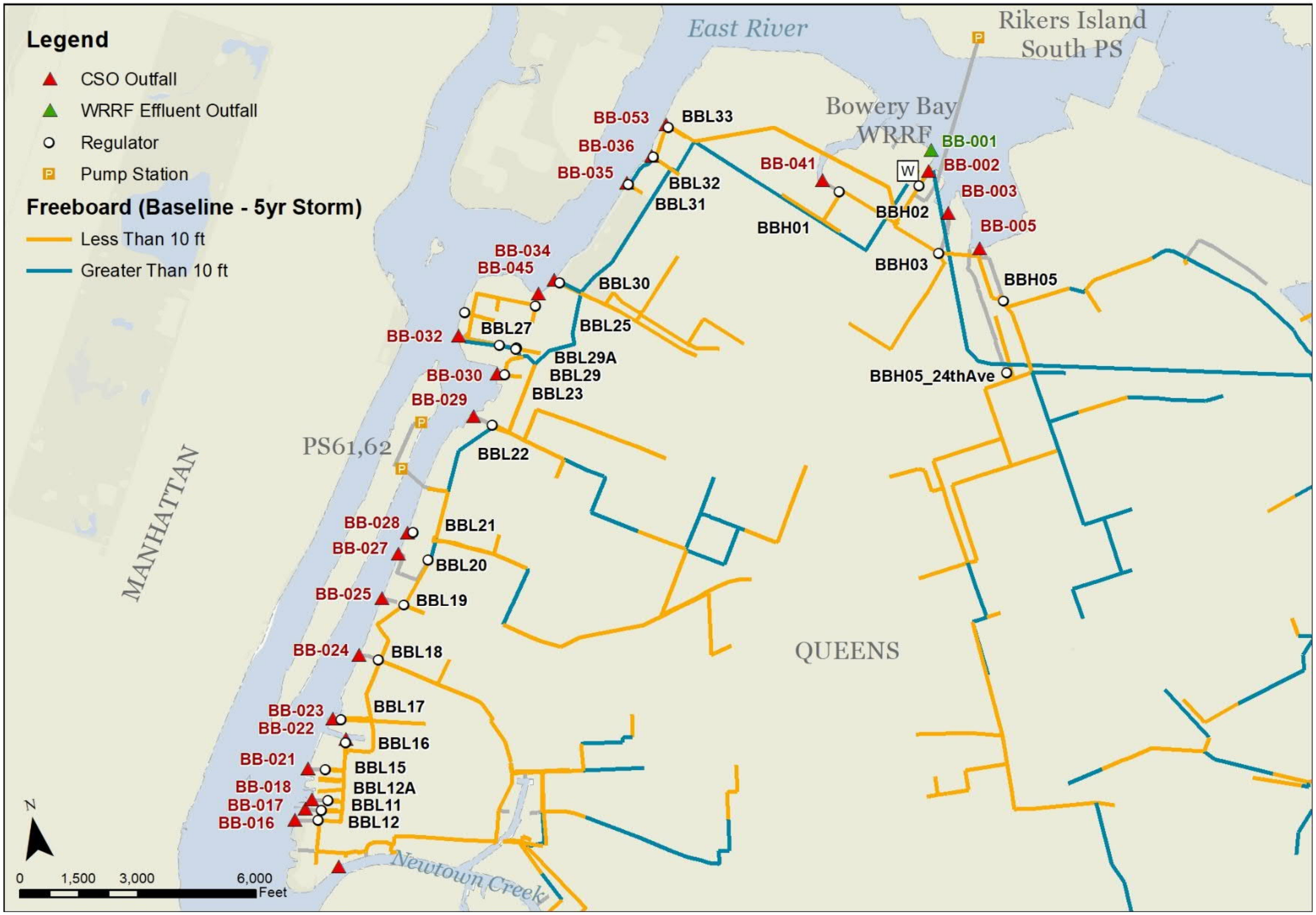


Figure 8.5-7. HGL Impacts of Bowery Bay Collection System Under Baseline Conditions, 5-Year Storm

Table 8.5-10. East River CSO Outfalls/Regulators Associated with the Hunts Point WRRF

Outfall	Regulator	Baseline Conditions		BMP Regulator	Key Regulator	Outfall in Proximity to Public Access	Higher Frequency Regulator
		Annual CSO Volume (MG)	Annual CSO Activations				
HP-022	HP-01	28.8	29	✓		✓	✓
HP-021	HP-02	201.8	44	✓		✓	✓
HP-019	HP-03	15.3	35	✓		✓	✓
HP-011	HP-05	664.9	34	✓	✓	✓	✓
HP-025	HP-08	95.9	45	✓		✓	✓
HP-002	HP-09	47.8	19	✓		✓	✓
HP-003	HP-10	138.2	30	✓	✓		✓
HP-017	HP-11	38.5	28	✓		✓	✓
HP-018	HP-12	3.4	15	✓		✓	
HP-009	HP-13	323.2	36	✓	✓		✓

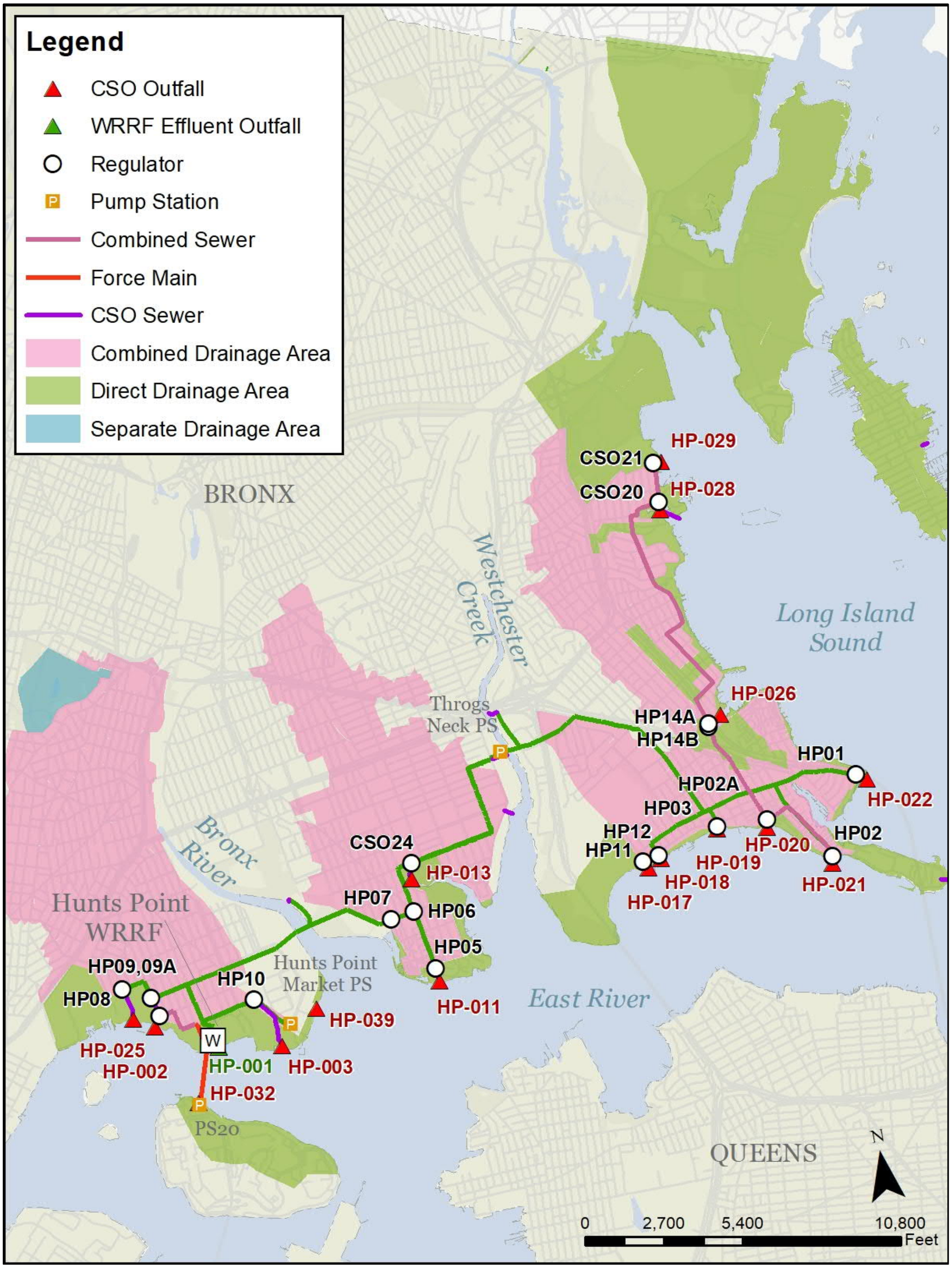


Figure 8.5-8. CSO Outfalls/Regulators Tributary to East River from the Hunts Point WRRF System

- The sewers tributary to each regulator, or relief structure, are relatively flat due to the topography. Depth of cover on the gravity sewers varies, ranging from relatively shallow (<10 feet of cover) to about 50 feet.
- Regulators contributing to CSO outfalls discharging to the East River activate between 0 to 45 times during the typical year with a total average annual overflow volume (AAOV) of 2,370 MGY.
- Interceptor freeboard for the 5-year design storm and many of the larger storms during the typical year is generally less than 10 feet from the ground surface indicating the system is highly sensitive to hydraulic grade line impacts.
- The Optimizer modeling identified alternatives that included modifications to as many as 12 regulators and relief structures throughout the Hunts Point WRRF collection system that resulted in varying degrees of improved capture and hydraulic performance. However, upon performing InfoWorks runs for the 2008 typical year, limited reductions in AAOV (<1 percent) and activation frequency (<10 percent) were predicted for the better performing alternatives.
- The limited performance improvement is a result of the hydraulic grade line sensitivities along the entire stretch of the interceptor.

<u>Follow-up Evaluations Based on Full InfoWorks Model</u>

The most promising optimization alternatives coming out of the Optimizer evaluations are summarized in Table 8.5-11:

Table 8.5-11. Hunts Point Optimization Components for Retained Alternatives

Outfall	Regulator	Components	
		ER-1	ER-2
HP-016	HP-04		
HP-018	HP-12		
HP-019	HP-03		
HP-025	HP-08		

<u>KEY</u>

Increase Orifice Size

Replace Branch Interceptor

These alternatives were further analyzed in more detail using the full Hunts Point WRRF system InfoWorks model. The resulting impacts of Alternatives ER-1 and ER-2 on peak hydraulic grade line in the 5-year storm are summarized in Figure 8.5-9 and Figure 8.5-10, respectively. The annual CSO volume and frequency for these optimization alternatives are summarized in Table 8.5-12 and estimated probable bid costs and construction/implementation considerations are summarized in Table 8.5-13.

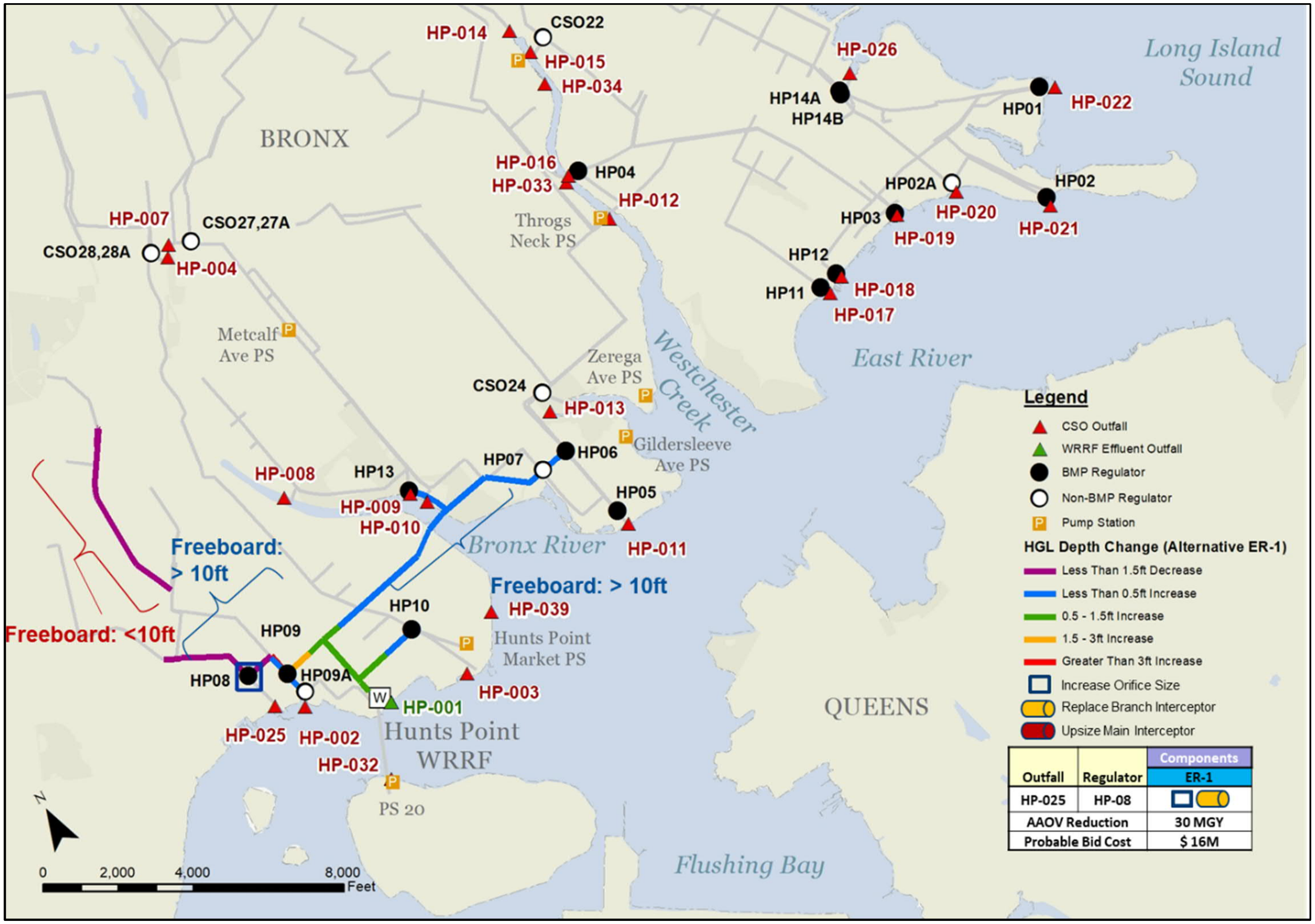
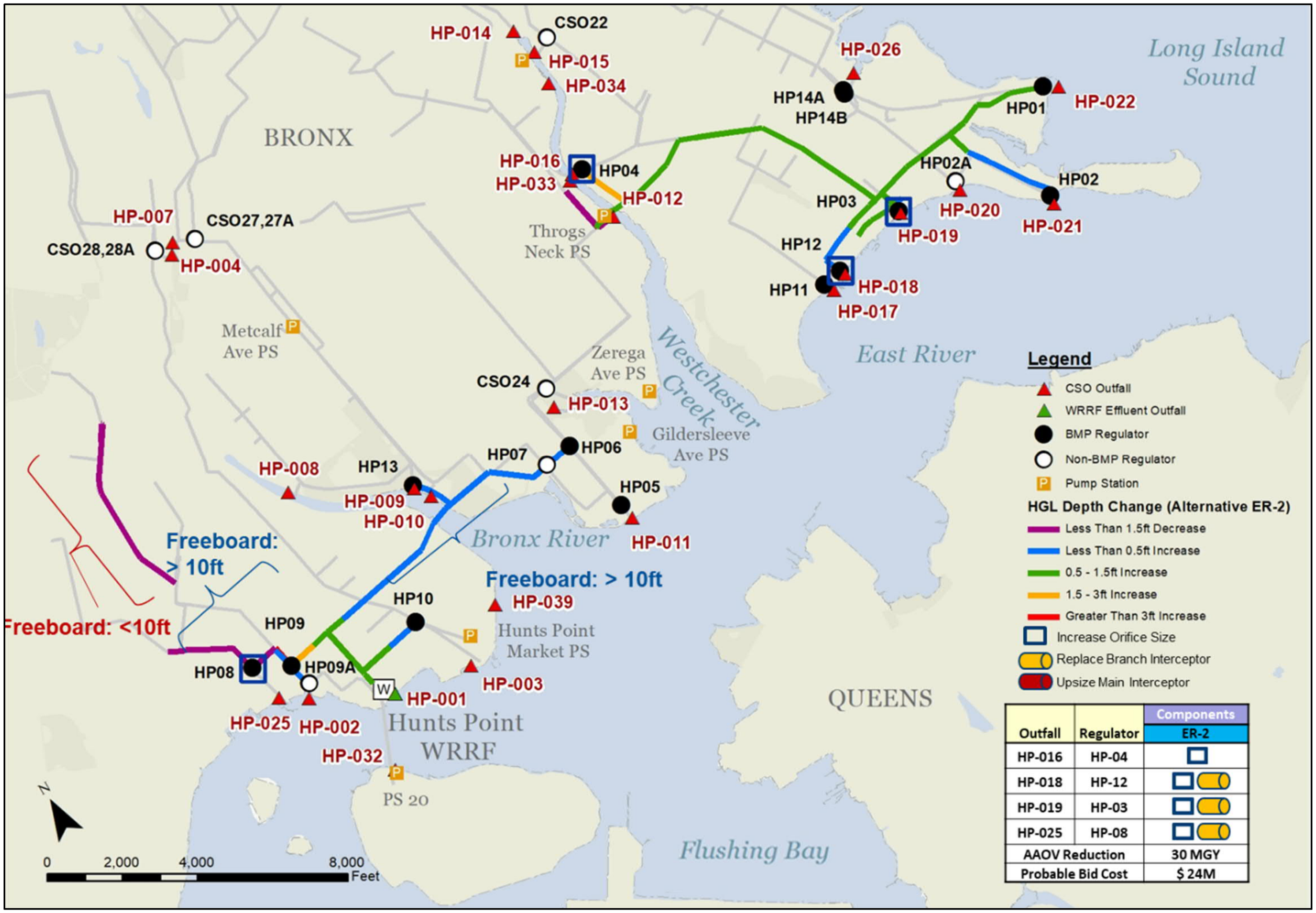


Figure 8.5-9. Hydraulic Grade Line Impacts of Alternative ER-1 vs. Baseline Conditions (5-Year Storm)



Outfall	Regulator	Components ER-2
HP-016	HP-04	Increase Orifice Size
HP-018	HP-12	Increase Orifice Size, Replace Branch Interceptor
HP-019	HP-03	Increase Orifice Size, Replace Branch Interceptor
HP-025	HP-08	Increase Orifice Size, Replace Branch Interceptor
AAOV Reduction		30 MGY
Probable Bid Cost		$ 24M

Figure 8.5-10. Hydraulic Grade Line Impacts of Alternative ER-2 vs. Baseline Conditions (5-Year Storm)

Table 8.5-12. Summary of Performance of Hunts Point Optimization Alternatives for East River

Outfall(1)	Regulator	Baseline Conditions Typical Year		Alternative ER-1(2)		Alternative ER-2(3)	
		Annual CSO Volume (MG)	Annual CSO Activations	Annual CSO Volume (MG)	Annual CSO Activations	Annual CSO Volume (MG)	Annual CSO Activations
HP-022	HP-01	28.8	29	28.8	29	30.7	30
HP-021	HP-02	202	44	202	44	209	44
HP-019	HP-03	15.3	35	15.3	35	5.8	14
HP-011	HP-05	665	34	682	34	682	34
HP-025	HP-08	95.9	45	21.3	14	22.4	14
HP-002	HP-09	47.8	19	62.8	21	62.8	21
HP-003	HP-10	138	30	142	30	143	30
HP-017	HP-11	38.5	28	38.5	28	41.9	29
HP-018	HP-12	3.4	15	3.4	15	2.7	14
HP-009	HP-13	323	36	323	36	337	36
Total		**2,370**	**45**	**2,348**	**44**	**2,348**	**44**

Notes:
(1) Outfalls and regulators with negligible impacts to Annual CSO Volume and Activations are not included in this table.
(2) ER-1 reduces CSO volume to the East River by 37 MGY. This alternative results in an increase in treated CSO volume to the Bronx River of 15 MGY and Westchester Creek of 1 MGY.
(3) ER-2 reduces CSO volume to the East River by 34 MGY and Westchester Creek by 2 MGY. This alternative results in an increase in treated CSO volume to the Bronx River of 14 MGY.

Table 8.5-13. Summary of Cost and Implementation Considerations for Hunts Point Optimization Alternatives for East River

Alternative	Probable Bid Cost ($M)	Implementation Considerations
ER-1	$16M	• Reduction in CSO to the East River of 37 MGY • Increase in CSO to the Bronx River of 15 MGY and Westchester Creek of 1 MGY • Net CSO reduction of 21 MGY
ER-2	$24M	• Reduction in CSO to the East River of 34 MGY and Westchester Creek of 2 MGY • Increase in CSO to the Bronx River of 14 MGY • Net CSO reduction of 22 MGY

Given the potential cost-effective reduction in CSO activation frequency and volume, Alternatives ER-1 and ER-2 were retained for further consideration. However, the increases in CSO discharges to the Bronx River (which was evaluated under a separate LTCP) are a concern and must be considered in the selection of the preferred alternative for the East River. Tunnel storage options for the outfalls to the East River from the Hunts Point WRRF system are evaluated later in this section.

8.5.a.4 System Optimization for East River Outfalls in the Wards Island WRRF System

Table 8.5-14 summarizes the CSO outfalls and associated regulators tributary to the East River from the Wards Island WRRF system that were the initial focus of the optimization evaluations. The locations of these outfalls/regulators are shown in Figure 8.5-11. Table 8.5-14 identifies the annual CSO volume and activation frequency under Baseline Conditions, and whether the outfall/regulator falls within one or more of the following categories:

- One of the 100 monitored regulators listed in the WRRF SPDES permits ("BMP Regulator")
- A "key regulator" as identified in the WRRF SPDES permits
- An outfall in proximity to a public access location (typically within 500 feet of an access location)
- Regulators that activated more than average for the waterbody

Table 8.5-14. East River CSO Outfalls/Regulators Associated with the Wards Island WRRF

Outfall	Regulator	Baseline Conditions		BMP Regulator	Key Regulator	Outfall in Proximity to Public Access	Higher Frequency Regulator
		Annual CSO Volume (MG)	Annual CSO Activations				
WIM-003	WIM-02B	89.6	43	✓			✓
WIM-008	WIM-07	115	45	✓			✓
WIM-016	WIM-15	13.3	38	✓			✓
WIB-072	WIB-68	33.1	37	✓			✓

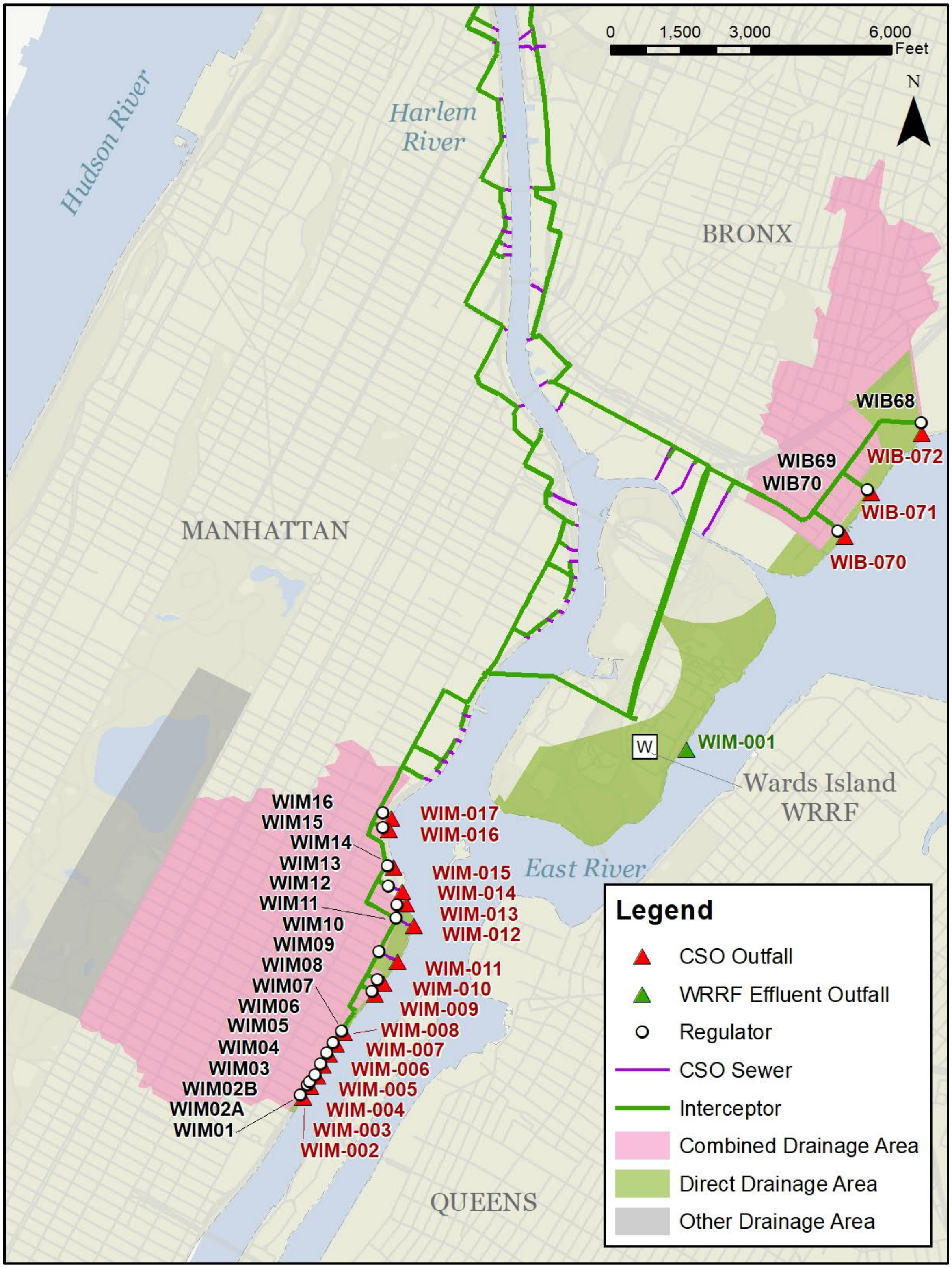


Figure 8.5-11. CSO Outfalls/Regulators Tributary to East River from the Wards Island WRRF System

Findings/Observations from Optimizer Evaluations

The Optimizer evaluations served as an initial screening step to identify potentially promising optimization alternatives to be further evaluated using the full Wards Island WRRF InfoWorks model. These evaluations included the assessment of the impacts to CSO volume, activation and peak hydraulic grade line elevations relative to Baseline Conditions, as well as other general system conditions. General collection system information and findings of the initial Optimizer evaluations included the following:

- The Wards Island WRRF collection system serves the northeastern portion of Manhattan and western Bronx. The Manhattan interceptor parallels the Harlem River Drive, while the Bronx Interceptor initially parallels the Hudson River along Palisades Avenue, then bends eastward along the Harlem River and then to the south generally following the Major Deegan Expressway.
- A total of 75 regulators contribute flow to the interceptors. During wet-weather, flow in excess of the interceptor capacity can overflow to CSO outfalls discharging to the Hudson River (3 CSOs), Harlem River (49 CSOs), Bronx Kill (3 CSOs) and East River (20 CSOs). The interceptor sewers convey flow to the Wards Island WRRF located to the south and east of Randall's Island Park.
- The sewers tributary to each regulator are relatively flat due to the topography. Depth of cover on the gravity sewers varies, ranging from relatively shallow (<10 feet of cover) to about 50 feet.
- Regulators contributing to CSO outfalls discharging to the East River from the Wards Island WRRF system activate between 0 to 50 times during the typical year with a total average annual overflow volume (AAOV) of 311 MGY.
- Freeboard for the 5-year design storm and many of the larger storms during the typical year is generally less than 10 feet from the ground surface indicating the portions of the collection system along the East River are highly sensitive to hydraulic grade line impacts.
- The Optimizer modeling identified alternatives that included modifications to as many as 25 regulators throughout the WRRF collection system that resulted in varying degrees of improved capture and hydraulic performance. However, upon performing InfoWorks runs for the 2008 typical year, limited reductions in AAOV (<1.5 percent) and activation frequency (<2.5 percent) were predicted for the better performing alternatives.

Follow-up Evaluations Based on Full InfoWorks Model

No retained alternatives were identified from the initial optimization runs due to hydraulic grade line impacts that increased the potential risk of flooding, while providing negligible reductions in CSO volume and activations to the East River. Figure 8.5-12 illustrates the hydraulic grade line sensitivities where optimization alternatives increase the potential risk of street flooding and basement backups. Tunnel options for CSO outfalls to the East River from the Wards Island WRRF system are evaluated later in this section.

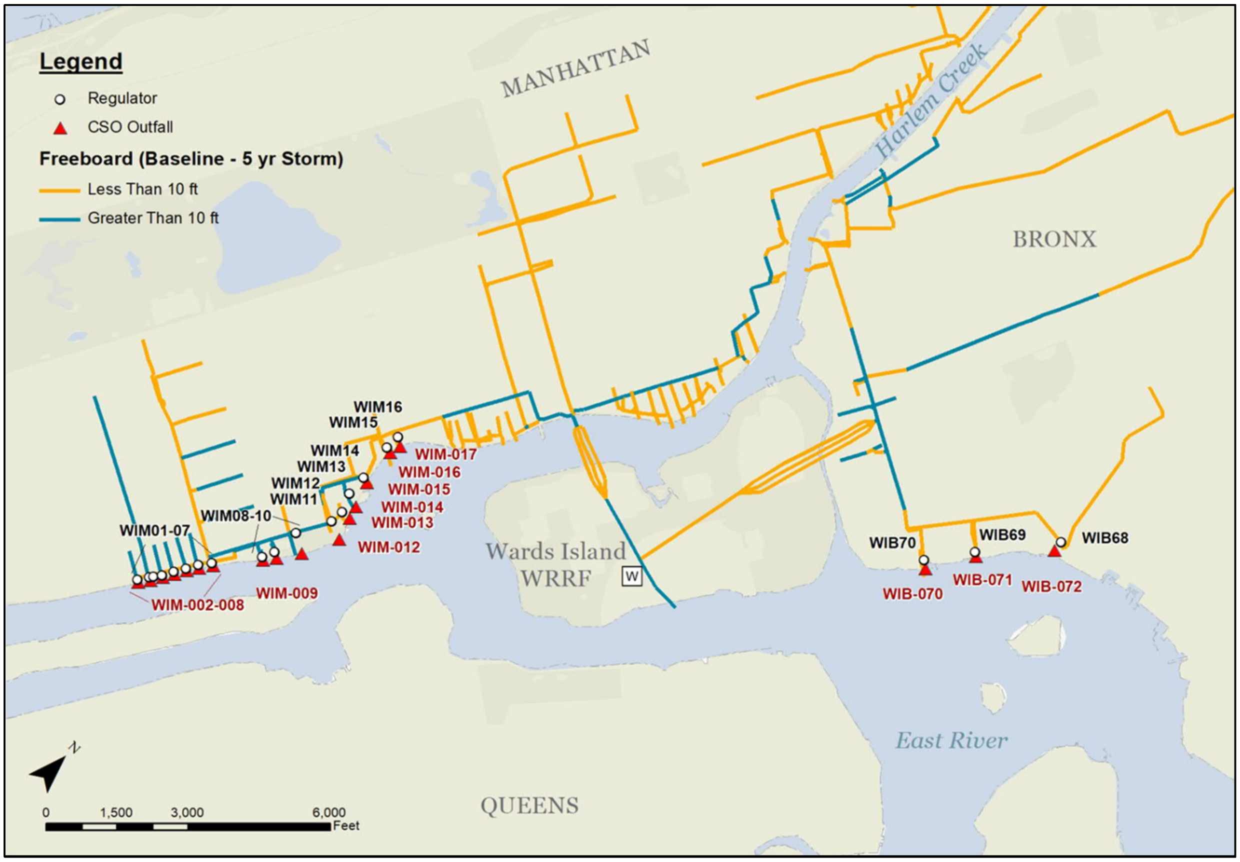


Figure 8.5-12. Hydraulic Grade Line Impacts of Wards Island Collection System Under Baseline Conditions (5-Year Storm)

8.5.a.5 System Optimization for East River Outfalls in the Newtown Creek WRRF System

Table 8.5-15 summarizes the CSO outfalls and associated regulators tributary to the East River from the Newtown Creek WRRF system that were the initial focus of the optimization evaluations. The locations of these outfalls/regulators are shown in Figure 8.5-13. Table 8.5-15 identifies the annual CSO volume and activation frequency under Baseline Conditions, and whether the outfall/regulator falls within one or more of the following categories:

- One of the 100 monitored regulators listed in the WRRF SPDES permits (“BMP Regulator”)
- A “key regulator” as identified in the WRRF SPDES permits
- An outfall in proximity to (typically within 500 feet) a public access location
- Regulators that activated more than average for the waterbody

Table 8.5-15. East River CSO Outfalls/Regulators Associated with the Newtown Creek WRRF

Outfall	Regulator	Baseline Conditions		BMP Regulator	Key Regulator	Outfall in Proximity to Public Access	Higher Frequency Regulator
		Annual CSO Volume (MG)	Annual CSO Activations				
NCB-006	NCB-09	113	17	✓		✓	
NCB-012	NCB-06	16.3	8	✓			
NCB-013	NCB-05	98.2	28	✓			✓
NCB-014	NCB-04	727	30	✓	✓		✓
NCM-032	NCM-50	5.57	11	✓			
NCM-036	NCM-47	79.9	15	✓	✓		
NCM-037	NCM-44	0.94	4	✓			
NCM-041	NCM-42	29.2	16	✓			
NCM-045	NCM-40	22.11	14	✓			
NCM-049	NCM-37	17.6	12	✓			
NCM-050	NCM-19	34.76	19	✓			
NCM-052	NCM-36	24.44	15	✓			
NCM-063	NCM-21	10.12	9	✓			
NCM-066	NCM-17	4.95	12	✓			
NCM-069	NCM-10	9.24	12	✓			
NCM-078	NCM-16	1.06	4	✓			
NCB-004	NCB-10	17.9	36			✓	✓
NCB-007	NCB-8	8.63	29				✓
NCB-008	NCB-7	23.2	26				✓
NCB-027	NCB-12	18.8	30				✓

Table 8.5-15. East River CSO Outfalls/Regulators Associated with the Newtown Creek WRRF

Outfall	Regulator	Baseline Conditions		BMP Regulator	Key Regulator	Outfall in Proximity to Public Access	Higher Frequency Regulator
		Annual CSO Volume (MG)	Annual CSO Activations				
NCM-005	NCM-51	49.9	38				✓
NCM-018	NCM-45	11.7	34				✓
NCM-062	NCM-22	13.35	34				✓

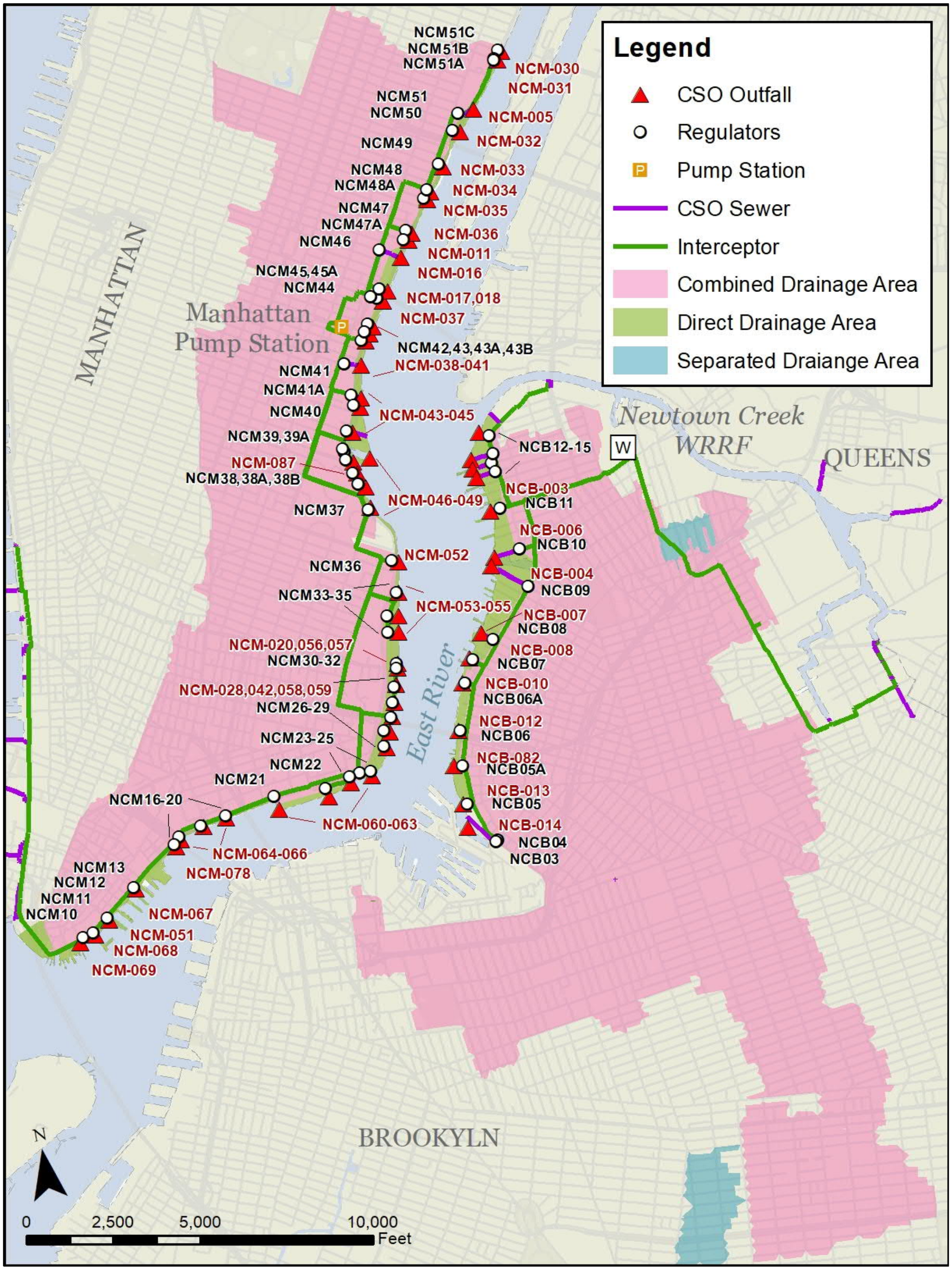


Figure 8.5-13. CSO Outfalls/Regulators Tributary to East River from the Newtown Creek WRRF System

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Findings/Observations from Optimizer Evaluations

The Optimizer evaluations served as an initial screening step to identify potentially promising optimization alternatives to be further evaluated using the full Newtown Creek WRRF InfoWorks model. These evaluations included the assessment of the impacts to CSO volume, activation and peak hydraulic grade line elevations relative to Baseline Conditions, as well as other general system conditions. General collection system information and findings of the initial Optimizer evaluations included the following:

- The Newtown Creek WRRF collection system serves the east side and southern portion of Manhattan, along with northern Brooklyn and a portion of Queens. The southern branch of the Manhattan interceptor starts in the vicinity of Outfall NCM-081, and runs south parallel to the Hudson River shoreline. The interceptor continues around the southern tip of Manhattan, then runs north parallel to the East River, to the Manhattan Pumping Station. The northern branch of the Manhattan Interceptor runs south from approximately East 71st Street, parallel to the East River shoreline, to the Manhattan Pumping Station. The Manhattan Pumping Station pumps the flow across the East River to the Newtown Creek WRRF. On the Brooklyn side, the Kent Avenue Interceptor serves the area with outfalls tributary to the East River. The Kent Avenue Interceptor joins with the Morgan Avenue Interceptor, which serves the area tributary to Newtown Creek, before entering the Brooklyn Pumping Station at the Newtown Creek WRRF. A total of 85 regulators divert flow to the interceptors. During wet-weather, flow in excess of the interceptor capacity can overflow to CSO outfalls discharging to the Hudson River (9 CSOs), Newtown Creek (8 CSOs) and East River (63 CSOs).
- Depth of cover on the gravity sewers varies, ranging from relatively shallow (<10 feet of cover) to about 20 feet.
- Regulators contributing to CSO outfalls discharging to the East River activate between 0 to 38 times during the typical year with a total average annual overflow volume (AAOV) of 1,490 MGY.
- Freeboard for the 5-year design storm and many of the larger storms during the typical year is generally less than 10 feet from the ground surface indicating the system is highly sensitive to hydraulic grade line impacts.
- The Optimizer modeling identified alternatives that included modifications to as many as 20 regulators throughout the WRRF collection system that resulted in varying degrees of improved capture and hydraulic performance. However, upon performing InfoWorks runs for the 2008 typical year limited reductions in AAOV (<3 percent) and activation frequency (<2 percent) were predicted for the better performing alternatives.
- The limited performance improvement is a result of the hydraulic grade line sensitivities and the capacity of each pumping station. Also, since the system was generally running full during wet--weather, alternatives that reduced CSO at one location tended to result in offsetting increases at other locations.

Follow-up Evaluations Based on Full InfoWorks Model

No retained alternatives were identified from the initial optimization runs due to hydraulic grade line (HGL) impacts that increased the potential risk of flooding, while providing negligible reductions in CSO volume and activations to the East River. Figure 8.5-14 illustrates the hydraulic grade line sensitivities where optimization alternatives would increase the potential risk of street flooding and basement backups.

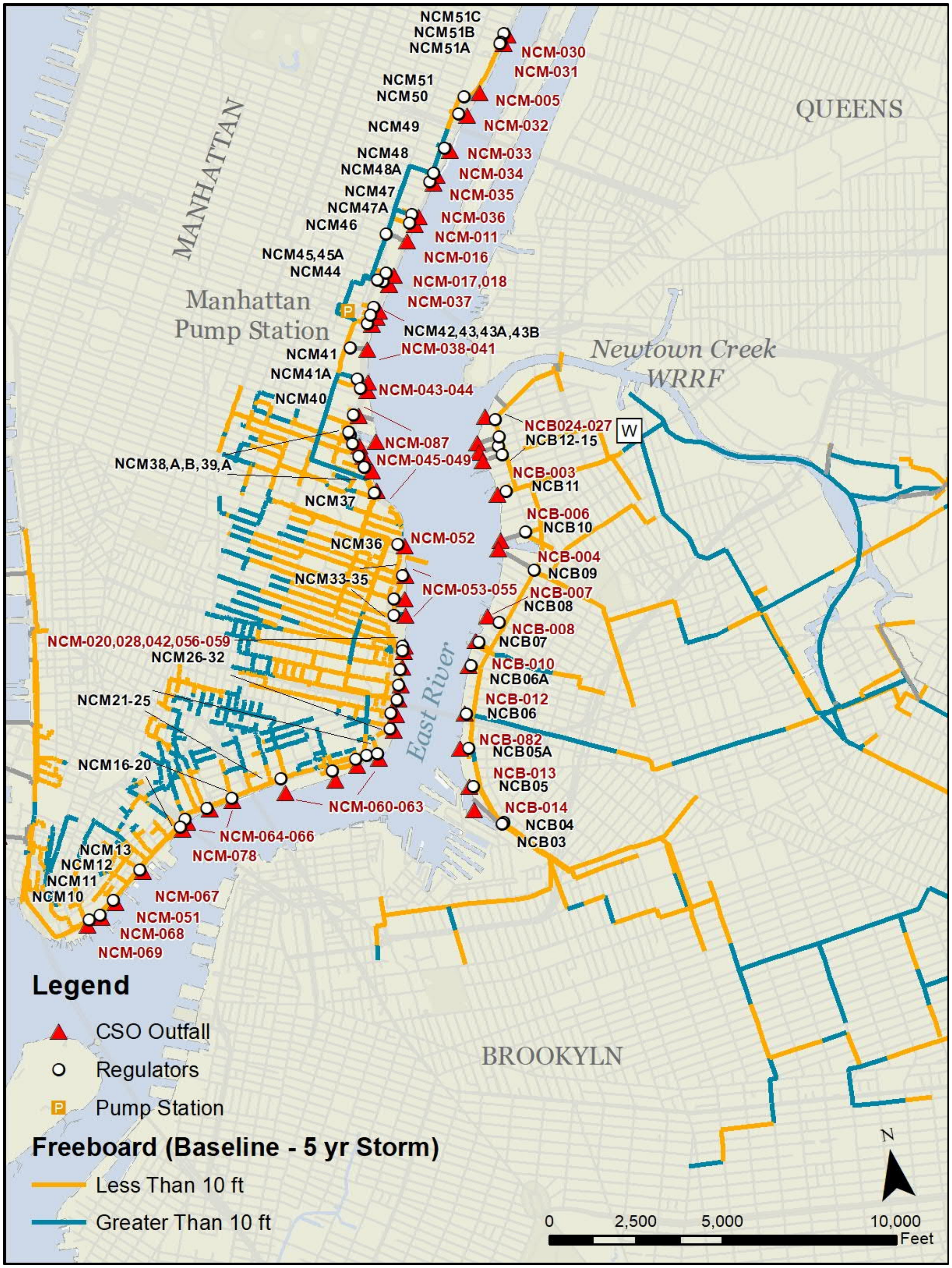

Figure 8.5-14. Hydraulic Grade Line Impacts of Newtown Creek Collection System Under Baseline Conditions (5-Year Storm)

However, based in input from the public, the InfoWorks model was used to specifically look at additional alternatives to reduce CSOs at Outfalls NCB-004 and NCB-006, which discharge at the mouth of Bushwick Inlet, as well as Outfalls NCB-013 and NCB-014 in the vicinity of Wallabout Channel. As indicated in Figure 8.5-13 above, these two sets of outfalls are located along opposite ends of the Kent Avenue Interceptor. The crest of the overflow weir at Regulator NCB-04, that discharges to Outfall NCB-014, is at elevation -7.73, which is just below the crown of the interceptor at that location. The overflow weir at Regulator NCB-05, associated with Outfall NCB-013, is approximately four feet higher. The overflow weirs at the regulators associated with Outfalls NCB-004 and NCB-006 are about six and just under three feet higher than the weir at NCB-014, respectively.

The interceptor between NCB-014 and NCB-006 runs surcharged during wet-weather, and the peak hydraulic grade line is often above the elevation of the weirs at NCB-006, NCB-013, and NCB-014. Optimization measures such as raising weirs or increasing the size of the connections between the regulators and the interceptors resulted in no net benefit in terms of CSO reduction. Alternatives to reduce CSO volume at Outfalls NCB-004 and NCB-006 resulted in increases in volume at NCB-013 and NCB-014, and vice versa. Raising weirs and/or opening up interceptor connections at both locations resulted in unacceptable increases in the peak hydraulic grade line along the interceptor. For these reasons, no further optimization alternatives were recommended for those outfalls.

Tunnel options are evaluated later in this section.

8.5.a.6 System Optimization for East River Outfalls in the Red Hook WRRF System

The locations of the CSO outfalls and associated regulators tributary to the East River from the Red Hook WRRF system are shown in Figure 8.5-15. The Red Hook WRRF is located at the downstream end of the interceptor system, which extends along the Brooklyn shoreline to Gowanus Bay, and then back north along Gowanus Canal. The optimization evaluations for the Red Hook system were conducted on the system as a whole, without separately evaluating optimization alternatives for the East River outfalls independently of the New York Bay outfalls. This approach was taken due to the hydraulic connectivity among the outfalls provided by the single interceptor system. The Red Hook optimization evaluations are presented as part of the New York Bay evaluations in Section 8.6, below.

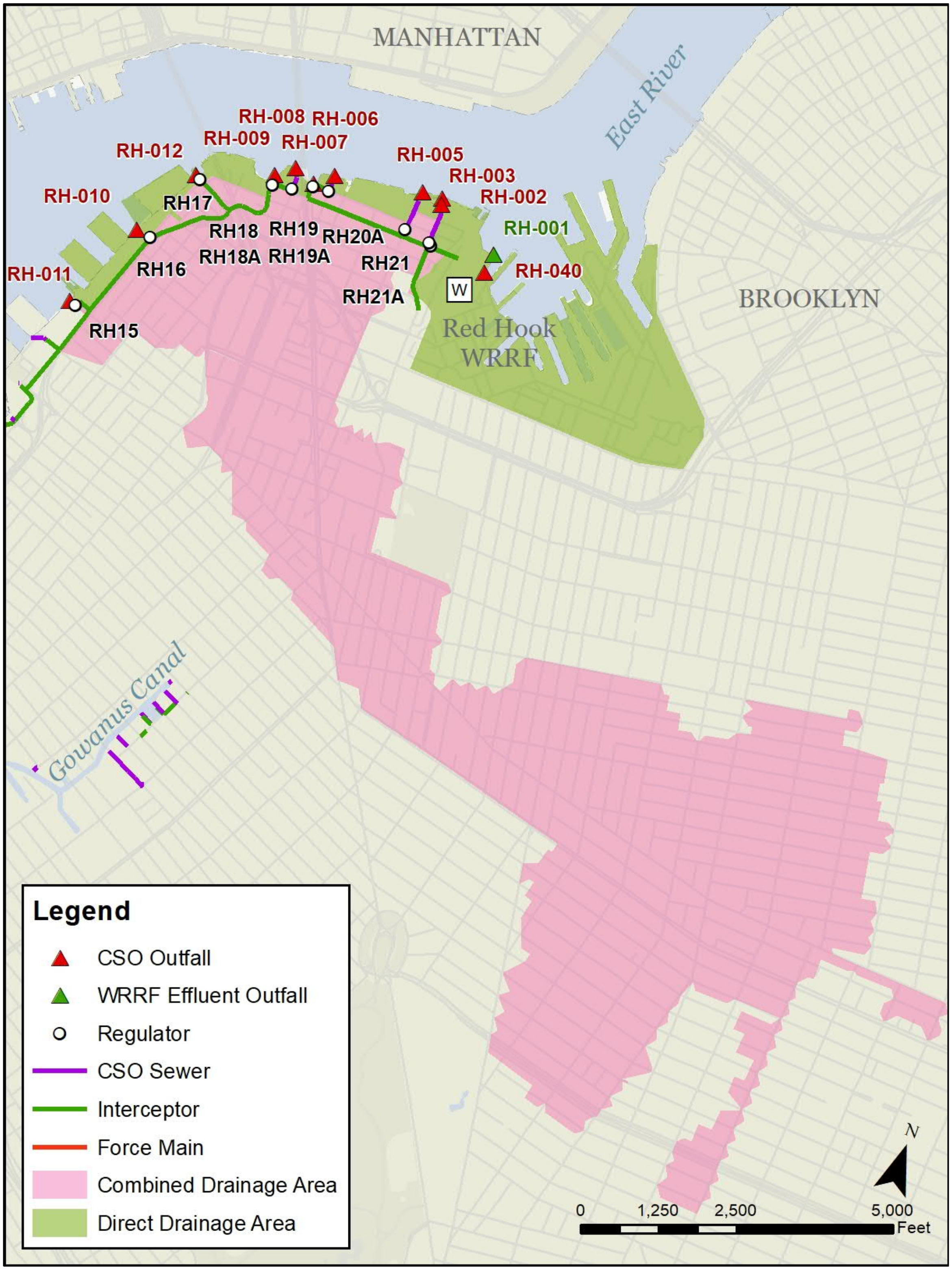

Figure 8.5-15. CSO Outfalls/Regulators Tributary to East River from the Red Hook WRRF System

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8.5.b Storage Tunnel Alternatives for 25/50/75/100 Percent CSO Control

Conceptual storage tunnel alternatives were developed to provide 25, 50, 75, and 100 percent CSO control of the annual CSO volume discharged to the East River in the Typical Year. The approach to sizing and layout of the storage tunnel alternatives was as follows:

- For the 50 percent CSO control tunnel, the Typical Year annual overflow volume of each CSO outfall to the East River was reviewed and combinations of outfalls were identified where capture of 100 percent of the CSO from those outfalls would approximately match 50 percent of the total CSO volume from all outfalls to the East River.
- The locations of these outfalls were assessed in relation to the length and diameter of tunnel needed to capture the outfalls.
- Based on DEP expertise, a combination of outfalls was selected that provided reasonable tunnel length/diameter to provide 50 percent volume capture.
- A similar approach was taken for the 75 percent CSO control tunnel.
- For the 25 percent CSO control tunnel, the 50 percent CSO tunnel was downsized until the volume of storage provided would result in approximately 25 percent CSO control.
- For the 100 percent CSO control tunnel, it was assumed that every CSO outfall to the East River that was predicted to be active in the 2008 Typical Year would be tied into the tunnel. Where multiple outfalls were located in close proximity to each other, it was assumed that a near-surface consolidation conduit would be provided to a single drop shaft.
- For each storage tunnel alternative, the dewatering rate required to dewater the storage tunnel within 24 hours was compared to the available dry-weather flow capacity in the WRRF closest to the downstream end of the tunnel. If insufficient dry-weather flow capacity was available at the WRRF to accept the additional dewatering flows, a high-rate clarification wet-weather flow treatment system with disinfection was added to the alternative to treat the dewatered flow.
- A detailed siting assessment was not conducted, so the specific locations of various features of the tunnel alternatives (mining shaft, TBM removal shaft, drop shafts, dewatering pumping station, dewatered flow treatment facility, near-surface diversion structures/connection conduits) were not identified.

The main features of the 25, 50, 75, and 100 percent CSO control storage tunnel modeling scenarios for the East River are summarized in Table 8.5-16. Figure 8.5-16 to Figure 8.5-19 present conceptual layouts of the storage tunnel alternatives. The 25 percent capture tunnel would capture overflow from Outfalls BB-005, BB-005 (24th Avenue), BB-028, and NCB-014 (Figure 8.5-16). The tunnel would start at a mining shaft in the general vicinity of Outfall NCB-014, and run north along the East River shoreline. The tunnel would pick up Outfall NCB-028, then head towards Bowery Bay to pick up Outfalls BB-005 and BB-005 (24th Avenue). The total tunnel length would be about 42,700 feet (8.1 miles), with a diameter of 17 feet. Under this configuration, the tunnel would be dewatered to the Red Hook WRRF, but it could also be configured to dewater to the Bowery Bay WRRF.

Table 8.5-16. Summary of 25, 50, 75 and 100 Percent CSO Control Alternatives for East River

Alternative	ER-7	ER-8	ER-9			ER-10		
Level of CSO Control(1)	25%	50%	75%			100%		
WRRF Outfalls Captured(2)	BB/NC	HP/BB/NC	BB/NC/RH	TI	HP/WI/NC	BB/NC/RH	TI	HP/WI/NC
Length (mi.)	8.1	15.3	8.1	3	10.8	9.5	2.7	15.9
Diameter (ft.)	17	28	37	17	22	37	17	26
Volume (MG)	71	367	344	23	163	394	23	321
Outfalls Captured	• BB-005 • BB-005 (24th Ave.) • BB-028 • NCB-014	• HP-011 • HP-021 • BB-005 • BB-005 (24th Ave.) • BB-028 • NCB-014	• BB-005 • BB-005 (24th Ave.) • BB-028 • BB-029 • BB-034 • BB-041 • NCB-006 • NCB-013 • NCB-014 • RH-005	• TI-003 • TI-023	• HP-011 • HP-021 • HP-025 • WIM-003 • NCM-036	• 26 BB outfalls • 14 NC outfalls • 12 RH outfalls	• Ti-003 • TI-004 • TI-005 • TI-023	• 12 HP outfalls • 19 WI outfalls • 48 NC outfalls
Net CSO Volume Reduction (MGY)	1,294	2,643	2,482	210	1,132	2,814	213	2,145
Wet-Weather Flow Treatment Facility Capacity for Dewatering Flow (MGD)	71	367	344	23	163	394	23	321
Estimated Probable Bid Cost(3)	$1,500M	$4,700M	$5,100M	$600M	$2,300M	$8,300M	$800M	$9,100M
Total Estimated Probable Bid Cost by Level of Control(3)	$1,500M	$4,700M	$8,000M			$18,200M		

Notes:
(1) Annual percent CSO reduction based on the 2008 Typical Year.
(2) HP = Hunts Point; BB = Bowery Bay; NC = Newtown Creek; RH = Red Hook; TI = Tallman Island; WI = Wards Island
(3) 2019 dollars.

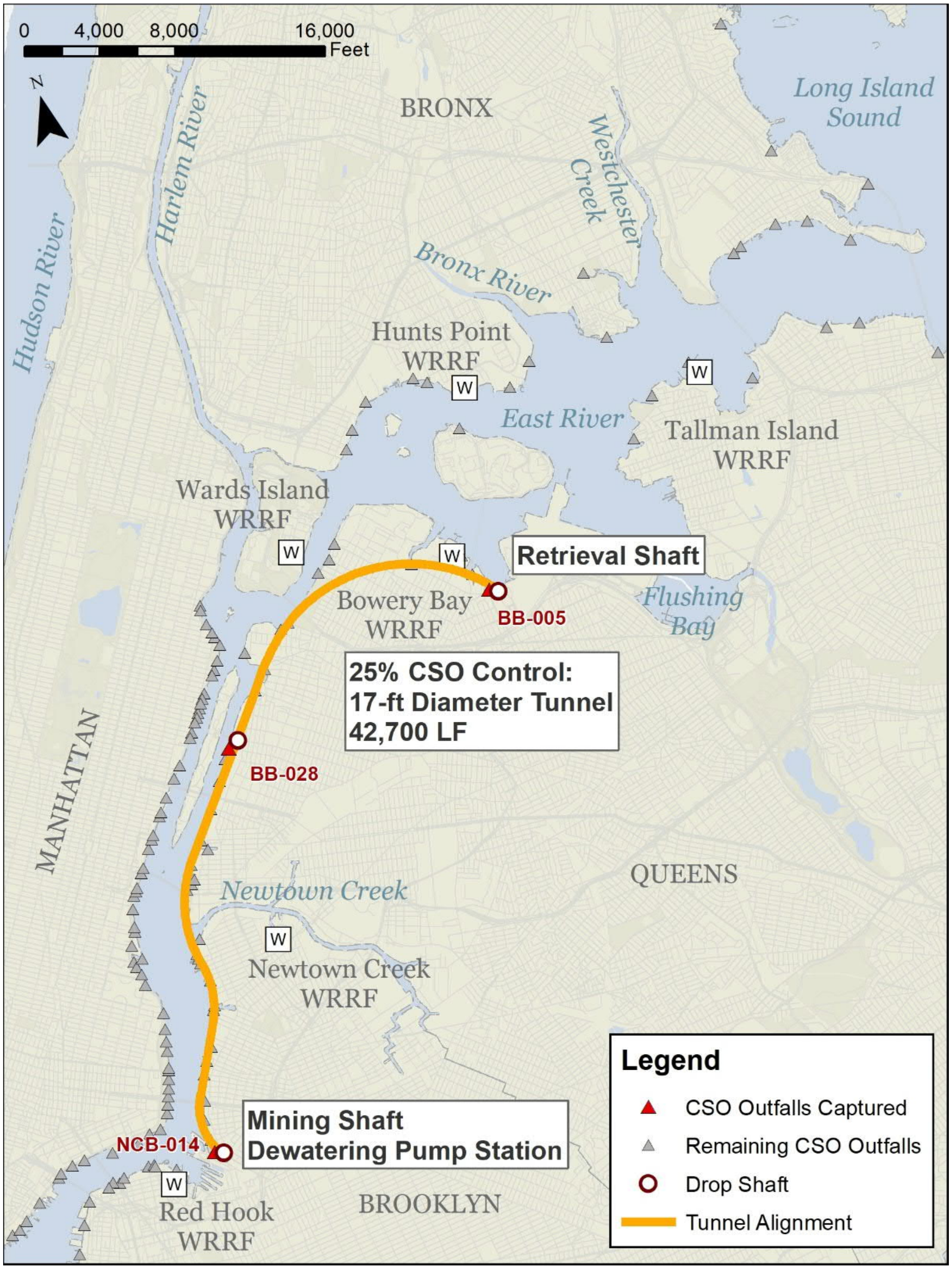

Figure 8.5-16. 25 Percent CSO Control Tunnel for East River

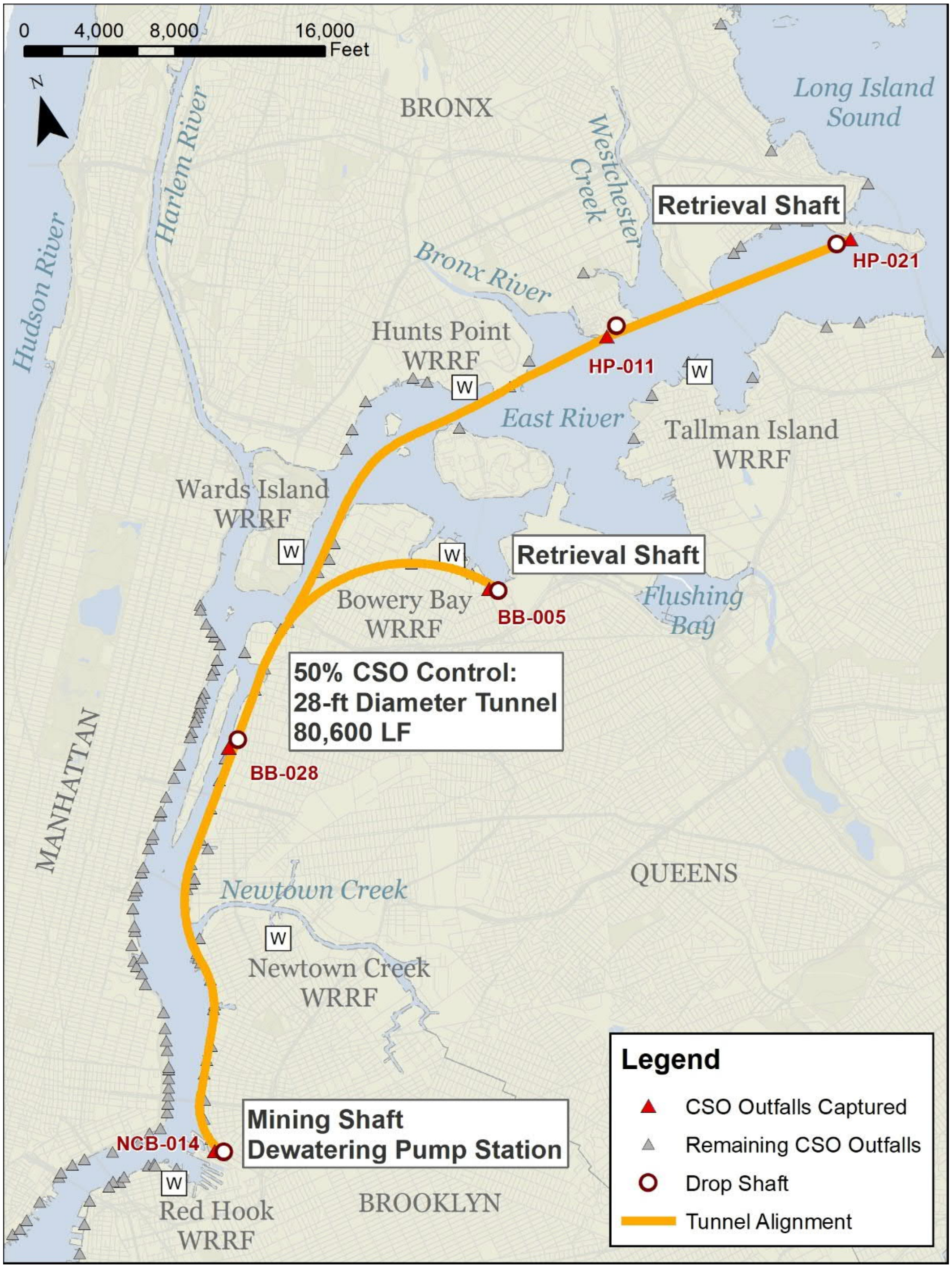

Figure 8.5-17. 50 Percent CSO Control Tunnel for East River

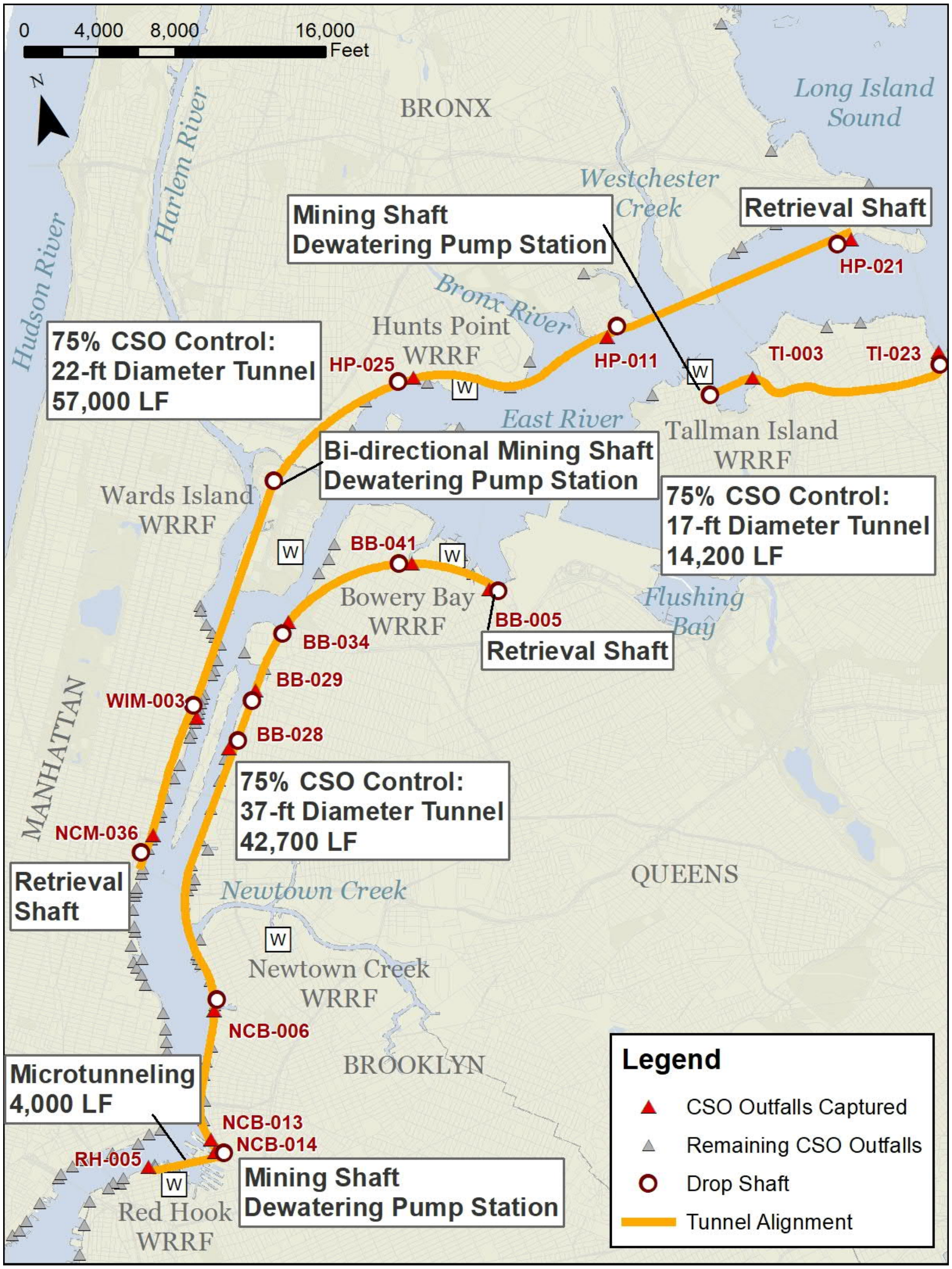

Figure 8.5-18. 75 Percent CSO Control Tunnels for East River

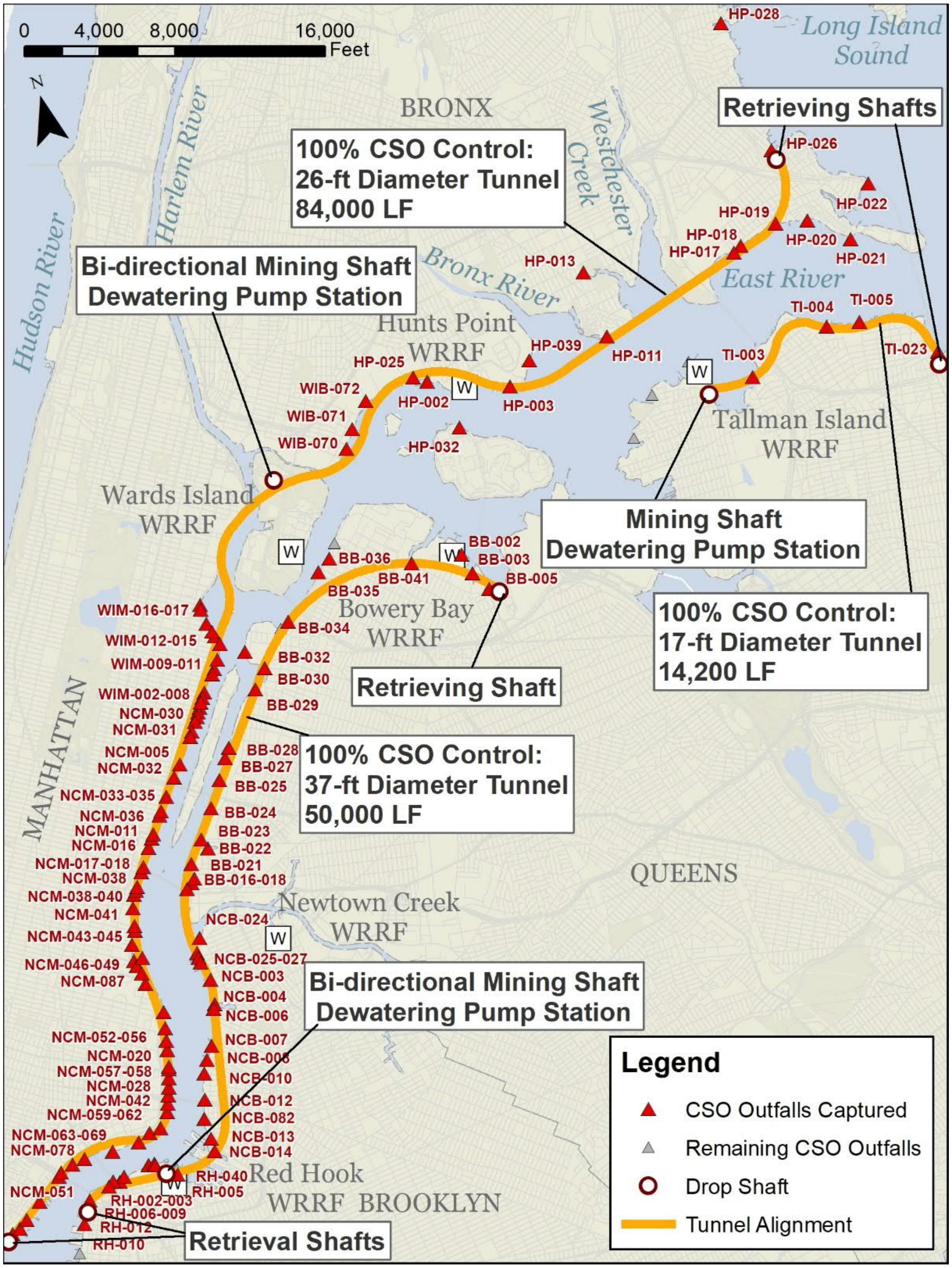

Figure 8.5-19. 100 Percent CSO Control Tunnels for East River

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The 50 percent CSO control tunnel would pick up the same outfalls as the 25 percent CSO control tunnel, but in addition would also pick up Outfalls HP-011 and HP-021. It would run along the same route as the 25 percent CSO control tunnel from Outfall NCB-014 to Outfall BB-028. North of Outfall BB-028, the tunnel would split, with one branch going to Outfall BB-005, and the other branch extending north to pick up Outfalls HP-011 and HP-021 (Figure 8.5-17). The total length of the 50 percent CSO control tunnel would be about 80,600 feet, and the diameter would be 28 feet.

The 75 percent CSO control tunnel capturing the BB/NC/RH outfalls would start near Outfall NCB-014 and run north along the shore of the East River, then turn east towards Bowery Bay (Figure 8.5-18). A separate microtunnel would connect the RH-005 outfall to the downstream end of the tunnel. The tunnel length would be about 42,700 feet (8 miles), with a diameter of 37 feet. For this configuration, the tunnel would be dewatered to the Red Hook WRRF, but the tunnel could be configured to dewater to the Bowery Bay WRRF.

The 75 percent CSO control tunnel capturing the TI outfalls would start with a mining shaft near the Tallman Island WRRF and run across Powell Cove to Outfall TI-003, then east to Outfall TI-023 (Figure 8.5-18). The tunnel length would be about 14,200 feet (3 miles), with a diameter of 17 feet. For this configuration, the tunnel would be dewatered to the Tallman Island WRRF.

The 75 percent CSO control tunnel capturing the HP/WI/NC outfalls would start with a mining shaft in the vicinity of the Wards Island WRRF, and run along the shoreline of the East River north and east to Outfall HP-021, and south to Outfall NCM-036 (Figure 8.5-18). The tunnel length would be about 57,000 feet (11 miles), with a diameter of 22 feet. For this configuration, the tunnel would be dewatered to the Wards Island WRRF.

The 100 percent CSO control tunnel capturing the BB/NC/RH outfalls would be configured similar to the 75 percent CSO control tunnel, but the southern end would be extended past Outfall NCB-014 to Outfall RH-012 (Figure 8.5-19). The tunnel length would be about 50,000 feet (10 miles), with a diameter of 37 feet. For this configuration, the tunnel would be dewatered to the Red Hook WRRF, but the tunnel could be configured to dewater to the Bowery Bay WRRF.

The 100 percent CSO control tunnel capturing the TI outfalls would start with a mining shaft near Outfall TI-019, and run west along the shoreline of the East River to Outfall TI-023 (Figure 8.5-19). The mining shaft could also be located near the Tallman Island WRRF, with the tunnel running in two directions from that location. The tunnel length would be about 20,600 feet (4 miles), with a diameter of 14 feet. For this configuration, the tunnel would be dewatered to the Tallman Island WRRF.

The 100 percent CSO control tunnel capturing the HP/WI/NC outfalls would start with a mining shaft in the vicinity of the Wards Island WRRF, and run along the shoreline of the East River north and east to Outfall HP-026, and south to Outfall NCM-069 (Figure 8.5-19). Multiple near-surface consolidation conduits would be provided to convey flow from adjacent outfalls to common drop shafts. The tunnel length would be about 84,000 feet (16 miles), with a diameter of 26 feet. For this configuration, the tunnel would be dewatered to the Wards Island WRRF.

The dewatering capacity needed and the location where the dewatering flow would be conveyed for treatment varies with each of the alternatives described above. However, dedicated wet-weather high-rate treatment facilities would be necessary for the treatment of the CSO retained in the storage tunnel.

While these alternatives provide relatively high levels of CSO control, the significant challenges to implementation include:

- Very high implementation cost
- Limited siting availability for shafts, dewatering pumping station, dewatering flow treatment facility
- Long implementation period
- Significant and prolonged construction impacts (truck traffic, noise, dust) for surface consolidation sewers due to the large number of drop shafts necessary to divert CSO to the tunnel
- Negligible improvement in the annual attainment of applicable water quality standards
- Construction impacts and likelihood of utility conflicts for near-surface diversion structures and connecting conduits

Despite these challenges, these alternatives were retained in order to provide an assessment of a range of levels of CSO control for the East River, per the CSO Control Policy and the Clean Water Act.

8.5.c Summary of Retained Alternatives for East River

The goal of the previous evaluations was to develop a list of retained CSO control measures for the East River. These CSO control measures, whether individually or in combination, form the basis of basin-wide alternatives to be assessed using more rigorous cost-performance and cost-attainment analyses. Table 8.5-17 lists all of the CSO control measures originally identified in the "Alternatives Toolbox" shown above in Figure 8.5-2, and identifies whether the CSO control measure was retained for further analysis. The reasons for excluding the non-retained CSO control measures from further consideration are also noted in the table.

Table 8.5-17. Summary of Control Measure Screening for East River

Control Measure	Category	Retained for Further Analysis?	Remarks
Additional GI Build-out	Source Control	NO(1)	Planned GI build-out in the watershed is included in the baseline. It is unlikely that additional sites will be identified due to site constraints in publicly owned properties.
High Level Storm Sewers	Source Control	NO(1)	No cost-effective opportunities identified
Regulator Modifications	System Optimization	YES	Incorporated into optimization alternatives ER-1, ER-2, ER-5 and ER-6.
Parallel Interceptor Sewer	System Optimization	YES	Incorporated into optimization alternatives ER-1, ER-2 and ER-6.
Bending Weirs/Control Gates	System Optimization	NO	No cost-effective or constructible site opportunities were identified
Pumping Station Optimization	System Optimization	NO	Limited benefit in terms of CSO reduction.

Table 8.5-17. Summary of Control Measure Screening for East River

Control Measure	Category	Retained for Further Analysis?	Remarks
Pumping Station Expansion	System Optimization	NO	Limited benefit in terms of CSO reduction.
Gravity Flow Redirection to Other Watersheds	CSO Relocation	YES	Optimization Alternatives ER-1 and ER-2 shift some CSO volume between the East River and other waterbodies
Pumping Station Modification	CSO Relocation	NO	No cost-effective opportunities identified.
Flow Redirection with Conduit and Pumping	CSO Relocation	NO	No cost-effective opportunities identified.
Floatables Control	Floatables Control	YES	Programmatic floatables control will be applied and expanded Citywide
Environmental Dredging	Water Quality/ Ecological Enhancement	NO	No specific locations of CSO sediment mounding identified.
Wetland Restoration and Daylighting	Water Quality/ Ecological Enhancement	NO	No daylighting opportunities were identified.
Outfall Disinfection	Treatment: Satellite	NO	Not feasible due to short length of outfalls.
Retention/Treatment Basins	Treatment: Satellite	NO	Significant siting constraints and very high costs. Tunnel storage covers 25/50/75/100% CSO control alternatives.
High-Rate Clarification	Treatment: Satellite	YES	Incorporated into the storage tunnel alternatives for treatment of captured CSO during tunnel dewatering.
WRRF Expansion	Centralized Treatment	NO	Insufficient space available. Limited benefit compared to potential cost.
In-System Storage (Outfalls)	Storage	NO	Negligible levels of CSO control due to short outfalls.
Off-line Storage (Tanks)	Storage	NO	Significant siting constraints and very high costs. Tunnel storage covers 25/50/75/100% CSO control alternatives.
Off-line Storage (Tunnels)	Storage	YES	Tunnel storage alternatives ER-7, ER-8, ER-9 and ER-10 cover 25/50/75/100% CSO control.

Note:

(1) Additional GI and HLSS are considered to be ongoing programs that will continue to be implemented system-wide outside of the LTCP program.

As shown, the retained CSO control measures include system optimization measures, tunnel storage (with high-rate clarification for dewatering flows), and programmatic floatables control.

8.5.d CSO Volume and Loading Reductions for Retained Alternatives for East River

Table 8.5-18 summarizes the projected performance of the retained East River alternatives in terms of annual CSO volume and fecal coliform load reduction, based on the 2008 Typical Year. These data are plotted on Figure 8.5-20. In all cases, the predicted reductions shown are relative to the Baseline Conditions using 2008 JFK rainfall as described in Section 6. The baseline assumptions were described in detail in Section 6 and include the implementation of the grey infrastructure projects from the approved WWFPs, the Recommended Plans from the previously submitted LTCPs, and the projected level of GI identified in Section 5.

Table 8.5-18. East River Retained Alternatives Performance Summary (2008 Rainfall)

Alternative	Annual Performance Based on 2008 Typical Year				
	Remaining CSO Volume (MGY) (1)	Frequency of Overflow (2)	Additional Untreated CSO Volume to Other Waterbodies (MGY) (3)	Net CSO Volume Reduction (%)	Net Fecal Coliform Reduction (%)
Baseline Conditions	5,193	61	-	-	-
ER-1. Optimization of Regulators Associated with Outfall HP-025	5,156	61	16	<1	<1
ER-2. Optimization of Regulators Associated with Outfalls HP-016, HP-018, HP-019 and HP-025	5,159	61	12	<1	<1
ER-5. Optimization of Regulators Associated with Outfall TI-023	5,151	61	0	<1	<1
ER-6. Optimization of Regulators Associated with Outfalls TI-003 and TI-023	5,107	61	0	2	2
ER-7. Tunnel Storage for 25% CSO Control (52 MG Capacity)	3,898	61	0	25	25
ER-8. Tunnel Storage for 50% CSO Control (371 MG Capacity)	2,550	61	0	51	51
ER-9. Tunnel Storage for 75% CSO Control (529 MG Capacity)	1,369	46	0	74	74
ER-10. Tunnel Storage for 100% CSO Control (758 MG Capacity)	0	0	0	100	100

Notes:

(1) Remaining CSO includes all discharges to the East River from the Tallman Island, Hunts Point, Bowery Bay, Red Hook, Newtown Creek, North River, and Wards Island WRRF Collection Systems.
(2) Frequency of overflow is based upon the most frequently active CSO outfall.
(3) Additional untreated CSO volume to other waterbodies accounts for increases at other CSO outfalls in response to the implementation of a CSO control alternative. Net CSO volume reduction and net fecal coliform reduction account for any additional CSO discharge to other waterbodies.

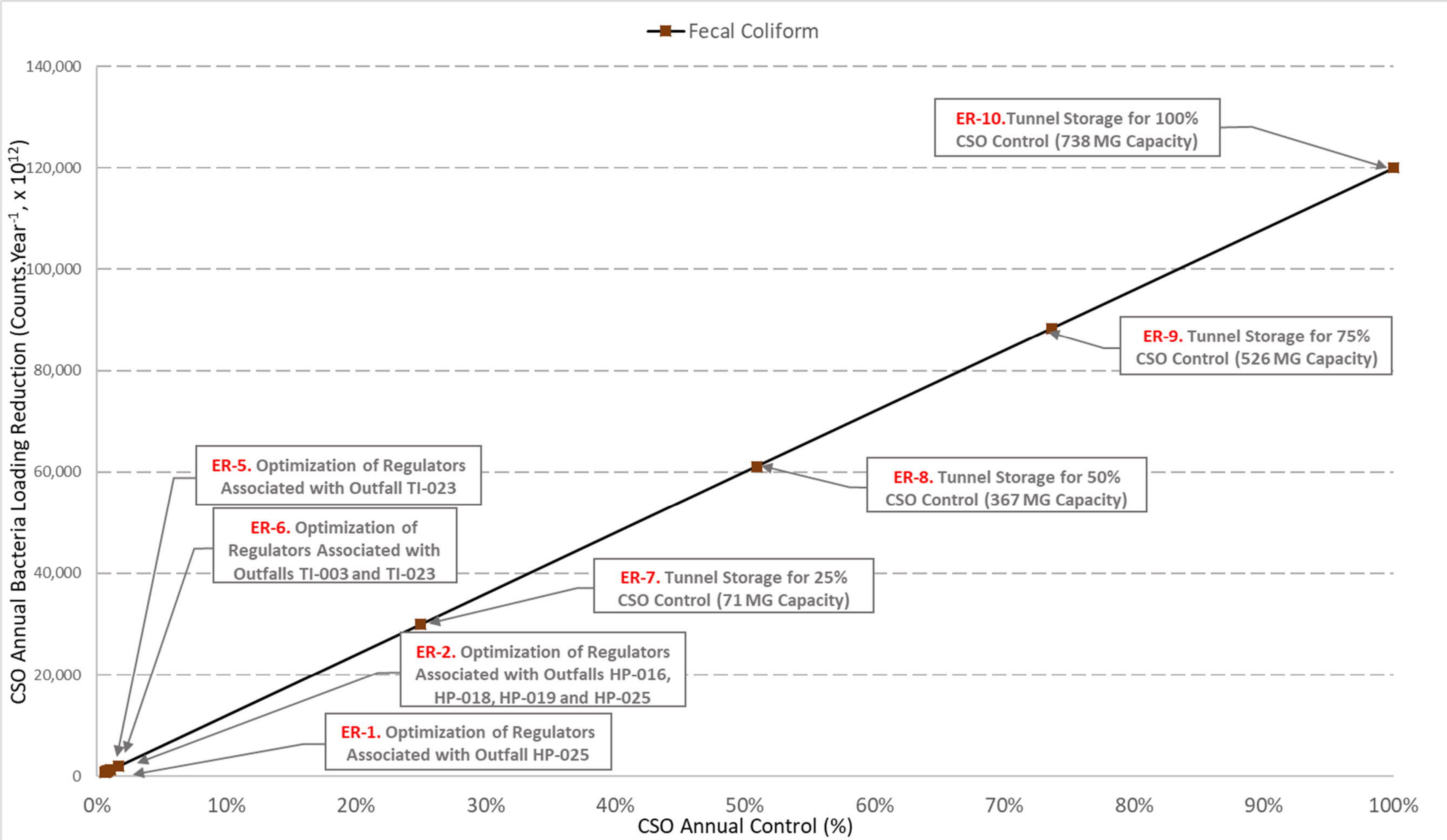

Figure 8.5-20. Untreated CSO Volume Reductions (as % CSO Annual Control) vs. Annual CSO Bacteria Loading Reduction (2008 Typical Year) for East River

Because the retained alternatives for the East River provide volume reduction and not treatment, the predicted bacteria loading reductions of the alternatives are very closely aligned with their projected CSO volume reductions.

8.5.e Cost Estimates for East River Retained Alternatives

Evaluation of the retained alternatives requires cost estimation. The methodology for developing these costs is dependent upon the type of technology and its O&M requirements. The construction costs were developed as Probable Bid Costs (PBC) and the total Net Present Worth (NPW) costs were determined by adding the estimated PBC to the NPW of the projected annual O&M costs at an assumed interest rate of 3 percent over a 100-year life cycle. Design, construction management, and land acquisition costs are not included in the cost estimates. All costs are in 2019 dollars and are considered Level 5 cost estimates by AACE International with an accuracy of -50 percent to +100 percent.

8.5.e.1 Alternative ER-1. Optimization of Outfall HP-025

Costs for Alternative ER-1 include planning-level estimates of the costs to optimize the performance of Regulator HP-8 associated with Outfall HP-025 and reflect the description provided in Section 8.5.a. Site acquisition costs are not included. The total cost, expressed as NPW, for Alternative ER-1 is $16M as shown in Table 8.5-19.

Table 8.5-19. Costs for Alternative ER-1

Item	2019 Cost ($ Million)
Probable Bid Cost	$16
Annual O&M Cost	$0
Net Present Worth	$16

8.5.e.2 Alternative ER-2. Optimization of Outfalls HP-016, HP-018, HP-019 and HP-025

Costs for Alternative ER-2 include planning-level estimates of the costs to optimize the performance of Regulators HP-4, HP-12, HP-3, and HP-8 associated with Outfalls HP-016, HP-018, HP-019, and HP-025 and reflects the description provided in Section 8.5.a. Site acquisition costs are not included. The total cost, expressed as NPW, for Alternative ER-2 is $24M as shown in Table 8.5-20.

Table 8.5-20. Costs for Alternative ER-2

Item	2019 Cost ($ Million)
Probable Bid Cost	$24
Annual O&M Cost	$0
Net Present Worth	$24

8.5.e.3 Alternative ER-5. Optimization of Outfall TI-023

Costs for Alternative ER-5 include planning-level estimates of the costs to install a bending weir at Regulator TI-13 associated with Outfall TI-023 and reflects the description provided in Section 8.5.a. Site acquisition costs are not included. The total cost, expressed as NPW, for Alternative ER-5 is $4M as shown in Table 8.5-21.

Table 8.5-21. Costs for Alternative ER-5

Item	2019 Cost ($ Million)
Probable Bid Cost	$3
Annual O&M Cost	$1
Net Present Worth	$4

8.5.e.4 Alternative ER-6. Optimization of Outfalls TI-003 and TI-023

Costs for Alternative ER-6 include planning-level estimates of the costs to optimize Regulator TI-10B (Outfall TI-003) and install a bending weir at Regulator TI-13 (Outfall TI-023) and reflects the description provided in Section 8.5.a. Site acquisition costs are not included. The total cost, expressed as NPW, for Alternative ER-6 is $7M as shown in Table 8.5-22.

Table 8.5-22 Costs for Alternative ER-6

Item	2019 Cost ($ Million)
Probable Bid Cost	$6
Annual O&M Cost	$1
Net Present Worth	$7

8.5.e.5 Alternative ER-7. Tunnel Storage for 25 Percent CSO Control

Costs for Alternative ER-7 include planning-level estimates of the costs for a CSO storage tunnel sized for 25 percent CSO control. A description of the tunnel components is provided in Section 8.5.b and illustrated in Table 8.5-16. Site acquisition costs are not included. The total cost, expressed as NPW, for Alternative ER-7 is $1,700M as shown in Table 8.5-23.

Table 8.5-23. Costs for Alternative ER-7

Item	2019 Cost ($ Million)
Probable Bid Cost	$1,500
Annual O&M Cost	$6
Net Present Worth	$1,700

8.5.e.6 Alternative ER-8. Tunnel Storage for 50 Percent CSO Control

Costs for Alternative ER-8 include planning-level estimates of the costs for a CSO storage tunnel sized for 50 percent CSO control. A description of the optimization components is provided in Section 8.5.b and illustrated in Table 8.5-16. Site acquisition costs are not included. The total cost, expressed as NPW, for Alternative ER-8 is $5,200M as shown in Table 8.5-24.

Table 8.5-24. Costs for Alternative ER-8

Item	2019 Cost ($ Million)
Probable Bid Cost	$4,700
Annual O&M Cost	$16
Net Present Worth	$5,200

8.5.e.7 Alternative ER-9. Tunnel Storage for 75 Percent CSO Control

Costs for Alternative ER-9 include planning-level estimates of the costs for the three CSO storage tunnels sized for 75 percent CSO control. A description of the optimization components is provided in Section 8.5.b and illustrated in Table 8.5-16. Site acquisition costs are not included. The total cost, expressed as NPW, for Alternative ER-9 is $9,000M as shown in Table 8.5-25.

Table 8.5-25. Costs for Alternative ER-9

Item	2019 Cost ($ Million)
Probable Bid Cost	$8,000
Annual O&M Cost	$30
Net Present Worth	$9,000

8.5.e.8 Alternative ER-10. Tunnel Storage for 100 Percent CSO Control

Costs for Alternative ER-10 include planning-level estimates of the costs for the three CSO storage tunnels sized for 100 percent CSO control. A description of the optimization components is provided in Section 8.5.b and illustrated in Table 8.5-16. Site acquisition costs are not included. The total cost, expressed as NPW, for Alternative ER-9 is $19,900M as shown in Table 8.5-26.

Table 8.5-26. Costs for Alternative ER-10

Item	2019 Cost ($ Million)
Probable Bid Cost	$18,200
Annual O&M Cost	$37
Net Present Worth	$19,400

The cost estimates of these retained alternatives are summarized below in Table 8.5-27 and are then used in the development of the cost-performance and cost-attainment plots presented in Section 8.5.f.

Table 8.5-27. Cost of Retained Alternatives

Alternative	PBC(1) ($ Million)	Annual O&M Cost ($ Million/Year)	Total Net Present Worth(2) ($ Million)
ER-1. Optimization of Regulators Associated with Outfall HP-025	$16	$0	$16
ER-2. Optimization of Regulators Associated with Outfalls HP-016, HP-018, HP-019, and HP-025	$24	$0	$24
ER-5. Optimization of Regulators Associated with Outfall TI-023	$3	$1	$4
ER-6. Optimization of Regulators Associated with Outfalls TI-003 and TI-023	$6	$1	$7
ER-7. Tunnel Storage for 25% CSO Control (52 MG Capacity)	$1,500	$6	$1,700
ER-8. Tunnel Storage for 50% CSO Control (371 MG Capacity)	$4,700	$16	$5,200
ER-9. Tunnel Storage for 75% CSO Control (529 MG Capacity)	$8,000	$30	$9,000
ER-10. Tunnel Storage for 100% CSO Control (758 MG Capacity)	$18,200	$37	$19,400

Notes:
(1) The Probable Bid Cost (PBC) for the construction contract based upon 2019 dollars.
(2) The Net Present Worth (NPW) is based upon a 100-year service life for tunnels and is calculated by multiplying the annual O&M cost by a present worth of 31.599 and adding this value to the PBC.

8.5.f Cost-Benefit Curves for Retained Alternatives

The final step of the analysis is to evaluate the cost-effectiveness of the basin-wide retained alternatives based on their NPW and projected impact on CSO loadings and attainment of applicable WQS. Section 8.5.f.1 below presents plots of cost versus CSO volume and bacteria load reduction (Cost-Performance Curves), and Section 8.5.g below presents plots of cost versus percent attainment with WQS for selected points along the East River (Cost-Attainment Curves).

8.5.f.1 Cost-Performance Curves

Cost-performance curves were developed by plotting the costs of the retained alternatives against their predicted level of CSO control, both in terms of CSO volume reduction, and in bacteria load reduction. In each case, a best-fit cost curve was developed based on those alternatives judged most cost-effective for a defined level of CSO control as estimated by IW modeling for the typical year rainfall (2008).

Figure 8.5-21 presents a plot of CSO volume reduction versus NPW for the retained alternatives, while Figure 8.5-22 plots the cost of the alternatives against fecal coliform loading reductions.

8.5.g Cost-Attainment Curves

This section evaluates the relationship of the costs of the retained alternatives versus their expected level of attainment of bacteria Primary Contact WQ Criteria as modeled using the LTCPRM water quality model for the 10-year simulation. As indicated in Section 6, based on the 10-year WQ simulations for the East River/Long Island Sound, for the Class SB Coastal Primary Recreational waters of Long Island Sound, east of the Throgs Neck Bridge, the Class SB Coastal Primary Recreational WQ Criteria for *Enterococci* and the Class SB WQ criteria for fecal coliform are both met at least 95 percent of the time under Baseline Conditions. Similarly, for the Class SB waters of the East River between the Whitestone Bridge and the Throgs Neck Bridge, as well as the Class I waters of the East River west and south of the Whitestone Bridge, the WQ criteria for fecal coliform are met at least 95 percent of the time under Baseline Conditions.

As a result, implementation of any of the retained alternatives described above, including the 100 percent CSO capture tunnel, results in nominal improvement in the percent attainment of WQ criteria applicable to each reach of the waterbody. Cost-attainment plots are presented below for four locations along the East River/Long Island Sound:

- LTCP sampling Station E-2, located in the Coastal Primary Recreational Class SB Long Island Sound east of Weir Creek (Figure 8.5-23)
- LTCP sampling Station E-5, located in the Class SB reach of the East River between the Throgs Neck and Whitestone Bridges (Figure 8.5-24)
- LTCP sampling Station E-7, located in the Class I reach of the East River adjacent to Bowery Bay (Figure 8.5-25)
- LTCP sampling Station E-12, located in the Class I reach of the East River adjacent to Newtown Creek (Figure 8.5-26)

The locations of these stations are shown on Figure 8.5-32 below. The plots show NPW versus percent attainment with the applicable WQ criteria for bacteria. Figure 8.5-23 shows the attainment with the Class SB WQ criteria for fecal coliform on both an annual and recreational season (May 1st through October 31st) basis, and the attainment with the Class SB Coastal Primary Recreational WQ Criteria for *Enterococci* (30-day geometric mean and STV, recreational season basis). The plots for all four criteria are superimposed on each other at the 100 percent value.

Figure 8.5-24 shows the attainment with the Class SB WQ criteria for fecal coliform on both an annual and recreational season (May 1st through October 31st) basis. The two are superimposed on each other at the 100 percent value.

Figure 8.5-25 and Figure 8.5-26 show the attainment with the Class I WQ criteria for fecal coliform on both an annual and recreational season (May 1st through October 31st) basis. For each figure, the two plots are superimposed on each other at the 100 percent value.

These plots indicate that each of the retained alternatives represent essentially no performance improvement in terms of percent attainment with WQ criteria at highly variable levels of cost, due to the 100 percent level of attainment under Baseline Conditions.

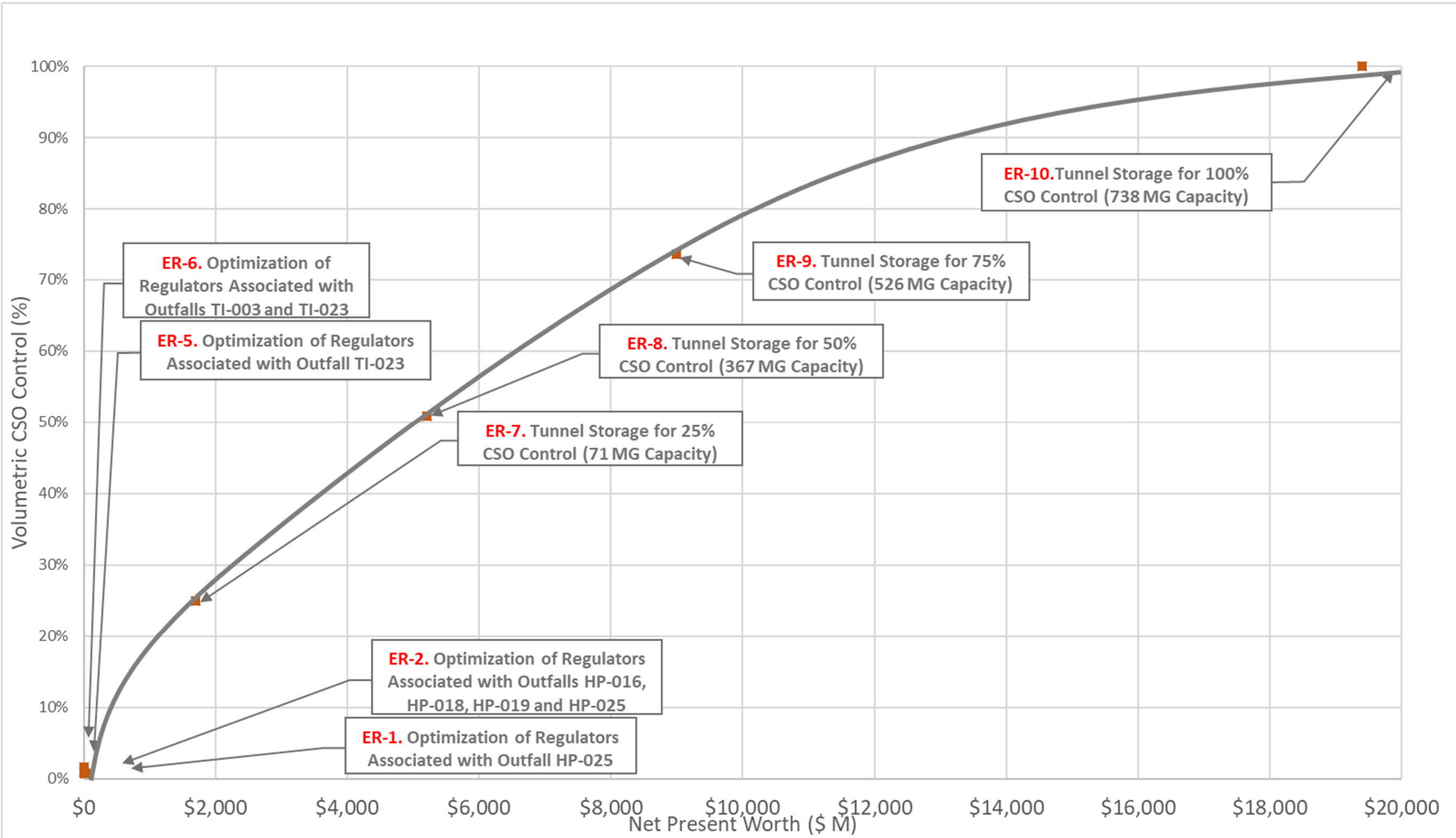

Figure 8.5-21. Cost vs. CSO Control – East River (2008 Typical Year)

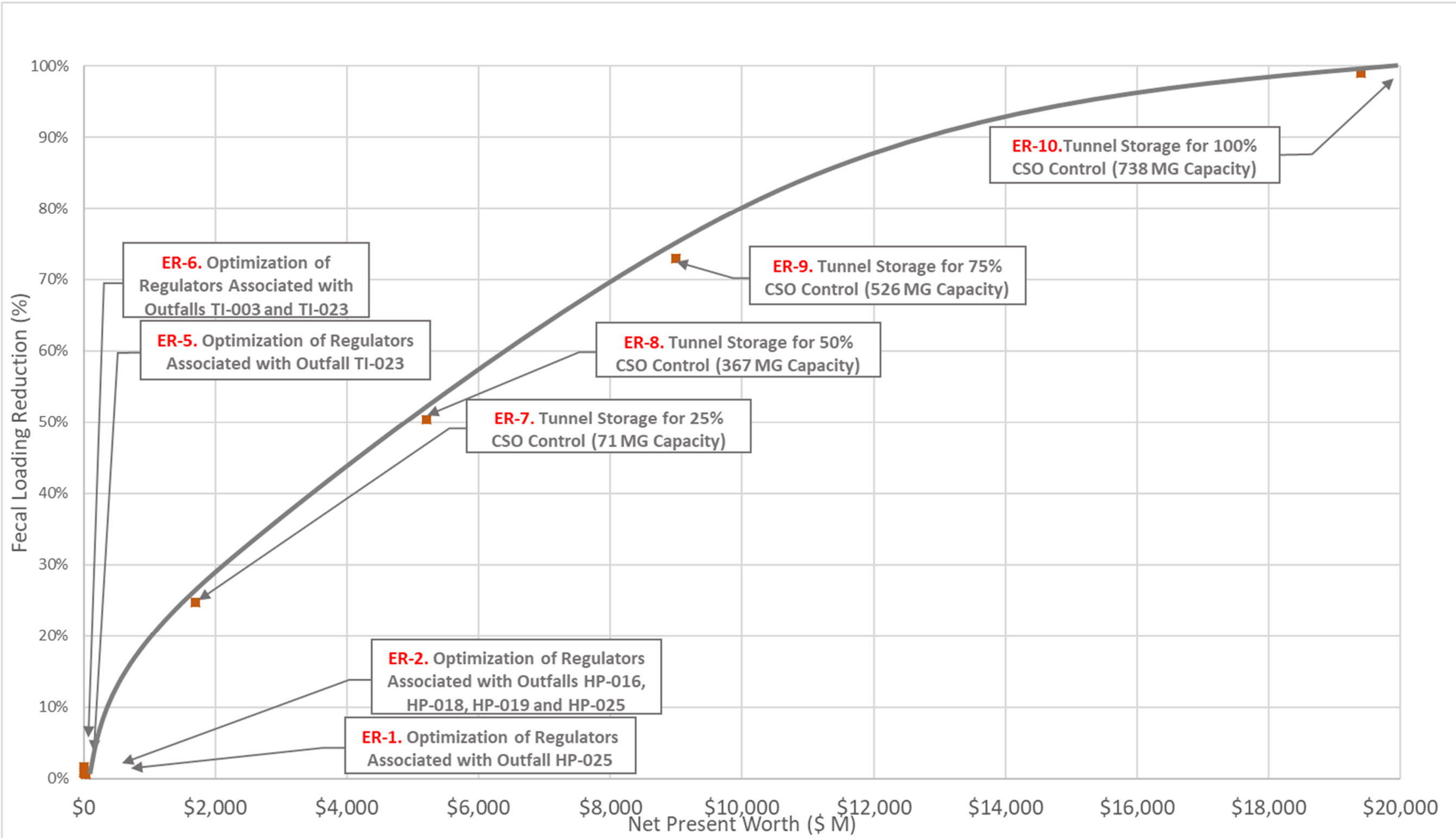

Figure 8.5-22. Cost vs. Fecal Coliform Loading Reduction – East River (2008 Typical Year)

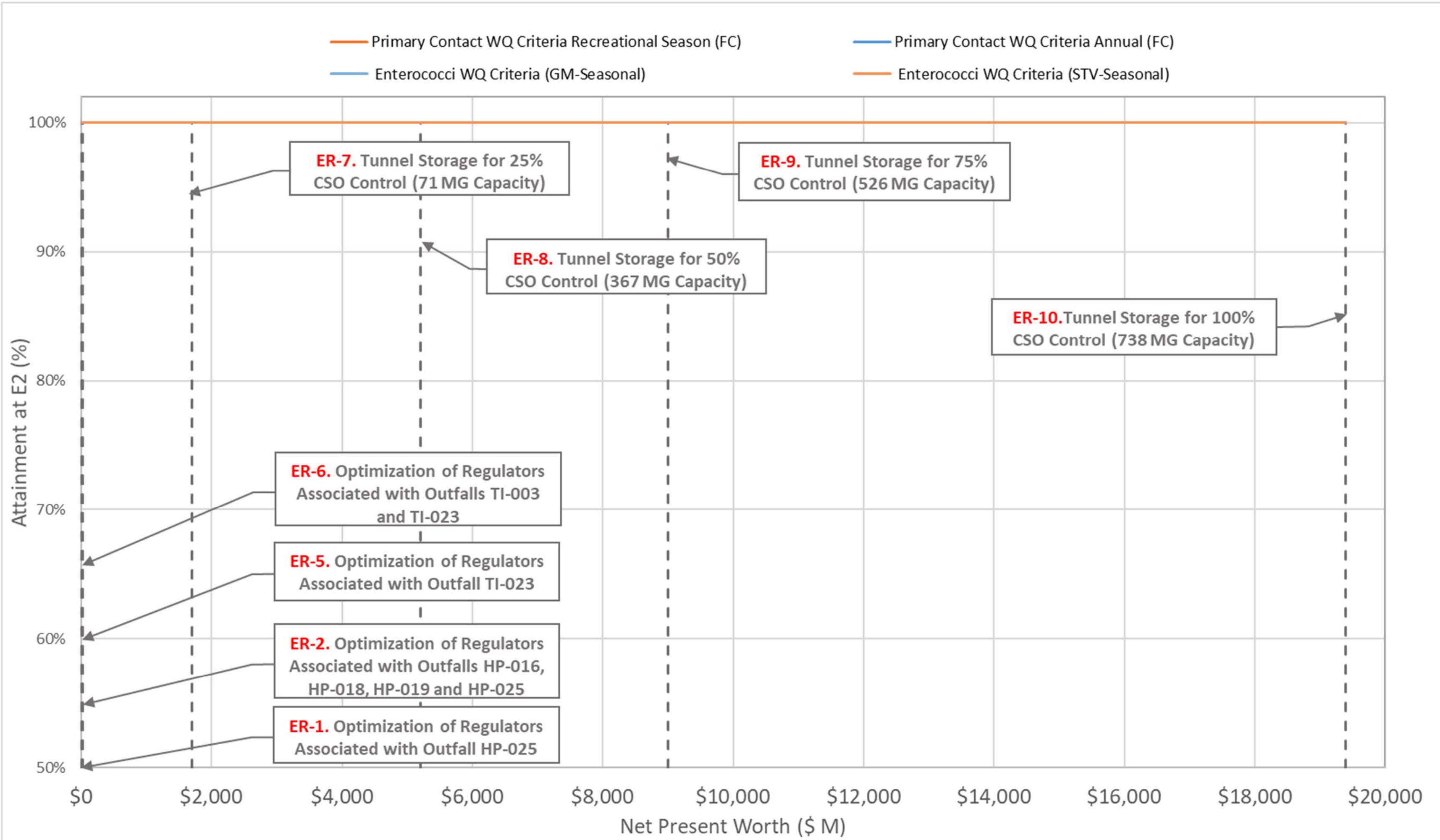

Figure 8.5-23. Cost vs. Bacteria Attainment at Class SB Coastal Primary Recreational Station E-2

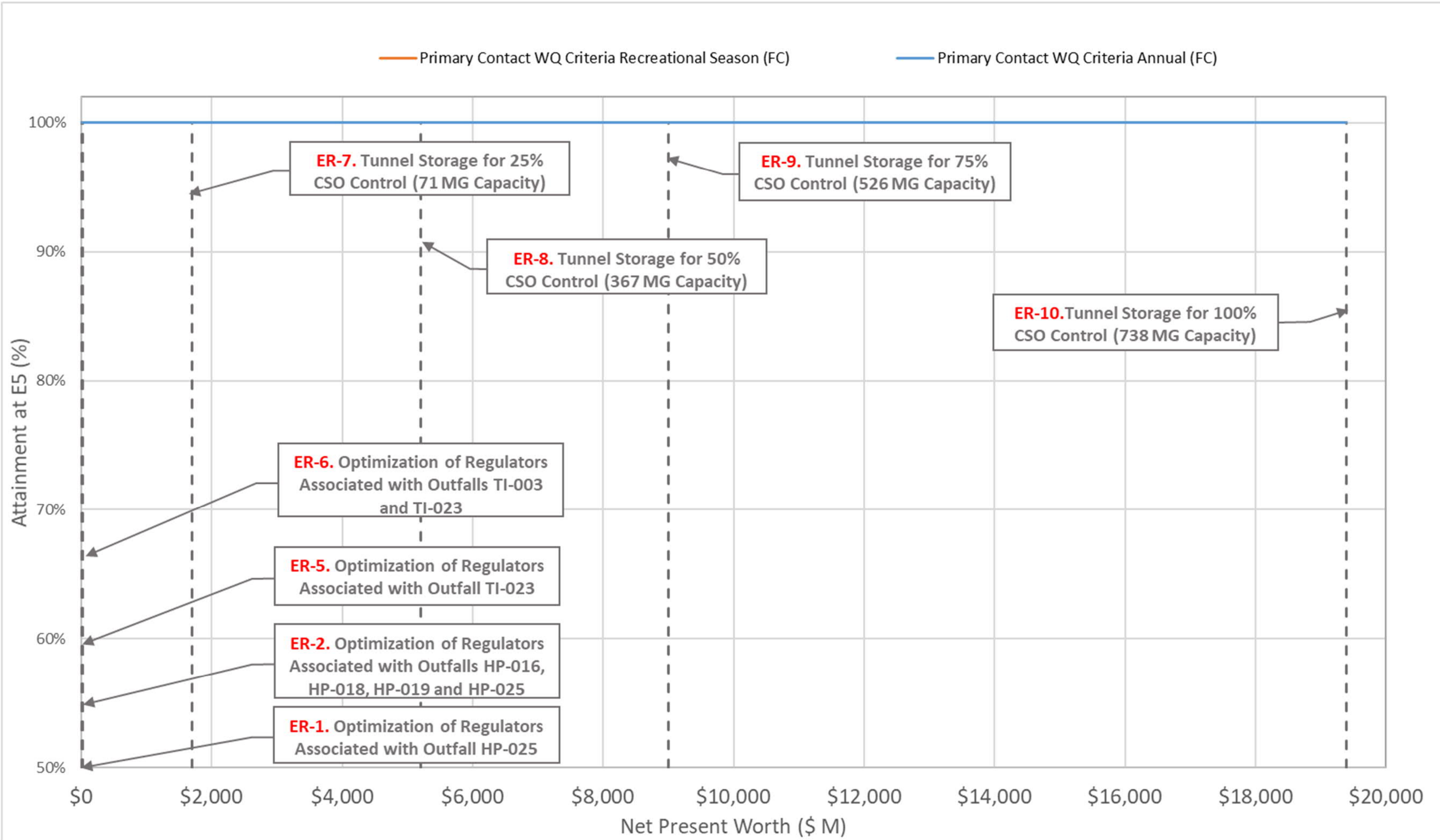

Figure 8.5-24. Cost vs. Bacteria Attainment at Class SB Station E5

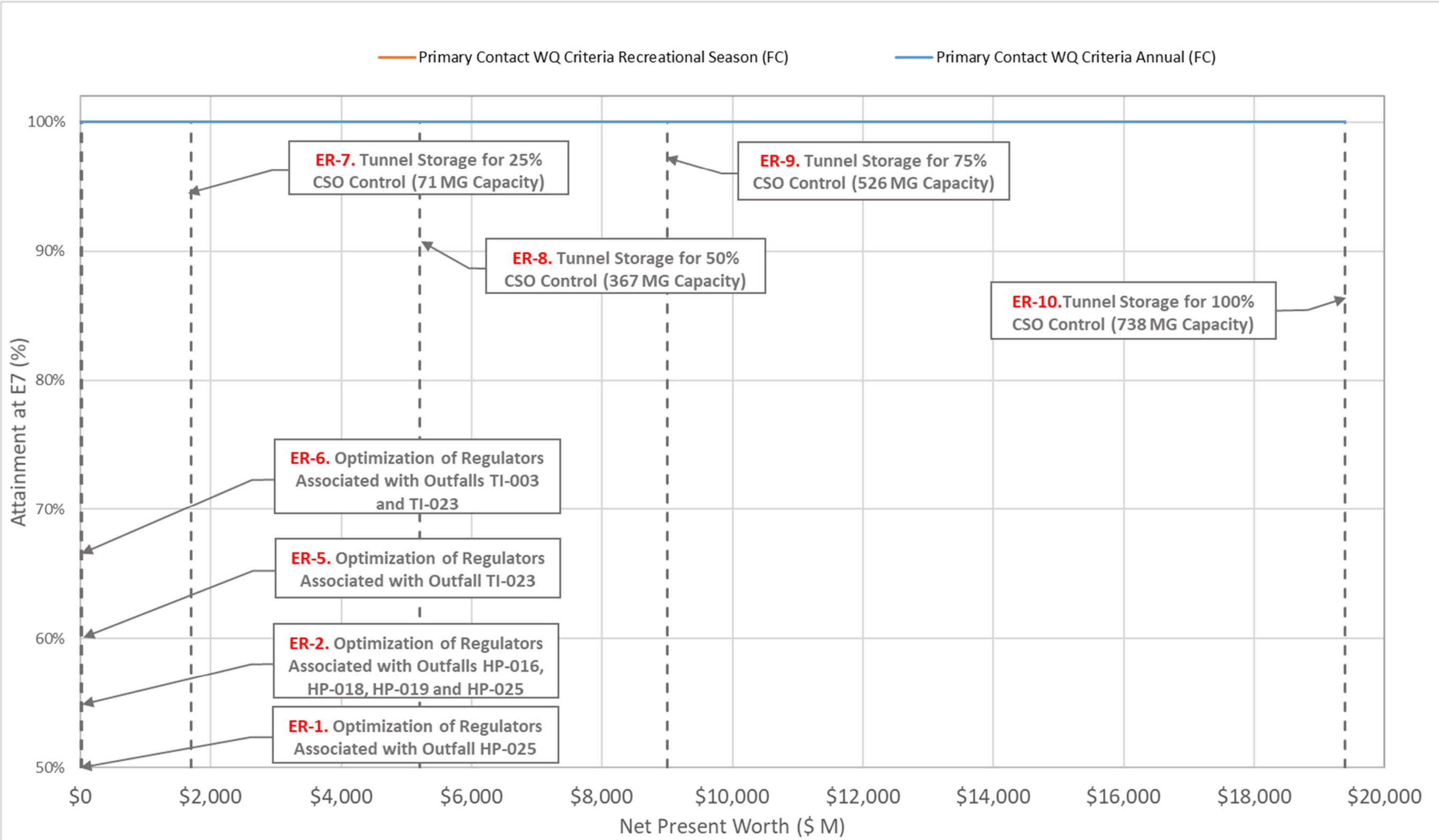

Figure 8.5-25. Cost vs. Bacteria Attainment at Class I Station E7

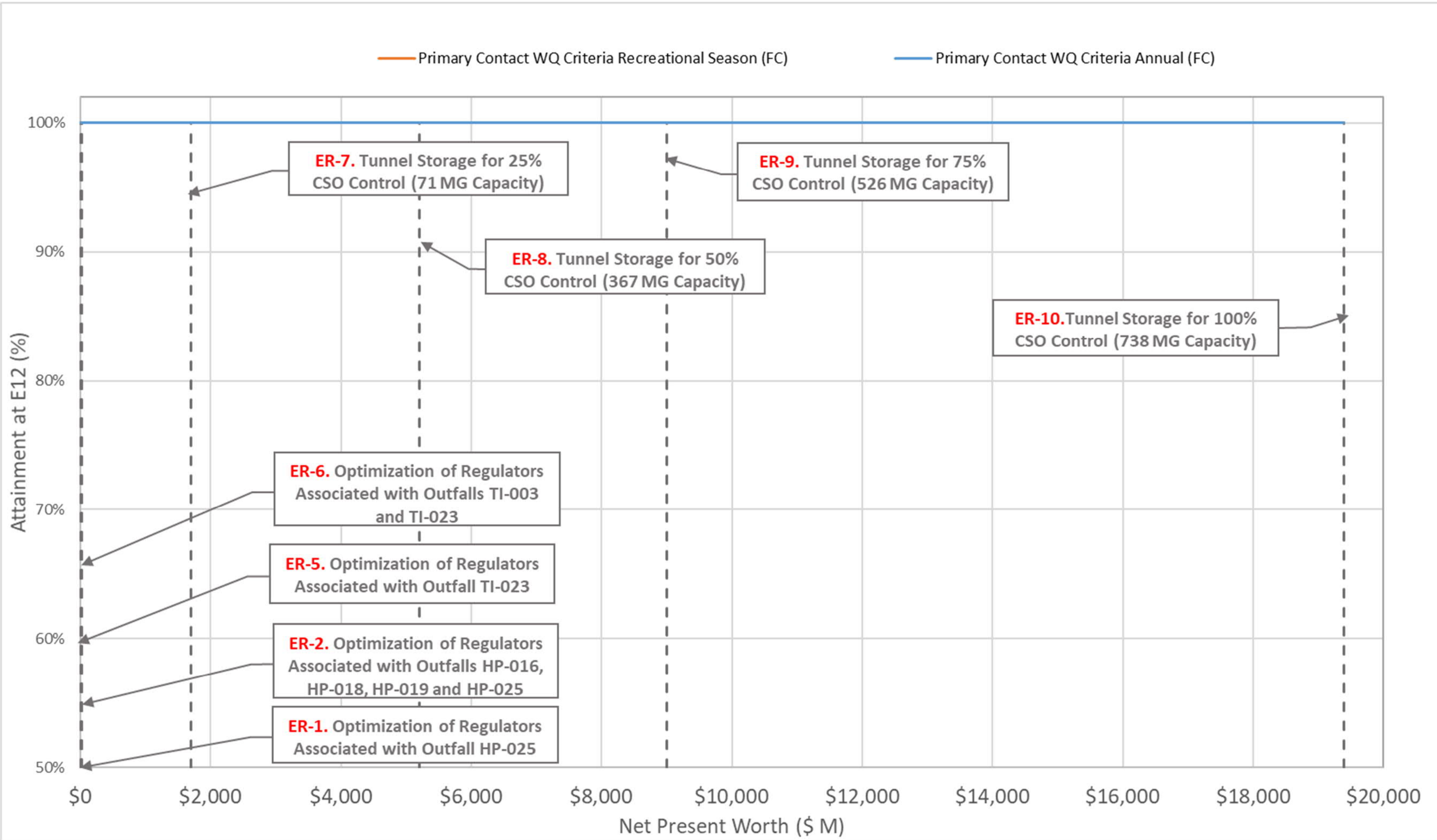

Figure 8.5-26. Cost vs. Bacteria Attainment at Class I Station E12

8.5.h Conclusion on Preferred Alternative

The selection of the preferred alternative for the East River is based on multiple considerations including public input, environmental and water quality benefits, and projected costs. However, as described above and in Section 6, the East River attains applicable water quality standards for bacteria and dissolved oxygen greater than 95 percent of the time under Baseline Conditions. The CSO storage tunnel alternatives would provide a range of levels of CSO reduction to the East River, but the costs associated with those alternatives are very high, and those high-cost alternatives would not change the level of attainment of WQ. Section 9 presents affordability issues and impacts on disadvantaged communities that would come into play if the CSO program costs were to further significantly increase. For these reasons, the CSO storage tunnel alternatives are not recommended.

Of the six optimization alternatives carried forward in the evaluation, ER-6 was selected as the preferred alternative for inclusion in the Recommended Plan. Implementation is projected to reduce net CSO volumes by 86 MGY during the typical year at a PBC of $6M. Note that these costs do not include costs for land acquisition, design, and construction management. This alternative consists of increasing the regulator orifice opening on Regulator TI-10B (CSO TI-003) and installation of a bending weir at Regulator TI-13 (CSO TI-023). While this project provides a relatively nominal reduction in CSO discharge, the project is consistent with DEP BMP practices for maximizing flow to the WRRF.

In summary, the following conclusions can be drawn from these analyses:

1. Under Baseline Conditions, fecal coliform standards attainment is projected to be 100 percent at all East River Stations annually and during the recreational season (May 1st through October 31st), while DO attainment is greater than 99 percent at all stations within the Class I and SB portions of the East River.
2. Under Baseline Conditions, *Enterococci* GM and STV standards attainment is projected to be 100 percent within the Class SB Coastal Primary Recreational portions of Long Island Sound (all stations east of the Throgs Neck Bridge), during the recreational season.
3. The most cost-effective alternative, based on the KOTC analysis approach, consistent with EPA's CSO Control Policy is Alternative ER-6.
4. The PCM will document the WQ improvements upon implementation of these projects.
5. While the annual volume of CSO remaining in the East River is acknowledged to remain relatively high, the time to recovery analysis presented further below demonstrates that the duration of impact of the remaining CSOs is low.

Figure 8.5-27 presents a mosaic of the level of attainment with the Class SB Coastal Primary Recreational WQ Criteria for *Enterococci* (30-day geometric mean) in the applicable area of Long Island Sound, east of the Throgs Neck Bridge, on a recreational season (May 1st through October 31st) basis. Figure 8.5-28 presents a mosaic of the level of attainment with the Class SB Coastal Primary Recreational WQ Criteria for *Enterococci* (30-day STV) in the applicable area of Long Island Sound, east of the Throgs Neck Bridge, on a recreational season (May 1st through October 31st) basis. Figure 8.5-29 presents a mosaic of the level of attainment with the Class SB and Class I WQ criteria for fecal coliform in the East River and Long Island Sound, on an annual basis, and Figure 8.5-30 presents the level of attainment in the recreational season (May 1st through October 31st). Figure 8.5-31 presents the level of attainment with the Existing WQ Criteria for DO on an average annual basis.

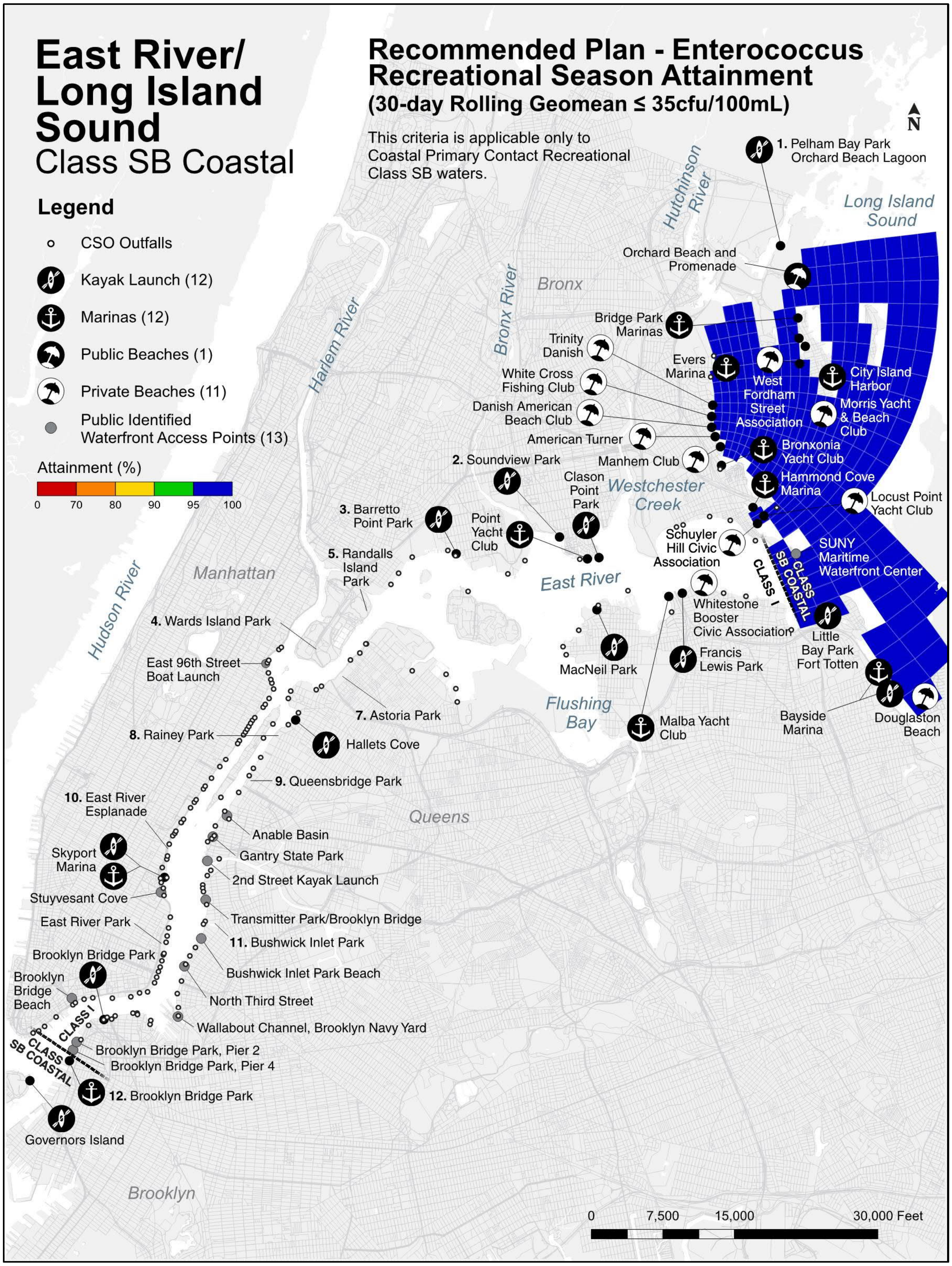

Figure 8.5-27. *Enterococci* Class SB Coastal Primary Recreational GM Attainment (10-year Runs) – Long Island Sound, Recommended Plan

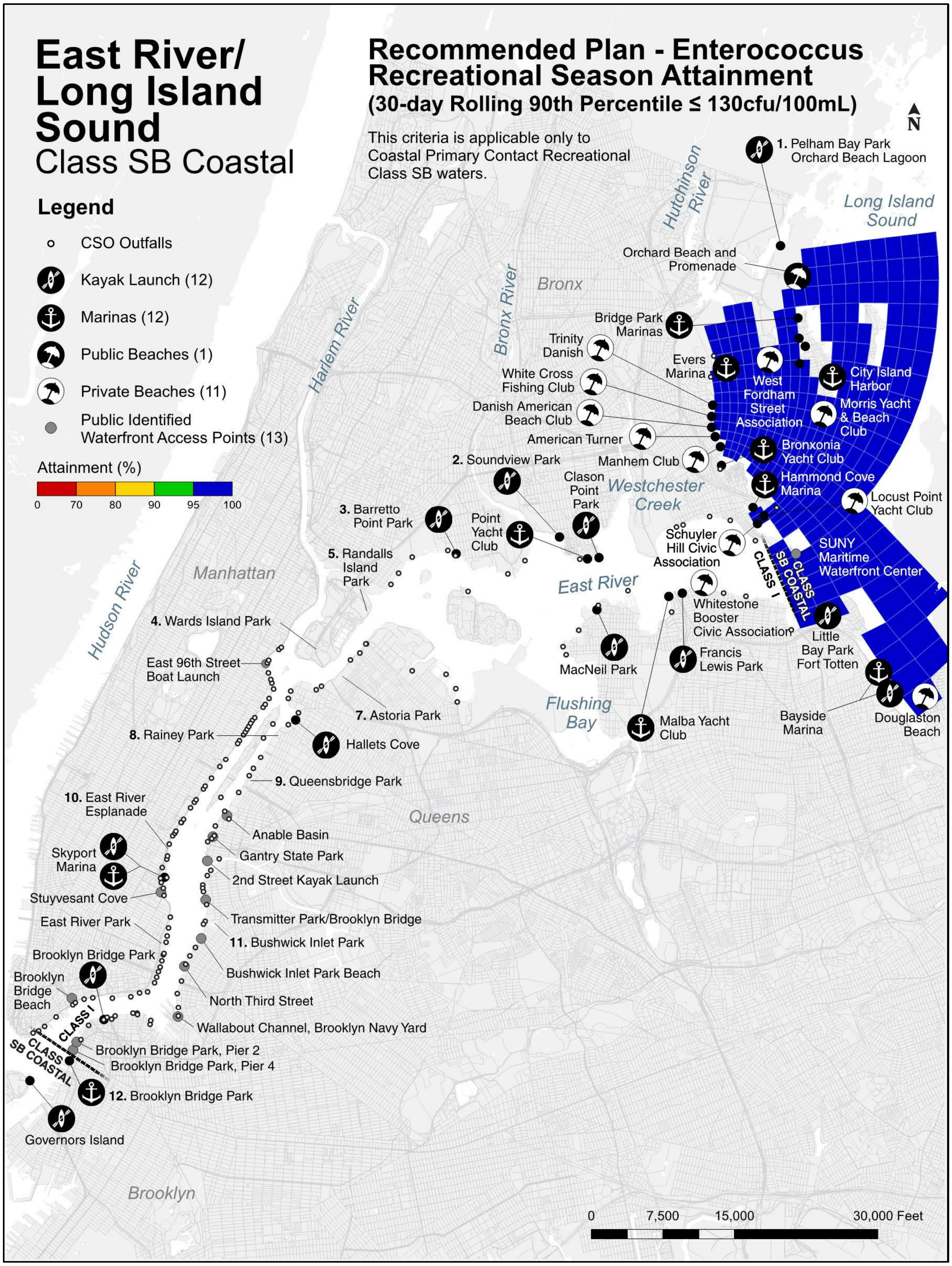

Figure 8.5-28. *Enterococci* Class SB Coastal Primary Recreational STV Attainment (10-year Runs) – Long Island Sound, Recommended Plan

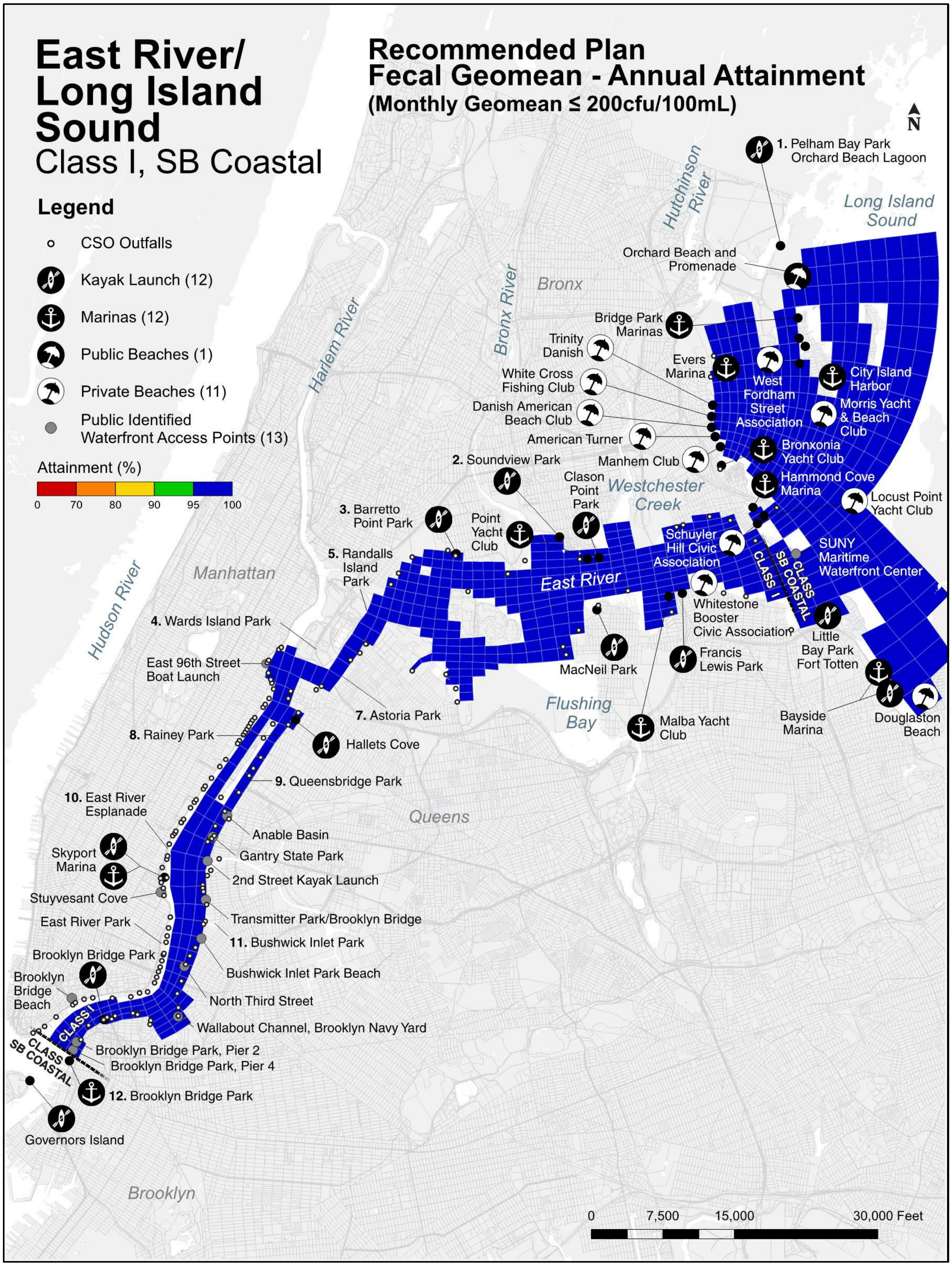

Figure 8.5-29. Fecal Coliform Class I and SB - Annual Attainment (10-year Runs), Recommended Plan

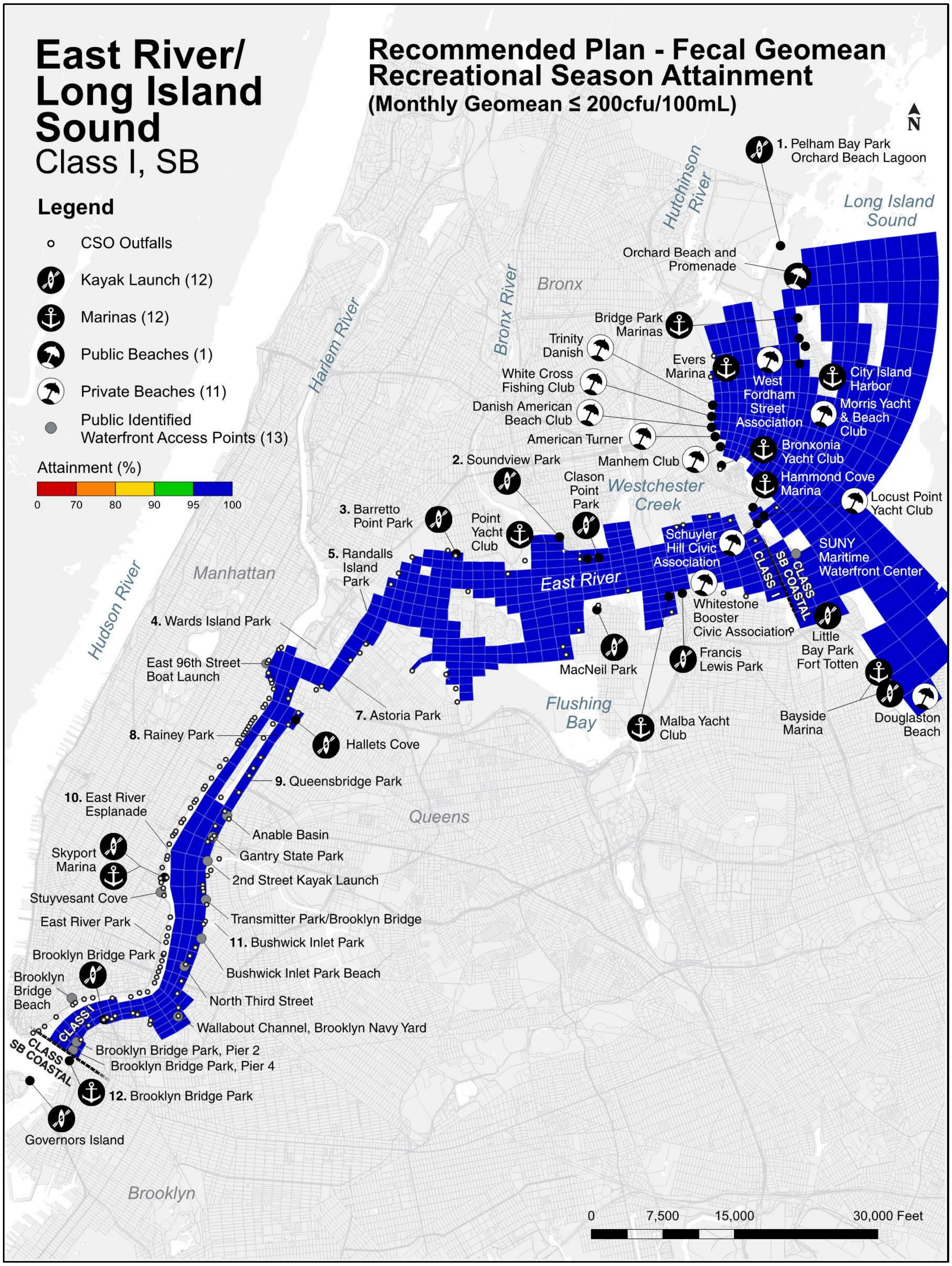

Figure 8.5-30. Fecal Coliform Class I and SB – Recreational Season Attainment (10-year Runs), Recommended Plan

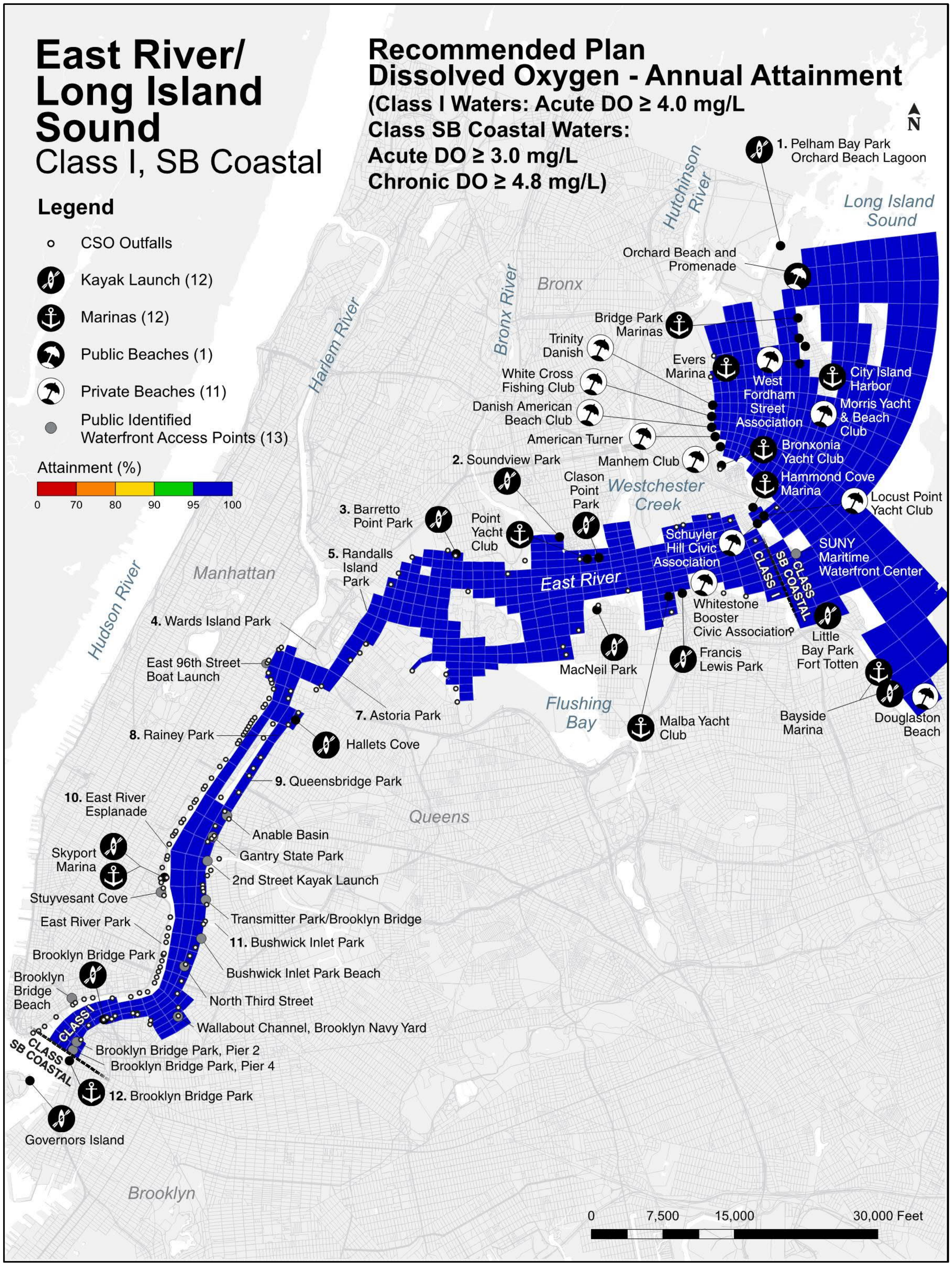

Figure 8.5-31: Dissolved Oxygen Class I and SB - Annual Attainment (2008), Recommended Plan

Table 8.5-28 presents the *Enterococci* maximum 30-day geometric mean and STV, and the percent of time that the *Enterococci* criteria would be attained for the recreational season (May 1st through October 31st), for the 10-year simulation period, within the Class SB Coastal Primary Recreational waters of Long Island Sound, with the Recommended Plan. The locations of the stations and supplemental model output locations listed in Table 8.5-28 are shown on Figure 8.5-32. As indicated in Table 8.5-28, recreational season (May 1st through October 31st) compliance for the Recommended Plan would be in the 99 to 100 percent range for the Class SB coastal primary contact recreational portions of Long Island Sound.

Table 8.5-28. Model Calculated 10-Year *Enterococci* Maximum 30-day GM and STV and Percent Attainment of Class SB Coastal Primary Recreational WQ Criteria for Long Island Sound, Recommended Plan

ER-6 Optimization of Regulators Associated with Outfalls TI-003 and TI-023				
Station	Maximum Recreational Season(1) 30-day *Enterococci* (cfu/100mL)		10 Year Percent Attainment	
	GM	90th Percentile STV	**Annual** Monthly GM <35 cfu/100mL	**Recreational Season(1)** Monthly GM <30 cfu/100mL
Long Island Sound east of Throgs Neck Bridge (Class SB Coastal Primary Recreational)				
ER-1	6	237	100%	99%
ER-2	7	49	100%	100%
ER-3	13	102	100%	100%
Orchard Beach	4	31	100%	100%
Bridge Park Marinas	5	52	100%	100%
City Island Harbor	4	19	100%	100%
Morris Yacht and Beach Club	7	88	100%	100%
West Fordham Street Association	8	129	100%	100%
Evers Marina	8	378	100%	99%
Trinity Danish Beach	8	334	100%	99%
White Cross Fishing Club	8	334	100%	99%
Danish American Beach Club	8	334	100%	99%
American Turner Beach	8	334	100%	99%
Manhem Club Beach/Bronxonia Yacht Club	8	334	100%	99%

Table 8.5-28. Model Calculated 10-Year *Enterococci* Maximum 30-day GM and STV and Percent Attainment of Class SB Coastal Primary Recreational WQ Criteria for Long Island Sound, Recommended Plan

ER-6 Optimization of Regulators Associated with Outfalls TI-003 and TI-023				
Station	**Maximum Recreational Season(1) 30-day *Enterococci* (cfu/100mL)**		**10 Year Percent Attainment**	
	GM	**90th Percentile STV**	**Annual** Monthly GM <35 cfu/100mL	**Recreational Season(1)** Monthly GM <30 cfu/100mL
Long Island Sound east of Throgs Neck Bridge (Class SB Coastal Primary Recreational)				
Hammond Cove Marina	5	31	100%	100%
Locust Point Yacht Club	5	31	100%	100%
Schuyler Hill Civic Association	6	40	100%	100%
Douglaston Beach	10	78	100%	100%
Bayside Marina Little Bay Park Fort Totten	12	155	100%	99%

Note:
(1) The recreational season is from May 1st through October 31st.

Table 8.5-29 presents the fecal coliform maximum monthly geometric mean, and the percent of time that the fecal coliform WQ criteria would be attained on an annual basis and for the recreational season (May 1st through October 31st), for the 10-year simulation period, within the Class SB and Class I waters of the East River, with the Recommended Plan. The locations of the stations and supplemental model output locations listed in Table 8.5-29 are shown on Figure 8.5-29. As indicated in Table 8.5-29, annual and recreational season (May 1st through October 31st) compliance for the Recommended Plan would be 100 percent for the Class SB and Class I portions of the East River.

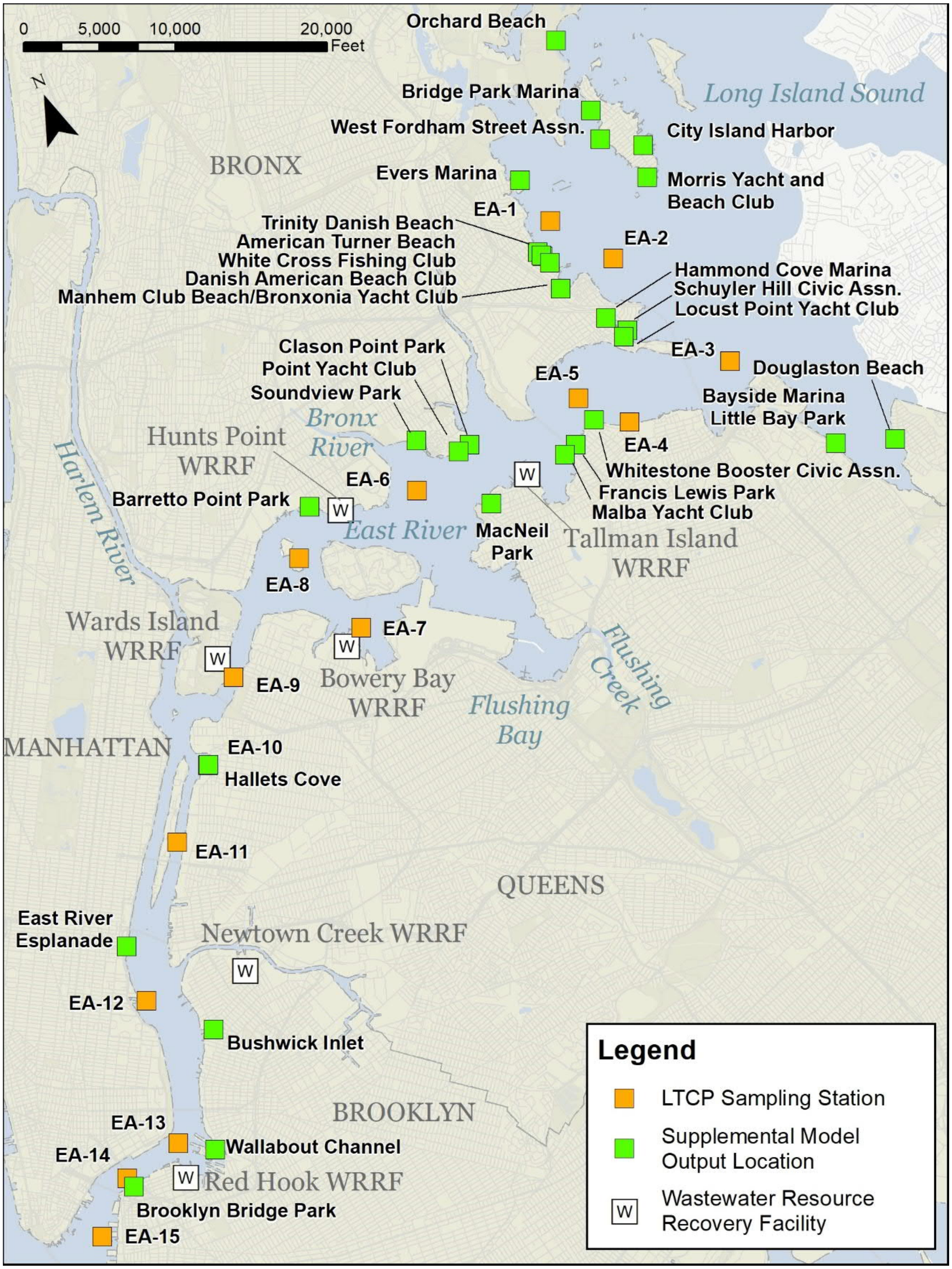

Figure 8.5-32. Sampling Stations and Supplemental Model Output Locations on the East River/Long Island Sound

Table 8.5-29. Model Calculated 10-Year Fecal Coliform Maximum Monthly GM and Percent Attainment of WQ Criteria for East River, Recommended Plan

	Maximum Monthly GMs (cfu/100mL)		% Attainment (GM ≤200 cfu/100mL)	
Description	**Annual**	**Recreational Season(1)**	**Annual**	**Recreational Season(1)**
East River between Whitestone Bridge and Throgs Neck Bridge (Class SB)				
E-4	54	35	100%	100%
E-5	61	42	100%	100%
Whitestone Booster Civic Association	67	49	100%	100%
Francis Lewis Park	66	44	100%	100%
East River, Battery to Whitestone Bridge (Class I)				
ER-6	104	88	100%	100%
ER-7	138	106	100%	100%
ER-8	131	100	100%	100%
ER-9	161	112	100%	100%
ER-10	181	125	100%	100%
ER-11	184	122	100%	100%
ER-12	180	119	100%	100%
ER-13	178	114	100%	100%
ER-14	179	114	100%	100%
ER-15	172	108	100%	100%
Clason Point Park	100	79	100%	100%
Point Yacht Club	118	103	100%	100%
Soundview Park	108	92	100%	100%
Barretto Point Park	124	99	100%	100%
East River Esplanade	182	122	100%	100%
Malba Yacht Club	71	52	100%	100%
MacNeil Park	81	57	100%	100%
Hallets Cove	181	125	100%	100%
Bushwick Inlet	188	122	100%	100%
Wallabout Channel	205	139	99%	100%
Brooklyn Bridge Park	179	114	100%	100%

Note:
(1) The recreational season is from May 1st through October 31st.

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The average annual attainment of the Existing WQ Criterion for DO (Class SB and I) for the entire water column is presented for the preferred alternative in Table 8.5-30. As indicated in Table 8.5-30, the Existing WQ Criterion for DO (Class I) are predicted to be attained at all stations for the Recommended Plan. DO attainment in the Class I portion of the East River is 100 percent at all stations for the preferred alternative.

As discussed in Section 6, analysis of attainment of Class SB DO criteria are complex because the standard allows for excursions from the daily average limit of 4.8 mg/L for a limited number of consecutive calendar days. To simplify the analysis, attainment was based solely upon attainment of the daily average without the allowed excursions. The results indicate 100 percent attainment of the acute criterion (never less than 3.0 mg/L) within the Class SB waters for the Recommended Plan. Attainment of the chronic criterion (greater than or equal to 4.8 mg/L) is also 100 percent for the Recommended Plan.

The key components of the Recommended Plan include enlargement of the regulator orifice openings at Regulators TI-10B and TI-13 associated with Outfalls TI-003 and TI-023, respectively. In addition, Regulator TI-13 (CSO TI-023) would be modified to accommodate the installation of a bending weir. The implementation of these elements is predicted to result in a net reduction of 86 MGY of CSO to the East River, with a PBC of $7M. The proposed schedule for the implementation of the Recommended Plan is presented in Section 9.2.

Table 8.5-30. Model Calculated (2008) Preferred Alternative DO Percent Attainment of Existing Class SB and I WQ Criteria

ER-6 Optimization of Regulators Associated with Outfalls TI-003 and TI-023		
Long Island Sound east of Throgs Neck Bridge (Class SB Coastal Primary Contact Recreational)		
Station	**Acute (≥ 3.0 mg/L)**	**Chronic (≥ 4.8 mg/L)**
ER-1	100	100
ER-2	100	100
ER-3	100	100
East River between Throgs Neck and Whitestone Bridges (Class SB)		
Station	**Acute (≥ 3.0 mg/L)**	**Chronic (≥ 4.8 mg/L)**
E-4	100	100
E-5	100	100
East River, Whitestone Bridge to Battery (Class I)		
Station	**Instantaneous (≥ 4.0 mg/L)**	
ER-6	100	
ER-7	100	
ER-8	100	
ER-9	100	
ER-10	100	
ER-11	100	
ER-12	100	
ER-13	100	
ER-14	100	
ER-15	100	

8.5.i Use Attainability Analysis

The CSO Order requires that a UAA be included in an LTCP "where existing WQS do not meet the Section 101(a)(2) goals of the CWA, or where the proposed alternative set forth in the LTCP will not achieve existing WQS or the Section 101(a)(2) goals." The UAA shall "examine whether applicable waterbody classifications, criteria, or standards should be adjusted by the State." The UAA process specifies that States can remove a designated use that is not an existing use if the scientific assessment can demonstrate that attaining the designated use is not feasible for at least one of six reasons:

1. Naturally occurring loading concentrations prevent the attainment of the use; or
2. Natural, ephemeral, intermittent or low flow conditions or water levels prevent the attainment of the use, unless these conditions may be compensated for by the discharge of sufficient volume of effluent discharges without violating State water conservation requirements to enable uses to be met; or
3. Human caused conditions or sources of pollution prevent the attainment of the use and cannot be remedied or would cause more environmental damage to correct than to leave in place; or
4. Dams, diversions or other types of hydrologic modifications preclude the attainment of the use, and it is not feasible to restore the waterbody to its original condition or to operate such modification in a way that would result in the attainment of the use; or
5. Physical conditions related to the natural features of the waterbody, such as the lack of a proper substrate, cover, flow, depth, pools, riffles, and the like, unrelated to water quality, preclude attainment of aquatic life protection uses; or
6. Controls more stringent than those required by Sections 301(b) and 306 of the Act would result in substantial and widespread economic and social impact.

As part of the LTCP, elements of a UAA, including the six conditions presented above, will be used to determine if changes to the designated use are warranted, considering a potential adjustment to the designated use classification as appropriate.

As noted in previous sections, with the implementation of the Recommended Plan, the East River is predicted to meet the Existing WQ fecal coliform bacteria criterion of 200 cfu/100mL on both an annual and recreational season (May 1st through October 31st) basis for both the 2008 Typical Year rainfall and the 10-year continuous simulation. For the Class SB Coastal Primary Recreation section of Long Island Sound, the *Enterococci* geometric mean criterion of 35 cfu/100mL and the 30-day STV criterion of 135 cfu/100mL are projected to be attained during the recreational season for the Recommended Plan. In addition, Class SB and I DO criteria are also predicted to be achieved for the Recommended Plan on an annual average basis. Therefore, a Use Attainability Analysis is not needed for the East River/Long Island Sound.

8.5.j Time to Recovery

As noted above, Long Island Sound east of the Throgs Neck Bridge is a Class SB Coastal Primary Recreational waterbody. The East River between the Throgs Neck and Whitestone Bridges is a Class SB waterbody, while the East River west and south of the Whitestone Bridge is a Class I waterbody. The applicable Water Quality Criteria for bacteria for these waterbodies include monthly geometric mean criteria. However, to gain insight into the shorter-term impacts of wet-weather sources of bacteria, DEP has performed an analysis to assess the amount of time following the end of a rainfall event required for the

East River/Long Island Sound to recover and return to fecal coliform concentrations less than 1,000 cfu/100mL.

The analyses consisted of examining the WQ model-calculated bacteria concentrations in the East River/Long Island Sound for recreational periods (May 1st through October 31st) abstracted from 10 years of model simulations. For the East River/Long Island Sound, the JFK Airport rainfall data was compared against water quality model bacteria results for the 10 recreational seasons to determine how long it took for the water column concentration to return to target threshold concentrations from the end of the rain event. The chosen target threshold concentration was 1,000 cfu/100mL for fecal coliform. The various rainfall events were then placed into rain event size "bins" ranging from less than 0.1 inch to greater than 1.5 inches. Only rain events that reached the target threshold concentrations before the beginning of the next storm were included. The median time to recovery for each bin at each water quality station was calculated. Table 8.5-31 presents the median time to recovery for the Recommended Plan for the East River/Long Island Sound. Results are presented for the greater than 1.0 to 1.5 inch rainfall bin, which includes the 90th percentile event.

DEC has advised that it seeks to have a time to recovery of less than 24 hours, and this target has been consistent in the previously approved LTCPs. As indicated in Table 8.5-31, for the Recommended Plan, most of the stations assessed had median time to recovery of zero hours, indicating that the fecal coliform concentration never reached the level of 1,000 cfu/100mL for more than half of the storms within the 1-to-1.5 inch rainfall bin assessed.

Table 8.5-31. East River Time to Recovery, Fecal Coliform, Recommended Plan

Location	Time to Recovery (hours) Fecal Coliform Threshold (1,000 cfu/100mL)(1)
Long Island Sound East of Throgs Neck Bridge (Class SB Coastal Primary Contact Recreational)	
ER-1	0(2)
ER-2	0
ER-3	0
Orchard Beach	0
Bridge Park Marinas	0
City Island Harbor	0
Morris Yacht and Beach Club	0
West Fordham Street Association	0
Evers Marina	0
Trinity Danish Beach	0
White Cross Fishing Club	0
Danish American Beach Club	0
American Turner Beach	0
Manhem Club Beach/Bronxonia	0
Hammond Cove Marina	0
Locust Point Yacht Club	0
Schuyler Hill Civic Association	0
Douglaston Beach	0
Bayside Marina Little Bay Park Fort	0

Table 8.5-31. East River Time to Recovery, Fecal Coliform, Recommended Plan

Location	Time to Recovery (hours) Fecal Coliform Threshold (1,000 cfu/100mL)(1)
East River between Throgs Neck and Whitestone Bridges (Class SB)	
E-4	0
E-5	0
Whitestone Booster Civic	0
Francis Lewis Park	0
East River, Whitestone Bridge to Battery (Class I)	
ER-6	0
ER-7	0
ER-8	0
ER-9	0
ER-10	0
ER-11	0
ER-12	0
ER-13	0
ER-14	0
ER-15	0
Clason Point Park	0
Point Yacht Club	2
Soundview Park	0
Barretto Point Park	0
East River Esplanade	0
Malba Yacht Club	0
MacNeil Park	0
Hallets Cove	0
Bushwick Inlet	0
Wallabout Channel	8.5
Brooklyn Bridge Park	0

Notes:

(1) Median time to recovery values presented for storms from the 10-year simulation, recreational seasons, in the size range of >1.0 to 1.5-inches of rainfall, which includes the 90th percentile rain event.

(2) Median time to recovery of "0" means that the average concentration across the water column never reached the 1,000 cfu/100mL threshold at the referenced station for more than half of the storms within the 1-to-1.5 inch rainfall bin assessed.

A similar analysis was conducted to assess time to recovery to an *Enterococci* concentration of 130 cfu/100mL, corresponding to the STV criterion for Class SB coastal primary contact recreational waters. The results of that analysis for the Recommended Plan are presented in Table 8.5-32. As indicated in Table 8.5-32, for the Recommended Plan, all of the stations assessed had median time to recovery of zero hours, indicating that the concentration of *Enterococci* at those locations was less than 130 cfu/100mL for more than half of the storms within the 1-to-1.5 inch rainfall bin assessed.

Table 8.5-32. East River Time to Recovery, *Enterococci*, Recommended Plan

Location	Time to Recovery (hours) *Enterococci* Threshold (130 cfu/100mL)[(1)]
Long Island Sound East of Throgs Neck Bridge (Class SB Coastal Primary Contact Recreational)	
ER-1	0[(2)]
ER-2	0
ER-3	0
Orchard Beach	0
Bridge Park Marinas	0
City Island Harbor	0
Morris Yacht and Beach Club	0
West Fordham Street Association	0
Evers Marina	0
Trinity Danish Beach	0
White Cross Fishing Club	0
Danish American Beach Club	0
American Turner Beach	0
Manhem Club Beach/Bronxonia	0
Hammond Cove Marina	0
Locust Point Yacht Club	0
Schuyler Hill Civic Association	0
Douglaston Beach	0
Bayside Marina Little Bay Park	0

Notes:

(1) Median time to recovery values presented for storms from the 10-year simulation, recreational seasons, in the size range of >1.0 to 1.5-inches of rainfall, which includes the 90th percentile rain event.

(2) Median time to recovery of "0" means that the average concentration across the water column never reached the 130 cfu/100mL threshold at the referenced station for more than half of the storms within the 1-to-1.5 inch rainfall bin assessed.

8.5.k Recommended LTCP Elements to Meet Water Quality Goals for East River

The actions identified in this LTCP include:

- Enlargement of regulator orifice openings at TI-10B and TI-13 associated with Outfalls TI-003 and TI-023, respectively and installation of a bending weir within Regulator TI-13 (CSO TI-023).
- Costs (2019 dollars) for the recommended alternative are: NPW $7M, PBC of $6M, and annual O&M of $1M.
- Compliance with Existing WQ Criteria. As a result, a UAA is not required for the East River/Long Island Sound as part of this LTCP.
- DEP will establish with the DOHMH (through public notification) a wet-weather advisory for the recreational season (May 1st through October 31st) informing the public which recreational activities are not recommended in the East River/Long Island Sound at that time. The LTCP includes a

recovery time analysis that can be used to establish the duration of the wet-weather advisory for public notification.

DEP is committed to improving water quality in this waterbody, which will be advanced by the improvements and actions identified in this LTCP. These identified actions have been balanced with input from the public and awareness of the cost to the residents of NYC.

8.6 CSO Control Alternatives for New York Bay

As shown in Section 6, WQS for bacteria and dissolved oxygen are generally met in most of New York Bay under Baseline Conditions. Non-attainment of dissolved oxygen criteria and *Enterococcus* STV criteria in an area off the southwest corner of Staten Island is driven by sources from outside of NYC, as no NYC CSOs are located in that vicinity. Along the Brooklyn shoreline, the *Enterococcus* geometric mean criteria are met under Baseline Conditions, but the *Enterococcus* STV criteria are not met. As described below, a high level of CSO control (50 percent) would be needed to meet the *Enterococcus* STV criteria along the Brooklyn shoreline. Therefore, attainment of WQS was generally not a factor in evaluating CSO control alternatives for New York Bay. Rather, the focus was on evaluating alternatives for cost-effective reduction of CSO activations and volume.

The CSO control alternatives that passed the initial screening phase and were retained for New York Bay generally fell within the categories of system optimization and tunnel storage. System optimization alternatives covered the categories of fixed weirs, parallel interceptor/sewer, bending weirs or control gates, and gravity flow tipping to other watersheds. The storage tunnel alternatives, used to assess 50, 75 and 100 percent CSO capture, also included high-rate clarification for the dewatering flows from the tunnels. Storage tanks were not evaluated due to the number of outfalls and the general lack of available sites of sufficient size for storage tanks. Each control measure was initially evaluated on three of the key considerations described in Section 8.1: (1) benefits, as expressed by level of CSO control and WQS attainment; (2) costs; and (3) challenges, such as siting and operations. Using this methodology, the retained control measures listed in Section 8.1 were evaluated on a cost-performance basis and used to develop the basin-wide alternatives.

The Citywide/Open Waters Baseline Conditions include implementation of the Recommended Plans from the LTCPs for the tributary waterbodies previously submitted to DEC under this program, as well as other grey infrastructure projects implemented as part of earlier planning programs. Those projects are summarized in Section 4. The following sections present the evaluations of the system optimization and tunnel storage alternatives for New York Bay.

8.6.a System Optimization Alternatives

The approach to the initial identification and evaluation of system optimization alternatives for New York Bay using the Optimatics Optimizer software was presented in Section 3. As described in Section 3, the Optimizer software was configured to prioritize monitored regulators discharging outside the period of critical wet-weather events, high-discharge frequency regulators, and regulators discharging in proximity to official and publicly-identified public access points (kayak launches/marinas).

The optimization alternatives for outfalls to New York Bay associated with the Red Hook, Owls Head, and Port Richmond WRRF collections systems were evaluated independently, as the three systems are hydraulically independent. However, the Red Hook WRRF system also includes outfalls discharging to the East River, and the Port Richmond WRRF includes outfalls that discharge to Kill Van Kull. Thus, the New York Bay optimization alternatives associated with the Red Hook WRRF system needed to be considered in conjunction with alternatives for the East River outfalls associated with the Red Hook WRRF system, and the New York Bay optimization alternatives associated with the Port Richmond WRRF needed to be considered in conjunction with alternatives for Kill Van Kull.

The sections below present the evaluations of New York Bay optimization alternatives associated with the Red Hook, Owls Head, and Port Richmond WRRF collection systems, respectively.

8.6.a.1 System Optimization for Outfalls in the Red Hook WRRF System

As described above in Section 8.4, optimization of the Red Hook WRRF system outfalls discharging to the East River were evaluated in conjunction with the Red Hook outfalls to New York Bay, due to the hydraulic connectivity among the outfalls through the single interceptor. Table 8.6-1 summarizes the CSO outfalls and associated regulators tributary to the East River and New York Bay from the Red Hook WRRF system that were the initial focus of the optimization evaluations. The locations of these outfalls/regulators are shown in Figure 8.6-1. Table 8.6-1 identifies the annual CSO volume and activation frequency under Baseline Conditions, and whether the outfall/regulator falls within one or more of the following categories:

- One of the 100 monitored regulators listed in the WRRF SPDES permits ("BMP Regulator")
- A "Key Regulator" as identified in the WRRF SPDES permits
- An outfall in proximity to (typically within 500 feet of) a public access location
- Regulators that activated more than average for the waterbody

Findings/Observations from Optimizer Evaluations

The Optimizer evaluations served as an initial screening step to identify potentially promising optimization alternatives to be further evaluated using the full Red Hook WRRF InfoWorks model. These evaluations included the assessment of the impacts to CSO volume, activation, and peak hydraulic grade line elevations relative to Baseline Conditions, as well as other general system conditions. General collection system information and findings of the initial Optimizer evaluations included the following:

- The Red Hook WRRF is located at 63 Flushing Avenue in Brooklyn next to the Brooklyn Navy Yard. The collection system primarily serves the western Brooklyn neighborhoods of Carroll Gardens, Gowanus, Boerum Hill, Cobble Hill, Brooklyn Heights, and Vinegar Hill.
- The main interceptor conveying flow to the Red Hook WRRF interceptor system extends along the Brooklyn shoreline from the southern end of the East River to Gowanus Bay, and then back north along Gowanus Canal.
- The Red Hook WRRF collection system is relatively shallow (<10 feet of cover) at the upstream ends of each interceptor, but reaches approximately 25 feet of cover as the interceptor approaches the Red Hook WRRF.
- Regulators from the Red Hook system contributing to CSO outfalls discharging to New York Bay generally activate between 13 to 43 times during the typical year with a total average annual overflow volume (AAOV) of 141 MGY. Regulators from the Red Hook system contributing to CSO outfalls discharging to the East River generally activate between 0 to 26 times during the typical year with a total AAOV of 189 MGY.

Table 8.6-1. New York Bay and East River CSO Outfalls/Regulators Associated with the Red Hook WRRF

Waterbody	Outfall	Regulator	Baseline Conditions		BMP Regulator	Key Regulator	Outfall in Proximity to Public Access	Higher Frequency Regulator
			Annual CSO Volume	Annual CSO Activations				
New York Bay	RH-014	RH-14	33.2	43				✓
	RH-016	RH-12	34.9	19				✓
	RH-018	RH-11	10.4	19				
	RH-019	RH-9	15.0	20				✓
	RH-021	RH-9A	2.7	21				✓
	RH-028	RH-02	22.0	14	✓	✓		
	RH-029	RH-1	2.5	22				✓
	RH-002	RH-21A	0	0	✓			
East River	RH-005	RH-20A	134.0	20	✓	✓		✓
	RH-006	RH-19A	8.1	26				✓
	RH-008	RH18A	3.1	16			✓	
	RH-009	RH-18	2.5	18			✓	
	RH-011	RH-15	4.5	16			✓	
	RH-013	RH-14	0.3	6			✓	
	RH-040	RH-26	24.4	23				✓

Figure 8.6-1. CSO Outfalls/Regulators Tributary to New York Bay and the East River from the Red Hook WRRF System

- Freeboard for the 5-year design storm and many of the larger storms during the typical year is less than 10 feet from the ground surface at multiple locations along the interceptor.
- The Optimizer modeling identified alternatives that included modifications to up to 17 regulators resulting in varying degrees of improved capture and hydraulic performance. Upon performing InfoWorks runs for the 2008 typical year, limited net reductions in AAOV (approximately 1 percent) were predicted for the better performing alternatives, but the activation frequency of the most active regulator could be reduced by approximately 50 percent.
- The performance improvements were limited by hydraulic grade line sensitivities. While the interceptor has available storage capacity during smaller storms, the rise in grade line during the 5-year storm translates upstream during the 5-year design storm, affecting some of the shallower reaches of the interceptor beyond the level of acceptable risk.
- In addition, hydraulic balancing occurs, where CSO volume and activations increase at regulators/outfalls upstream or downstream of those regulators/outfalls where reductions were observed in response to the system optimization measures. Although the optimization alternatives reduced the activation frequency of the most active outfall in the Red Hook system (RH-014), which discharges to New York Bay, the CSO volume to the East River increased slightly (about 3 percent, 5 MG).

Follow-up Evaluations Based on Full InfoWorks Model

The most promising optimization alternative coming out of the Optimizer evaluations is summarized in Table 8.6-2:

Table 8.6-2. Red Hook Optimization Components for Retained Alternatives

Outfall	Regulator	Components
		NYB-1
RH-005	RH-20A	
RH-014	RH-13	

KEY

Increase Orifice Size

Modify Weir

Replace Branch Interceptor

This alternative was further analyzed in more detail using the full Red Hook WRRF system InfoWorks model. The resulting impacts of Alternative NYB-1 on peak hydraulic grade line in the 5-year storm are summarized in Figure 8.6-2. The annual CSO volume and frequency for this optimization alternative are summarized in Table 8.6-3, and estimated probable bid costs and construction/implementation considerations are summarized in Table 8.6-4.

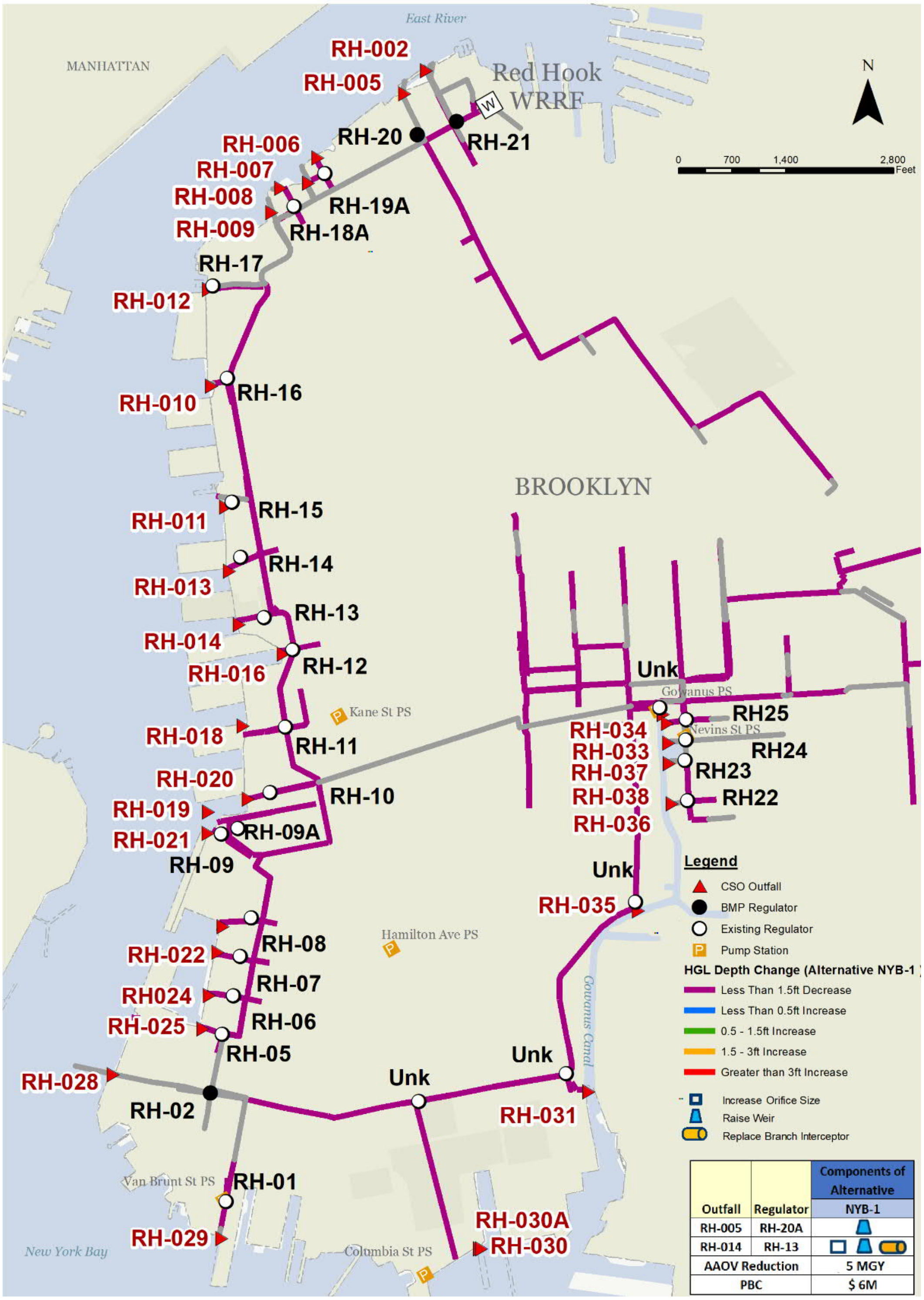

Figure 8.6-2. Hydraulic Grade Line Impacts of Alternative NYB-1 vs. Baseline Conditions (5-Year Storm)

Table 8.6-3. Summary of Performance of Red Hook Optimization Alternative NYB-1 for New York Bay and East River

Waterbody	Outfall(1)	Regulator	Baseline Conditions Typical Year		Alternative NYB-1	
			Annual CSO Volume (MG)	Annual CSO Activations	Annual CSO Volume (MG)	Annual CSO Activations
East River(2)	RH-005	R-20A	134	20	137	21
	RH-006	R-19A	8.1	26	8.2	26
	RH-008	R-18A	3.1	16	3.2	17
	RH-009	R-18	2.5	18	2.6	18
	RH-011	R-15	4.5	16	4.8	17
	RH-012	R-17	9.6	14	10.2	17
New York Bay(2)	RH-014	R-13	33.2	43	10.1	21
	RH-016	R-12	34.9	19	37.8	20
	RH-018	R-11	10.4	19	10.9	19
	RH-019	R-9	15.0	20	15.4	21
	RH-028	R-2	22.0	14	30.0	15
	RH-029	R-1	2.5	22	2.5	22
	RH-040	R-26	24.4	23	24.8	24
	Total		**414**	**43 (Max.)**	**409**	**26 (Max.)**

Notes:
(1) Outfalls and regulators with negligible impacts to Annual CSO Volume and Activations are not included in this table.
(2) Reduction of 10 MG to New York Bay is partially offset by an increase of 5 MG to the East River.

Table 8.6-4. Summary of Cost and Implementation Considerations for New York Bay Optimization Alternative NYB-1

Alternative	Probable Bid Cost ($M)	Implementation Considerations
NYB-1	$6M	• Reduction in CSO to New York Bay of 10 MGY • Increase in CSO to East River of 5 MGY • Net reduction in CSO of 5 MGY • Reduces activation frequency of most active outfall (RH-014) from 42 to 21 activations/year

Given the potential cost-effective reduction in CSO activation frequency and volume, Alternative NBY-1 was retained for further consideration. Tunnel storage alternatives for Red Hook WRRF outfalls tributary to New York Bay are evaluated later in this section.

8.6.a.2 System Optimization for New York Bay Outfalls in the Port Richmond WRRF System

Table 8.6-5 summarizes the CSO outfalls and associated regulators tributary to New York Bay from the Port Richmond WRRF system that were the initial focus of the optimization evaluations. The locations of these outfalls/regulators are shown in Figure 8.6-3. Table 8.6-5 identifies the annual CSO volume and activation frequency under Baseline Conditions, and whether the outfall/regulator falls within one or more of the following categories:

- One of the 100 monitored regulators listed in the WRRF SPDES permits ("BMP Regulator")
- A "key regulator" as identified in the WRRF SPDES permits
- An outfall in proximity to (typically within 500 feet of) a public access location
- Regulators that activated more than average for the waterbody

Table 8.6-5. New York Bay CSO Outfalls/Regulators Associated with the Port Richmond WRRF

Outfall	Regulator	Baseline Conditions		BMP Regulator	Key Regulator	Outfall in Proximity to Public Access	Higher Frequency Regulator
		Annual CSO Volume (MG)	Annual CSO Activations				
PR-013	R-17	40.7	30			✓	✓
PR-014	R-15	28.3	30				✓
PR-017	R-09	13.1	30				✓
PR-018	R-08	2.88	20				✓
PR-019	R-07	67.4	38			✓	✓
PR-020	R-05	25.2	44				✓
PR-021	R-04	7.25	38			✓	✓
PR-030	R-06	8.55	41				✓
PR-031	R-13	183	34	✓	✓		
PR-032	R-16	7.39	26				✓
PR-23A	R-03/R-01	41.9	25			✓	✓

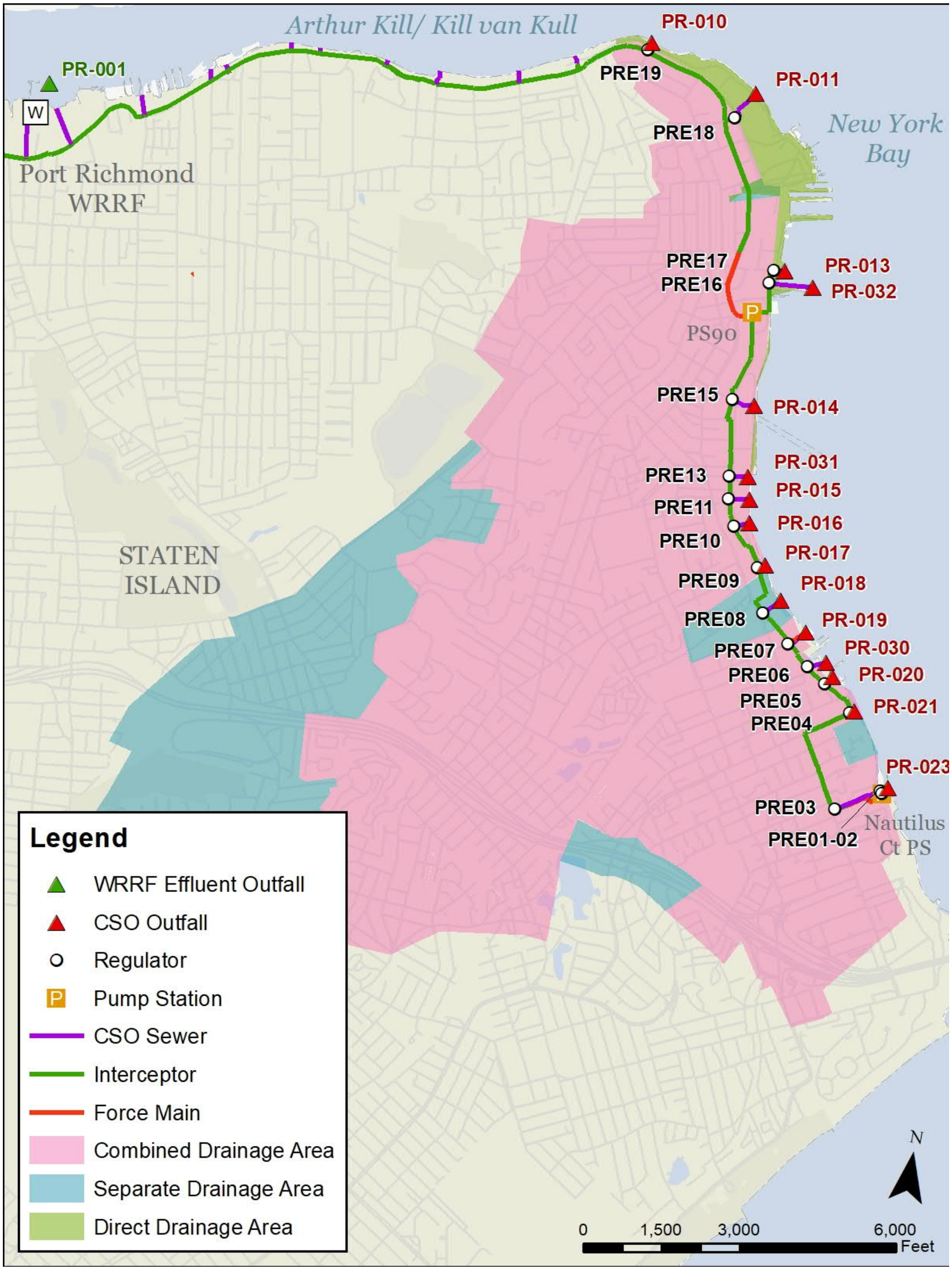

Figure 8.6-3. CSO Outfalls/Regulators Tributary to New York Bay from the Port Richmond WRRF System

Findings/Observations from Optimizer Evaluations

The Optimizer evaluations served as an initial screening step to identify potentially promising optimization alternatives to be further evaluated using the full Port Richmond WRRF InfoWorks model. These evaluations included the assessment of the impacts to CSO volume, activation and peak hydraulic grade line elevations relative to Baseline Conditions, as well as other general system conditions. General collection system information and findings of the initial Optimizer evaluations included the following:

- The Port Richmond WRRF collection system serves the northern part of Staten Island. The East Interceptor runs east from the WRRF along the shoreline of Kill Van Kull, then turns south along the shoreline of New York Bay. The West Interceptor runs west from the WRRF along the shoreline of Kill Van Kull.
- A total of 35 regulators contribute flow to the interceptors. During wet-weather, flow in excess of the interceptor capacity can overflow to CSO outfalls discharging to New York Bay (15 CSOs), and Kill Van Kull (19 CSOs). The interceptor sewers convey flow to the Port Richmond WRRF located along Kill Van Kull.
- Depth of cover on the gravity sewers varies, ranging from relatively shallow (<10 feet of cover) to over 20 feet.
- Regulators from the Port Richmond system contributing to CSO outfalls discharging to New York Bay activate between 3 to 44 times during the typical year with a total average annual overflow volume (AAOV) of 431 MGY.
- Freeboard for the 5-year design storm and many of the larger storms during the typical year is generally less than 10 feet from the ground surface indicating the portions of the collection system along New York Bay are highly sensitive to hydraulic grade line impacts.
- The Optimizer modeling identified alternatives that included modifications to as many as 20 regulators throughout the WRRF collection system that resulted in varying degrees of improved capture and hydraulic performance. However, upon performing InfoWorks runs for the 2008 typical year, limited reductions in AAOV (<1 percent) and activation frequency (<8 percent) were predicted for the better performing alternatives.

Follow-up Evaluations Based on Full InfoWorks Model

No retained alternatives were identified from the initial optimization runs due to hydraulic grade line impacts that increased the potential risk of flooding, while providing negligible reductions in CSO volume and activations to New York Bay. Figure 8.6-4 illustrates the hydraulic grade line sensitivities where optimization alternatives increase the potential risk of street flooding and basement backups.

Additional Optimization Alternative

In prior WWFP evaluations for the Port Richmond WRRF system, an optimization alternative had been identified that was unique to the configuration of the system in the vicinity of the Hannah Street Pumping Station. That alternative was reassessed as part of the Citywide/Open Waters LTCP, and was determined to be a potentially feasible, cost-effective means of reducing CSO activations and volume to New York Bay.

The Hannah Street Pumping Station is located along the East Interceptor, just downstream of the branch interceptor connection from Regulators R-16 (Outfall PR-032) and R-17 (Outfall PR-013) (see Figure 8.6-3). The force main from the Hannah Street Pumping Station ties back into the East Interceptor on Bay Street, north of Victory Boulevard. The force main crosses over a combined sewer on Victory Boulevard, that feeds into Regulator R-17. The invert elevation of the Victory Boulevard combined sewer is above the invert of the East Interceptor at the point where the force main ties into the interceptor. As a result, the opportunity exists to divert the dry-weather flow and a portion of the wet-weather flow from the Victory Boulevard combined sewer directly to the interceptor via a gravity flow connection. This alternative would not only reduce CSOs at Regulator R-17 (Outfall PR-013), but would also reduce pumping costs and energy requirements at the Hannah Street Pumping Station. The sizing and configuration of the diversion connection was set to limit the peak wet-weather flow through the connection, so as not to create adverse hydraulic grade line impacts in the East Interceptor downstream of the proposed connection. Figure 8.6-5 shows a conceptual layout of the proposed bypass connection. This alternative has been designated "NBY-2."

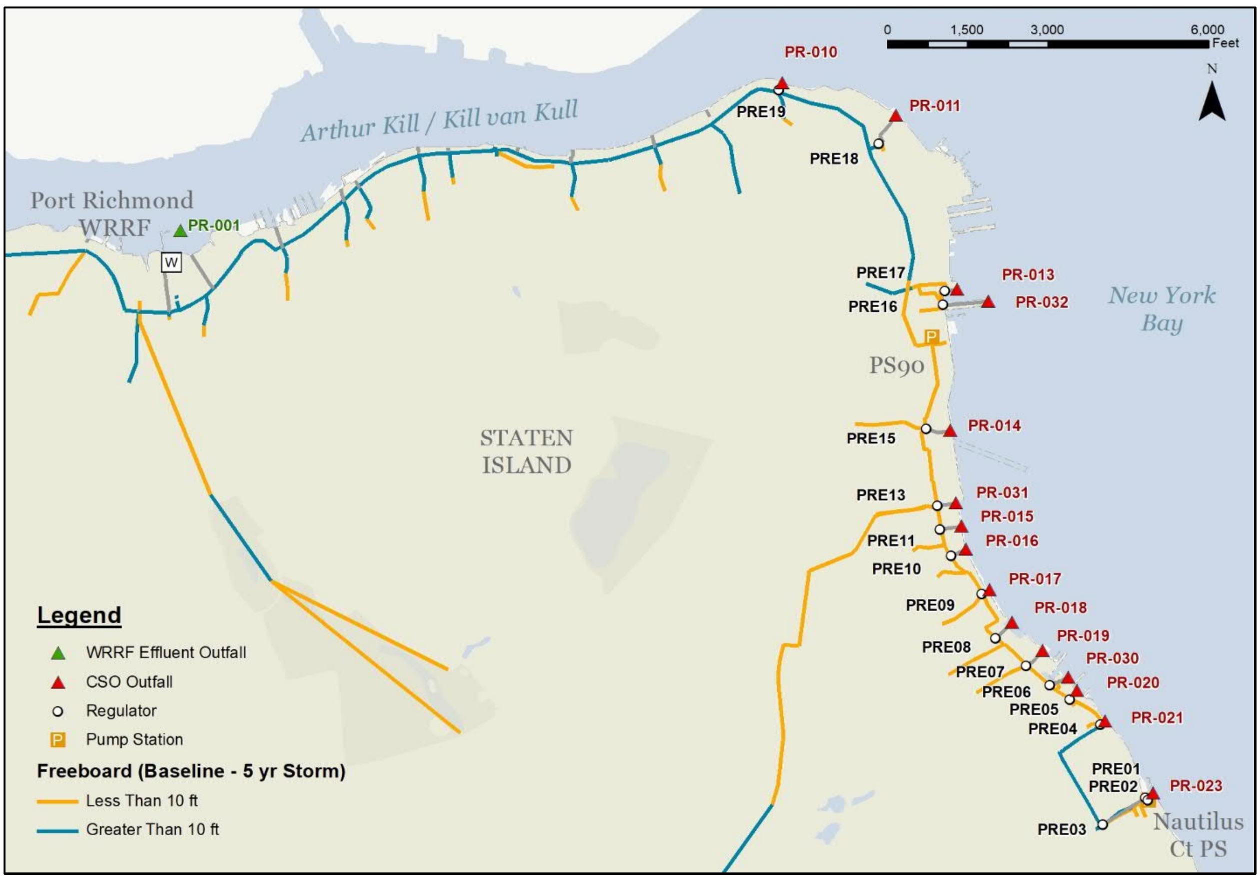

Figure 8.6-4. Baseline Conditions Hydraulic Grade Line Impacts in Port Richmond System (5-Year Storm)

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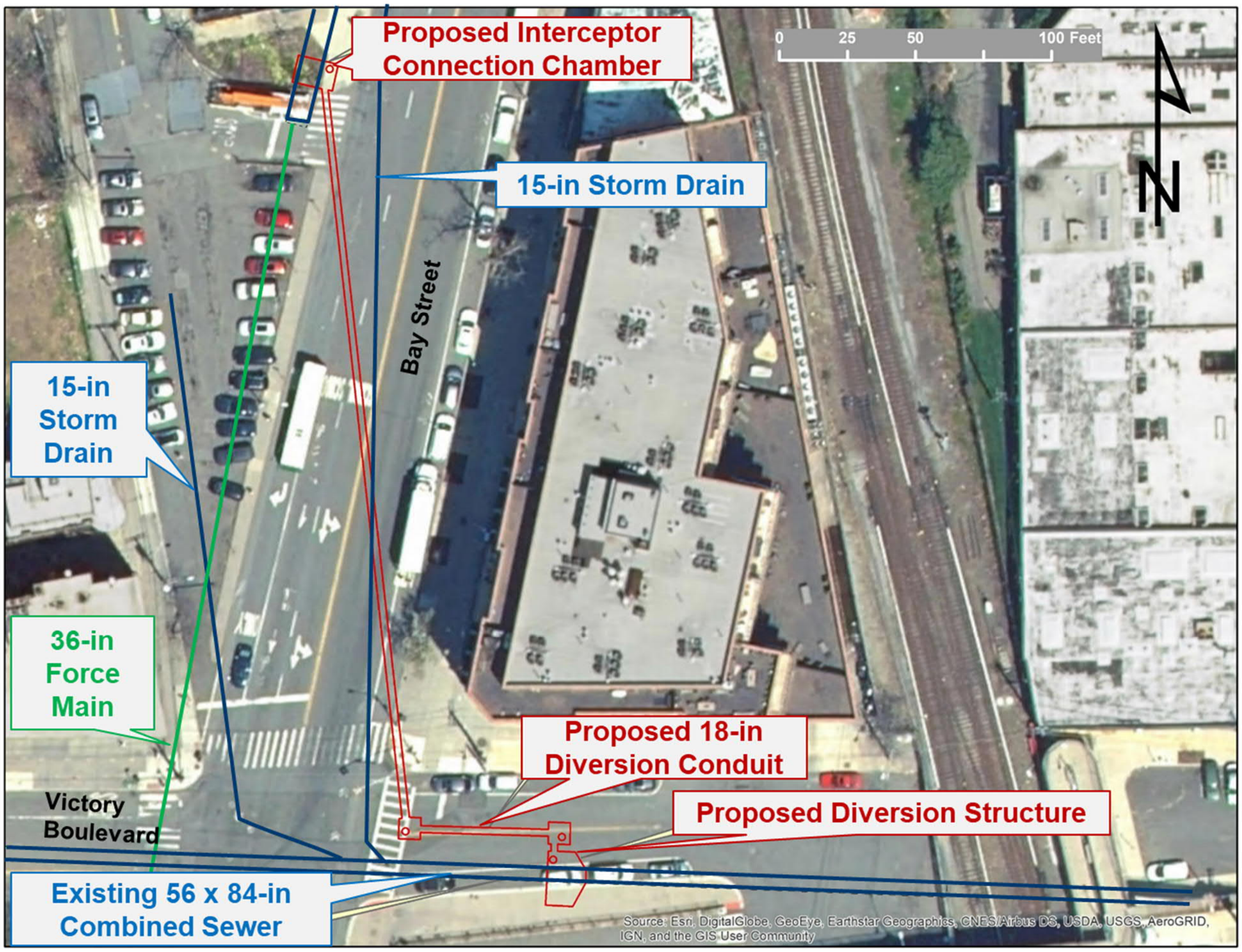

Figure 8.6-5. Conceptual Layout of Alternative NYB-2 - Hannah Street Pumping Station Bypass

The predicted impacts of Alternative NYB-2 on CSO activations and volumes to New York Bay are presented in Table 8.6-6. As indicated in Table 8.6-6, Alternative NYB-2 results in a slight increase (5 MG, 3 percent) in the CSO volume to Kill Van Kull, primarily at Outfall PR-029. The total decrease in CSO volume to New York Bay is 42 MG, so the alternative results in an overall net CSO reduction of 37 MG. Estimated probable bid costs and construction/implementation considerations for Alternative NYB-3 are summarized in Table 8.6-7.

Table 8.6-6. Performance of Alternative NYB-2, 2008 Typical Year

Waterbody	Outfall(1)	Baseline Conditions Typical Year		Alternative NYB-2	
		Annual CSO Volume (MG)	Annual CSO Activations	Annual CSO Volume (MG)	Annual CSO Activations
New York Bay(2)	PR-010	0.96	8	0.96	8
	PR-011	0.22	3	0.22	3
	PR-013	40.7	30	19.5	18
	PR-014	28.3	30	30.1	26
	PR-015	2.14	15	2.10	15
	PR-016	1.72	16	1.63	15
	PR-017	13.1	30	11.6	26
	PR-018	2.88	20	2.14	14
	PR-019	67.4	38	62.0	33
	PR-020	25.2	44	23.5	42
	PR-021	7.25	38	7.02	36
	PR-23A	41.9	25	41.6	25
	PR-030	8.55	41	7.8	39
	PR-031	183	34	175	33
	PR-032	7.39	26	3.7	17
	Subtotal	**431**	**44 (Max.)**	**389**	**42 (Max.)**
Kill Van Kull(2)	PR-006	6.35	15	6.5	15
	PR-026	1.40	6	1.6	6
	PR-027	1.71	10	1.8	10
	PR-028	15.1	23	15.5	23
	PR-029	146	47	149	47
	PR-037	2.93	12	3.1	12
	Subtotal	**173**	**47 (Max.)**	**178**	**47 (Max.)**
Total		**604**	**47 (Max.)**	**567**	**47 (Max.)**

Notes:
(1) Outfalls and regulators with negligible impacts to Annual CSO Volume and Activations are not included in this table.
(2) Reduction of 42 MG to New York Bay is partially offset by an increase of 5 MG to Kill Van Kull.

Table 8.6-7. Summary of Cost and Implementation Considerations for New York Bay Optimization Alternative NYB-2

Alternative	Probable Bid Cost ($M)	Implementation Considerations
NYB-2	$22M	• Reduction in CSO to New York Bay of 42 MGY • Increase in CSO to Kill Van Kull of 5 MGY • Net reduction in CSO of 37 MGY

Tunnel options for CSO outfalls to New York Bay from the Port Richmond WRRF system are evaluated later in this section.

8.6.a.3 System Optimization for New York Bay Outfalls in the Owls Head WRRF System

Table 8.6-8 lists the CSO outfalls and associated regulators tributary to New York Bay from the Owls Head WRRF system that were the initial focus of the optimization evaluations. The locations of these outfalls/regulators are shown in Figure 8.6-6. Table 8.6-8 identifies the annual CSO volume and activation frequency under Baseline Conditions, and whether the outfall/regulator falls within one or more of the following categories:

- One of the 100 monitored regulators listed in the WRRF SPDES permits ("BMP Regulator")
- A "key regulator" as identified in the WRRF SPDES permits
- An outfall in proximity to (typically within 500 feet) a public access location
- Regulators that activated more than average for the waterbody

Table 8.6-8. New York Bay CSO Outfalls/Regulators Associated with the Owls Head WRRF

Outfall	Regulator	Baseline Conditions		BMP Regulator	Key Regulator	Outfall in Proximity to Public Access	Higher Frequency Regulator
		Annual CSO Volume	Annual CSO Activations				
OH-002	OH-6A,B,C	407	41	✓	✓		✓
OH-003	OH-7A,B,C	374	57	✓			✓
OH-004	OH-7D	9.2	12	✓			
OH-015	OH-9A,B,C	1,105	64	✓		✓	✓
OH-017	OH-1	449	39	✓	✓	✓	✓
OH-018	OH-2,3	121	32	✓			✓
OH-019	OH-4	22.7	26	✓			✓

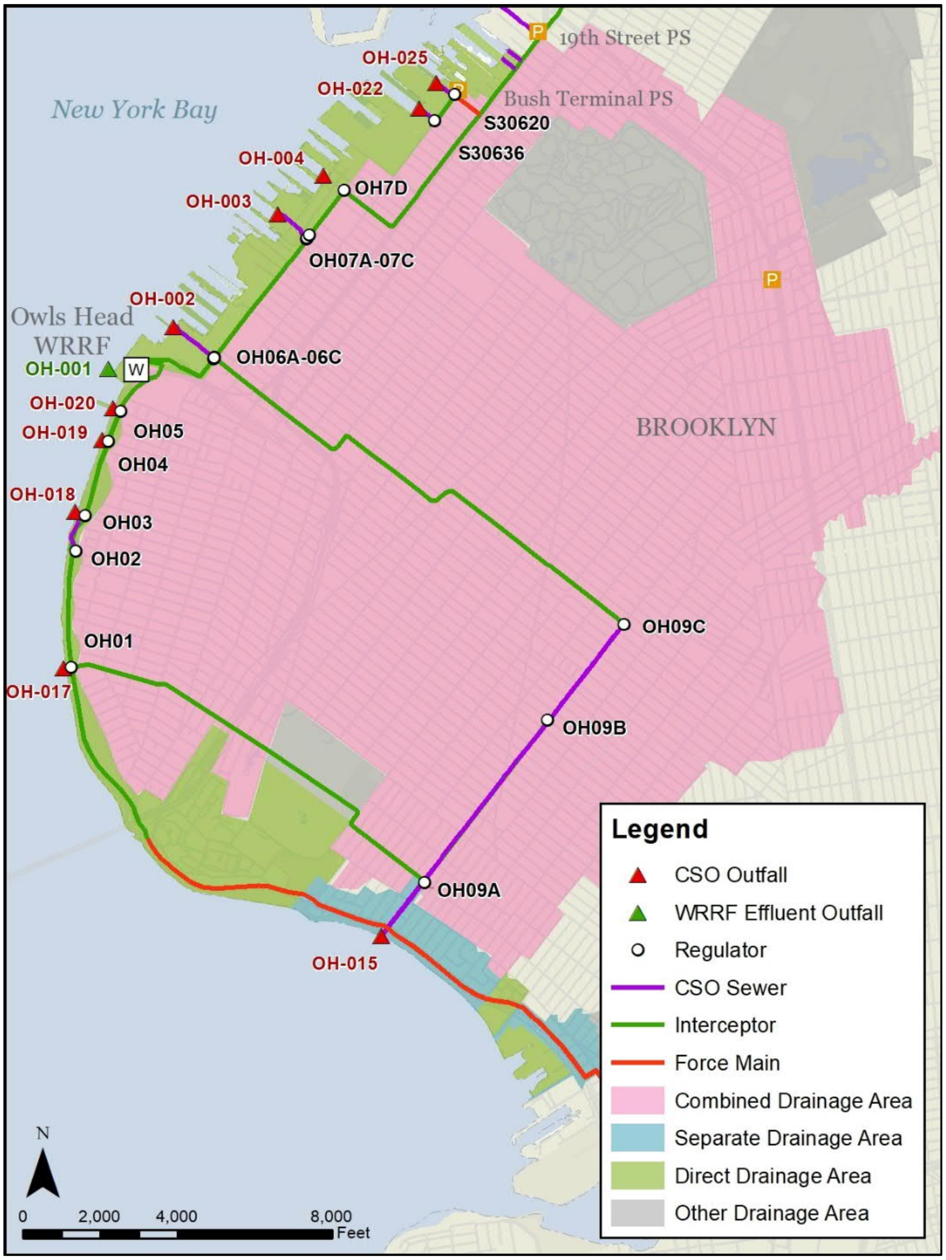

Figure 8.6-6. CSO Outfalls/Regulators Tributary to New York Bay from the Owls Head WRRF System

Findings/Observations from Optimizer Evaluations

The Optimizer evaluations served as an initial screening step to identify potentially promising optimization alternatives to be further evaluated using the full Owls Head WRRF InfoWorks model. These evaluations included the assessment of the impacts to CSO volume, activation and peak hydraulic grade line elevations relative to Baseline Conditions, as well as other general system conditions. General collection system information and findings of the initial Optimizer evaluations included the following:

- The Owls Head WRRF is located in the Bay Ridge section of Brooklyn, and its collection system serves the southwestern side of Brooklyn. One interceptor runs north from the WRRF parallel to the shoreline of New York Bay, extending to the east side of Gowanus Canal. A second branch runs south from the WRRF parallel to the New York Bay shoreline, then southeast along the shoreline of Gravesend Bay.
- A total of 21 regulators divert flow to the interceptors. During wet-weather, flow in excess of the interceptor capacity can overflow to CSO outfalls discharging to the New York Bay (10 CSOs), Gowanus Canal (8 CSOs), and Coney Island Creek (1 CSO).
- Depth of cover on the gravity sewers varies, ranging from relatively shallow (<10 feet of cover) to about 20 feet.
- Regulators from the Owls Head system contributing to CSO outfalls discharging to New York Bay activate between 0 to 64 times during the typical year with a total AAOV of 2,489 MGY.
- Interceptor freeboard for the 5-year design storm and many of the larger storms during the typical year is generally less than 10 feet from the ground surface indicating the system is highly sensitive to hydraulic grade line impacts.
- The Optimizer modeling identified alternatives that included modifications to as many as nine regulators throughout the WRRF collection system that resulted in varying degrees of improved capture and hydraulic performance. However, upon performing InfoWorks runs for the 2008 typical year, limited AAOV (<1 percent) reductions were predicted for the better performing alternatives.
- The limited performance improvement is a result of the hydraulic grade line sensitivities along the interceptor running south from the Owls Head WRRF. Also, since the system was generally running full during wet-weather, alternatives that reduced CSO at one location tended to result in offsetting increases at other locations.

Follow-up Evaluations Based on Full InfoWorks Model

Although no retained alternatives were identified from the initial optimization runs due to the reasons listed here, further optimization evaluations using the InfoWorks model are discussed below.

- Hydraulic grade line impacts that increased the potential risk of flooding
- Negligible reductions in CSO volume to New York Bay

Figure 8.6-7 illustrates the HGL sensitivities where optimization alternatives increase the potential risk of street flooding and basement backups.

Figure 8.6-7. HGL Impacts of Owls Head Collection System Under Baseline Conditions, 5-Year Storm

Additional Optimization Using InfoWorks Model

As part of the evaluations of the Optimizer alternatives using the InfoWorks model, an opportunity was identified for using a control gate to optimize the overflow volume from Regulator 9C, which discharges to Outfall OH-015. The combined sewer tributary to Regulator 9C is a double-barrel conduit, with one barrel sitting on top of the other. At Regulator 9C, flow from the upper conduit is diverted to the lower conduit, where the flow can enter a branch sewer on 60th Street for conveyance to the regulators associated with Outfall OH-002. The InfoWorks model indicated that approximately 90 percent of the overflow at Outfall OH-015 comes out of the lower outfall conduit, while the upper conduit was not running full. Flow remaining in the upper conduit downstream of Regulator 9C can still be diverted to the interceptor system further downstream at Regulator 9A.

Simply closing off the connection between the upper and lower conduits at Regulator 9C was predicted to have unacceptable hydraulic grade line impacts upstream of Regulator 9C during the 5-year storm. However, if a control gate could be installed in the connection between the upper and lower conduits, the gate could be triggered to close during smaller storms, but open during large storms to avoid the upstream hydraulic grade line impacts. Functionally, the gate would be controlled based on level measurement upstream of Regulator 9C, such that once the water surface upstream reached a pre-determined set point, the gate would be triggered to re-open.

This alternative was designated as "NYB-3." The predicted impacts of Alternative NYB-3 on CSO activations and volumes to New York Bay are presented in Table 8.6-9. This alternative would not affect discharges from the Owls Head system to Gowanus Canal or Coney Island Creek. As indicated in Table 8.6-9, Alternative NYB-2 is predicted to reduce CSO volumes at Outfalls OH-002 and OH-015, and slightly increase CSO volume at Outfall OH-017, with a net overall reduction in CSO volume to New York Bay of 90 MG. The increase in overflow at Outfall OH-017 is due to more flow being diverted into the interceptor from the upper barrel of the OH-015 system at Regulator 9A, while the reduction at Outfall OH-002 is due to less flow being diverted into the 60th Street combined sewer at Regulator 9C.

Estimated probable bid costs and construction/implementation considerations for Alternative NYB-3 are summarized in Table 8.6-10.

Table 8.6-9. Performance of Alternative NYB-3, 2008 Typical Year

Outfall(1)	Regulator	Baseline Conditions Typical Year		Alternative NYB-1	
		Annual CSO Volume (MG)	Annual CSO Activations	Annual CSO Volume (MG)	Annual CSO Activations
OH-002	OH-6A,B,C	407	41	367	41
OH-003	OH-7A,B,C	373	57	374	57
OH-004	OH-7D	9.2	12	9.2	12
OH-015	OH-9A,B,C	1,105	64	994	64

Table 8.6-9. Performance of Alternative NYB-3, 2008 Typical Year

Outfall[1]	Regulator	Baseline Conditions Typical Year		Alternative NYB-1	
		Annual CSO Volume (MG)	Annual CSO Activations	Annual CSO Volume (MG)	Annual CSO Activations
OH-017	OH-1	449	39	508	40
OH-018	OH-2,3	121	32	123	33
OH-019	OH-4	22.7	26	22.8	27
OH-020	OH-5	1.3	25	1.2	25
Total		2,489	**64 (Max.)**	**2,399**	**64 (Max.)**

Table 8.6-10. Summary of Cost and Implementation Considerations for New York Bay Optimization Alternative NYB-3

Alternative	Probable Bid Cost ($M)	Implementation Considerations
NYB-3	$5M	• Reduction in CSO to New York Bay of 90 MGY

Tunnel storage options for the outfalls to New York Bay from the Owls Head WRRF system are evaluated in the subsection below.

8.6.b Storage Tunnel Alternatives for 25/50/75/100 Percent CSO Control

Conceptual storage tunnel alternatives were developed to provide modeling scenarios for 25, 50, 75, and 100 percent CSO control of the annual CSO volume discharged to New York Bay in the Typical Year. The approach to sizing and layout of the storage tunnel alternatives was as follows:

- For the 50 percent CSO control tunnel, the Typical Year annual overflow volume of each CSO outfall to New York Bay was reviewed and combinations of outfalls were identified where capture of 100 percent of the CSO from those outfalls would approximately match 50 percent of the total CSO volume from all outfalls to New York Bay.
- The locations of these outfalls were assessed in relation to the length and diameter of tunnel needed to capture the outfalls.
- Based on DEP expertise, a combination of outfalls was selected that provided reasonable tunnel length/diameter to provide 50 percent volume capture.
- A similar approach was taken for the 75 percent CSO control tunnel.

- For the 25 percent CSO control tunnel, the 50 percent CSO tunnel was downsized until the volume of storage provided would result in approximately 25 percent CSO control.
- For the 100 percent CSO control tunnel, it was assumed that every CSO outfall to New York Bay that was predicted to be active in the 2008 Typical Year would be tied into the tunnel. Where multiple outfalls were located in close proximity to each other, it was assumed that a near-surface consolidation conduit would be provided to a single drop shaft.
- For each storage tunnel alternative, the dewatering rate required to dewater the storage tunnel within 24 hours was compared to the available dry-weather flow capacity in the WRRF closest to the downstream end of the tunnel. If insufficient dry-weather flow capacity was available at the WRRF to accept the additional dewatering flows, a high-rate clarification wet-weather flow treatment system with disinfection was added to the alternative to treat the dewatered flow.
- A detailed siting assessment was not conducted, so the specific locations of various features of the tunnel alternatives (mining shaft, TBM removal shaft, drop shafts, dewatering pumping station, dewatered flow treatment facility, near-surface diversion structures/connection conduits) were not identified.

The main features of the 25, 50, 75, and 100 percent CSO control storage tunnels for New York Bay are summarized in Table 8.6-11. The 25 percent capture tunnel would capture overflow from Outfalls OH-015 and OH-017 (Figure 8.6-8). The tunnel would start at a mining shaft in the general vicinity of the Owls Head WRRF, and run south along the New York Bay shoreline. The tunnel would pick up Outfalls OH-015 and OH-017, then continue south past Outfall OH-017 to an equipment removal shaft. The total tunnel length would be about 24,500 feet (4.6 miles), with a diameter of 12 feet. The tunnel would be dewatered to the Owls Head WRRF.

The 50 percent CSO control tunnel would pick up the same outfalls as the 25 percent CSO control tunnel, and run along the same route (Figure 8.6-8). The difference would be that the tunnel would consist of two parallel 23-foot diameter barrels.

The 75 percent CSO control tunnel would follow the same route as the 50 percent tunnel, but would extend north of the Owls Head WRRF to capture Outfalls OH-002 and OH-003 (Figure 8.6-9). This tunnel system would have a length of 28,500 feet (5.4 miles) consist of two parallel 28-foot diameter barrels.

The 100 percent CSO control tunnel capturing the OH/RH outfalls would start with a mining shaft near the Red Hook WRRF, and run along the shoreline of New York Bay to a point south of Outfall OH-015 (Figure 8.6-10). The mining shaft could also be located near the Owls Head WRRF, with the tunnel running in two directions from that location. The tunnel would consist of two parallel barrels, each 23-foot diameter, with a length of about 49,000 feet (9 miles). The tunnel could be dewatered to the either the Red Hook or Owls Head WRRF, depending on the location of the mining shaft.

The 100 percent CSO control tunnel capturing the PR outfalls would start with a mining shaft in the vicinity of Outfall PR-10, and run south along the shoreline of New York Bay to Outfall PR-023A (Figure 8.6-10). The tunnel would have a length of approximately 16,300 feet (5 miles), and a diameter of 25 feet. The tunnel would be dewatered to the Port Richmond WRRF.

Table 8.6-11. Summary of 25, 50, 75, and 100 Percent CSO Control Alternatives for New York Bay

Alternative	**NYB-4**	**NYB-5**	**NYB-6**	**NYB-7**	
Level of CSO Control[1]	**25%**	**50%**	**75%**	**100%**	
WRRF Outfalls Captured[2]	**OH**	**OH**	**OH**	**OH/RH**	**PR**
Length (mi.)	4.6	2 x 4.6[3]	2 x 5.4[4]	2 x 9.3[5]	3.1
Diameter (ft.)	12	23	28	23	25
Volume (MG)	22	156	253	300	61
Outfalls Captured	• OH-015 • OH-017	• OH-015 • OH-017	• OH-002 • OH-003 • OH-015 • OH-017	• 10 OH outfalls • 12 RH outfalls	• 15 PR outfalls
Net CSO Volume Reduction (MGY)	768	1,554	2,335	2,630	431
Wet-Weather Flow Treatment Facility Capacity for Dewatering Flow (MGD)	22	156	253	300	61
Estimated Probable Bid Cost[5]	$900M	$2,900	$4,300M	$6,700	$1,800
Total Estimated Probable Bid Cost by Level of Control[6]	$900M	$2,900	$4,300M	$8,500	

Notes:

(1) Modeled annual percent CSO reduction based on the 2008 Typical Year.
(2) OH = Owls Head; RH = Red Hook; PR = Port Richmond
(3) "2 x 4.6" = Double-barrel tunnel, 4.6 miles long
(4) "2 x 5.4" = Double-barrel tunnel, 5.4 miles long
(5) "2 x 9.3" = Double-barrel tunnel, 9.3 miles long
(6) 2019 dollars.

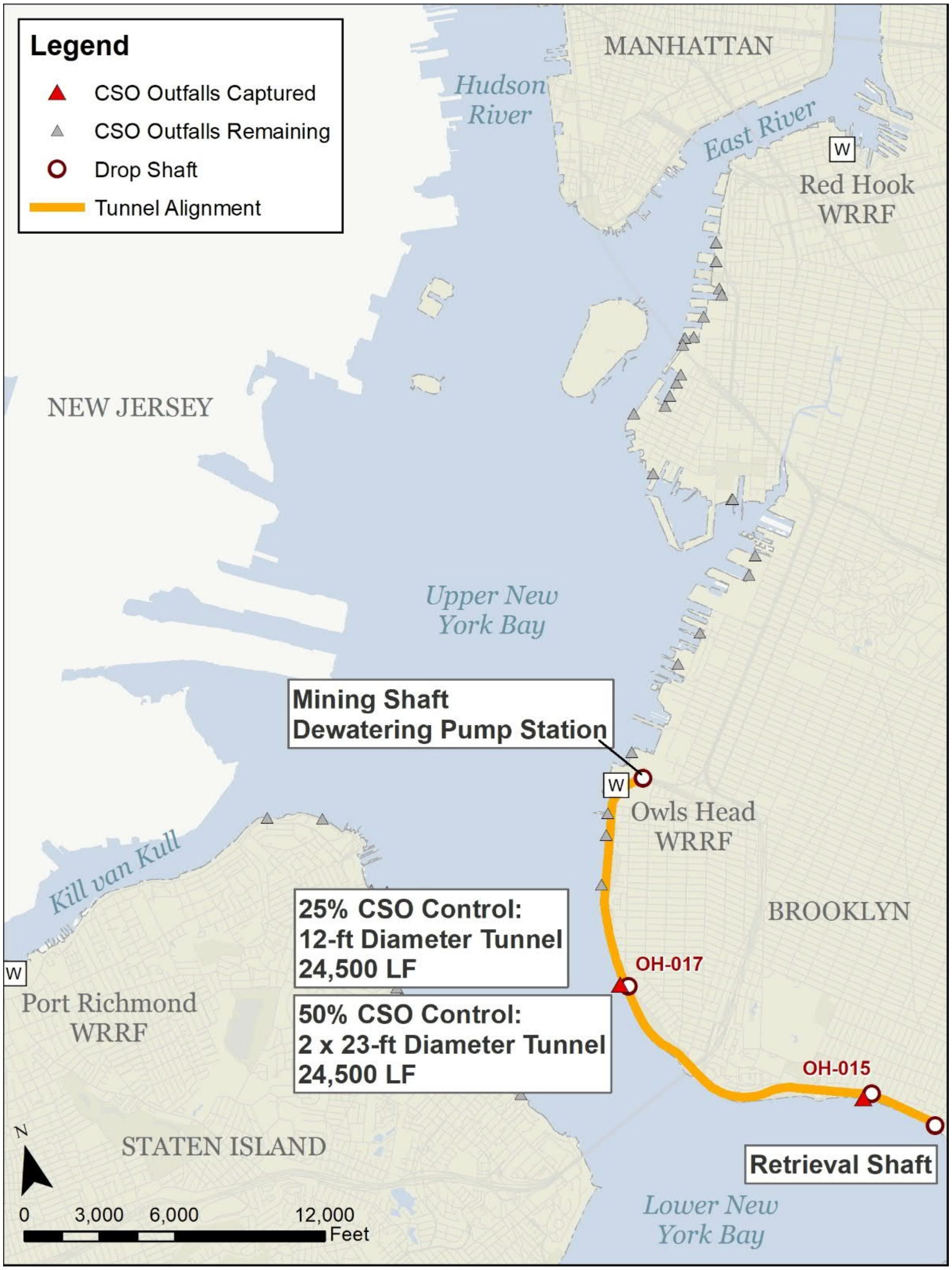

Figure 8.6-8. 25 and 50 Percent CSO Control Tunnels for New York Bay

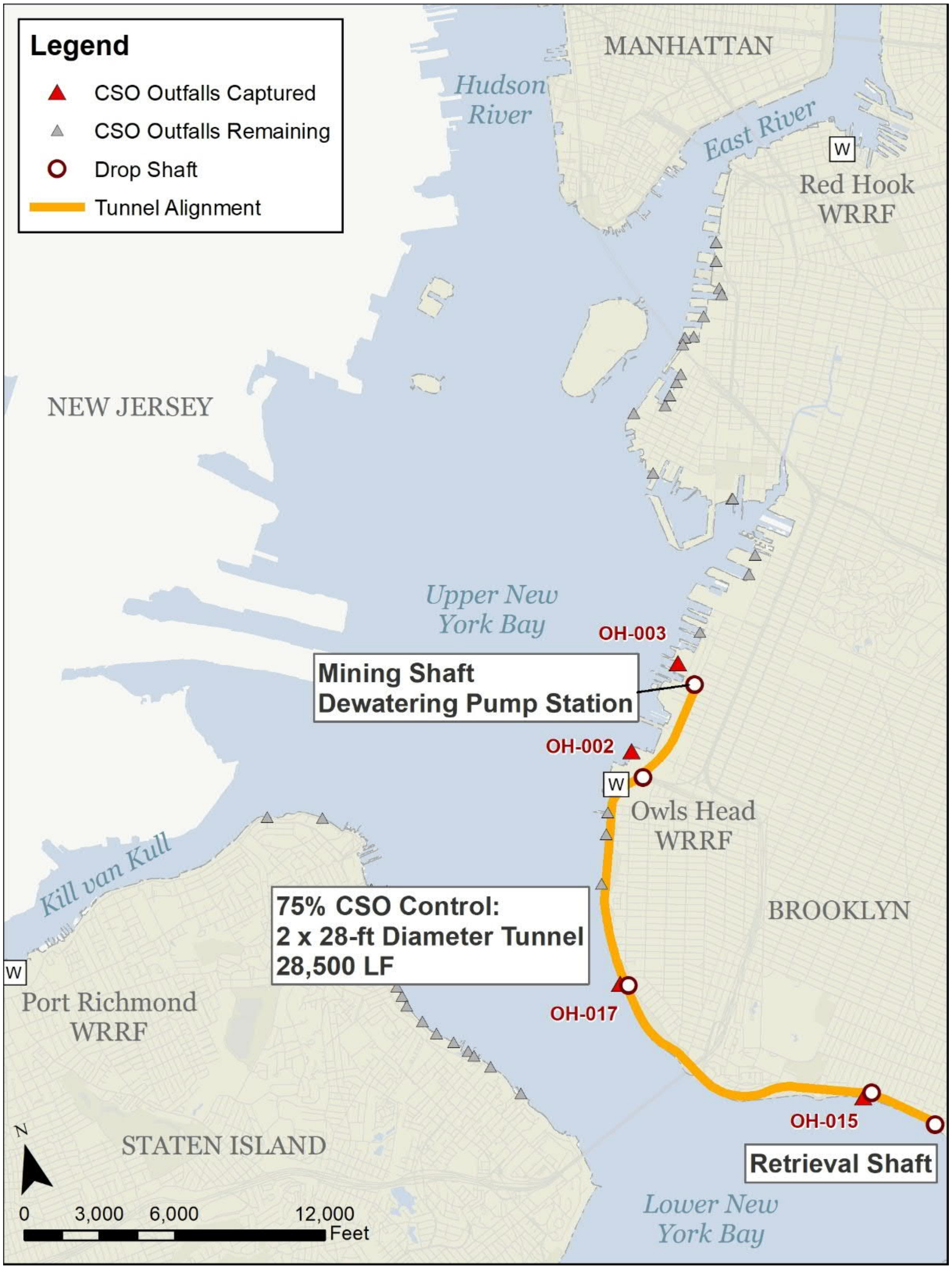

Figure 8.6-9. 75 Percent CSO Control Tunnel for New York Bay

Figure 8.6-10. 100 Percent CSO Control Tunnels for New York Bay

The dewatering capacity needed and the location where the dewatering flow would be conveyed for treatment varies with each of the alternatives described above. However, dedicated wet-weather high-rate treatment facilities would be necessary for the treatment of the CSO retained in the storage tunnels.

While these alternatives provide relatively high levels of CSO control, the significant challenges to implementation include:

- Very high implementation cost
- Limited siting availability for shafts, dewatering pumping station, dewatering flow treatment facility
- Long implementation period
- Significant and prolonged construction impacts (truck traffic, noise, dust) for surface consolidation sewers due to the large number of drop shafts necessary to divert CSO to the tunnel
- Negligible improvement in the annual attainment of applicable water quality standards
- Construction impacts and likelihood of utility conflicts for near-surface diversion structures and connecting conduits

Despite these challenges, these alternatives were retained in order to provide an assessment of a range of levels of CSO control for New York Bay, per the CSO Policy and the Clean Water Act.

8.6.c Summary of Retained Alternatives for New York Bay

The goal of the previous evaluations was to develop a list of retained control measures for New York Bay. These control measures, whether individually or in combination, form the basis of basin-wide alternatives to be assessed using more rigorous cost-performance and cost-attainment analyses. Table 8.6-12 lists all of the control measures originally identified in the “Alternatives Toolbox” shown above in Figure 8.6-2, and identifies whether the control measure was retained for further analysis. The reasons for excluding the non-retained control measures from further consideration are also noted in the table.

Table 8.6-12. Summary of Control Measure Screening for New York Bay

Control Measure	Category	Retained for Further Analysis?	Remarks
Additional GI Build-out	Source Control	NO(1)	Planned GI build-out in the watershed is included in the baseline. It is unlikely that additional sites will be identified due to site constraints in publicly owned properties.
High Level Storm Sewers	Source Control	NO(1)	No cost-effective opportunities identified
Regulator Modifications	System Optimization	YES	Incorporated into optimization Alternatives NYB-1 and NYB-3
Parallel Interceptor Sewer	System Optimization	YES	Incorporated into optimization Alternative NYB-2

Table 8.6-12. Summary of Control Measure Screening for New York Bay

Control Measure	Category	Retained for Further Analysis?	Remarks
Bending Weirs/Control Gates	System Optimization	NO	Incorporated into optimization Alternative NYB-3
Pumping Station Optimization	System Optimization	NO	Limited benefit in terms of CSO reduction.
Pumping Station Expansion	System Optimization	NO	Limited benefit in terms of CSO reduction.
Gravity Flow Redirection to Other Watersheds	CSO Relocation	YES	Optimization Alternatives NYB-1 and NYB-2 shift some CSO volume between New York Bay and other waterbodies
Pumping Station Modification	CSO Relocation	NO	No cost-effective opportunities identified.
Flow Redirection with Conduit and Pumping	CSO Relocation	NO	No cost-effective opportunities identified.
Floatables Control	Floatables Control	YES	Programmatic floatables control will be applied and expanded Citywide.
Environmental Dredging	Water Quality/ Ecological Enhancement	NO	No specific locations of CSO sediment mounding identified.
Wetland Restoration and Daylighting	Water Quality/ Ecological Enhancement	NO	No daylighting opportunities were identified.
Outfall Disinfection	Treatment: Satellite	NO	Not feasible due to short length of outfalls.
Retention/Treatment Basins	Treatment: Satellite	NO	Significant siting constraints and very high costs. Tunnel storage covers 25/50/75/100% CSO control alternatives.
High-Rate Clarification	Treatment: Satellite	YES	Incorporated into the storage tunnel alternatives for treatment of captured CSO during tunnel dewatering.
WRRF Expansion	Centralized Treatment	NO	Insufficient space available. Limited benefit compared to potential cost.
In-System Storage (Outfalls)	Storage	NO	Negligible levels of CSO control due to short outfalls.
Off-line Storage (Tanks)	Storage	NO	Significant siting constraints and very high costs. Tunnel storage covers 25/50/75/100% CSO control alternatives.
Off-line Storage (Tunnels)	Storage	YES	Tunnel storage Alternatives NYB-4, NYB-5, NYB-6 and NYB-7 cover 25/50/75/100% CSO control.

Note:
(1) Additional GI and HLSS are considered to be ongoing programs that will continue to be implemented system-wide outside of the LTCP program.

As shown, the retained control measures include system optimization measures, tunnel storage (with high-rate clarification for dewatering flows), and programmatic floatables control.

8.6.d CSO Volume and Loading Reductions for Retained Alternatives for New York Bay

Table 8.6-13 summarizes the projected performance of the retained New York Bay alternatives in terms of annual CSO volume and fecal coliform load reduction, based on the 2008 Typical Year. These data are plotted on Figure 8.6-11. In all cases, the predicted reductions shown are relative to the Baseline Conditions using 2008 JFK rainfall as described in Section 6. The baseline assumptions were described in detail in Section 6 and include the implementation of the grey infrastructure projects from the approved WWFPs, the Recommended Plans from the previously submitted LTCPs, and the projected level of GI identified in Section 5. Since Alternatives NYB-1, NYB-2 and NYB-3 are hydraulically independent of each other, Table 8.6-13 includes values for each of those alternatives independently, and also for a case where all three alternatives would be implemented (combined NYB-1, NYB-2 and NYB-3).

Table 8.6-13. New York Bay Retained Alternatives Performance Summary (2008 Rainfall)

Alternative	Annual Performance Based on 2008 Typical Year				
	Remaining CSO Volume (MGY) (1)	Frequency of Overflow (2)	Additional Untreated CSO Volume to Other Waterbodies (MGY) (3)	Net CSO Volume Reduction (%)	Net Fecal Coliform Reduction (%)
Baseline Conditions	3,062	64	0	0	0
NYB-1. Optimization of Regulators Associated with Outfalls RH-005 and RH-014	3,057(4)	64	5	<1	<1
NYB-2. Hannah Street Pumping Station Bypass	3,025(5)	64	5	1	1
NYB-3. Control Gate at Regulator 9C (Outfall OH-015)	3,152	64	0	3	3
NYB-1, NYB-2, NYB-3 Combined	2,930(6)	64	10	4	4
NYB-4. Tunnel Storage for 25% CSO Control (22 MG Capacity)	2,294	57	0	25	25
NYB-5. Tunnel Storage for 50% CSO Control (156 MG Capacity)	1,508	57	0	51	51
NYB-6. Tunnel Storage for 75% CSO Control (253 MG Capacity)	727	42	0	76	76
NYB-7. Tunnel Storage for 100% CSO Control (361 MG Capacity)	0	0	0	100	100

Notes:

(1) Remaining CSO includes all discharges to New York Bay from the Red Hook, Owls Head, and Port Richmond WRRF Collection Systems.
(2) Frequency of overflow is based upon the most frequently active CSO outfall.
(3) Additional untreated CSO volume to other waterbodies accounts for increases at other CSO outfalls in response to the implementation of a CSO control alternative. Net CSO volume reduction and net fecal coliform reduction account for any additional CSO discharge to other waterbodies.
(4) Reduction in CSO to New York Bay of 10 MG; alternative also results in an increase in CSO to the East River of 5 MG.
(5) Reduction in CSO to New York Bay of 42 MG; alternative also results in an increase in CSO to Kill Van Kull of 5 MG.
(6) See Notes 4 and 5.

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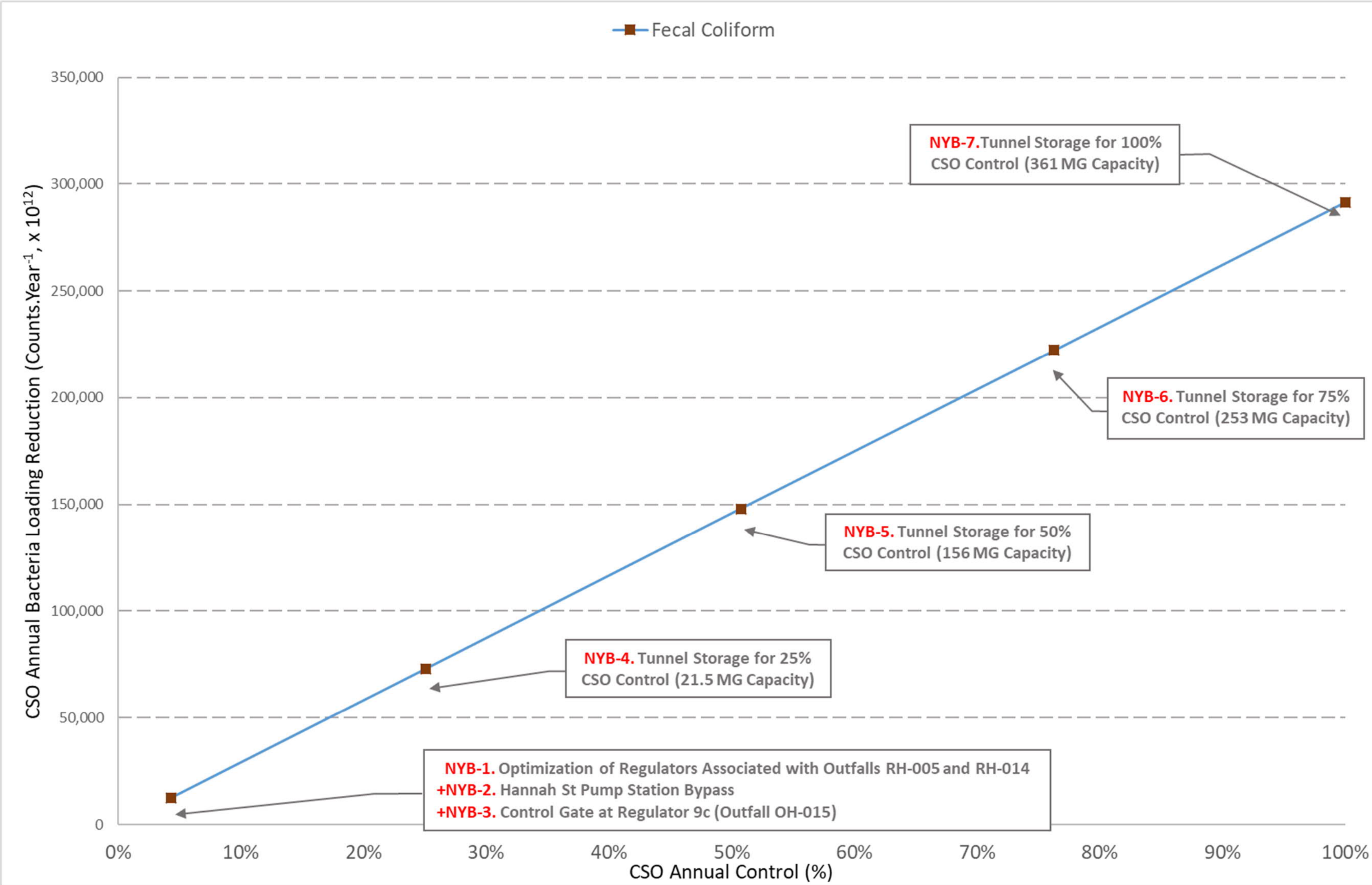

Figure 8.6-11. Untreated CSO Volume Reductions (as Percent CSO Annual Control) vs. Annual CSO Bacterial Loading Reduction (2008 Typical Year) for New York Bay

Because the retained alternatives for New York Bay provide volume reduction and not treatment, the predicted bacteria loading reductions of the alternatives are very closely aligned with their projected CSO volume reductions.

8.6.e Cost Estimates for East River Retained Alternatives

Evaluation of the retained alternatives requires cost estimation. The methodology for developing these costs is dependent upon the type of technology and its O&M requirements. The construction costs were developed as Probable Bid Costs (PBC) and the total Net Present Worth (NPW) costs were determined by adding the estimated PBC to the NPW of the projected annual O&M costs at an assumed interest rate of 3 percent over a 100-year life cycle. Design, construction management, and land acquisition costs are not included in the cost estimates. All costs are in 2019 dollars and are considered Level 5 cost estimates by AACE International with an accuracy of -50 percent to +100 percent.

8.6.e.1 Alternative NYB-1. Optimization of Outfalls RH-005 and RH-014

Costs for Alternative NYB-1 include planning-level estimates of the costs to optimize the performance of Regulator RH-20A associated with Outfall RH-005, and Regulator RH-13, associated with Outfall RH-014 and reflect the description provided in Section 8.6.a. Site acquisition costs are not included. The total cost, expressed as NPW, for Alternative NYB-1 is $6M as shown in Table 8.6-14.

Table 8.6-14. Costs for Alternative NYB-1

Item	2019 Cost ($ Million)
Probable Bid Cost	$6
Annual O&M Cost	$0
Net Present Worth	$6

8.6.e.2 Alternative NYB-2. Hannah Street Pumping Station Bypass

Costs for Alternative NYB-2 include planning-level estimates of the costs to construct a bypass connection for the flow in the Victory Boulevard combined sewer, to direct the dry-weather flow and a portion of the wet-weather flow directly to the East Interceptor by gravity, and reflects the description provided in Section 8.6.a. Site acquisition costs are not included. The total cost, expressed as NPW, for Alternative NYB-2 is $22M as shown in Table 8.6-15.

Table 8.6-15. Costs for Alternative NYB-2

Item	2019 Cost ($ Million)
Probable Bid Cost	$22
Annual O&M Cost	$0
Net Present Worth	$22

8.6.e.3 Alternative NBY-3. Control Gate for Regulator 9C, Outfall OH-015

Costs for Alternative NYB-3 include planning-level estimates of the costs to install a control gate in Regulator OH-9C associated with Outfall OH-015 and reflects the description provided in Section 8.6.a. Site acquisition costs are not included. The total cost, expressed as NPW, for Alternative NYB-3 is $23M as shown in Table 8.6-16.

Table 8.6-16. Costs for Alternative NYB-3

Item	2019 Cost ($ Million)
Probable Bid Cost	$5
Annual O&M Cost	$0.5
Net Present Worth	$23

8.6.e.4 Alternative NYB-4. Tunnel Storage for 25 Percent CSO Control

Costs for Alternative NYB-4 include planning-level estimates of the costs for a CSO storage tunnel sized for 25 percent CSO control. A description of the tunnel components is provided in Section 8.6.b and illustrated in Table 8.6-11. Site acquisition costs are not included. The total cost, expressed as NPW, for Alternative NYB-4 is $1,100M as shown in Table 8.6-17.

Table 8.6-17. Costs for Alternative NYB-4

Item	2019 Cost ($ Million)
Probable Bid Cost	$900
Annual O&M Cost	$5
Net Present Worth	$1,100

8.6.e.5 Alternative NYB-5. Tunnel Storage for 50 Percent CSO Control

Costs for Alternative NYB-5 include planning-level estimates of the costs for a CSO storage tunnel sized for 50 percent CSO control. A description of the optimization components is provided in Section 8.6.b and illustrated in Table 8.6-11. Site acquisition costs are not included. The total cost, expressed as NPW, for Alternative NYB-5 is $3,200M as shown in Table 8.6-18.

Table 8.6-18. Costs for Alternative NYB-5

Item	2019 Cost ($ Million)
Probable Bid Cost	$2,900
Annual O&M Cost	$9
Net Present Worth	$3,200

8.6.e.6 Alternative NYB-6. Tunnel Storage for 75 Percent CSO Control

Costs for Alternative NYB-6 include planning-level estimates of the costs for the CSO storage tunnel sized for 75 percent CSO control. A description of the optimization components is provided in Section 8.6.b and illustrated in Table 8.6-11. Site acquisition costs are not included. The total cost, expressed as NPW, for Alternative NYB-6 is $4,700M as shown in Table 8.6-19.

Table 8.6-19. Costs for Alternative NYB-6

Item	2019 Cost ($ Million)
Probable Bid Cost	$4,300
Annual O&M Cost	$13
Net Present Worth	$4,700

8.6.e.7 Alternative NBY-7. Tunnel Storage for 100 Percent CSO Control

Costs for Alternative NYB-7 include planning-level estimates of the costs for the two CSO storage tunnels sized for 100 percent CSO control. A description of the optimization components is provided in Section 8.6.b and illustrated in Table 8.6-11. Site acquisition costs are not included. The total cost, expressed as NPW, for Alternative NYB-7 is $9,100M as shown in Table 8.6-20.

Table 8.6-20. Costs for Alternative NYB-7

Item	2019 Cost ($ Million)
Probable Bid Cost	$8,500
Annual O&M Cost	$21
Net Present Worth	$9,100

The cost estimates of these retained alternatives are summarized below in Table 8.6-21 and are then used in the development of the cost-performance and cost-attainment plots presented in Section 8.6.f.

Table 8.6-21. Cost of Retained Alternatives – New York Bay

Alternative	PBC(1) ($ Million)	Annual O&M Cost ($ Million/Year)	Total Net Present Worth(2) ($ Million)
NYB-1. Optimization of Regulators Associated with Outfalls RH-005 and RH-014	$6	$0	$6
NYB-2. Hannah Street Pumping Station Bypass	$22	$0	$22
NYB-3. Real Time Control of Regulator 9C (Outfall OH-015)	$5	$0.5	$23
NYB-1, NYB-2, NYB-3 Combined	$33	$0.5	$51
NYB-4. Tunnel Storage for 25% CSO	$900	$5	$1,100

Table 8.6-21. Cost of Retained Alternatives – New York Bay

Alternative	PBC(1) ($ Million)	Annual O&M Cost ($ Million/Year)	Total Net Present Worth(2) ($ Million)
Control (22 MG Capacity)			
NYB-5. Tunnel Storage for 50% CSO Control (156 MG Capacity)	$2,900	$9	$3,200
NYB-6. Tunnel Storage for 75% CSO Control (253 MG Capacity)	$4,300	$13	$4,700
NYB-7. Tunnel Storage for 100% CSO Control (361 MG Capacity)	$8,500	$21	$9,100

Notes:

(1) The Probable Bid Cost (PBC) for the construction contract based upon 2019 dollars.
(2) The Net Present Worth (NPW) is based upon a 100-year service life for tunnels and is calculated by multiplying the annual O&M cost by a present worth of 31.599 and adding this value to the PBC.

8.6.f Cost-Benefit Curves for Retained Alternatives

The final step of the analysis is to evaluate the cost-effectiveness of the basin-wide retained alternatives based on their NPW and projected impact on CSO loadings and attainment of applicable WQS. Section 8.6.f.1 below presents plots of cost versus CSO volume and bacteria load reduction (Cost-Performance Curves), and Section 8.6.g below presents plots of cost versus percent attainment with WQS for selected points within New York Bay (Cost-Attainment Curves).

8.6.f.1 Cost-Performance Curves

Cost-performance curves were developed by plotting the costs of the retained alternatives against their predicted level of CSO control, both in terms of CSO volume reduction, and in bacteria load reduction. In each case, a best-fit cost curve was developed based on those alternatives judged most cost-effective for a defined level of CSO control as estimated by IW modeling for the typical year rainfall (2008).

Figure 8.6-12 presents a plot of CSO volume reduction versus NPW for the retained alternatives, while Figure 8.6-13 plots the cost of the alternatives against fecal coliform loading reductions.

8.6.g Cost-Attainment Curves

This section evaluates the relationship of the costs of the retained alternatives versus their expected level of attainment of bacteria Primary Contact WQ Criteria as modeled using the LTCPRM water quality model for the 10-year simulation. As indicated in Section 6, based on the 10-year WQ simulations for New York Bay, the Class SB WQ Criteria for fecal coliform and Class SB Coastal Primary Recreational WQ Criteria for *Enterococci* 30-day geometric mean are both met at least 95 percent of the time under Baseline Conditions. Attainment of the Class SB Coastal Primary Recreational WQ Criteria for *Enterococci* 30-day STV ranges from about 50 to greater than 95 percent.

As a result, implementation of any of the retained alternatives described above, including the 100 percent CSO capture tunnel, results in nominal improvement in the percent attainment of the Class SB WQ Criteria for fecal coliform and Class SB Coastal Primary Recreational WQ Criteria for *Enterococci* 30-day geometric mean.

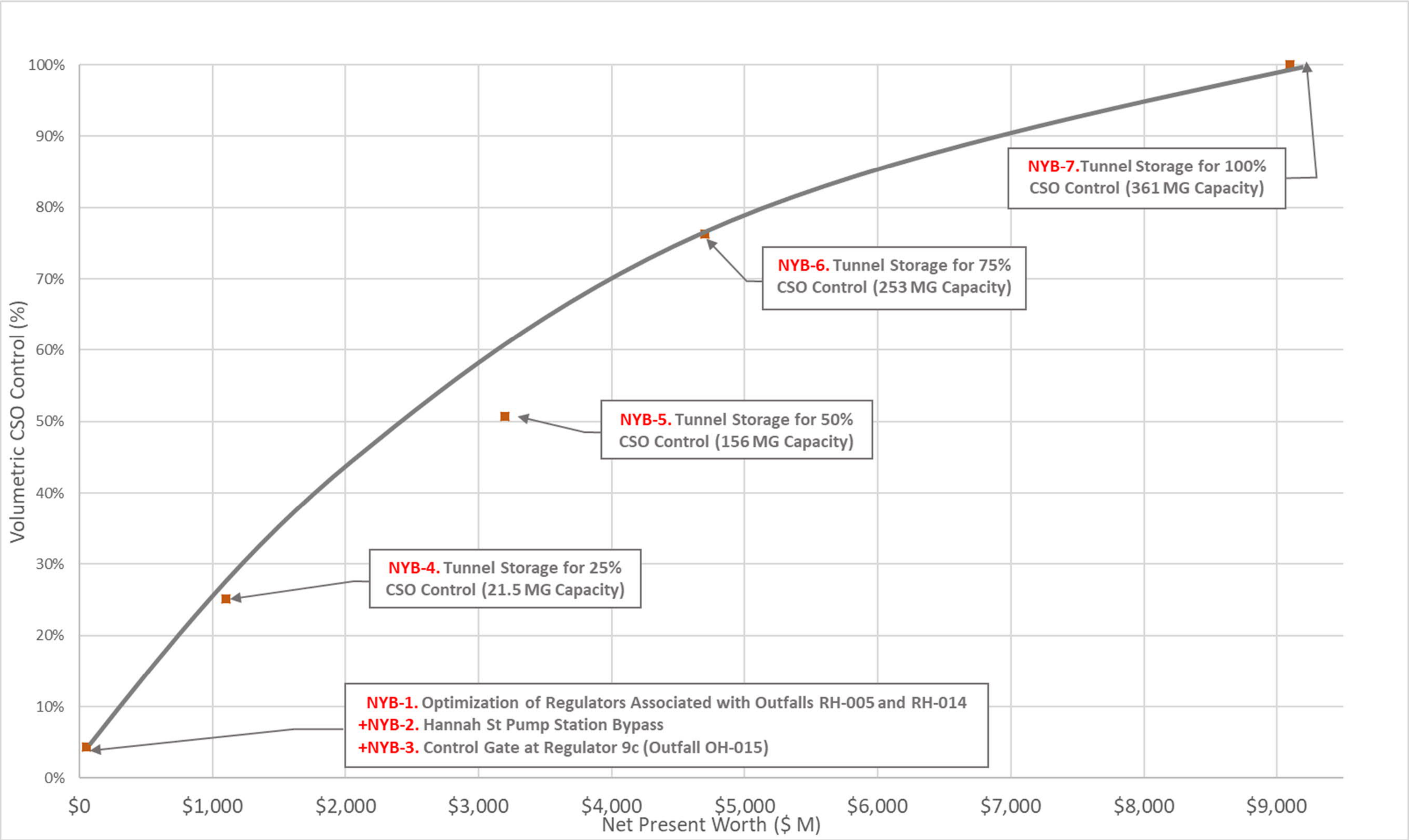

Figure 8.6-12. Cost vs. CSO Control – New York Bay (2008 Typical Year)

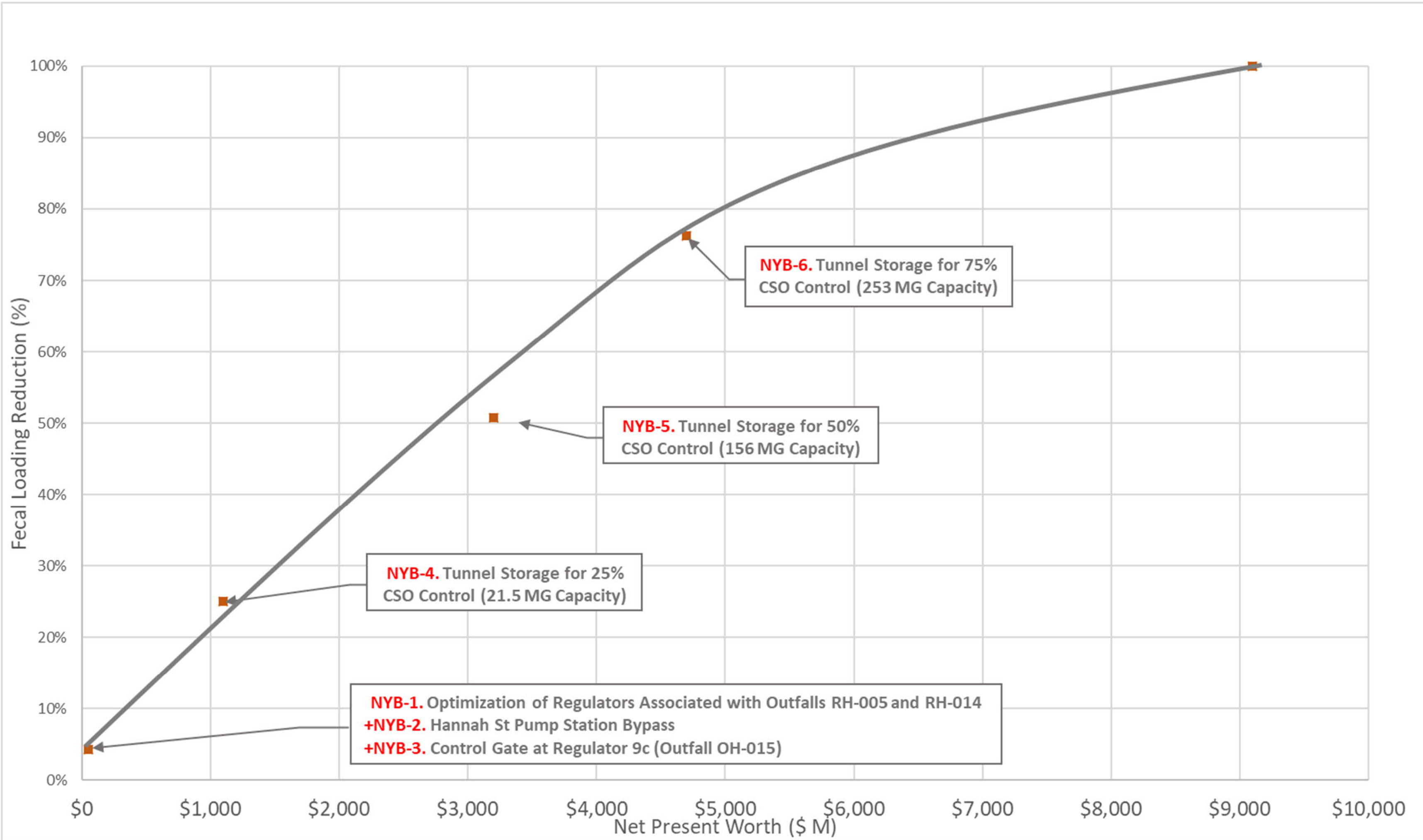

Figure 8.6-13. Cost vs. Fecal Coliform Load Reduction – New York Bay (2008 Typical Year)

Cost-attainment plots are presented below for three locations within New York Bay:

- LTCP sampling Station NB-4, located along the Brooklyn shoreline of New York Bay adjacent to the Owls Head WRRF (Figure 8.6-14).
- LTCP sampling Station NB-5, located west of Station NB-4, in Upper New York Bay approximately half way between the Brooklyn and Staten Island shorelines (Figure 8.6-15).
- LTCP sampling Station NB-6, located along the Brooklyn shoreline of Graves End Bay adjacent to Dyker Beach Park (Figure 8.6-16).

The locations of these stations are shown on Figure 8.6-23 below. The plots in Figure 8.6-14 to Figure 8.6-15 show NPW versus percent attainment with the Class SB WQ Criteria for fecal coliform on both an annual and recreational season (May 1st through October 31st) basis, and the attainment with the Class SB Coastal Primary Recreational WQ Criteria for *Enterococci* (30-day geometric mean and STV, recreational season basis). In each of these three figures, the plots for attainment with the Class SB criteria for fecal coliform on an annual and recreational season basis, as well as the plots for attainment with the Class SB Coastal Primary Recreational WQ Criteria for *Enterococci* (30-day geometric mean) are generally superimposed on each other at a level of 100 percent.

These plots indicate that each of the retained alternatives represent essentially no performance improvement in terms of percent attainment with the Class SB WQ Criteria for fecal coliform on both an annual and recreational season (May 1st through October 31st) basis, and the attainment with the Class SB Coastal Primary Recreational WQ Criteria for *Enterococci* (30-day geometric mean) at highly variable levels of cost, due to the 100 percent or near-100 percent level of attainment under Baseline Conditions. Attainment with the Class SB Coastal Primary Recreational WQ Criteria for *Enterococci* (30-day STV) throughout New York Bay would require the 50 percent level of CSO control, with an un-escalated PBC of $2,900M ($3,200M NPW).

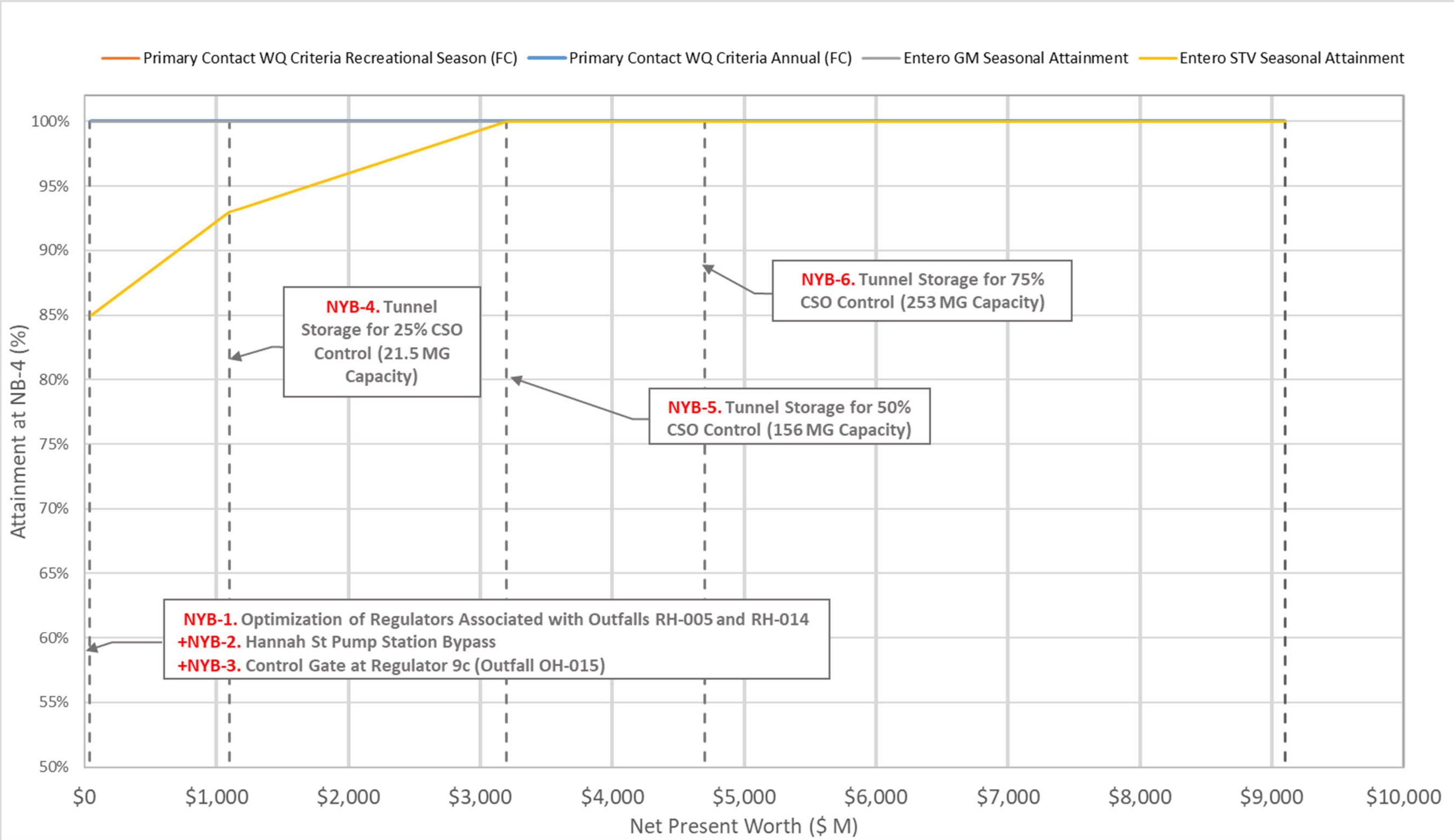

Figure 8.6-14. Cost vs. Bacteria Attainment at Class SB Coastal Primary Recreational Station NB-4

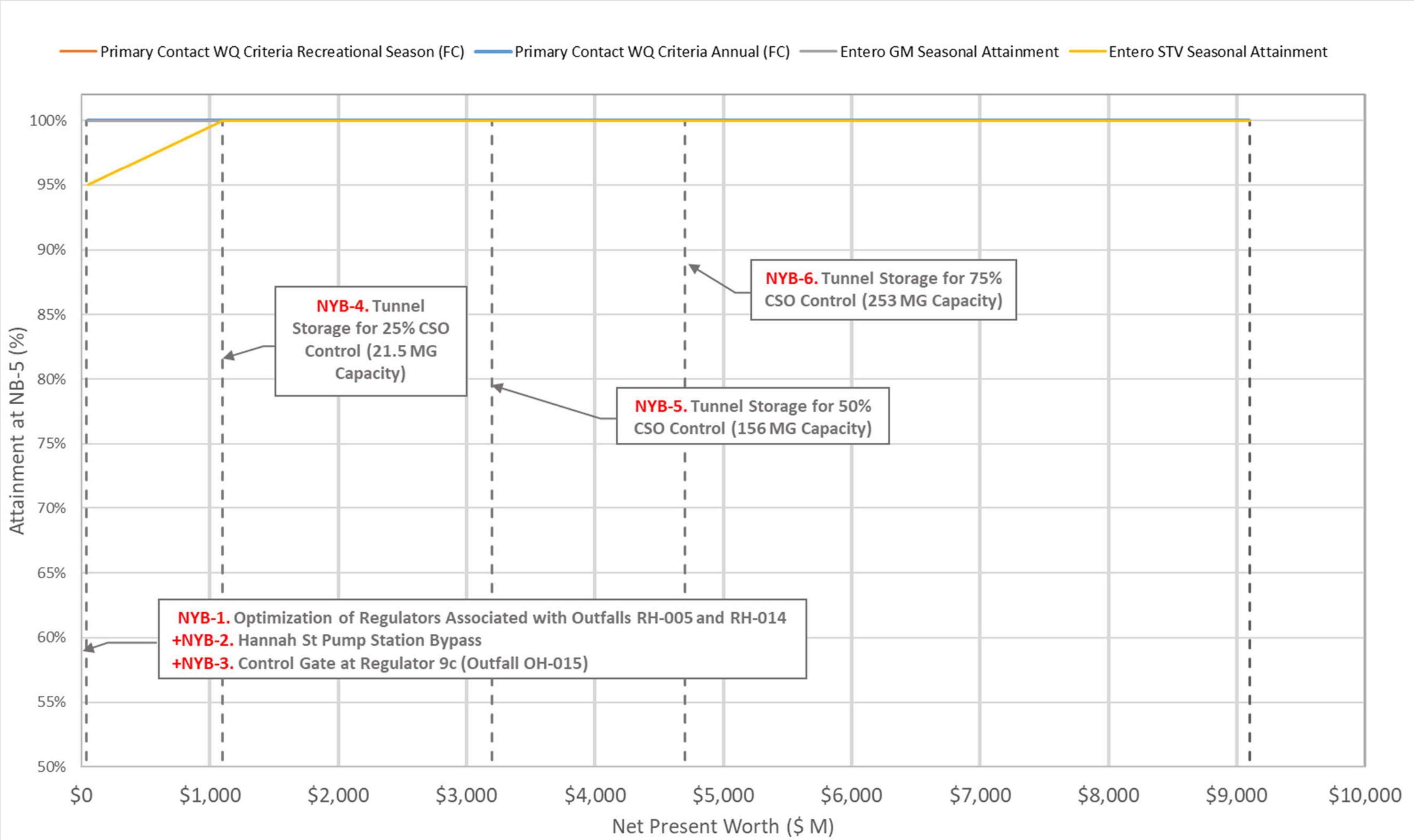

Figure 8.6-15. Cost vs. Bacteria Attainment at Class SB Coastal Primary Recreational Station NB-5

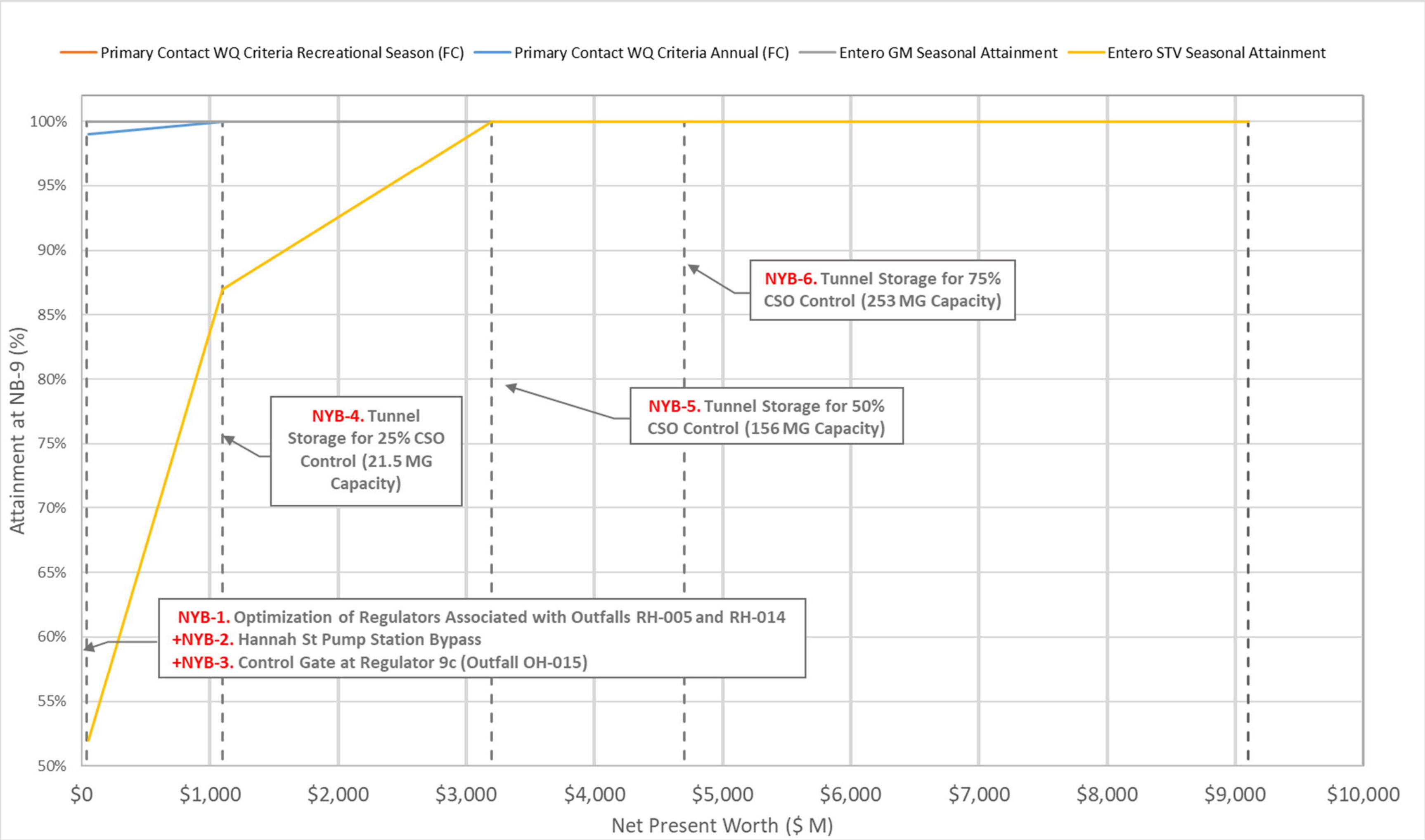

Figure 8.6-16. Cost vs. Bacteria Attainment at Class SB Coastal Primary Recreational Station NB-9

8.6.h Conclusion on Preferred Alternative

The selection of the preferred alternative for New York Bay is based on multiple considerations including public input, environmental and water quality benefits, and projected costs. However, as described above and in Section 6, New York Bay is achieving Class SB fecal coliform WQ criteria, and Class SB Coastal Primary Recreational *Enterococci* WQ 30-day geometric mean criteria greater than 95 percent of the time under Baseline Conditions. The CSO storage tunnel alternatives would provide a range of levels of CSO reduction to New York Bay, but the costs associated with those alternatives are very high. The 50 percent CSO control tunnel would generally achieve attainment with the Class SB Coastal Primary Recreational *Enterococci* WQ 30-day STV criteria throughout New York Bay, but at an un-escalated PBC of $2,900M. Those high-cost alternatives would not substantially change the level of the other applicable WQ criteria for bacteria. Section 9 presents affordability issues and impacts on disadvantaged communities that would come into play if the CSO program costs were to further significantly increase. Also, as presented below in the discussion of time to recovery, the duration of impacts of wet-weather events in New York Bay is short. For these reasons, the CSO storage tunnel alternatives are not recommended.

All three of the optimization alternatives carried forward in the evaluation, NYB-1, NYB-2, and NYB-3, were selected for inclusion in the Recommended Plan. Implementation is projected to reduce net CSO volumes by 132 MGY during the typical year at a PBC of $33M. These projected costs do not include costs for land acquisition, design, and construction management. Alternative NYB-1 consists of modifying the weir at Regulator RH-020A (CSO RH-005), and modifying the weir, increasing the regulator orifice opening, and enlarging the branch interceptor connection at Regulator RH-13 (CSO RH-014). Alternative NYB-2 consists of installing a diversion connection on the Victory Boulevard combined sewer upstream of Regulator 17 (CSO PR-013). This connection would divert dry-weather flow and a portion of the wet-weather flow directly to the East Interceptor by gravity. Alternative NYB-3 consists of installing a control gate in Regulator 9C (CSO OH-015), to keep more wet-weather flow in the upper of the two combined sewer conduits entering the regulator.

In summary, the following conclusions can be drawn from these analyses:

1. Under Baseline Conditions, attainment with the Class SB WQ Criteria for fecal coliform is projected to be 100 percent at all New York Bay Stations annually and during the recreation season (May 1st through October 31st), while attainment with the Class SB WQ Criteria for DO is greater than 99 percent at all stations within New York Bay with the exception of an area off the southwestern tip of Staten Island. DO attainment at that location is not affected by NYC CSOs.
2. Under Baseline Conditions, the Class SB Coastal Primary Recreational *Enterococci* GM criteria attainment is projected to be in the 99 to 100 percent range, while the Class SB Coastal Primary Recreational *Enterococci* STV criteria attainment is projected to be in the 50 to 100 percent range.
3. The most cost-effective alternative, based on the KOTC analysis approach, consistent with EPA's CSO Control Policy is a combination of Alternatives NYB-1, NYB-2, and NYB-3.
4. The PCM will document the WQ improvements upon implementation of these projects.
5. While the annual volume of CSO remaining in New York Bay is acknowledged to remain relatively high, the time to recovery analysis presented further below demonstrates that the duration of impact of the remaining CSOs is low.

Figure 8.6-17 presents a mosaic of the level of attainment with the Class SB Coastal Primary Recreational WQ Criteria for *Enterococci* (30-day geometric mean) in New York Bay, on a recreational season (May 1st through October 31st) basis, for the Recommended Plan. Figure 8.6-18 presents a mosaic of the level of attainment with the Class SB Coastal Primary Recreational WQ Criteria for *Enterococci* (30-day STV) in New York Bay, on a recreational season (May 1st through October 31st) basis, for the Recommended Plan. Figure 8.6-19 presents a mosaic of the level of attainment with the Class SB WQ Criteria for fecal coliform in New York Bay, on an annual basis, for the Recommended Plan, and Figure 8.6-20 presents the level of attainment in the recreational season (May 1st through October 31st). Figure 8.6-21 presents the level of attainment with the Existing WQ Criteria for DO (acute) on an average annual basis, and Figure 8.6-22 presents the level of attainment with the Existing WQ Criteria for DO (chronic) on an average annual basis.

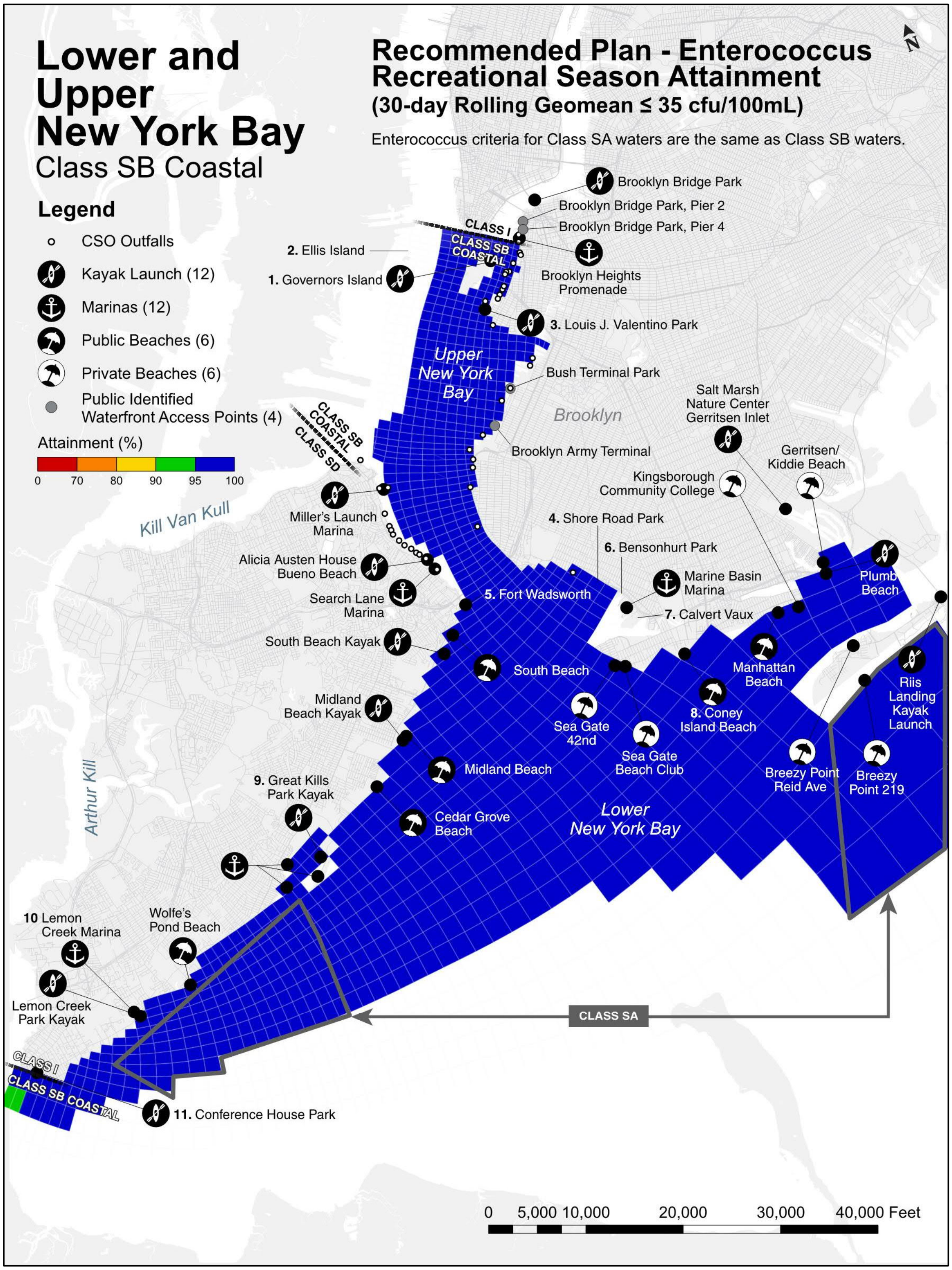

Figure 8.6-17. *Enterococci* Class SB Coastal Primary Recreational GM Attainment (10-year Runs) – New York Bay, Recommended Plan

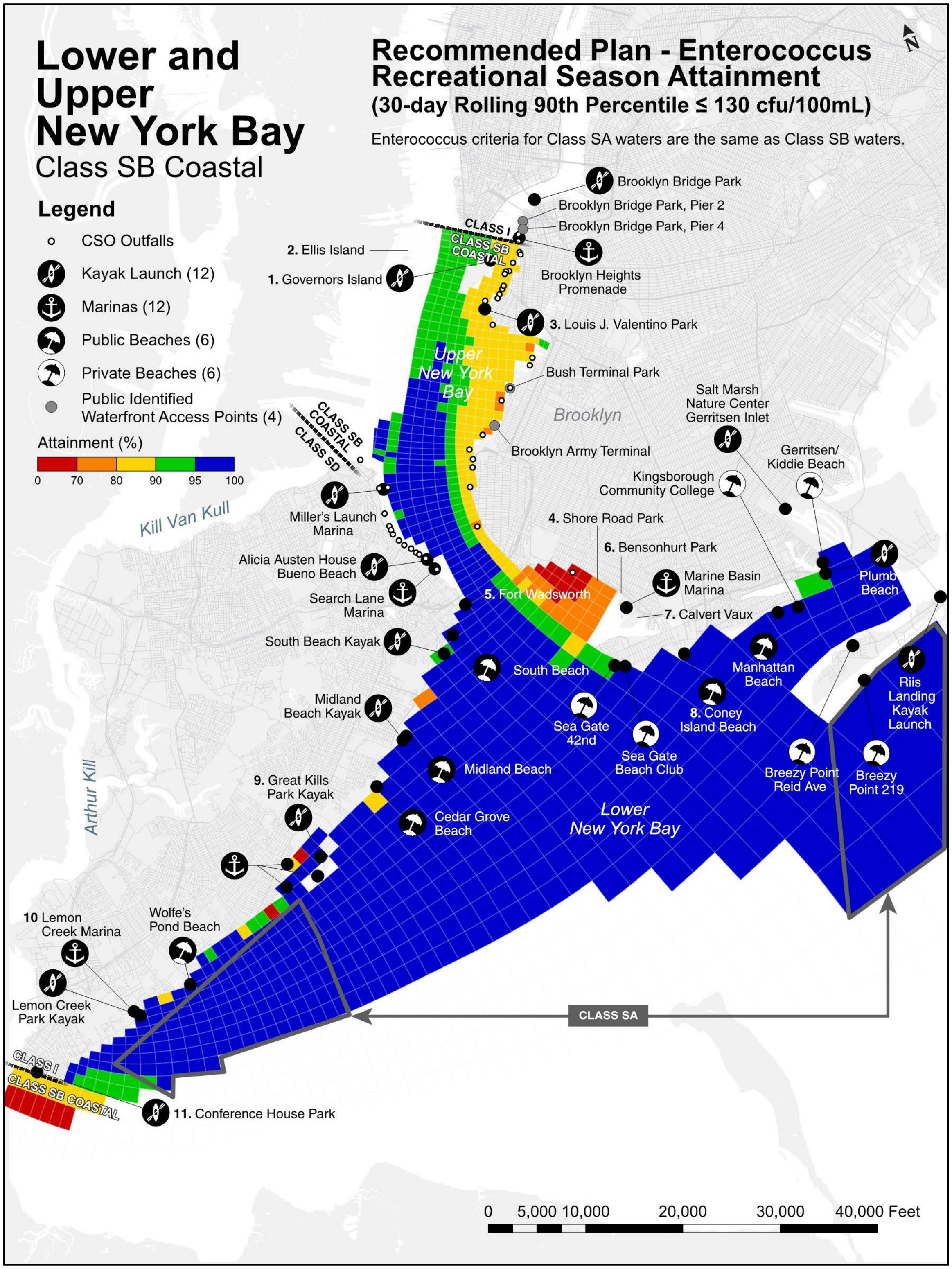

Figure 8.6-18. *Enterococci* Class SB Coastal Primary Recreational STV Attainment (10-year Runs) – New York Bay, Recommended Plan

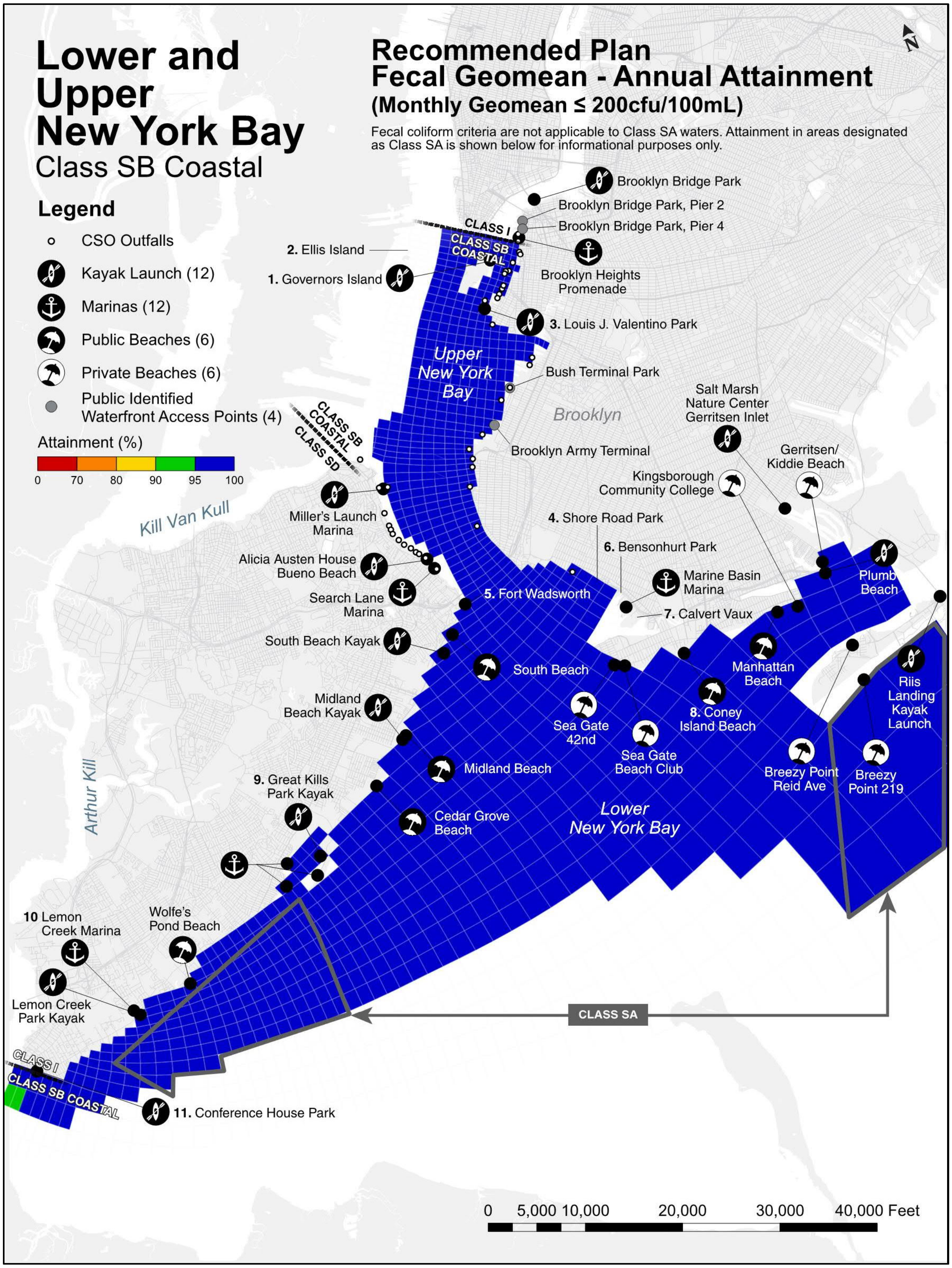

Figure 8.6-19. Fecal Coliform Class SB - Annual Attainment (10-year Runs), New York Bay, Recommended Plan

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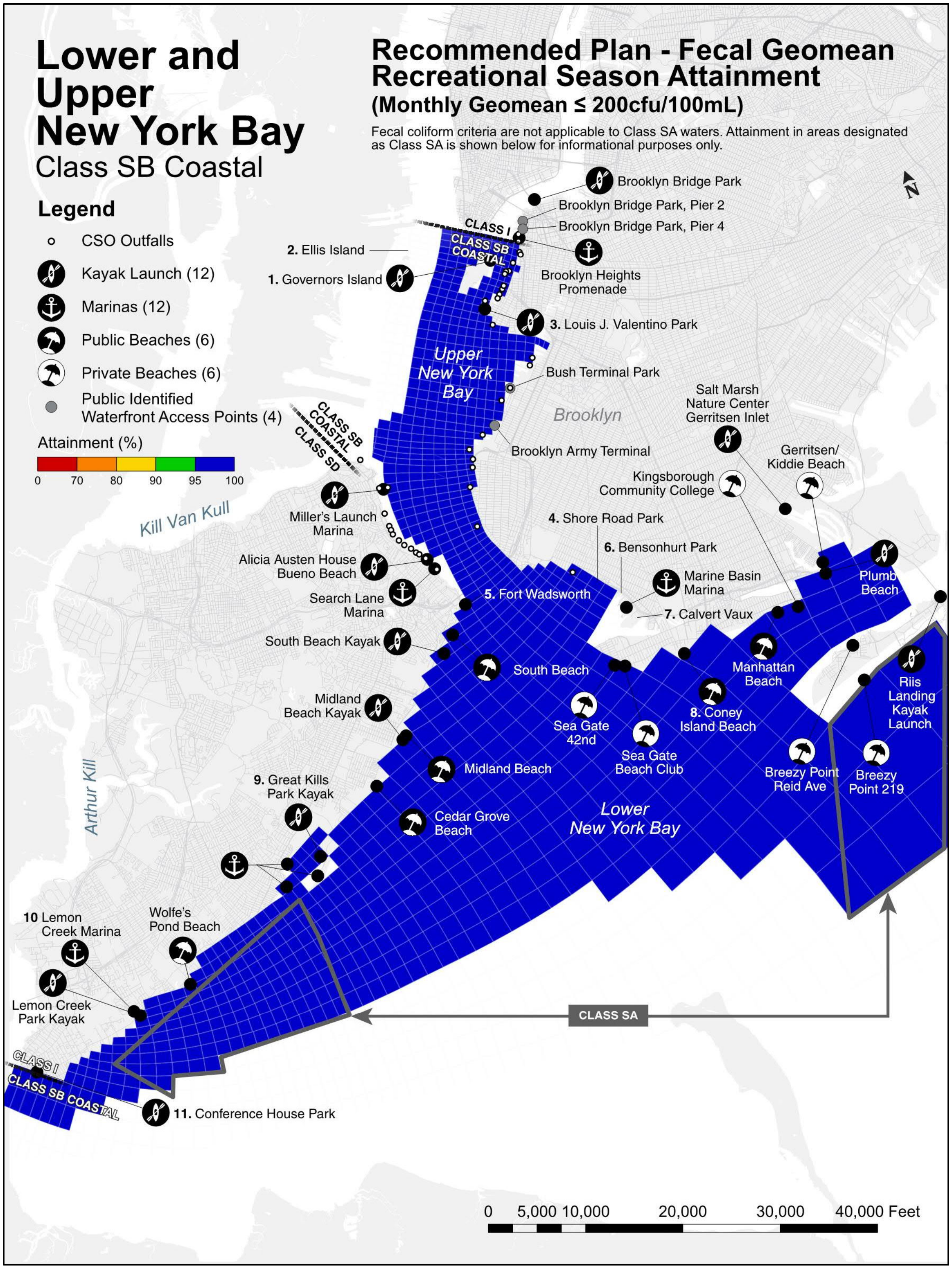

Figure 8.6-20. Fecal Coliform Class SB – Recreational Season Attainment (10-year Runs), Recommended Plan

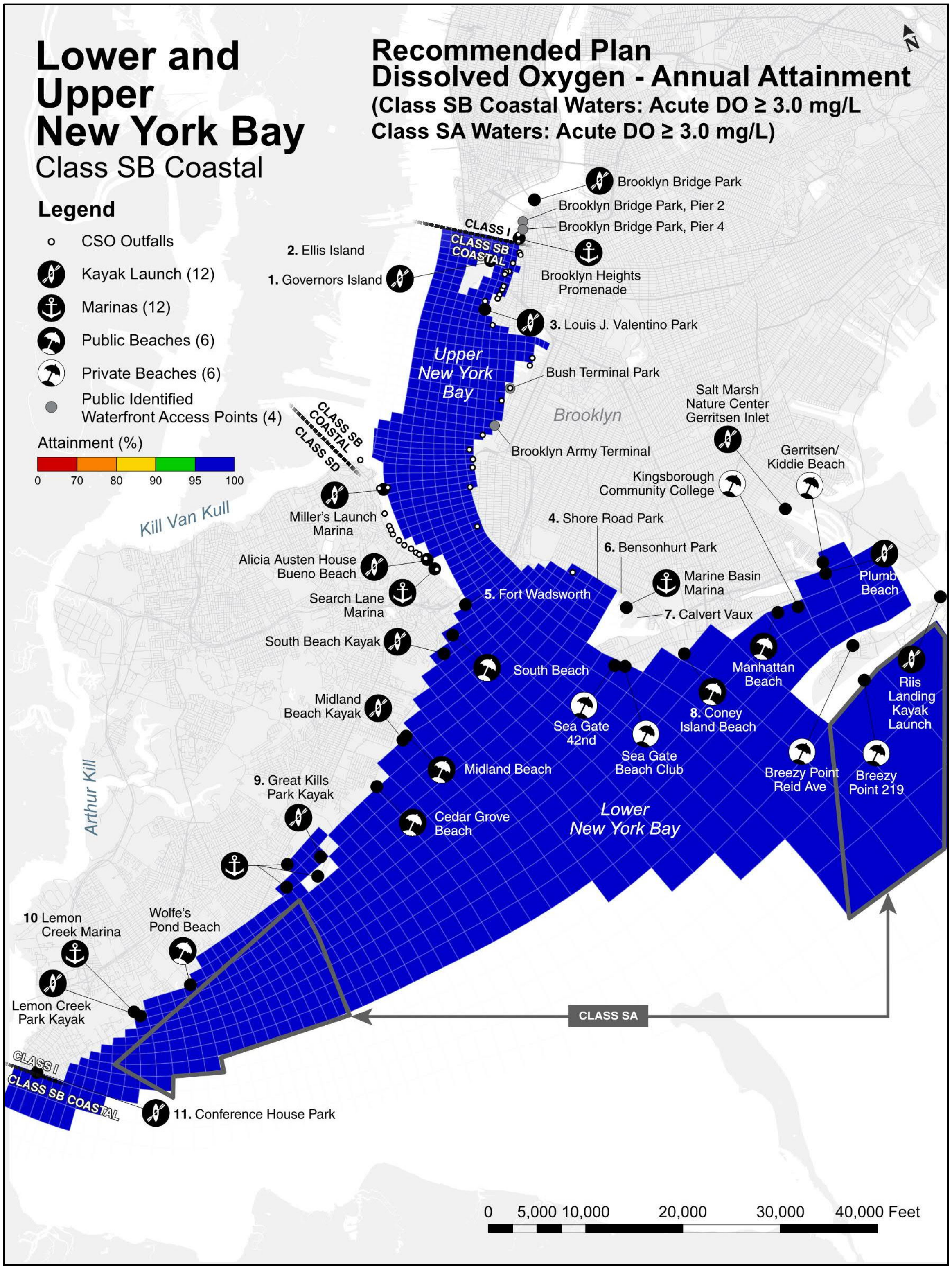

Figure 8.6-21. DO Class SB Acute Criteria - Annual Attainment (2008 Typical Year), New York Bay, Recommended Plan

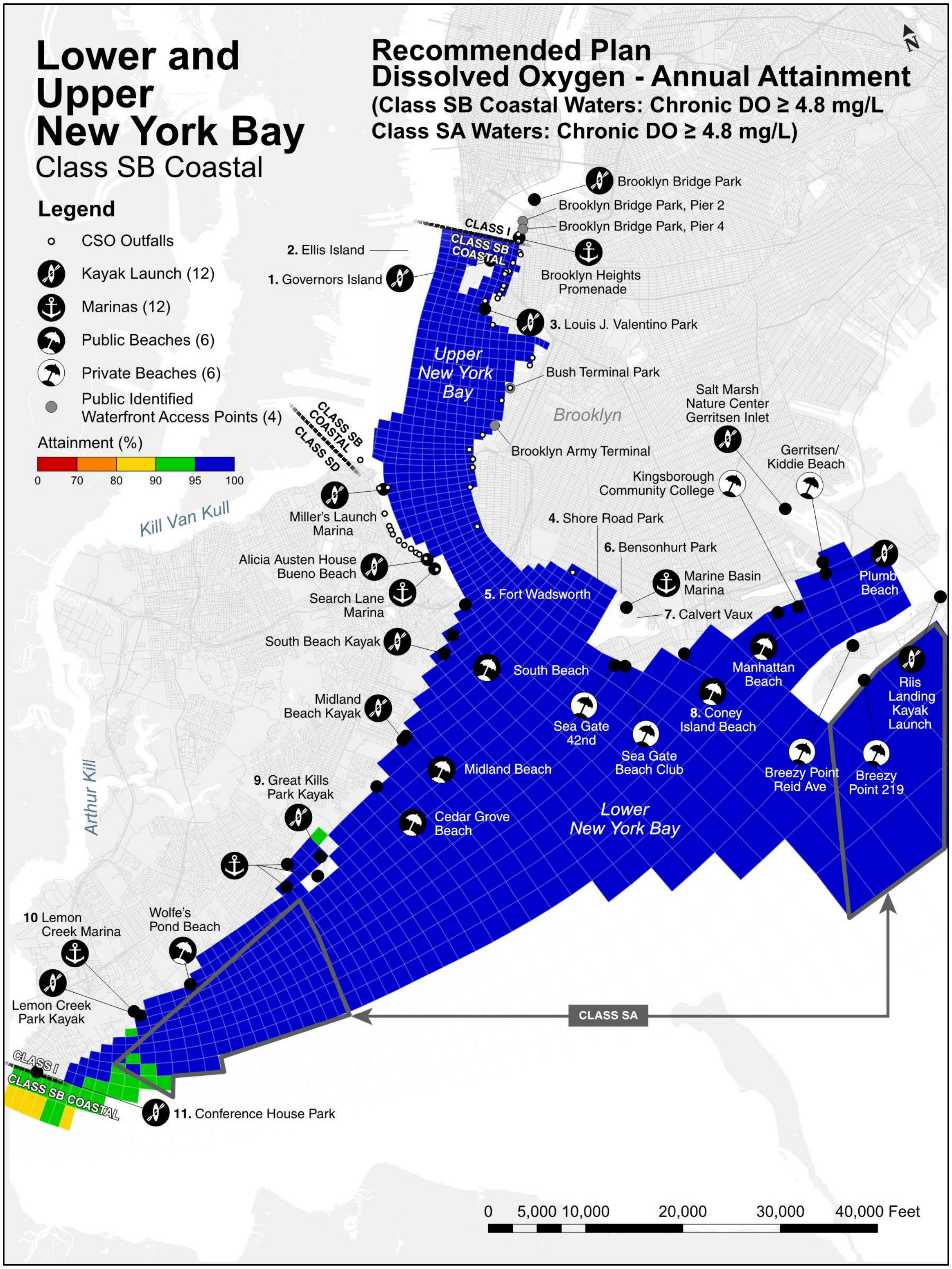

Figure 8.6-22. DO Class SB Chronic Criteria - Annual Attainment (2008 Typical Year), Recommended Plan

AECOM with Hazen

Table 8.6-22 presents the *Enterococci* maximum 30-day geometric mean and STV, and the percent of time that the *Enterococci* criteria would be attained for the recreational season (May 1st through October 31st), for the 10-year simulation period, within the Class SB Coastal Primary Recreational waters of New York Bay, with the Recommended Plan. The locations of the stations and supplemental model output locations listed in Table 8.6-22 are shown on Figure 8.6-23. As indicated in Table 8.6-22, compliance of the Recommended Plan with the *Enterococci* 30-day geometric mean criteria would be greater than 95 percent throughout New York Bay. Compliance with the *Enterococci* 30-day STV criteria would be above 95 percent in portions of the Bay, but along the Brooklyn shoreline the compliance would be less than 95 percent, with a low of about 50 percent in Gravesend Bay. Another pocket of low attainment with the *Enterococci* STV criteria is located off the southwest tip of Staten Island. This location is affected primarily by loads from outside of NYC, and is not affected by NYC CSOs.

Table 8.6-22. Model Calculated 10-Year *Enterococci* Maximum 30-day GM and STV and Percent Attainment of Class SB Coastal Primary Recreational WQ Criteria for New York Bay, Recommended Plan

Station	Maximum Recreational Season(1) 30-day *Enterococci* (cfu/100mL)		10 Year Percent Attainment Recreational Season(1)	
	GM	90th Percentile STV	30-Day GM <35 cfu/100mL	30-Day STV <130 cfu/100mL
New York Bay (Class SB Coastal Primary Recreational)				
NB-1	40	555	99.7%	85%
NB-2	36	464	100%	90%
NB-3	39	595	99.8%	85%
NB-4	40	647	99.7%	85%
NB-5	34	366	100%	95%
NB-6	33	290	100%	96%
NB-7	37	772	99.8%	84%
NB-8	29	278	100%	97%
NB-9	52	3619	99.5%	52%
NB-10	10	134	100%	99%
NB-11	13	166	100%	98%
NB-12	13	128	100%	100%
K5A	119	1,417	97%	67%
J11	10	363	100%	91%
N9A	6	55	100%	100%

Table 8.6-22. Model Calculated 10-Year *Enterococci* Maximum 30-day GM and STV and Percent Attainment of Class SB Coastal Primary Recreational WQ Criteria for New York Bay, Recommended Plan

Station	Maximum Recreational Season(1) 30-day *Enterococci* (cfu/100mL)		10 Year Percent Attainment Recreational Season(1)	
	GM	90th Percentile STV	30-Day GM <35 cfu/100mL	30-Day STV <130 cfu/100mL
New York Bay (Class SB Coastal Primary Recreational)				
Governors Island	1	1	100%	100%
Louis Valentino Park	41	535	99.7%	87%
Search Lane Marina	33	323	100%	97%
Marine Basin Marina	28	875	100%	76%
Sea Gate Beach Club/42nd	26	392	100%	94%
Coney Island Beach	12	185	100%	98%
Manhattan Beach/ Kingsborough Community College Beach	7	83	100%	100%
Gerritson/Plumb Beach	8	281	100%	97%
Riis Landing Kayak Launch	5	47	100%	100%
Breezy Point Reid Ave. Beach	6	60	100%	100%
Breezy Point 219	2	8	100%	100%
Millers Launch Marina	36	346	99.9%	96%
Alice Austen House Buono Beach	33	323	100%	97%
South Beach Kayak/Midland Beach	11	126	100%	100%
Cedar Grove Beach	8	98	100%	100%
Great Kills Park Kayak	1	1	100%	100%
Wolf's Pond Beach	23	257	100%	97%
Lemon Creek Marina/Kayak	23	257	100%	97%

Note:
(1) The recreational season is from May 1st through October 31st.

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Figure 8.6-23. Sampling Stations and Supplemental Model Output Locations on New York Bay

Table 8.6-23 presents the fecal coliform maximum monthly geometric mean, and the percent of time that the fecal coliform WQ criteria would be attained on an annual basis and for the recreational season (May 1st through October 31st), for the 10-year simulation period, within the Class SB waters of New York Bay, with the Recommended Plan. The locations of the stations listed in Table 8.6-23 are shown on Figure 8.6-23, along with the waterbody access locations. As indicated in Table 8.6-23, annual and recreational season (May 1st through October 31st) compliance for the Recommended Plan would be at least 95 percent for New York Bay, with most parts of the Bay being at 100 percent.

Table 8.6-23. Model Calculated 10-Year Fecal Coliform Maximum Monthly GM and Percent Attainment with Fecal Coliform WQ Criteria, Annual and Recreational Season, New York Bay, Recommended Plan

	Maximum Monthly Fecal Coliform GMs (cfu/100mL)		% Attainment (GM ≤200 cfu/100mL)	
Description	**Annual**	**Recreational Season(1)**	**Annual**	**Recreational Season(1)**
New York Bay (Class SB)				
NB-1	169	105	100%	100%
NB-2	164	97	100%	100%
NB-3	156	103	100%	100%
NB-4	159	106	100%	100%
NB-5	152	87	100%	100%
NB-6	146	84	100%	100%
NB-7	152	99	100%	100%
NB-8	122	68	100%	100%
NB-9	208	145	99%	100%
NB-10	66	26	100%	100%
NB-11	74	31	100%	100%
NB-12	81	25	100%	100%
K5A	276	134	95%	100%
J11	49	19	100%	100%
N9A	30	11	100%	100%
Governors Island	1	1	100%	100%
Louis Valentino Park	168	104	100%	100%
Search Lane Marina	142	80	100%	100%
Marine Basin Marina	160	90	100%	100%
Sea Gate Beach Club/42nd	117	63	100%	100%
Coney Island Beach	70	24	100%	100%
Manhattan Beach/ Kingsborough Community	39	14	100%	100%

Table 8.6-23. Model Calculated 10-Year Fecal Coliform Maximum Monthly GM and Percent Attainment with Fecal Coliform WQ Criteria, Annual and Recreational Season, New York Bay, Recommended Plan

	Maximum Monthly Fecal Coliform GMs (cfu/100mL)		% Attainment (GM ≤200 cfu/100mL)	
Description	**Annual**	**Recreational Season(1)**	**Annual**	**Recreational Season(1)**
College Beach				
Gerritson/Plumb Beach	39	17	100%	100%
Riis Landing Kayak Launch	29	12	100%	100%
Breezy Point Reid Ave. Beach	30	12	100%	100%
Breezy Point 219	11	2	100%	100%
Millers Launch Marina	148	85	100%	100%
Alice Austen House Buono Beach	142	80	100%	100%
South Beach Kayak/Midland Beach	82	39	100%	100%
Cedar Grove Beach	63	21	100%	100%
Great Kills Park Kayak	1	1	100%	100%
Wolf's Pond Beach	103	30	100%	100%
Lemon Creek Marina/Kayak	98	26	100%	100%

Note:
(1) The recreational season is from May 1st through October 31st.

The average annual attainment of the Existing WQ Criterion for DO (Class SB) for the entire water column is presented for the Recommended Plan in Table 8.6-24. As indicated in Table 8.6-24, the Existing WQ Criterion for DO (Class SB) are predicted to be attained at all stations in New York Bay for the Recommended Plan.

As discussed in Section 6, analysis of attainment of Class SB DO criteria are complex because the standard allows for excursions from the daily average limit of 4.8 mg/L for a limited number of consecutive calendar days. To simplify the analysis, attainment was based solely upon attainment of the daily average without the allowed excursions. The results indicate 99 to 100 percent attainment of the acute criterion (never less than 3.0 mg/L) and the chronic criterion (greater than or equal to 4.8 mg/L) for all stations within New York Bay except for Station K5A, located off the southwestern tip of Staten Island. As noted above, this location is affected primarily by loads from outside of NYC, and is not affected by NYC CSOs.

Table 8.6-24. Model Calculated (2008) Recommended Plan DO Percent Attainment of Existing Class SB and I WQ Criteria

New York Bay (Class SB Coastal Primary Contact Recreational)		
Station	**Acute (≥ 3.0 mg/L)**	**Chronic (≥ 4.8 mg/L)**
NB-1	100%	100%
NB-2	100%	100%
NB-3	100%	100%
NB-4	100%	100%
NB-5	100%	100%
NB-6	100%	100%
NB-7	100%	100%
NB-8	100%	100%
NB-9	100%	100%
NB-10	100%	100%
NB-11	100%	100%
NB-12	100%	99%
K5A	98%	89%
J11	100%	100%
N9A	100%	100%

<u>Recap</u>

The key components of the Recommended Plan include:

- NYB-1 - modifying the weir at Regulator RH-020A (CSO RH-005), increasing the regulator orifice opening, and enlarging the branch interceptor connection at Regulator RH-13 (CSO RH-014).
- NYB-2 - installing a diversion connection on the Victory Boulevard combined sewer upstream of Regulator 17 (CSO PR-013). This connection would divert dry-weather flow and a portion of the wet-weather flow directly to the East Interceptor by gravity.
- NYB-3 - installing a control gate in Regulator 9C (CSO OH-015), to keep more wet-weather flow in the upper of the two combined sewer conduits entering the regulator.

The implementation of these elements is predicted to result in a reduction of 142 MGY of CSO to New York Bay (132 MGY overall net reduction of CSO to Citywide/Open Waters waterbodies), with a PBC of $33M. The proposed schedule for the implementation of the Recommended Plan is presented in Section 9.2.

With the Recommended Plan, New York Bay will be in at least 95 percent attainment of the Class SB WQ Criteria for fecal coliform and the Class SB Coastal Primary Recreational Enterococci 30-day geometric mean criteria. All areas except for the area in the vicinity of Station K5A, off the southwestern tip of Staten Island, will be in attainment with the Class SB WQ Criteria for DO. Parts of New York Bay will be in attainment with the Class SB Coastal Primary Recreational *Enterococci* 30-day STV, but along the Brooklyn shoreline and in the vicinity of Station K5A, the compliance would be less than 95 percent, with a low of about 50 percent in Graves End Bay.

8.6.i Use Attainability Analysis

The CSO Order requires that a UAA be included in an LTCP "where existing WQS do not meet the Section 101(a)(2) goals of the CWA, or where the proposed alternative set forth in the LTCP will not achieve existing WQS or the Section 101(a)(2) goals." The UAA shall "examine whether applicable waterbody classifications, criteria, or standards should be adjusted by the State." The UAA process specifies that States can remove a designated use that is not an existing use if the scientific assessment can demonstrate that attaining the designated use is not feasible for at least one of six reasons:

1. Naturally occurring loading concentrations prevent the attainment of the use; or
2. Natural, ephemeral, intermittent or low flow conditions or water levels prevent the attainment of the use, unless these conditions may be compensated for by the discharge of sufficient volume of effluent discharges without violating State water conservation requirements to enable uses to be met; or
3. Human caused conditions or sources of pollution prevent the attainment of the use and cannot be remedied or would cause more environmental damage to correct than to leave in place; or
4. Dams, diversions or other types of hydrologic modifications preclude the attainment of the use, and it is not feasible to restore the waterbody to its original condition or to operate such modification in a way that would result in the attainment of the use; or
5. Physical conditions related to the natural features of the waterbody, such as the lack of a proper substrate, cover, flow, depth, pools, riffles, and the like, unrelated to water quality, preclude attainment of aquatic life protection uses; or
6. Controls more stringent than those required by Sections 301(b) and 306 of the Act would result in substantial and widespread economic and social impact.

As part of the LTCP, elements of a UAA, including the six conditions presented above, will be used to determine if changes to the designated use are warranted, considering a potential adjustment to the designated use classification as appropriate.

As noted in previous sections, with the implementation of the Recommended Plan, parts of New York Bay along the Brooklyn shoreline and in the vicinity of Station K5A will achieve less than 95 percent compliance with the Class SB Coastal Primary Recreation *Enterococci* 30-day STV criteria, and parts of

New York Bay in the vicinity of Station K5A will achieve less than 95 percent compliance with the Class SB DO criteria. Therefore, a Use Attainability Analysis is needed for New York Bay.

8.6.i.1 Use Attainability Analysis Elements

The objectives of the CWA include providing for the protection and propagation of fish, shellfish, wildlife, and recreation in and on the water. Cost-effectively maximizing the water quality benefits associated with CSO reduction is a cornerstone of this LTCP.

To simplify this process, DEP and DEC have developed a framework that outlines the steps taken under the LTCP in two possible scenarios:

1. Waterbody meets WQ requirements. This may either be the existing WQS (where primary contact is already designated) or for an upgrade to the Primary Contact WQ Criteria (where the existing standard is not a Primary Contact WQ Criteria). In either case, a high-level assessment of the factors that define a given designated use is performed, and if the level of CSO control required to meet this goal can be reasonably implemented, a change in designation may be pursued following implementation of CSO controls and Post-Construction Compliance Monitoring.

2. Waterbody does not meet WQ requirements. In this case, if a higher level of CSO control is not feasible, the UAA must justify the shortcoming using at least one of the six criteria (see Section 8.6.i above). It is assumed that if 100 percent elimination of CSO sources does not result in attainment, the UAA would include factor number 3 at a minimum as justification (human caused conditions or sources of pollution prevent the attainment of the use and cannot be remedied, or would cause more environmental damage to correct than to leave in place).

As indicated in Table 8.6-22 and Table 8.6-24, the modeled attainment of the Class SB Coastal Primary Recreational *Enterococci* STV criteria and the Class SB DO criteria will not be fully achieved upon implementation of the LTCP Recommended Plan. Implementation of the plan will lead to Class SB WQ Criteria for fecal coliform, and Class SB Coastal Primary Recreational *Enterococci* geometric mean criteria being fully attained throughout the waterbody. Future revisions of the New York Bay WQ classification should await completion of construction of the preferred alternative and the results of the Post-Construction Compliance Monitoring.

8.6.j Fishable/Swimmable Waters

The goal of this LTCP is to identify appropriate CSO controls necessary to achieve waterbody-specific WQS, consistent with EPA's CSO Control Policy and subsequent guidance. DEC considers that compliance with Class SB Coastal Primary Recreational WQS, the current classification for New York Bay, as fulfillment of the CWA's fishable/swimmable goal.

The preferred alternative summarized in Section 8.6.h results in the levels of attainment with fishable/swimmable criteria as follows:

- For the 10-year continuous simulation, summarized in Table 8.6-22, attainment of the Class SB Coastal Primary Recreational *Enterococci* STV criteria is not predicted to be met for the recreational season (May 1st through October 31st).

- Based on the 2008 typical year simulations, as summarized in Table 8.6-24, the preferred alternative would not achieve full attainment of the Class SB DO criteria on an annual average basis.

8.6.k Assessment of Highest Attainable Use

The 2012 CSO Order Goal Statement stipulates that, in situations where the proposed alternatives presented on the LTCP will not achieve the CWA Section 101(a)(2) goals, the LTCP will include a UAA. Because the analyses developed herein indicate that New York Bay is not projected to fully attain the Class SB Coastal Primary Recreational *Enterococci* STV criteria or the Class SB DO criteria, a UAA is required under the 2012 CSO Order. Table 8.6-25 summarizes the compliance for the identified plan.

Table 8.6-25. Recommended Plan Compliance with Water Quality Criteria

Compliance with Class SB Fecal Coliform Criteria 10-year Simulation(1)		Compliance with Class SB Coastal Primary Recreational *Enterococci* Criteria 10-year Simulation(1)		Compliance with Class SB DO Criteria 2008 Typical Year(1)	
Annual	**Recreational Season(2)**	**Recreational Season(2)**		**Annual**	
Monthly GM (≤ 200 mg/L)	**Monthly GM (≤ 200 mg/L)**	**30-day Rolling GM (≤ 35 mg/L)**	**30-day Rolling STV (≤ 130 mg/L)**	**Acute (≥ 3.0 mg/L)**	**Chronic (≥ 4.8 mg/L)**
95-100%	100%	97-100%	52-100%	99-100%	89-100%

Notes:

(1) Range of attainment based on Table 8.6-22 to Table 8.6-24 above.

(2) Recreational season is from May 1st through October 31st.

8.6.l Time to Recovery

As noted above, New York Bay is a Class SB Coastal Primary Recreational waterbody. The applicable Water Quality Criteria for bacteria for this waterbody include monthly and 30-day geometric mean criteria. However, to gain insight into the shorter-term impacts of wet-weather sources of bacteria, DEP has performed an analysis to assess the amount of time following the end of a rainfall event required for New York Bay to recover and return to fecal coliform concentrations less than 1,000 cfu/100mL.

The analyses consisted of examining the WQ model calculated bacteria concentrations in New York Bay for recreational season (May 1st through October 31st) abstracted from 10 years of model simulations. For New York Bay, the JFK Airport rainfall data was compared against water quality model bacteria results for the 10 recreational seasons to determine how long it took for the water column concentration to return to target threshold concentrations from the end of the rain event. The chosen target threshold concentration was 1,000 cfu/100mL for fecal coliform. The various rainfall events were then placed into rain event size "bins" ranging from less than 0.1 inch to greater than 1.5 inches. Only rain events that reached the target threshold concentrations before the beginning of the next storm were included. The median time to recovery for each bin at each water quality station was calculated. Table 8.6-26 presents the median time to recovery for the Recommended Plan for New York Bay. Results are presented for the greater than 1.0 to 1.5 inch rainfall bin, which includes the 90th percentile event.

DEC has advised that it seeks to have a time to recovery of less than 24 hours, and this target has been consistent in the previously approved LTCPs. As indicated in Table 8.6-26, for the Recommended Plan, all of the stations assessed except for NB-7 and NB-9 had median time to recovery of zero hours, indicating that the fecal coliform concentration never reached the level of 1,000 cfu/100mL at the referenced station for more than half of the storms within the 1-to-1.5 inch rainfall bin assessed. Times to recovery for Stations NB-7 and NB-9 were eight hours or less.

Table 8.6-26. New York Bay Time to Recovery, Fecal Coliform, Recommended Plan

Location	Median Time to Recovery (hours) Fecal Coliform Threshold (1,000 cfu/100mL)[(1)]
New York Bay (Class SB Coastal Primary Contact Recreational)	
NB-1	0[(2)]
NB-2	0
NB-3	0
NB-4	0
NB-5	0
NB-6	0
NB-7	4
NB-8	0
NB-9	8
NB-10	0
NB-11	0
NB-12	0
K5A	0
J11	0
N9A	0
Governors Island	0
Louis Valentino Park	0
Search Lane Marina	0
Marine Basin Marina	0
Sea Gate Beach Club/42nd	0
Coney Island Beach	0
Manhattan Beach/	0
Gerritson/Plumb Beach	0
Riis Landing Kayak Launch	0
Breezy Point Reid Ave. Beach	0
Breezy Point 219	0
Millers Launch Marina	0
Alice Austen House Buono Beach	0

Table 8.6-26. New York Bay Time to Recovery, Fecal Coliform, Recommended Plan

Location	Median Time to Recovery (hours) Fecal Coliform Threshold (1,000 cfu/100mL)(1)
South Beach Kayak/Midland	0
Cedar Grove Beach	0
Great Kills Park Kayak	0
Wolf's Pond Beach	0
Lemon Creek Marina/Kayak	0

Notes:

(1) Median time to recovery values presented for storms from the 10-year simulation, recreational seasons, in the size range of >1.0 to 1.5-inches of rainfall, which includes the 90th percentile rain event.

(2) Median time to recovery of "0" means that the average concentration across the water column never reached the 1,000 cfu/100mL threshold at the referenced station for more than half of the storms within the 1-to-1.5 inch rainfall bin assessed.

A similar analysis was conducted to assess time to recovery to an *Enterococci* concentration of 130 cfu/100mL, corresponding to the STV criterion for Class SB coastal primary contact recreational waters. The results of that analysis for the Recommended Plan are presented in Table 8.6-27. As indicated in Table 8.6-27, for the Recommended Plan, the highest median time to recovery for the stations assessed was 12 hours, and most of the stations assessed had median time to recovery of zero hours, indicating that the concentration of *Enterococci* at those locations was less than 130 cfu/100mL for the for more than half of the storms within the 1-to-1.5 inch rainfall bin assessed.

Table 8.6-27. New York Bay Time to Recovery, *Enterococci*, Recommended Plan

Location	Median Time to Recovery (hours) *Enterococci* Threshold (130 cfu/100mL)(1)
New York Bay (Class SB Coastal Primary Contact Recreational)	
NB-1	7
NB-2	6
NB-3	4
NB-4	5
NB-5	0(2)
NB-6	0
NB-7	11
NB-8	0
NB-9	12
NB-10	0
NB-11	0

Table 8.6-27. New York Bay Time to Recovery, *Enterococci*, Recommended Plan

Location	Median Time to Recovery (hours) *Enterococci* Threshold (130 cfu/100mL)[(1)]
NB-12	0
K5A	0
J11	2
N9A	0
Governors Island	0
Louis Valentino Park	7
Search Lane Marina	0
Marine Basin Marina	0
Sea Gate Beach Club/42nd	0
Coney Island Beach	0
Manhattan Beach/	0
Gerritson/Plumb Beach	0
Riis Landing Kayak Launch	0
Breezy Point Reid Ave. Beach	0
Breezy Point 219	0
Millers Launch Marina	0
Alice Austen House Buono Beach	0
South Beach Kayak/Midland	0
Cedar Grove Beach	0
Great Kills Park Kayak	0
Wolf's Pond Beach	0
Lemon Creek Marina/Kayak	0

Notes:
(1) Median time to recovery values presented for storms from the 10-year simulation, recreational seasons, in the size range of >1.0 to 1.5-inches of rainfall, which includes the 90th percentile rain event.
(2) Median time to recovery of "0" means that the average concentration across the water column never reached the 130 cfu/100mL threshold at the referenced station for more than half of the storms within the 1-to-1.5 inch rainfall bin assessed.

8.6.m Recommended LTCP Elements to Meet Water Quality Goals for New York Bay

The actions identified in this LTCP include:

- Modifying the weir at Regulator RH-020A (CSO RH-005), increasing the regulator orifice opening, and enlarging the branch interceptor connection at Regulator RH-13 (CSO RH-014) (NYB-1).
- Installing a diversion connection on the Victory Boulevard combined sewer upstream of Regulator 17 (CSO PR-013). This connection would divert dry-weather flow and a portion of the wet--weather flow directly to the East Interceptor by gravity (NYB-2).

- Installing a control gate in Regulator 9C (CSO OH-015), to keep more wet-weather flow in the upper of the two combined sewer conduits entering the regulator (NYB-3).
- Costs (2019 dollars) for the recommended alternative are: NPW $51M, PBC of $33M, and annual O&M of $0.5M.
- Compliance with Existing Class SB WQ Criteria for fecal coliform, and compliance with Class SB Coastal Primary Recreational *Enterococci* 30-day geometric mean criteria. However, full attainment of the Class SB DO criteria, and the Class SB Coastal Primary Recreational *Enterococci* 30-day STV criteria will not be achieved. As a result, a UAA is required as part of this LTCP for the referenced DO criteria and the *Enterococci* 30-day STV criteria.
- DEP will establish with the DOHMH (through public notification) a wet-weather advisory for the recreational season (May 1st through October 31st) during which recreational activities would not be recommended in New York Bay. The LTCP includes a recovery time analysis that can be used to establish the duration of the wet-weather advisory for public notification.

DEP is committed to improving water quality in this waterbody, which will be advanced by the improvements and actions identified in this LTCP. These identified actions have been balanced with input from the public and awareness of the cost to the residents of NYC.

8.7 CSO Control Alternatives for Arthur Kill/Kill Van Kull

No CSO outfalls are located on Arthur Kill, and thus no CSO discharges directly to Arthur Kill. As a result, no CSO control alternatives were developed specifically for Arthur Kill. As shown in Section 6, WQS for dissolved oxygen are met in Kill Van Kull under Baseline Conditions, and the non-attainment of the WQS for fecal coliform is driven by sources outside of NYC. Therefore, attainment of WQS was not a factor in evaluating CSO control alternatives for Kill Van Kull. Rather, the focus was on evaluating alternatives for cost-effective reduction of CSO activations and volume.

It should also be noted that DEP has implemented an extensive Bluebelt program on Staten Island. Bluebelts are ecologically rich and cost-effective drainage systems that naturally handle the runoff precipitation that falls on streets and sidewalks. The program preserves natural drainage corridors including streams, ponds, and wetlands, and enhances them to perform their functions of conveying, storing, and filtering runoff precipitation or stormwater. In addition to being an excellent mechanism for reducing urban flooding and improving the health of local waterways, Bluebelts also provide open green space for their communities and diverse habitat for wildlife since they are not constricted by closed pipes or underground infrastructure like traditional storm sewers. As New York City prepares for rising sea levels and heavier rains due to climate change, Bluebelts offer a natural and effective solution for stable and sound stormwater management.

The Staten Island Bluebelt system drains 15 watersheds clustered at the southern end of the Island, in addition to the Richmond Creek watershed. The combined area of these 16 watersheds totals approximately 10,000 acres. The Bluebelt drainage plan for these 16 watersheds connects natural drainage corridors with conventional storm sewers for an integrated stormwater management system.

Wetlands located within the watershed areas act as flood control measures. Urban wetlands are especially valuable because impervious surfaces, like streets and rooftops, increase the rate, velocity, and volume of stormwater runoff. By temporarily storing stormwater, urban wetlands help protect adjacent and downstream property owners from flood damage.

For Kill Van Kull, the CSO control alternatives that passed the initial screening phase and were retained generally fell within the categories of system optimization and tunnel storage. System optimization alternatives covered the categories of fixed weirs, parallel interceptor/sewer, bending weirs or control gates, and gravity flow tipping to other watersheds. The storage tunnel alternatives, used to assess 50, 75 and 100 percent CSO capture, also included high-rate clarification for the dewatering flows from the tunnels. Storage tanks were not evaluated due to the number of outfalls and the general lack of available sites of sufficient size for storage tanks. Each CSO control measure was initially evaluated on three of the key considerations described in Section 8.1: (1) benefits, as expressed by level of CSO control and WQS attainment; (2) costs; and (3) challenges, such as siting and operations. Using this methodology, the retained CSO control measures listed in Section 8.1 were evaluated on a cost-performance basis and used to develop the basin-wide alternatives.

The Citywide/Open Waters Baseline Conditions include implementation of the Recommended Plans from the LTCPs for the tributary waterbodies previously submitted to DEC under this program, as well as other grey infrastructure projects implemented as part of earlier planning programs. Those projects are summarized in Section 4.The following sections present the evaluations of the system optimization and tunnel storage alternatives for Kill Van Kull.

8.7.a System Optimization Alternatives

The approach to the initial identification and evaluation of system optimization alternatives for Kill Van Kull using the Optimatics Optimizer software was presented in Section 3. As described in Section 3, the Optimizer software was configured to prioritize monitored regulators discharging outside the period of critical wet-weather events, high-discharge frequency regulators, and regulators discharging in proximity to official and publicly-identified public access points (kayak launches/marinas).

The CSO outfalls to Kill Van Kull are all part of the Port Richmond WRRF collection system, which also includes outfalls discharging to New York Bay. Thus, the Kill Van Kull optimization alternatives needed to be considered in conjunction with alternatives for New York Bay associated with the Port Richmond WRRF.

The section below presents the evaluations of Kill Van Kull optimization alternatives.

8.7.a.1 System Optimization for Kill Van Kull Outfalls in the Port Richmond WRRF System

Table 8.7-1 summarizes the CSO outfalls and associated regulators tributary to Kill Van Kull from the Port Richmond WRRF system that were the initial focus of the optimization evaluations. The locations of these outfalls/regulators are shown in Figure 8.7-1. Table 8.7-1 identifies the annual CSO volume and activation frequency under Baseline Conditions, and whether the outfall/regulator falls within one or more of the following categories:

- One of the 100 monitored regulators listed in the WRRF SPDES permits ("BMP Regulator")
- A "key regulator" as identified in the WRRF SPDES permits
- An outfall in proximity to (typically within 500 feet of) a public access location
- Regulators that activated more than average for the waterbody

Table 8.7-1. Kill Van Kull CSO Outfalls/Regulators Associated with the Port Richmond WRRF

Outfall	Regulator	Baseline Conditions		BMP Regulator	Key Regulator	Outfall in Proximity to Public Access	Higher Frequency Regulator
		Annual CSO Volume (MG)	Annual CSO Activations				
PR-006	R-23	6.35	15			✓	
PR-028	R-5W	15.1	23				✓
PR-029	R-6W	146	47	✓	✓		✓

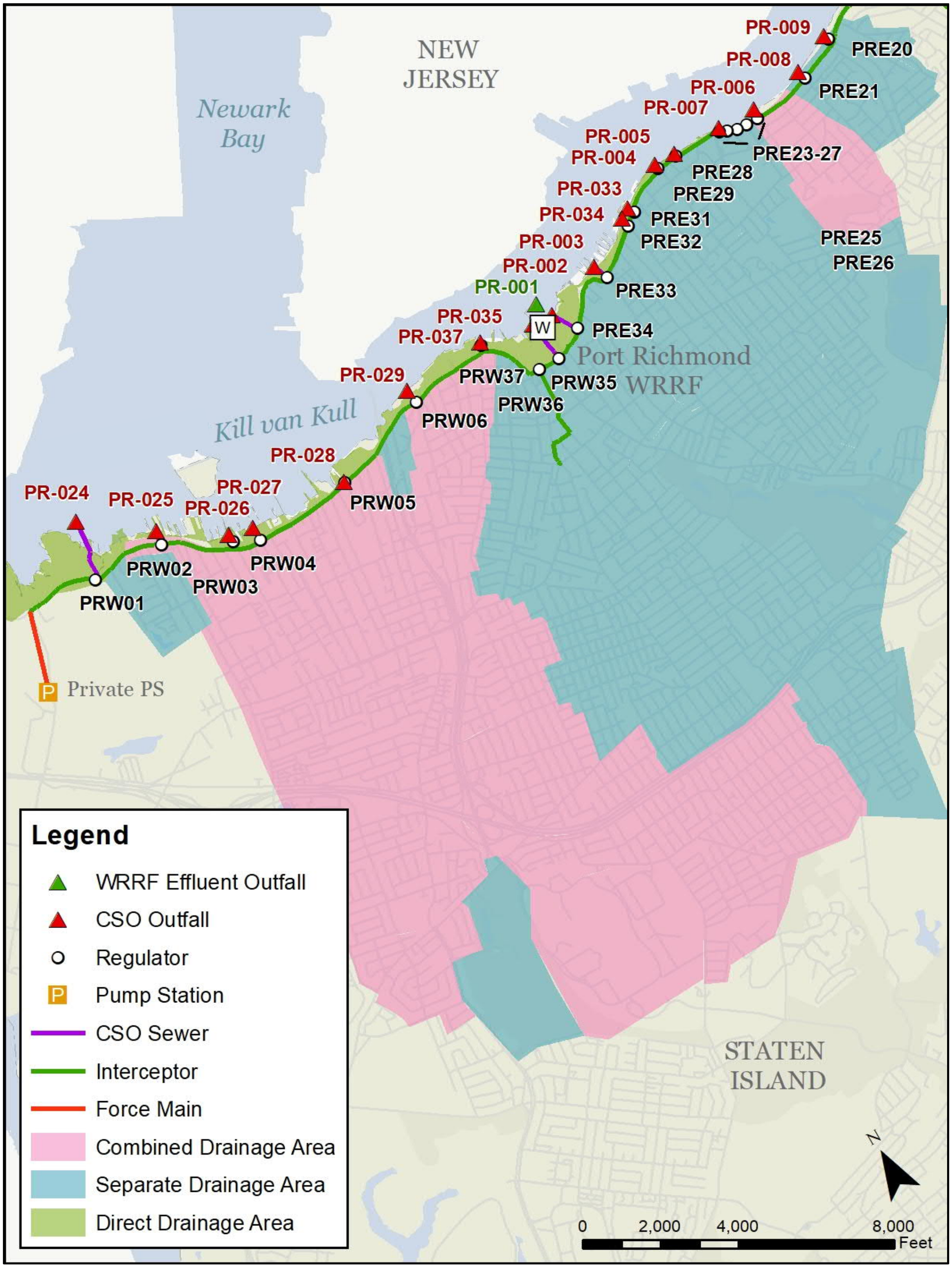

Figure 8.7-1. CSO Outfalls/Regulators Tributary to Kill Van Kull from the Port Richmond WRRF System

Findings/Observations from Optimizer Evaluations

The Optimizer evaluations served as an initial screening step to identify potentially promising optimization alternatives to be further evaluated using the full Port Richmond WRRF InfoWorks model. These evaluations included the assessment of the impacts to CSO volume, activation, and peak hydraulic grade line elevations relative to Baseline Conditions, as well as other general system conditions. General collection system information and findings of the initial Optimizer evaluations included the following:

- The Port Richmond WRRF collection system serves the northern part of Staten Island. The East Interceptor runs east from the WRRF along the shoreline of Kill Van Kull, then turns south along the shoreline of Kill Van Kull. The West Interceptor runs west from the WRRF along the shoreline of Kill Van Kull.
- A total of 35 regulators contribute flow to the interceptors. During wet-weather, flow in excess of the interceptor capacity can overflow to CSO outfalls discharging to Kill Van Kull (19 CSO outfalls). The interceptor sewers convey flow to the Port Richmond WRRF located along Kill Van Kull.
- Depth of cover on the gravity sewers varies, ranging from relatively shallow (<10 feet of cover) to over 20 feet.
- Regulators from the Port Richmond system contributing to CSO outfalls discharging to Kill Van Kull activate between 0 to 47 times during the typical year with a total average annual overflow volume (AAOV) of 173 MGY.
- Freeboard for the 5-year design storm and many of the larger storms during the typical year is generally less than 10 feet from the ground surface indicating the portions of the collection system along Kill Van Kull are highly sensitive to hydraulic grade line impacts.
- The Optimizer modeling identified alternatives that included modifications to as many as 20 regulators throughout the WRRF collection system that resulted in varying degrees of improved capture and hydraulic performance. However, upon performing InfoWorks runs for the 2008 typical year, limited reductions in AAOV (<1 percent) and activation frequency (<8 percent) were predicted for the better performing alternatives.

Follow-up Evaluations Based on Full InfoWorks Model

No retained alternatives were identified from the initial optimization runs due to hydraulic grade line impacts that increased the risk of potential flooding, while providing negligible reductions in CSO volume and activations to Kill Van Kull. Figure 8.7-2 illustrates the hydraulic grade line sensitivities where optimization alternatives increase the potential risk of street flooding and basement backups.

Additional Optimization Alternatives

As indicated in Table 8.7-1, Outfall PR-029 is the largest outfall discharging to Kill Van Kull. Given that nearly 85 percent of the total CSO volume to Kill Van Kull in the Typical Year is discharged from Outfall PR-029, this outfall was targeted for further investigation of the feasibility of reducing CSOs using a real-time controlled gate. Currently, the size of the connection between Regulator R-6W (which discharges to Outfall PR-029) and the West Interceptor limits the peak wet-weather flow from the upstream combined sewer system into the interceptor. This limitation in the peak wet-weather flow is necessary to protect the interceptor from excessive surcharging during larger wet-weather events. However, if the interceptor connection could be enlarged and fitted with a remotely controlled gate, in concept more flow could be allowed into the interceptor during smaller storms, thereby reducing CSO volumes. In larger storms, the gate could be triggered to throttle, to protect the interceptor from high flows just as the current regulator configuration does today.

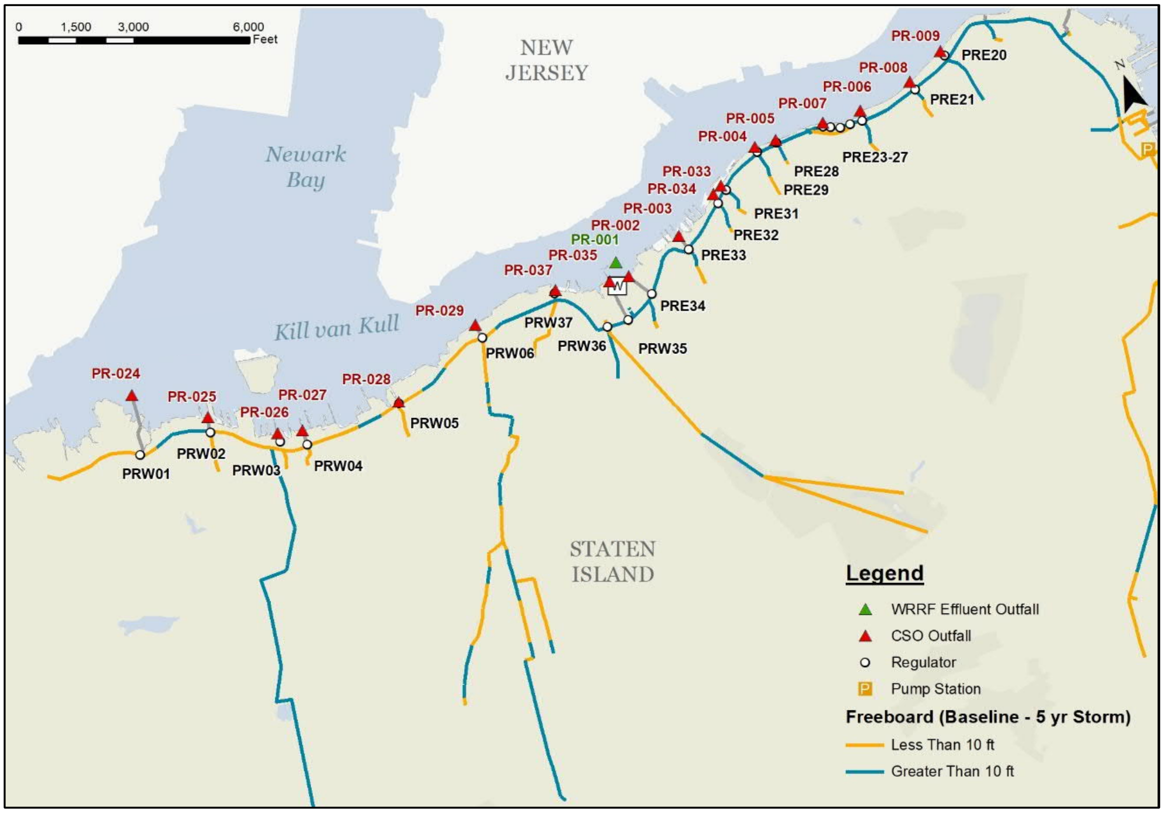

Figure 8.7-2. Depth to Peak Hydraulic Grade Line, 5-year Storm, Baseline Conditions, Kill Van Kull

A number of potential configurations of the interceptor connection and gate were tested using the InfoWorks model. These configurations involved various degrees of up-sizing of the interceptor connection, coupled with a gate that would be triggered to throttle as soon as the hydraulic grade line in the interceptor reached a high-level set point. However, the findings were that in large storms, the hydraulic grade line in the interceptor rose so quickly, that a remotely controlled gate could not react fast enough to prevent adverse hydraulic grade line impacts in the interceptor. For alternatives that successfully prevented adverse hydraulic grade line impacts, the set point in the interceptor for triggering the gate to close had to be set so low, that almost no CSO reduction benefit was achieved. As a result of these findings, this alternative was not pursued further.

The Hannah Street Pumping Station is scheduled in the near term for a needed upgrade to maintain a state of good repair for the pumping station, and the upgrade will maintain the current pumping capacity of the existing facility. The Hannah Street Pumping Station Bypass alternative described above under the New York Bay Section 8.5 (Alternative NYB-2) will increase flow into the downstream East Interceptor. Modeling evaluations indicated that further increasing the wet-weather flow to the East Interceptor beyond Alternative NYB-2 would likely have adverse impacts on the hydraulic grade line in the interceptor. For these reasons, expansion of the capacity of the Hannah Street Pumping Station was not evaluated further.

Storage options for CSO outfalls to Kill Van Kull from the Port Richmond WRRF system are evaluated in the following sub-section.

8.7.b Storage Alternatives for 25/50/75/100 Percent CSO Control

Conceptual storage alternatives were developed to provide 25, 50, 75, and 100 percent CSO control of the annual CSO volume discharged to Kill Van Kull in the Typical Year. The approach to sizing and layout of the storage alternatives was as follows:

- For 25, 50, and 75 percent CSO control, a storage tank for Outfall PR-029 was sized such that the capture at that outfall would equate to 25, 50, and 75 percent capture of the total CSO volume to Kill Van Kull.
- For 100 percent CSO control, it was assumed that every CSO outfall to Kill Van Kull that was predicted to be active in the 2008 Typical Year would be captured by a tunnel. Where multiple outfalls were located in close proximity to each other, it was assumed that a near-surface consolidation conduit would be provided to a single drop shaft.
- For each storage alternative, the dewatering rate required to dewater the storage facility within 24 hours was compared to the available dry-weather flow capacity in the Port Richmond WRRF. For the 100 percent CSO control tunnel, a high-rate clarification wet-weather flow treatment system with disinfection was added to the alternative to treat the dewatered flow.
- A detailed siting assessment was not conducted, so the specific locations of features of the storage alternatives (storage tank, tunnel mining shaft, TBM removal shaft, drop shafts, dewatering pumping station, dewatered flow treatment facility, near-surface diversion structures/connection conduits) were not identified.

The main features of the 25, 50, 75, and 100 percent CSO control storage alternatives for Kill Van Kull are summarized in Table 8.7-2. The 25, 50, and 75 percent capture storage tanks would capture overflow from Outfall PR-029 (see Figure 8.7-1 for location of Outfall PR-029). The size of the storage tank for each level of CSO control would be 2.5, 7.0, and 15.6 MG, respectively.

The 100 percent CSO control tunnel capturing the Port Richmond WRRF outfalls discharging to Kill Van Kull would start with a mining shaft near the Port Richmond WRRF, and run in two directions along the shoreline of Kill Van Kull. The westerly branch would run to Outfall PR-026, and the easterly branch would run to Outfall PR-006 (Figure 8.7-3). The tunnel would be 16 feet in diameter, with a length of about 21,000 feet (4.1 miles). A dedicated wet-weather high-rate treatment facility would be necessary for the treatment of the CSO retained in the storage tunnel.

Table 8.7-2. Summary of 25, 50, 75, and 100 Percent CSO Control Alternatives for Kill Van Kull

Alternative	KVK-1	KVK-2	KVK-3	KVK-4
Level of CSO Control[1]	**25%**	**50%**	**75%**	**100%**
WRRF Outfalls Captured[2]	**PR**	**PR**	**PR**	**PR**
Storage Tank Volume (MG)	2.5	7.0	15.6	N/A
Length (mi.)	N/A	N/A	N/A	4.1
Diameter (ft.)	N/A	N/A	N/A	16
Tunnel Volume (MG)	N/A	N/A	N/A	30
Outfalls Captured	• PR-029	• PR-029	• PR-029	• 6 PR outfalls
Net CSO Volume Reduction (MGY)	44	87	130	173
Wet-Weather Flow Treatment Facility Capacity for Dewatering Flow (MGD)	N/A	N/A	N/A	30
Estimated Probable Bid Cost[3]	$300M	$500M	$800M	$1,000M

Notes:
(1) Modeled annual percent CSO reduction based on the 2008 Typical Year.
(2) PR = Port Richmond
(3) 2019 dollars.

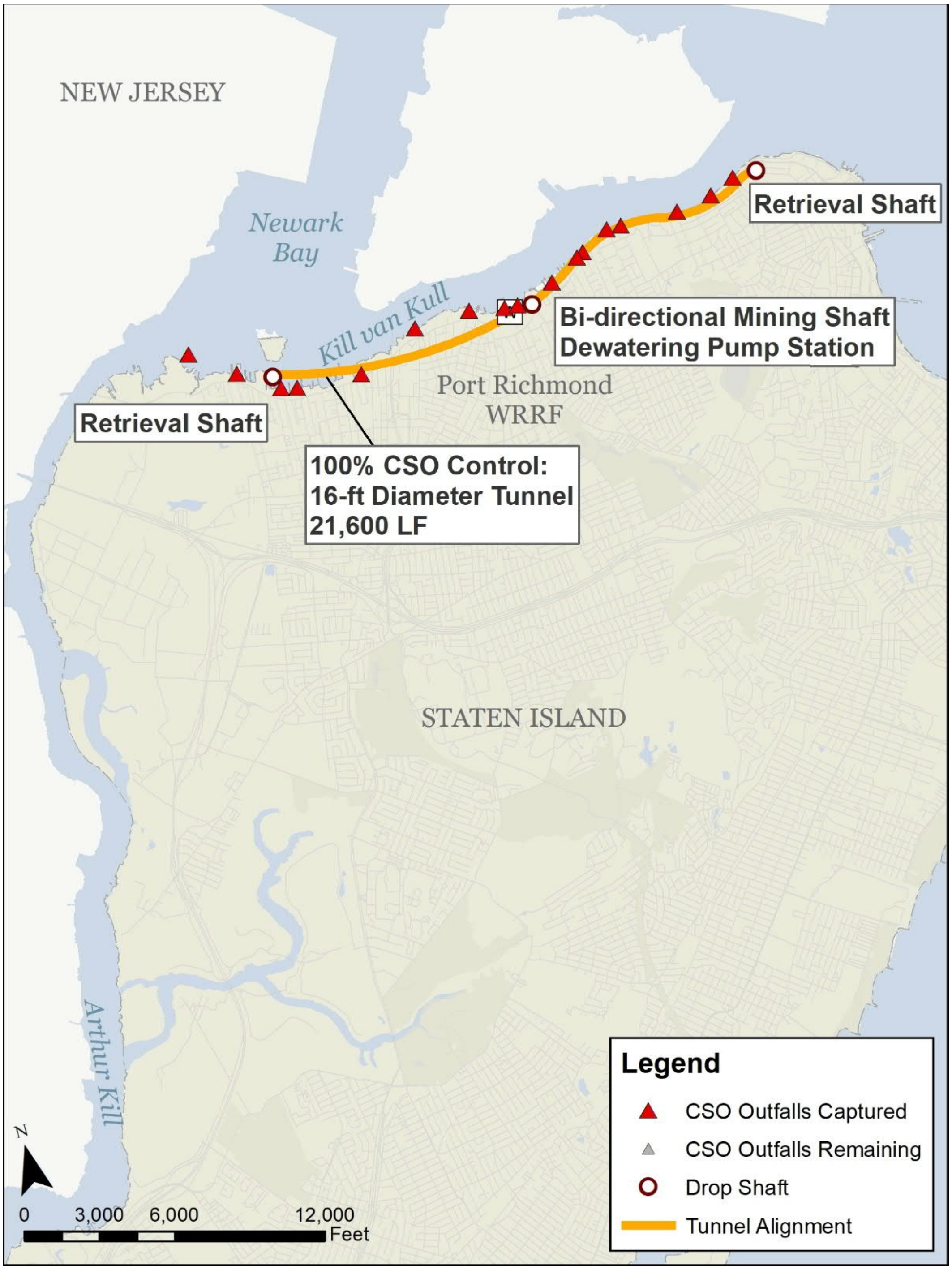

Figure 8.7-3. 100 Percent CSO Control Tunnel for Kill Van Kull (PR)

While these storage alternatives provide relatively high levels of CSO control, the significant challenges to implementation include:

- Very high implementation cost
- Limited siting availability for the storage tanks, or the shafts, dewatering pumping station, and dewatering flow treatment facility associated with the tunnel storage alternative
- Long implementation period
- Significant and prolonged construction impacts (truck traffic, noise, dust)
- Negligible improvement in the annual attainment of applicable water quality standards
- Construction impacts and likelihood of utility conflicts for near-surface diversion structures and connecting conduits

Despite these challenges, these alternatives were retained in order to provide an assessment of a range of levels of CSO control for Kill Van Kull, per the CSO Control Policy and the Clean Water Act.

8.7.c Summary of Retained Alternatives for Kill Van Kull

The goal of the previous evaluations was to develop a list of retained CSO control measures for Kill Van Kull. These CSO control measures, whether individually or in combination, form the basis of basin-wide alternatives to be assessed using more rigorous cost-performance and cost-attainment analyses. Table 8.7-3 lists all of the CSO control measures originally identified in the "Alternatives Toolbox" shown above in Figure 8.7-2, and identifies whether the CSO control measure was retained for further analysis. The reasons for excluding the non-retained CSO control measures from further consideration are also noted in the table.

Table 8.7-3. Summary of Control Measure Screening for Kill Van Kull

Control Measure	Category	Retained for Further Analysis?	Remarks
Additional GI Build-out	Source Control	NO(1)	Planned GI build-out in the watershed is included in the baseline. It is unlikely that additional sites will be identified due to site constraints in publicly owned properties. The Port Richmond WRRF system is largely a separate system, with a lot of pervious area.
High Level Storm Sewers	Source Control	NO(1)	No cost-effective opportunities identified
Regulator Modifications	System Optimization	NO	Optimization alternatives showed limited benefit in terms of CSO reduction
Parallel Interceptor Sewer	System Optimization	NO	Optimization alternatives showed limited benefit in terms of CSO reduction
Bending Weirs/Control Gates	System Optimization	NO	No hydraulically feasible opportunities identified

Table 8.7-3. Summary of Control Measure Screening for Kill Van Kull

Control Measure	Category	Retained for Further Analysis?	Remarks
Pumping Station Optimization	System Optimization	NO	No hydraulically feasible opportunities identified
Pumping Station Expansion	System Optimization	NO	No hydraulically feasible opportunities identified
Gravity Flow Redirection to Other Watersheds	CSO Relocation	NO	No cost-effective opportunities identified
Pumping Station Modification	CSO Relocation	NO	No hydraulically feasible opportunities identified.
Flow Redirection with Conduit and Pumping	CSO Relocation	NO	No cost-effective opportunities identified.
Floatables Control	Floatables Control	YES	Programmatic floatables control will be applied and expanded Citywide.
Environmental Dredging	Water Quality/ Ecological Enhancement	NO	No specific locations of CSO sediment mounding identified.
Wetland Restoration and Daylighting	Water Quality/ Ecological Enhancement	NO	No daylighting opportunities were identified.
Outfall Disinfection	Treatment: Satellite	NO	Not feasible due to short length of outfalls.
Retention/Treatment Basins	Treatment: Satellite	NO	Significant siting constraints and very high costs. Tunnel storage covers 25/50/75/100% CSO control alternatives.
High-Rate Clarification	Treatment: Satellite	YES	Incorporated into the storage tunnel alternative for treatment of captured CSO during tunnel dewatering.
WRRF Expansion	Centralized Treatment	NO	Insufficient space available. Limited benefit compared to potential cost.
In-System Storage (Outfalls)	Storage	NO	Negligible levels of CSO control due to short outfalls.
Off-line Storage (Tanks)	Storage	YES	Storage tank alternatives KVK-1, KVK-2 and KVK-3 cover 25/50/75% CSO control.
Off-line Storage (Tunnels)	Storage	YES	Tunnel storage Alternative KVK-4 covers 100% CSO control.

Note:
(1) Additional GI and HLSS are considered to be ongoing programs that will continue to be implemented system-wide outside of the LTCP program.

As shown, the retained CSO control measures include tunnel storage (with high-rate clarification for dewatering flows for the 100 percent CSO control tunnel), and programmatic floatables control.

8.7.d CSO Volume and Loading Reductions for Retained Alternatives for Kill Van Kull

Table 8.7-4 summarizes the projected performance of the retained Kill Van Kull alternatives in terms of annual CSO volume and fecal coliform load reduction, based on the 2008 Typical Year. These data are plotted on Figure 8.7-4. In all cases, the predicted reductions shown are relative to the Baseline Conditions.

Table 8.7-4. Kill Van Kull Retained Alternatives Performance Summary (2008 Rainfall)

Alternative	Annual Performance Based on 2008 Typical Year				
	Remaining CSO Volume (MGY) (1)	Frequency of Overflow (2)	Additional Untreated CSO Volume to Other Waterbodies (MGY) (3)	Net CSO Volume Reduction (%)	Net Fecal Coliform Reduction (%)
Baseline Conditions	173	47	0	0	0
KVK-1. Storage Tank at PR-029 for 25% CSO Control (2.5 MG Capacity)	129	23	0	25	25
KVK-2. Storage Tank at PR-029 for 50% CSO Control (7.0 MG Capacity)	86	23	0	50	50
KVK-3. Storage Tank at PR-029 for 75% CSO Control (15.6 MG Capacity)	43	23	0	75	75
KVK-4. Tunnel Storage for 100% CSO Control (30 MG Capacity)	0	0	0	100	100

Notes:
(1) Remaining CSO includes all discharges to Kill Van Kull from the Port Richmond WRRF Collection System.
(2) Frequency of overflow is based upon the most frequently active CSO outfall.
(3) Additional untreated CSO volume to other waterbodies accounts for increases at other CSO outfalls in response to the implementation of a CSO control alternative. Net CSO volume reduction and net fecal coliform reduction account for any additional CSO discharge to other waterbodies.

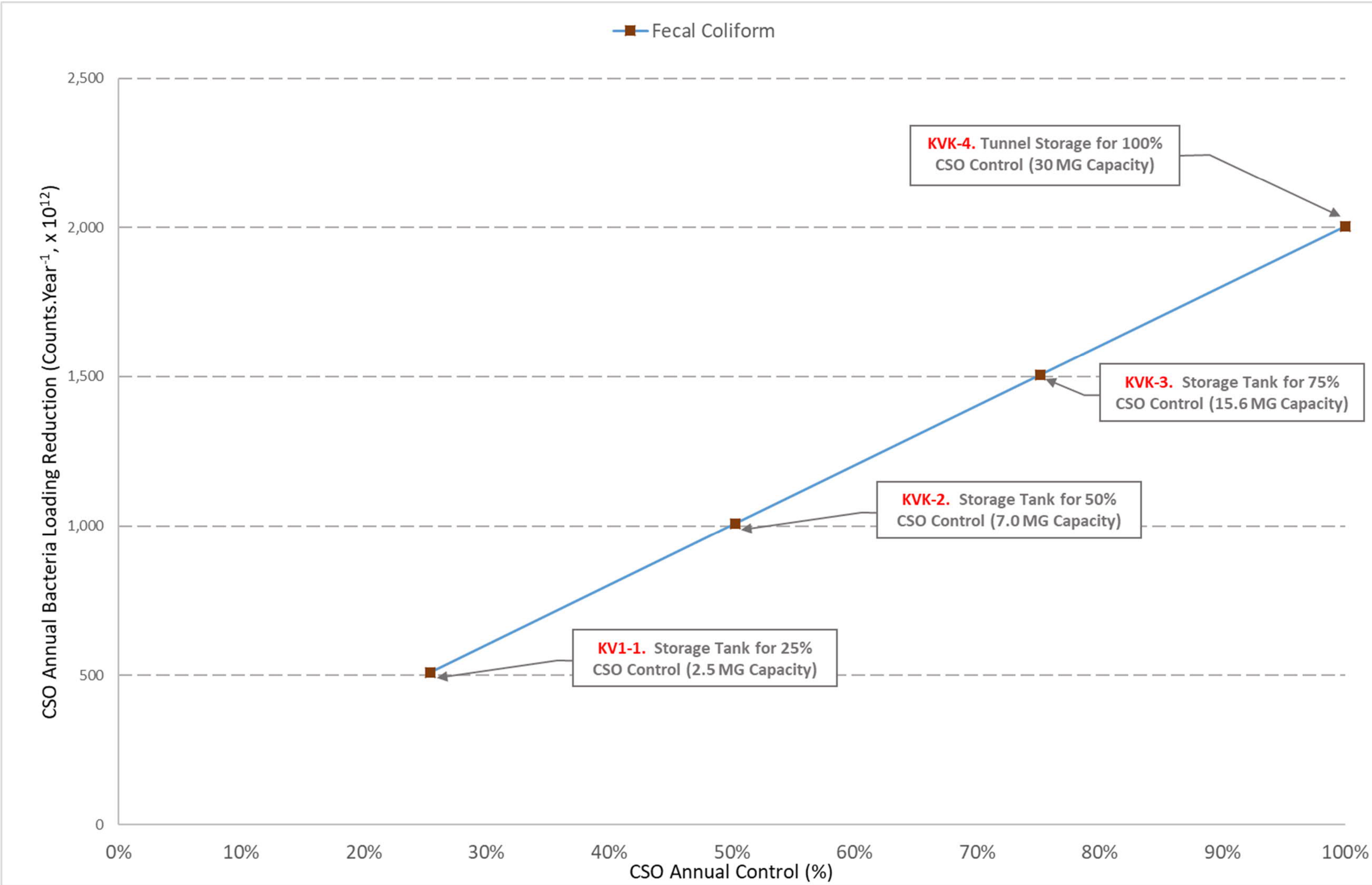

Figure 8.7-4. Untreated CSO Volume Reductions (as Percent CSO Annual Control) vs. Annual CSO Bacteria Loading Reduction (2008 Typical Year) for Kill Van Kull

Because the retained alternatives for Kill Van Kull provide volume reduction and not treatment, the predicted bacteria loading reductions of the alternatives are very closely aligned with their projected CSO volume reductions.

8.7.e Cost Estimates for Kill Van Kull Retained Alternatives

Evaluation of the retained alternatives requires cost estimation. The methodology for developing these costs is dependent upon the type of technology and its O&M requirements. The construction costs were developed as Probable Bid Costs (PBC) and the total Net Present Worth (NPW) costs were determined by adding the estimated PBC to the NPW of the projected annual O&M costs at an assumed interest rate of 3 percent over a 100-year life cycle. Design, construction management, and land acquisition costs are not included in the cost estimates. All costs are in 2019 dollars and are considered Level 5 cost estimates by AACE International with an accuracy of -50 percent to +100 percent.

8.7.e.1 Alternative KVK-1. Storage Tank for 25 Percent CSO Control

Costs for Alternative KVK-1 include planning-level estimates of the costs for a CSO storage tank sized for 25 percent CSO control. A description of the tank components is provided in Section 8.7.b and illustrated in Table 8.7-2. Site acquisition costs are not included. The total cost, expressed as NPW, for Alternative KVK-1 is $400M as shown in Table 8.7-5.

Table 8.7-5. Costs for Alternative KVK-1

Item	2019 Cost ($ Million)
Probable Bid Cost	$300
Annual O&M Cost	$2
Net Present Worth	$400

8.7.e.2 Alternative KVK-2. Storage Tank for 50 Percent CSO Control

Costs for Alternative KVK-2 include planning-level estimates of the costs for a CSO storage tank sized for 50 percent CSO control. A description of the tank components is provided in Section 8.7.b and illustrated in Table 8.7-2. Site acquisition costs are not included. The total cost, expressed as NPW, for Alternative KVK-2 is $600M as shown in Table 8.7-6.

Table 8.7-6. Costs for Alternative KVK-2

Item	2019 Cost ($ Million)
Probable Bid Cost	$500
Annual O&M Cost	$2
Net Present Worth	$600

8.7.e.3 Alternative KVK-3. Storage Tank for 75 Percent CSO Control

Costs for Alternative KVK-3 include planning-level estimates of the costs for a CSO storage tank sized for 75 percent CSO control. A description of the tank components is provided in Section 8.7.b and illustrated in Table 8.7-2. Site acquisition costs are not included. The total cost, expressed as NPW, for Alternative KVK-3 is $900M as shown in Table 8.7-7.

Table 8.7-7. Costs for Alternative KVK-3

Item	2019 Cost ($ Million)
Probable Bid Cost	$800
Annual O&M Cost	$3
Net Present Worth	$900

8.7.e.4 Alternative KVK-4. Tunnel Storage for 100 Percent CSO Control

Costs for Alternative KVK-4 include planning-level estimates of the costs for a CSO storage tunnel sized for 100 percent CSO control. A description of the tunnel components is provided in Section 8.7.b and illustrated in Table 8.7-2. Site acquisition costs are not included. The total cost, expressed as NPW, for Alternative KVK-4 is $1,100M as shown in Table 8.7-8.

Table 8.7-8. Costs for Alternative KVK-4

Item	2019 Cost ($ Million)
Probable Bid Cost	$1,000
Annual O&M Cost	$5
Net Present Worth	$1,100

The cost estimates of these retained alternatives are summarized below in **Table** 8.7**-**9 and are then used in the development of the cost-performance and cost-attainment plots presented in Section 8.7.f.

Table 8.7-9. Cost of Retained Alternatives – Kill Van Kull

Alternative	PBC(1) ($ Million)	Annual O&M Cost ($ Million/Year)	Total Net Present Worth(2) ($ Million)
KVK-1. Storage Tank at PR-029 for 25% CSO Control (2.5 MG Capacity)	$300	$2	$400
KVK-2. Storage Tank at PR-029 for 50% CSO Control (7.0 MG Capacity)	$500	$2	$600
KVK-3. Storage Tank at PR-029 for 75% CSO Control (15.6 MG Capacity)	$800	$3	$900
KVK-4. Tunnel Storage for 100% CSO Control (30 MG Capacity)	$1,000	$5	$1,100

Notes:
(1) The Probable Bid Cost (PBC) for the construction contract based upon 2019 dollars.
(2) The Net Present Worth (NPW) is based upon a 100-year service life for tunnels and is calculated by multiplying the annual O&M cost by a present worth of 31.599 and adding this value to the PBC.

8.7.f Cost-Benefit Curves for Retained Alternatives

The final step of the analysis is to evaluate the cost-effectiveness of the basin-wide retained alternatives based on their NPW and projected impact on CSO loadings and attainment of applicable WQS. Section 8.7.f.1 below presents plots of cost versus CSO volume and bacteria load reduction (Cost-Performance Curves), and Section 8.7.g below presents plots of cost versus percent attainment with WQS for selected points within Kill Van Kull (Cost-Attainment Curves).

8.7.f.1 Cost-Performance Curves

Cost-performance curves were developed by plotting the costs of the retained alternatives against their predicted level of CSO control, both in terms of CSO volume reduction, and in bacteria load reduction. In each case, a best-fit cost curve was developed based on those alternatives judged most cost-effective for a defined level of CSO control as estimated by IW modeling for the typical year rainfall (2008).

Figure 8.7-5 presents a plot of CSO volume reduction versus NPW for the retained alternatives, while Figure 8.7-6 plots the cost of the alternatives against fecal coliform loading reductions.

8.7.g Cost-Attainment Curves

This section evaluates the relationship of the costs of the retained alternatives versus their expected level of attainment of the bacteria Primary Contact WQ Criteria as modeled using the LTCPRM water quality model for the 10-year simulation. As indicated in Section 6, based on the 10-year WQ simulations for Kill Van Kull, the Class SD WQ Criteria for fecal coliform are not fully met in Kill Van Kull under Baseline Conditions, or a condition with No NYC CSO Loads. The remaining non-attainment is due to sources outside of NYC.

As a result, implementation of any of the retained alternatives described above, including the 100 percent CSO capture tunnel, results in nominal improvement in the percent attainment of the Class SB WQ Criteria for fecal coliform.

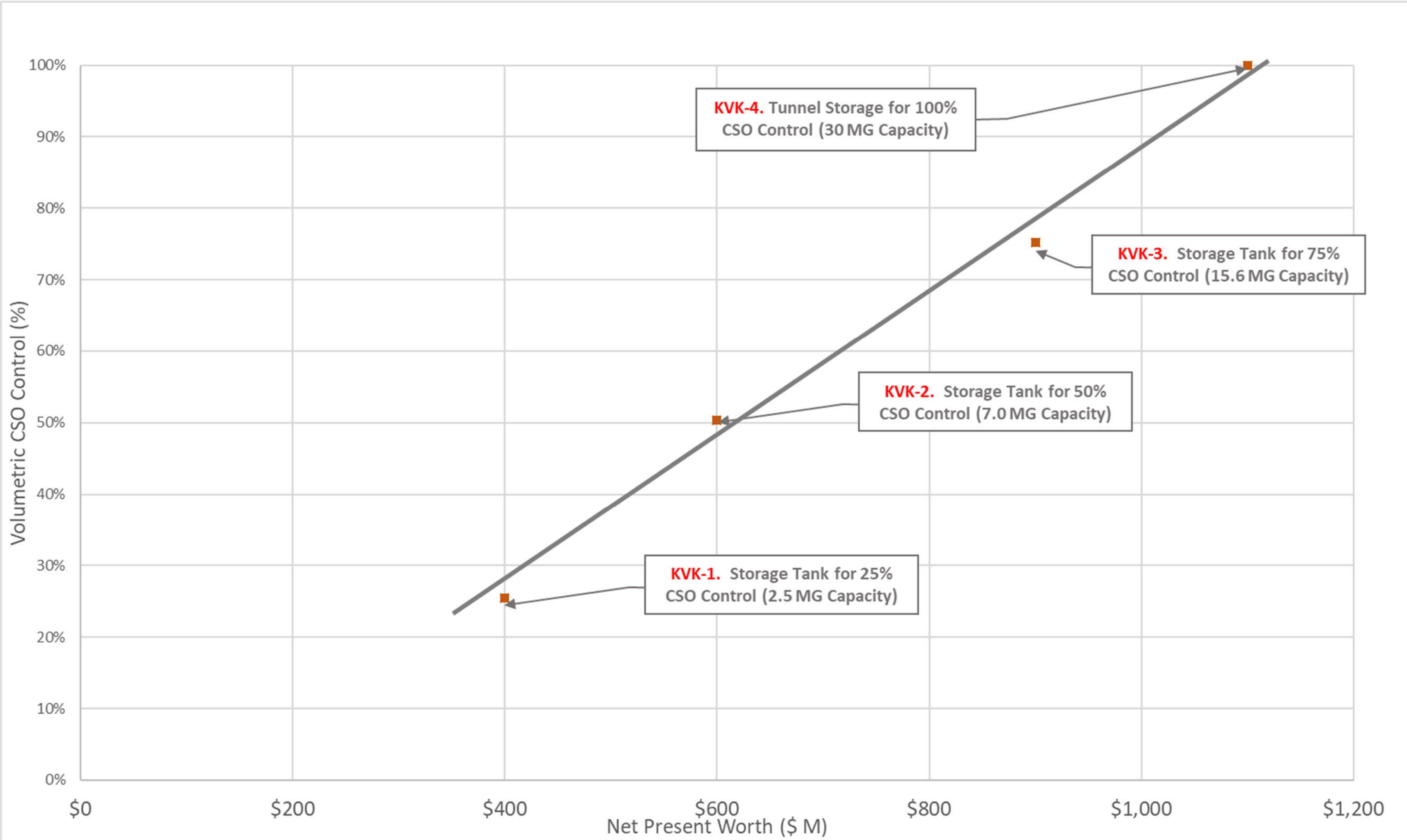

Figure 8.7-5. Cost vs. CSO Control – Kill Van Kull (2008 Typical Year)

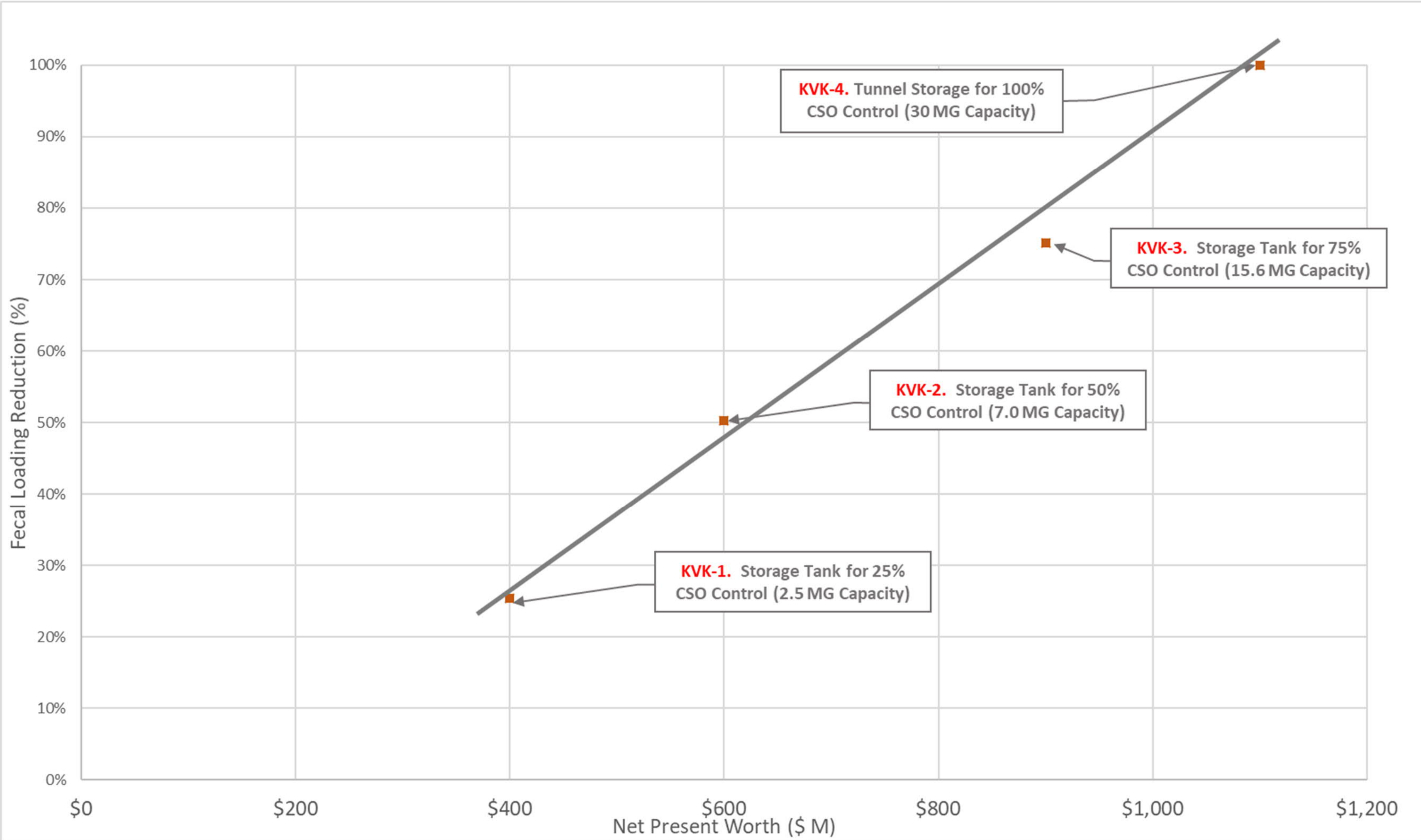

Figure 8.7-6. Cost vs. Fecal Coliform Load Reduction – Kill Van Kull (2008 Typical Year)

Cost-attainment plots are presented below for two locations within Kill Van Kull and one location within Arthur Kill. The locations of these stations are shown in Figure 8.7-13, and described as follows:

- LTCP sampling Station KK-3, located at the eastern mouth of Kill Van Kull (Figure 8.7-7)
- LTCP sampling Station KK-1, located in Kill Van Kull west of the Bayonne Bridge (Figure 8.7-8)
- LTCP sampling Station K-4, located in Arthur Kill adjacent to Cedar Point (Figure 8.7-9)

The plots in Figure 8.7-7 to Figure 8.7-9 show NPW versus percent attainment with the Class SD WQ Criteria for fecal coliform on both an annual and recreational season (May 1st through October 31st) basis. In Figure 8.7-7, the plots for attainment with the Class SD criteria for fecal coliform on an annual and recreational season basis are superimposed on each other at a level of 100 percent. Figure 8.7-7 to Figure 8.7-9 also include a point for zero cost, which corresponds to Baseline Conditions.

These plots indicate that each of the retained alternatives represent essentially no performance improvement in terms of percent attainment with the Class SD WQ Criteria for fecal coliform on both an annual and recreational season (May 1st through October 31st) basis. At Stations KK-3 and KK-1, the waterbody is already at 95 percent attainment or greater on both an annual and recreational season basis. At Station K-4 in Arthur Kill, attainment in the recreational season is greater than 95 percent under Baseline Conditions, while on an annual basis, the Baseline Conditions level of attainment of less than 80 percent would not be significantly improved even with 100 percent CSO control to Kill Van Kull.

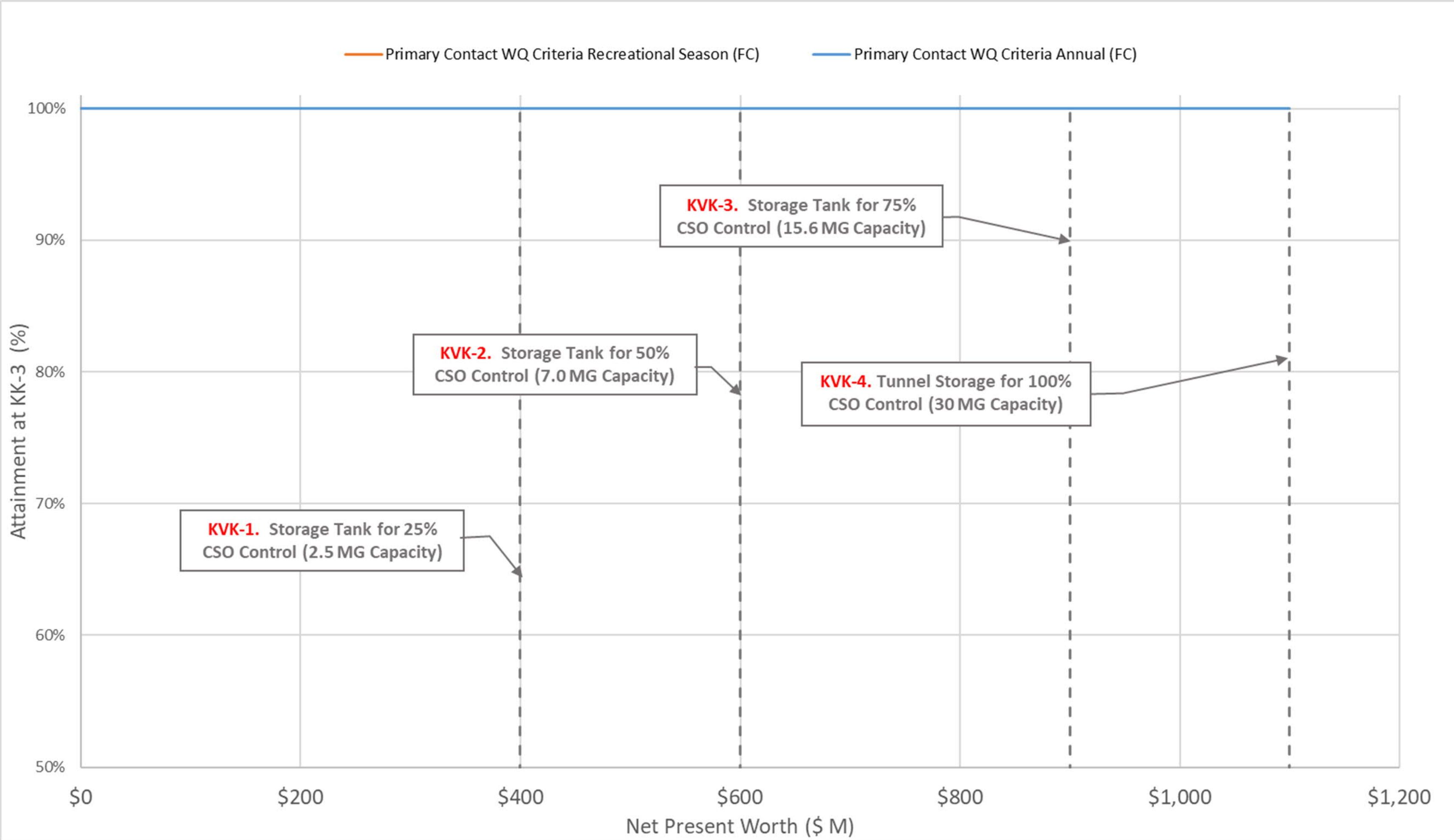

Figure 8.7-7. Cost vs. Bacteria Attainment at Class SD Station KK-3

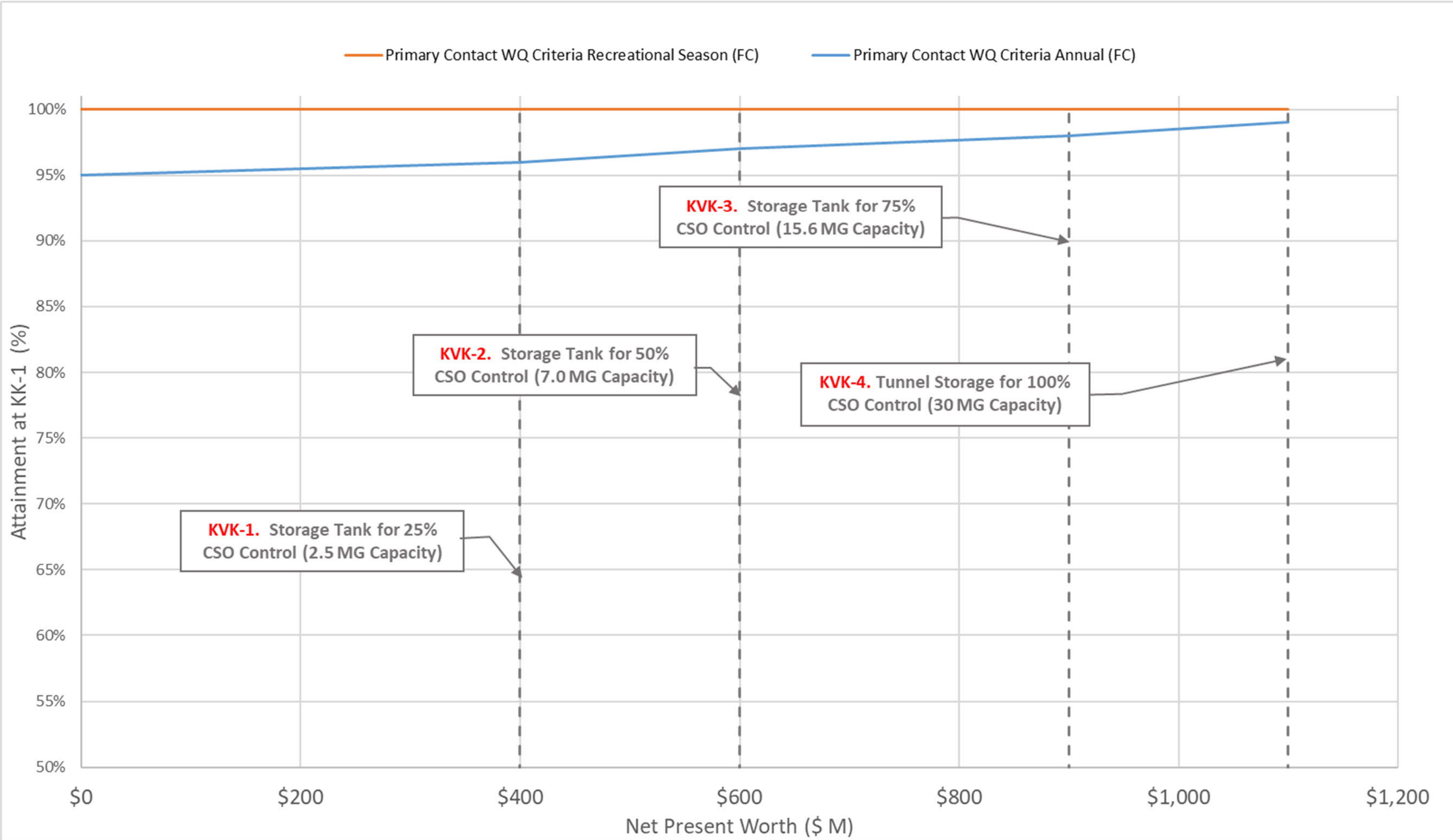

Figure 8.7-8. Cost vs. Bacteria Attainment at Class SD Station KK-1

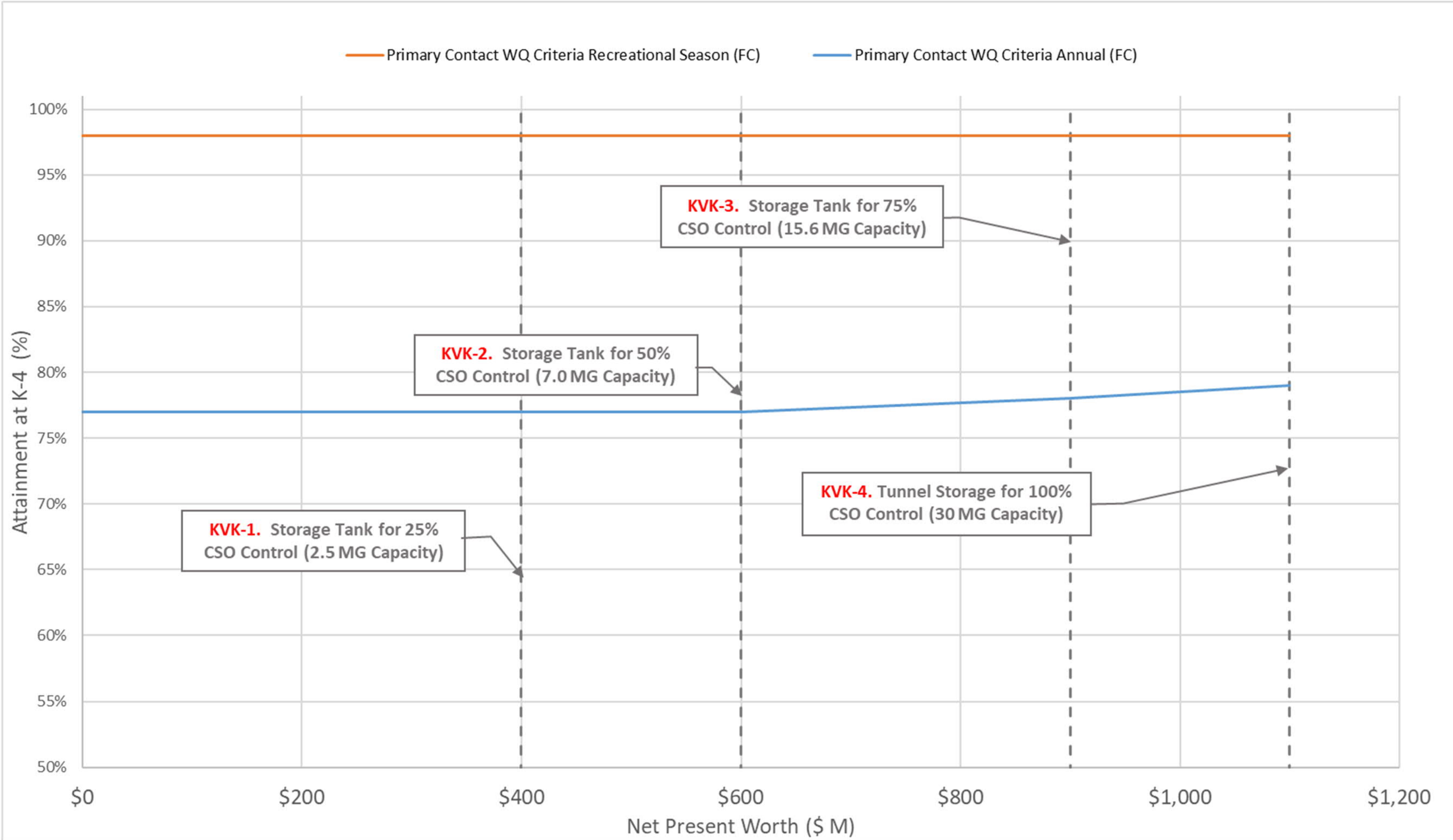

Figure 8.7-9. Cost vs. Bacteria Attainment at Class SD Station K-4

8.7.h Conclusion on Preferred Alternative

The selection of the preferred alternative for Kill Van Kull is based on multiple considerations including public input, environmental and water quality benefits, and projected costs. As described in Section 6, the reach of Kill Van Kull east of Newark Bay is achieving Class SD fecal coliform WQ criteria greater than 95 percent of the time under Baseline Conditions. For the reach along Newark Bay, attainment with the Class SD fecal coliform WQ criteria falls into the 80 to 95 percent range under both Baseline Conditions and 100 percent CSO control. Thus, the non-attainment in this reach is not due to NYC CSOs. Similarly, Baseline Conditions and 100 percent CSO control attainment of the Class SD fecal coliform criteria in Arthur Kill north of the Outerbridge Crossing Bridge is in the less than 70 to less than 95 percent range. Baseline Conditions and 100 percent CSO control attainment of the Class I fecal coliform criteria in Arthur Kill south of the Outerbridge Crossing Bridge is in the 90 to greater than 95 percent range. Therefore, the non-attainment in Arthur Kill is also not due to NYC CSOs.

As described above, none of the optimization alternatives evaluated for the CSOs discharging to Kill Van Kull from the Port Richmond WRRF system were found to either provide more than nominal CSO reduction, or to be hydraulically feasible. The CSO storage alternatives would provide a range of levels of CSO reduction to Kill Van Kull, but the costs associated with those alternatives are very high, and none of the storage alternatives would change the level of attainment with the applicable WQ criteria for fecal coliform. Section 9 presents affordability issues and impacts on disadvantaged communities that would come into play if the CSO program costs were to further significantly increase. Also, as presented below in the discussion of time to recovery, the duration of impacts of wet-weather events in Kill Van Kull is relatively short. For these reasons, none of the CSO storage alternatives was recommended.

In summary, no new CSO projects are recommended for Kill Van Kull. Water quality improvements will continue to be achieved through implementation of the GI program, as well as ongoing programmatic floatables control activities. The following conclusions can be drawn from these analyses:

1. Under Baseline Conditions, attainment with the Class SD WQ Criteria for fecal coliform is projected to be greater than 95 percent in Kill Van Kull east of Newark Bay annually and during the recreational season (May 1st through October 31st). Attainment with the Class SD WQ Criteria along Newark Bay falls into the 80 to 95 percent range under both Baseline Conditions and 100 percent CSO control, thus NYC CSOs are not causing the identified non-attainment.
2. Annual attainment with the Class SD WQ Criteria for fecal coliform in Arthur Kill north of the Outerbridge Crossing Bridge is in the less than 70 to less than 95 percent range under both Baseline Conditions and 100 percent CSO control. Annual attainment with the Class I WQ Criteria for fecal coliform in Arthur Kill south of the Outerbridge Crossing Bridge is in the 90 to greater than 95 percent range under both Baseline Conditions and 100 percent CSO control. Therefore, NYC CSOs are also not causing the non-attainment in Arthur Kill.
3. Under Baseline Conditions, attainment with the Class SD WQ Criteria for DO is greater than 95 percent in Kill Van Kull and Arthur Kill north of the Outerbridge Crossing Bridge on an annual average basis. In Arthur Kill south of the Outerbridge Crossing Bridge, attainment with the Class I WQ Criteria for DO falls into the 90 to 95 percent range under both Baseline Conditions and 100 percent CSO control. Therefore, NYC CSOs are not affecting the level of attainment with the applicable DO criteria in Kill Van Kull or Arthur Kill.

4. No hydraulically feasible or cost-effective alternatives were identified for the CSOs to Kill Van Kull.
5. The time to recovery analysis presented further below demonstrates that the duration of impact of the remaining CSOs is relatively low.

Figure 8.7-10 presents a mosaic of the level of attainment with the applicable WQ criteria for fecal coliform in Kill Van Kull and Arthur Kill on an annual basis, for the Recommended Plan, and Figure 8.7-11 presents a mosaic of the level of attainment for the recreational season (May 1st through October 31st). Figure 8.7-12 presents the level of attainment with the applicable WQ Criteria for DO on an average annual basis.

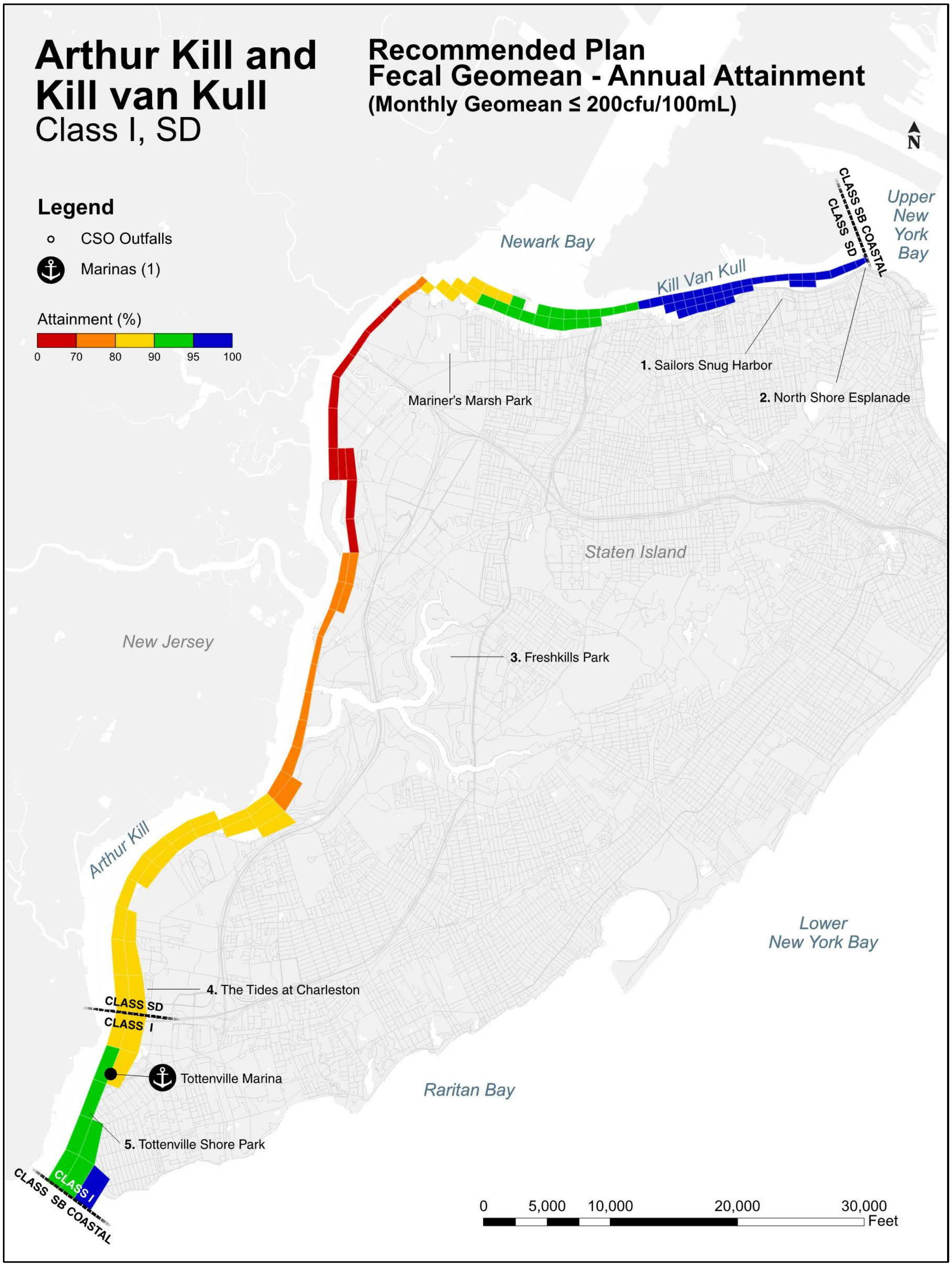

Figure 8.7-10. Fecal Coliform - Annual Attainment (10-year Runs), Kill Van Kull, Recommended Plan

Figure 8.7-11. Fecal Coliform – Recreational Season Attainment (10-year Runs), Kill Van Kull, Recommended Plan

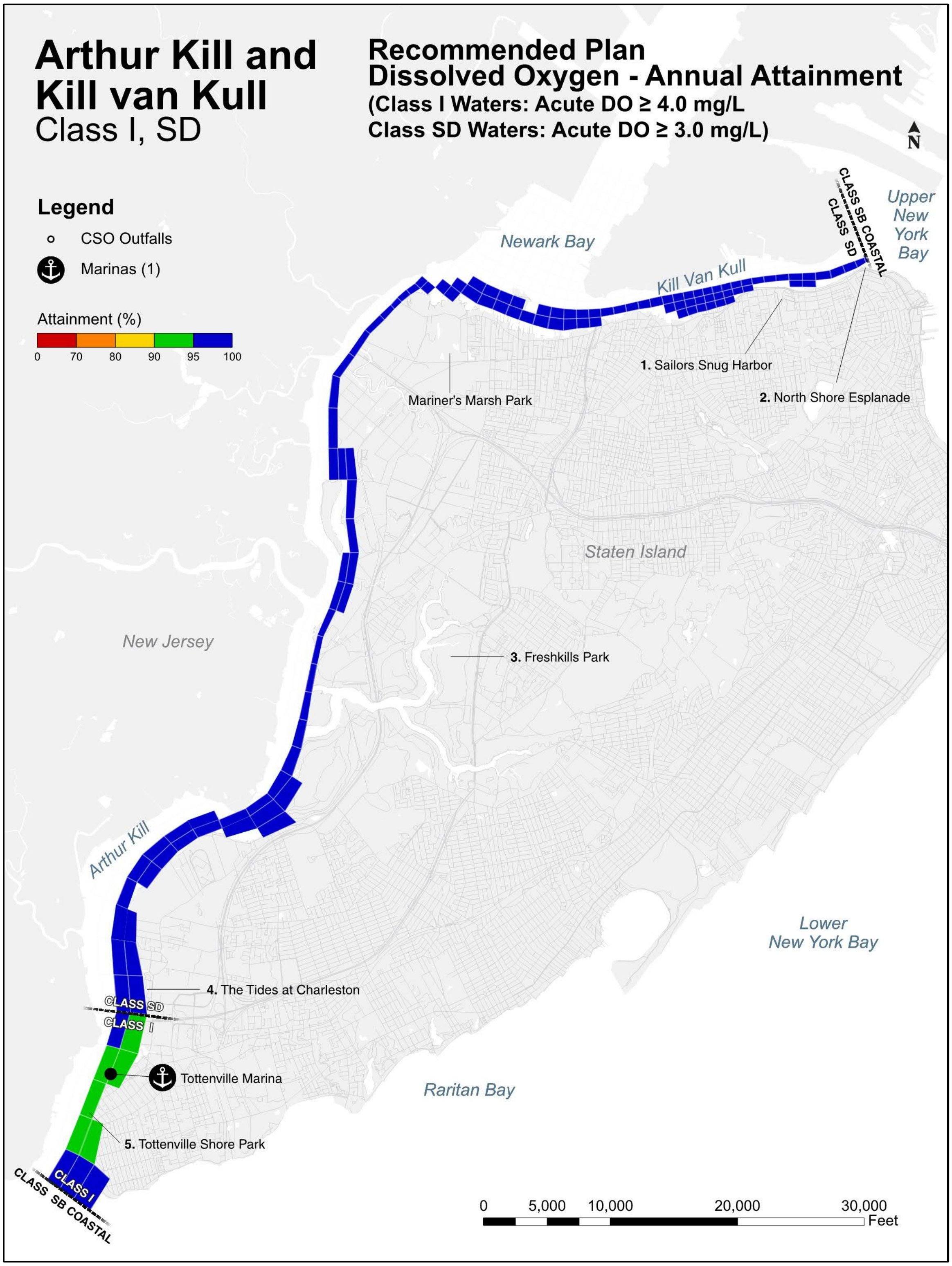

Figure 8.7-12. Annual Average DO Attainment, Arthur Kill and Kill Van Kull, Recommended Plan

Table 8.7-10 presents the fecal coliform maximum monthly geometric mean, and the percent of time that the fecal coliform WQ criteria would be attained on an annual basis and for the recreational season (May 1st through October 31st), for the 10-year simulation period, at locations within the Class SD waters of Kill Van Kull and the Class SD and Class I waters of Arthur Kill, with the Recommended Plan. The locations of the stations and supplemental model output locations listed in Table 8.7-10 are shown on Figure 8.7-13.

Table 8.7-10. Model Calculated 10-Year Fecal Coliform Maximum Monthly GM and Percent Attainment with Fecal Coliform WQ Criteria, Annual and Recreational Season, Kill Van Kull and Arthur Kill, Recommended Plan

	Maximum Monthly GMs (cfu/100mL)		% Attainment (GM ≤200 cfu/100mL)	
Description	**Annual**	**Recreational Season(1)**	**Annual**	**Recreational Season(1)**
Kill Van Kull (Class SD)				
KK-1	247	134	96%	100%
KK-2	243	134	96%	100%
KK-3	163	95	100%	100%
Mariners Marsh Park	428	237	86%	98%
Sailors Snug Harbor	183	106	100%	100%
Arthur Kill (Class SD)				
K3	647	456	60%	90%
K4	517	279	77%	98%
Arthur Kill (Class I)				
K5	339	142	93%	100%
Tottenville Marina	388	141	89%	100%

Note:
(1) The recreational season is from May 1st through October 31st.

Table 8.7-11 presents the average annual attainment of DO criteria for the 2008 typical year for the Recommended Plan at LTCP sampling locations in Kill Van Kull and Arthur Kill.

Table 8.7-11. 2008 Annual Average DO Attainment for Kill Van Kull and Arthur Kill, Recommended Plan

Station	2008 Annual Attainment (%) (Entire Water Column)
Kill Van Kull Class SD Instantaneous (≥3.0 mg/L)	
KK-1	100%
KK-2	100%
KK-3	100%
Arthur Kill Class SD Instantaneous (≥3.0 mg/L)	
K-3	100%
K-4	99%
Arthur Kill Class I Instantaneous (≥4.0 mg/L)	
K-5	94%

Note:
The recreational season is from May 1st through October 31st.

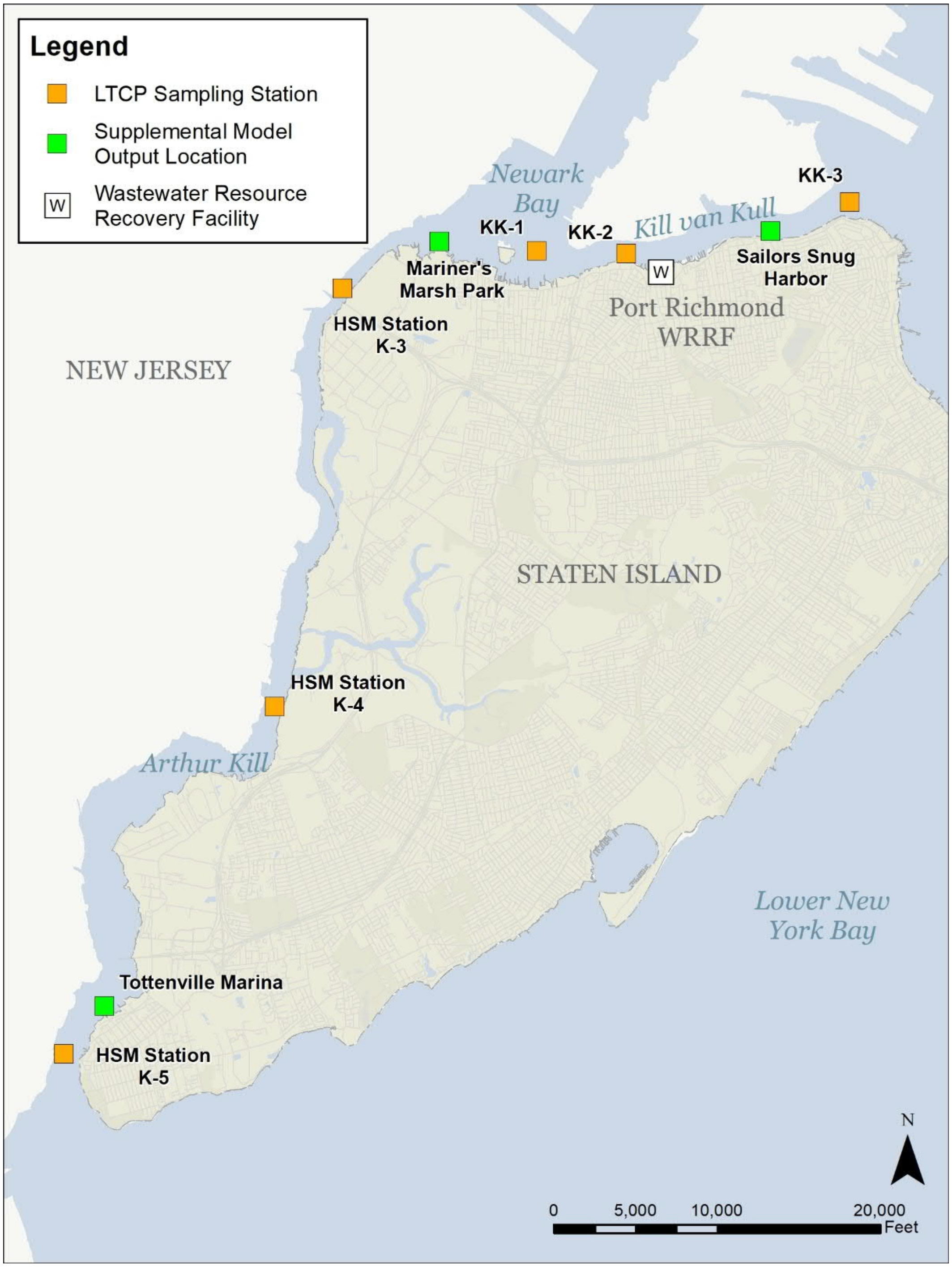

Figure 8.7-13. Sampling Stations and Supplemental Model Output Locations on Kill Van Kull and Arthur Kill

Recap

No projects are recommended for the CSO outfalls to Kill Van Kull that are associated with the Port Richmond WRRF as part of the Recommended Plan. No hydraulically feasible or cost-effective optimization alternatives were identified. While CSO storage alternatives were identified that would reduce the volume of CSO into Kill Van Kull, these alternatives carried high implementation costs, and would not improve the level of attainment with WQ criteria in Kill Van Kull or Arthur Kill. Programmatic GI and floatables control will continue to be implemented in the combined sewer areas tributary to Kill Van Kull.

With the Recommended Plan, attainment with WQ criteria is projected to be as follows:

- Attainment of the Class SD WQ Criteria for fecal coliform is projected to be greater than 95 percent in Kill Van Kull east of Newark Bay annually and during the recreational season (May 1st through October 31st).
- Attainment with the Class SD WQ Criteria along Newark Bay is projected to be in the 80 to 95 percent range on an annual basis, and greater than 95 percent during the recreational season (May 1st through October 31st).
- Annual attainment with the Class SD WQ Criteria for fecal coliform in Arthur Kill north of the Outerbridge Crossing Bridge is projected to be in the less than 70 to less than 95 percent range, while recreational season (May 1st through October 31st) attainment is projected to be in the 90 to greater than 95 percent range.
- Annual attainment with the Class I WQ Criteria for fecal coliform in Arthur Kill south of the Outerbridge Crossing Bridge is projected to be in the 80 to greater than 95 percent range for the Recommended Plan, while recreational season (May 1st through October 31st) attainment is projected to be greater than 95 percent.
- Attainment with the Class SD WQ Criteria for DO is projected to be greater than 95 percent in Kill Van Kull and Arthur Kill north of the Outerbridge Crossing Bridge on an annual average basis.
- Attainment with the Class I WQ Criteria for DO in Arthur Kill south of the Outerbridge Crossing Bridge is projected to be in the 90 to 95 percent range on an annual average basis.
- The gap analysis conducted in Section 6 demonstrates that the levels of attainment with WQ criteria in Kill Van Kull and Arthur Kill would not change with 100 percent control of the CSOs discharging to Kill Van Kull. The remaining non-attainment of WQ criteria in Kill Van Kull and Arthur Kill is due to non-NYC CSO sources.

8.7.i Use Attainability Analysis

The CSO Order requires that a UAA be included in an LTCP “where existing WQS do not meet the Section 101(a)(2) goals of the CWA, or where the proposed alternative set forth in the LTCP will not achieve existing WQS or the Section 101(a)(2) goals.” The UAA shall “examine whether applicable waterbody classifications, criteria, or standards should be adjusted by the State.” The UAA process specifies that States can remove a designated use that is not an existing use if the scientific assessment can demonstrate that attaining the designated use is not feasible for at least one of six reasons:

1. Naturally occurring loading concentrations prevent the attainment of the use; or

2. Natural, ephemeral, intermittent or low flow conditions or water levels prevent the attainment of the use, unless these conditions may be compensated for by the discharge of sufficient volume of effluent discharges without violating State water conservation requirements to enable uses to be met; or
3. Human caused conditions or sources of pollution prevent the attainment of the use and cannot be remedied or would cause more environmental damage to correct than to leave in place; or
4. Dams, diversions or other types of hydrologic modifications preclude the attainment of the use, and it is not feasible to restore the waterbody to its original condition or to operate such modification in a way that would result in the attainment of the use; or
5. Physical conditions related to the natural features of the waterbody, such as the lack of a proper substrate, cover, flow, depth, pools, riffles, and the like, unrelated to water quality, preclude attainment of aquatic life protection uses; or
6. Controls more stringent than those required by Sections 301(b) and 306 of the Act would result in substantial and widespread economic and social impact.

As part of the LTCP, elements of a UAA, including the six conditions presented above, will be used to determine if changes to the designated use are warranted, considering a potential adjustment to the designated use classification as appropriate.

As noted in previous sections, with the implementation of the Recommended Plan, parts of Kill Van Kull and Arthur Kill will achieve less than 95 percent compliance with the Class SD WQ Criteria for fecal coliform, and parts of Arthur Kill will achieve less than 95 percent compliance with the Class I WQ Criteria for fecal coliform and DO. Therefore, a Use Attainability Analysis is needed for Kill Van Kull and Arthur Kill.

8.7.i.1 Use Attainability Analysis Elements

The objectives of the CWA include providing for the protection and propagation of fish, shellfish, wildlife, and recreation in and on the water. Cost-effectively maximizing the water quality benefits associated with CSO reduction is a cornerstone of this LTCP.

To simplify this process, DEP and DEC have developed a framework that outlines the steps taken under the LTCP in two possible scenarios:

1. Waterbody meets WQ requirements. This may either be the existing WQS (where primary contact is already designated) or for an upgrade to the Primary Contact WQ Criteria (where the existing standard is not a Primary Contact WQ Criteria). In either case, a high-level assessment of the factors that define a given designated use is performed, and if the level of CSO control required to meet this goal can be reasonably implemented, a change in designation may be pursued following implementation of CSO controls and Post-Construction Compliance Monitoring.

2. Waterbody does not meet WQ requirements. In this case, if a higher level of CSO control is not feasible, the UAA must justify the shortcoming using at least one of the six criteria (see Section 8.7.i above). It is assumed that if 100 percent elimination of CSO sources does not result in attainment, the UAA would include factor number 3 at a minimum as justification (human caused conditions or sources of pollution prevent the attainment of the use and cannot be remedied, or would cause more environmental damage to correct than to leave in place).

As indicated in Table 8.7-10 and Table 8.7-11, the modeled attainment of the Class SD and Class I WQ Criteria for fecal coliform and the Class I DO criteria will not be fully achieved upon implementation of the LTCP Recommended Plan. Future revisions of the Kill Van Kull and Arthur Kill WQ classification should await the results of the Post-Construction Compliance Monitoring.

8.7.j Fishable/Swimmable Waters

The goal of this LTCP is to identify appropriate CSO controls necessary to achieve waterbody-specific WQS, consistent with EPA's CSO Control Policy and subsequent guidance. DEC considers that compliance with Class SD WQS, the current classification for Kill Van Kull, and Arthur Kill north of Outerbridge Crossing Bridge, and compliance with Class I WQS, the current classification for Arthur Kill south of Outerbridge Crossing Bridge, as fulfillment of the CWA's fishable/swimmable goal.

The preferred alternative summarized in Section 8.7.h results in the levels of attainment with fishable/swimmable criteria as follows:

- For the 10-year continuous simulation, summarized in Table 8.7-10, attainment of the Class SD WQ Criteria for fecal coliform is not predicted to be met on an annual basis in Kill Van Kull or Arthur Kill, and is not predicted to be met in Arthur Kill for the recreational season (May 1st through October 31st). Attainment of the Class I WQ Criteria for fecal coliform is not predicted to be met on an annual basis in Arthur Kill.
- Based on the 2008 typical year simulations, as summarized in Table 8.7-11, the Recommended Plan would not achieve full attainment of the Class I DO criteria in Arthur Kill on an annual average basis.

8.7.k Assessment of Highest Attainable Use

The 2012 CSO Order Goal Statement stipulates that, in situations where the proposed alternatives presented on the LTCP will not achieve the CWA Section 101(a)(2) goals, the LTCP will include a UAA. Because the analyses developed herein indicate that Kill Van Kull and Arthur Kill north of the Outerbridge Crossing Bridge are not projected to fully attain the Class SD WQ Criteria for fecal coliform, and that Arthur Kill south of the Outerbridge Crossing Bridge is not projected to fully meet the Class I WQ Criteria for bacteria or DO, a UAA is required under the 2012 CSO Order. Table 8.7-12 summarizes the compliance for the identified plan.

Table 8.7-12. Recommended Plan Compliance with Water Quality Criteria

Compliance with Class SD Fecal Coliform Criteria Monthly GM (≤ 200 mg/L) 10-year Simulation(1)		Compliance with Class SD DO Criteria (≥ 3.0 mg/L) 2008 Typical Year(1)
Annual	**Recreational Season(1)**	**Annual**
Kill Van Kull		
96-100%	100%	100%
Arthur Kill North of Outerbridge Crossing Bridge		
60-94%	90-98%	100%
Compliance with Class I Fecal Coliform Criteria Monthly GM (≤ 200 mg/L) 10-year Simulation(1)		**Compliance with Class I DO Criteria (≥ 4.0 mg/L) 2008 Typical Year(1)**
Annual	**Recreational Season(1)**	**Annual**
Arthur Kill South of Outerbridge Crossing Bridge		
80-95%	95-100%	90-100%

Notes:
(1) Range of attainment based on values at stations shown in Table 8.7-10 and Table 8.7-11 above.
(2) Recreational season is from May 1st through October 31st.

8.7.l Time to Recovery

As noted above, Kill Van Kull and Arthur Kill north of the Outerbridge Crossing Bridge are Class SD waterbodies, and Arthur Kill south of Outerbridge Crossing Bridge is a Class I waterbody. The applicable Water Quality Criteria for fecal coliform bacteria for these waterbodies are based on a monthly geometric mean. However, to gain insight into the shorter-term impacts of wet-weather sources of bacteria, DEP has performed an analysis to assess the amount of time following the end of a rainfall event required for Kill Van Kull and Arthur Kill to recover and return to fecal coliform concentrations less than 1,000 cfu/100mL.

The analyses consisted of examining the WQ model-calculated bacteria concentrations in Kill Van Kull and Arthur Kill for recreational periods (May 1st through October 31st) abstracted from 10 years of model simulations. For Kill Van Kull and Arthur Kill, the JFK Airport rainfall data was compared against water quality model bacteria results for the 10 recreational seasons to determine how long it took for the water column concentration to return to target threshold concentrations from the end of the rain event. The chosen target threshold concentration was 1,000 cfu/100mL for fecal coliform. The various rainfall events were then placed into rain event size "bins" ranging from less than 0.1 inch to greater than 1.5 inches. Only rain events that reached the target threshold concentrations before the beginning of the next storm were included. The median time to recovery for each bin at each water quality station was calculated. Table 8.7-13 presents the time to recovery for the baseline condition for Kill Van Kull and Arthur Kill. Results are presented for the greater than 1.0 to 1.5 inch rainfall bin, which includes the 90th percentile event.

DEC has advised that it seeks to have a time to recovery of less than 24 hours, and this target has been consistent in the previously approved LTCPs. As indicated in Table 8.7-13, for the Recommended Plan, all of the stations assessed had median time to recovery of less than three hours, and most of the stations had median time to recovery of zero hours, indicating that the fecal coliform concentration never reached the level of 1,000 cfu/100mL for more than half of the storms within the 1-to-1.5 inch rainfall bin assessed.

Table 8.7-13. Kill Van Kull and Arthur Kill Time to Recovery, Fecal Coliform, Recommended Plan

Location	Time to Recovery (hours) Fecal Coliform Threshold (1,000 cfu/100mL)(1)
Kill Van Kull (Class SD)	
KK-1	0(2)
KK-2	0
KK-3	0
Mariners Marsh Park	0
Sailors Snug Harbor	0
Arthur Kill (Class SD)	
K-3	2
K-4	0
Arthur Kill (Class I)	
K-5	0
Tottenville Marina	0

Notes:

(1) Median time to recovery values presented for storms from the 10-year simulation, recreational seasons, in the size range of >1.0 to 1.5-inches of rainfall, which includes the 90th percentile rain event.

(2) Median time to recovery of "0" means that the average concentration across the water column never reached the 1,000 cfu/100mL threshold at the referenced station for more than half of the storms within the 1-to-1.5 inch rainfall bin assessed.

8.7.m Recommended LTCP Elements to Meet Water Quality Goals for Kill Van Kull

The actions identified in this LTCP include:

- DEP will continue to implement the Green Infrastructure Program and programmatic floatables control activities for Kill Van Kull.
- Compliance with Class SD WQ Criteria for fecal coliform in portions of Kill Van Kull and Arthur Kill; compliance with Class I WQ Criteria for fecal coliform in portions of Arthur Kill; compliance with Class SD WQ Criteria for DO in Kill Van Kull and Arthur Kill, and compliance with Class I WQ Criteria for DO in portions of Arthur Kill. However, full attainment of the Class SD and Class I fecal coliform criteria, and the Class I DO criteria will not be achieved. As a result, a UAA is required as part of this LTCP.

- DEP will establish with the DOHMH (through public notification) a wet-weather advisory for the recreational season (May 1st through October 31st) during which recreational activities would not be recommended in Kill Van Kull and Arthur Kill. The LTCP includes a recovery time analysis that can be used to establish the duration of the wet-weather advisory for public notification.

DEP is committed to improving water quality in this waterbody, which will be advanced by the improvements and actions identified in this LTCP. These identified actions have been balanced with input from the public and awareness of the cost to the residents of NYC.

8.8 Summary of Recommended Plan

Sections 8.3 to 8.7 above presented the evaluations and conclusions regarding the components of the Citywide/Open Waters LTCP Recommended Plan for the Harlem River, Hudson River, East River/Long Island Sound, New York Bay, and Kill Van Kull, respectively. Table 8.8-1 summarizes the components, annual CSO volume reduction, and Probable Bid Cost (PBC) for the Recommended Plan by waterbody.

Table 8.8-1.Summary of Recommended Plan Components

Waterbody	Recommended Plan Description	Annual Net Untreated CSO Volume Reduction (MG)[1]	Probable Bid Cost ($M)[2]
Harlem River	No CSO project recommended[3]	0	$0
Hudson River	HUD-2: Enlargement of regulator orifice openings at Regulators NR-26A, 28, and 29A associated with Outfalls NR-040, 038, and 046, respectively.	7	$3
East River/Long Island Sound	ER-6: Enlargement of the regulator orifice opening on Regulator TI-10B (CSO TI-003) and installation of a bending weir at Regulator TI-13 (CSO TI-023).	86	$6
New York Bay	NYB-1: Modifying the weir at Regulator RH-020A (CSO RH-005), increasing the regulator orifice opening, and enlarging the branch interceptor connection at Regulator RH-13 (CSO RH-014). NYB-2: Installing a bypass connection on the Victory Boulevard combined sewer upstream of Regulator 17 (CSO PR-013). This connection would divert dry-weather flow and a portion of the wet-weather flow directly to the East Interceptor by gravity. NYB-3: Installing a control gate in Regulator 9C (CSO OH-015), to keep more wet-weather flow in the upper of the two combined sewer conduits entering the regulator.	132	$33
Kill Van Kull	No CSO project recommended[4]	0	$0
Totals		225	$42

Notes:

(1) Based on 2008 Typical Year.
(2) AACE International Level 5 cost estimates, in 2019 dollars.
(3) Tibbetts Brook Daylighting project is included under the Green Infrastructure Program as part of the LTCP Baseline Conditions. The project is estimated to reduce CSO volume to Harlem River by 228 MGY.
(4) No feasible optimization alternatives were identified for Kill Van Kull. Storage alternatives had high cost, and would not change the level of attainment with WQS.

As indicated in Table 8.8-1, the Recommended Plan is predicted to reduce annual CSO volume by 225 MG, at a PBC of $42M. As also noted in Table 8.8-1, the Tibbetts Brook Daylighting project, which is included in the Baseline Conditions, is estimated to also reduce annual CSO volume to the Harlem River by 228 MGY. The implementation schedule for the Recommended Plan is presented in Section 9.

Table 8.8-2 summarizes the status of projected WQ criteria compliance for the Recommended Plan. As indicated in Table 8.8-2, most WQ criteria are projected to be attained in most Open Waters waterbodies under the Recommended Plan. As described in Section 8.7 above, the non-attainment with the WQ criteria for fecal coliform in Kill Van Kull and Arthur Kill is attributable to non-NYC CSO sources. The gap analysis showed that a condition of No NYC CSO Loads for Kill Van Kull would not result in attainment of the criteria, and the load component analysis showed that the non-attainment was driven by sources from outside of NYC. Similarly, the non-attainment with the WQ criteria for DO in the Class I reach of Arthur Kill is also attributable to sources from outside of NYC. Attainment of the Class SB Coastal Primary Recreational *Enterococci* STV criteria in New York Bay could generally be achieved with a 50 percent CSO control storage alternative, at an un-escalated PBC of $3,000M. Within New York Bay, the median time to recovery to a fecal coliform level of 1,000 cfu/100mL for storms in the 1 to 1.5 inch range at all of the stations assessed except for NB-7 and NB-9 was zero hours, indicating that the fecal coliform concentration never reached the level of 1,000 cfu/100mL for more than half of the storms assessed. Median times to recovery for Stations NB-7 and NB-9 were eight hours or less. Median time to recovery to an *Enterococci* level of 130 cfu/100mL was similarly less than 12 hours at all stations assessed and was zero at many of the stations. Given the extremely high cost and implementation challenges associated with the tunnel storage alternatives for New York Bay, the relatively short time to recovery, and affordability issues identified in Section 9, an alternative to meet the Class SB Coastal Primary Recreational *Enterococci* STV criteria in New York Bay was not recommended.

As described in Sections 8.6 and 8.7, a UAA is required under the 2012 CSO Order for the following cases:

- New York Bay is not projected to fully attain the Class SB Coastal Primary Recreational *Enterococci* STV criteria or the Class SB DO criteria. Sources from outside of NYC are the driver for non-attainment of the Class SB DO criteria.
- Kill Van Kull and Arthur Kill north of the Outerbridge Crossing Bridge are not projected to fully attain the Class SD WQ criteria for fecal coliform. Sources from outside of NYC are the driver for non-attainment of the Class SD QW criteria for fecal coliform.
- Arthur Kill south of the Outerbridge Crossing Bridge is not projected to fully meet the Class I WQ criteria for fecal coliform or DO. Sources from outside of NYC are the driver for non-attainment of these criteria.

To provide perspective on the scope and costs associated with alternatives to provide higher levels of CSO control to the Open Waters waterbodies, Table 8.8-3 provides a summary of the volume of storage required and the estimated costs to provide 25, 50, 75, and 100 percent levels of CSO control by waterbody for the Open Waters waterbodies. The total PBC values from Table 8.8-3 are plotted against percent CSO control in Figure 8.8-1.

As indicated in Table 8.8-3 and Figure 8.8-1, the cost to provide even 25 percent CSO control for the Open Waters waterbodies is over $4B. In light of the high level of attainment with WQ criteria found throughout the Open Waters with limited exceptions, this LTCP focused on optimization alternatives. Cumulatively, these optimization projects will cost-effectively reduce CSO volume system-wide by 225 MG. These projects, in addition to ongoing programmatic GI and floatables control activities, including the Tibbetts Brook Daylighting project, will continue to provide improvements to water quality in the Open Waters waterbodies.

Table 8.8-2. Summary of Water Quality Criteria Compliance with Recommended Plan

Waterbody	WQS Classification	Attainment with Criteria[1]				
		Fecal Coliform Monthly GM≤200 CFU/100mL		*Enterococci* 30-day GM≤35 cfu/100mL[3]	*Enterococci* 30-day STV≤130 cfu/100mL[3]	DO Annual Average Attainment[4]
		Annual	Recreational Season[2]	Recreational Season[2]	Recreational Season[2]	Annual
Harlem River	Class I	Yes	Yes	N/A	N/A	Yes
Hudson River (North of Harlem River)	Class SB	Yes	Yes	N/A	N/A	Yes
Hudson River (South of Harlem River)	Class I	Yes	Yes	N/A	N/A	Yes
Long Island Sound (East of Throgs Neck Bridge)	Class SB Coastal Primary Recreational	Yes	Yes	Yes	Yes	Yes
East River (between Whitestone Bridge and Throgs Neck Bridge)	Class SB	Yes	Yes	N/A	N/A	Yes
East River (West of Whitestone Bridge)	Class I	Yes	Yes	N/A	N/A	Yes
New York Bay	Class SB Coastal Primary Recreational	Yes	Yes	Yes[5]	No	No[5]
Arthur Kill (South of Outerbridge Crossing Bridge)	Class I	No[6]	Yes	N/A	N/A	No[6]
Arthur Kill (North of Outerbridge Crossing Bridge)	Class SD	No[6]	No[6]	N/A	N/A	Yes
Kill Van Kull	Class SD	No[6]	Yes	N/A	N/A	Yes

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Table 8.8-2. Summary of Water Quality Criteria Compliance with Recommended Plan

Waterbody	WQS Classification	Attainment with Criteria(1)				
		Fecal Coliform Monthly GM≤200 CFU/100mL		*Enterococci* 30-day GM≤35 cfu/100mL(3)	*Enterococci* 30-day STV≤130 cfu/100mL(3)	DO Annual Average Attainment(4)
		Annual	Recreational Season(2)	Recreational Season(2)	Recreational Season(2)	Annual

Notes:

(1) "**Yes**" means ≥95% attainment with the criteria. "**No**" means <95% attainment with the criteria. Attainment based on 10-year model simulation.

(2) Recreational season is May 1st through October 31st.

(3) *Enterococci* criteria apply only to coastal primary recreational waters; N/A = Not applicable.

(4) DO criteria:
   a. Class SB acute ≥3 mg/L; chronic ≥ range of 3 to 4.8 mg/L (see Section 6 for more details on Class SB chronic criteria)
   b. Class I ≥4 mg/L
   c. Class SD ≥3 mg/L

(5) Only the area around Station K5A off the southwest end of Staten Island is out of compliance with the Class SB DO criteria. No NYC CSOs are in the vicinity of this location. A condition of No NYC CSO Loads would not achieve attainment with the criteria, and the load component analysis in Section 6 demonstrated that the non-attainment is driven by sources from outside of NYC.

(6) A condition of No NYC CSO Loads would not achieve attainment with the criteria, and the load component analysis in Section 6 demonstrated that the non-attainment is driven by sources from outside of NYC.

Table 8.8-3. Summary of Storage Volume Required and PBC for 25, 50, 75, and 100 Percent CSO Control for Open Waters Waterbodies

	25% CSO Control		50% CSO Control		75% CSO Control		100% CSO Control	
Waterbody	**Volume of Storage (MG)**	**PBC(1)**	**Volume of Storage (MG)**	**PBC(1)**	**Volume of Storage (MG)**	**PBC(1)**	**Volume of Storage (MG)**	**PBC(1)**
Harlem River	20	$800	130	$1,900	190	$3,200	269	$8,000
Hudson River	14	$600	79	$1,500	114	$2,900	142	$5,500
East River/Long Island Sound	71	$1,500	367	$4,700	526	$8,000	738	$18,200
New York Bay	22	$900	156	$2,900	253	$4,300	361	$8,500
Kill Van Kull	2.5	$300	7	$500	16	$800	30	$1,000
Totals	**129.5**	**$4,100**	**739**	**$11,500**	**1,099**	**$19,200**	**1,540**	**$41,200**

Note:
(1) AACE International Level 5 cost estimates, in 2019 dollars. Costs do not include land acquisition.

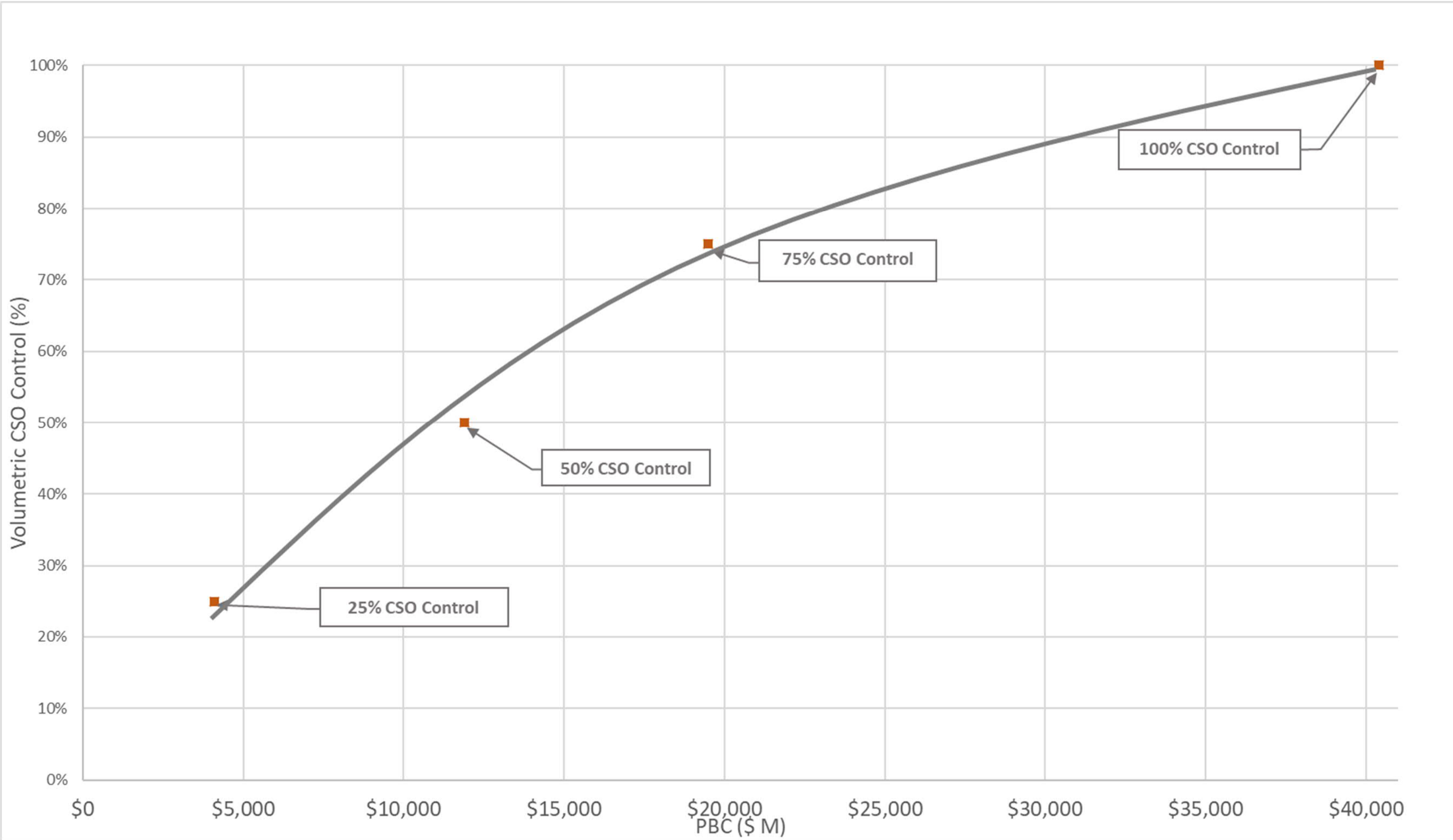


Figure 8.8-1. PBC vs. Percent CSO Control System-wide for Open Waters Waterbodies

9.0 LONG TERM CSO CONTROL PLAN IMPLEMENTATION

The evaluations performed for this Citywide/Open Waters LTCP concluded that under baseline conditions, the Harlem River, Hudson River, and East River are in full attainment with applicable bacteria and DO WQ Criteria. New York Bay, Arthur Kill, and Kill Van Kull have segments where applicable bacteria and DO WQ Criteria cannot be attained. After thorough analysis, it is clear that even under the theoretical case of no NYC CSO loads, New York Bay, Arthur Kill, and Kill Van Kull would not achieve full WQ Criteria attainment. The predominant loadings for these waterbodies are from outside of NYC.

Water quality in Citywide/Open Waters will be improved through the implementation of the following:

(1) Recommended Plan projects from the approved and pending LTCPs described in Section 4 of this LTCP;

(2) Constructed and planned GI projects in combined sewer areas including the Tibbetts Brook Daylighting Project described in Section 5;

(3) Programmatic floatables control activities; and

(4) The Recommended Plan for the Citywide/Open Waters LTCP, which includes the following projects:

- Optimization of regulators associated with Outfalls NR-038, NR-040, and NR-046 which discharge to the Hudson River;
- Bending weir at Outfall TI-023 plus optimization of the regulator associated with Outfall TI-003 which discharge to the East River;
- Optimization of regulators associated with Outfalls RH-005 and RH-014 which discharge to New York Bay;
- Gravity flow connection from the Victory Boulevard combined sewer to the East Interceptor, bypassing Hannah Street Pumping Station and diverting dry- and wet-weather flow upstream of Outfall PR-013, which discharges to New York Bay; and
- Control gate at Regulator 9C, associated with Outfall OH-015 which discharges to New York Bay.

Figure 9-1 illustrates the elements of the Citywide/Open Waters LTCP Recommended Plan.

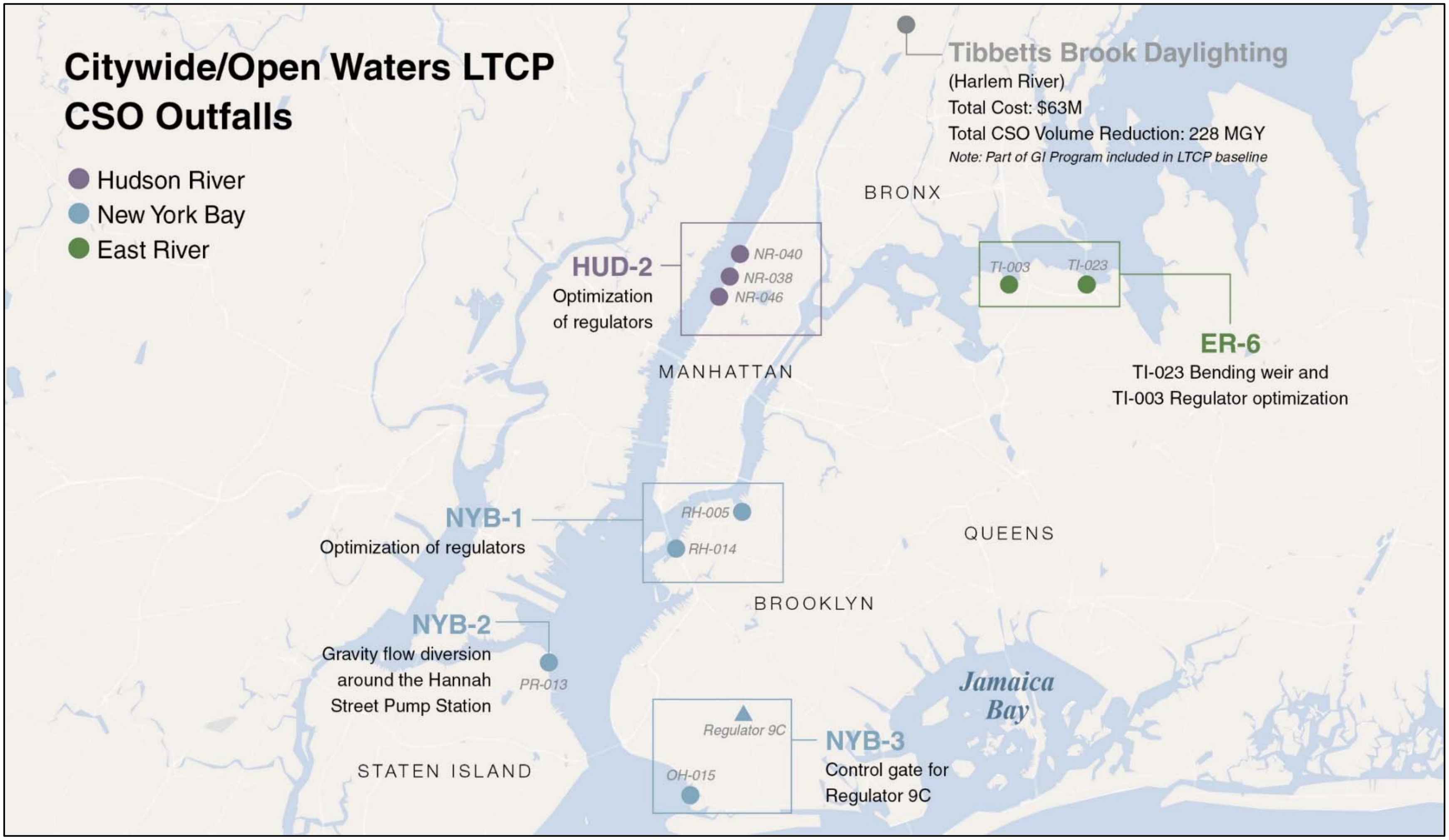


Figure 9-1. Overview of the Recommended Plan

Note: The Tibbetts Brook Daylighting Project is considered part of the Baseline Conditions for the Citywide/Open Waters LTCP.

9.1 Adaptive Management (Phased Implementation)

Adaptive management, as defined by the EPA, is the process by which new information about the characteristics of a watershed is incorporated into a watershed management plan on a continuing basis. The process relies on establishing a monitoring program, evaluating monitoring data and trends, and making adjustments or changes to the plan. DEP will continue to apply the principles of adaptive management to this LTCP based on its annual evaluation of monitoring data, which will be collected to sustain the operation and analyze the effectiveness of the currently operational CSO controls.

NYC is implementing a program to address stormwater discharges as part of its City-wide MS4 Permit. This Stormwater Management Program (SWMP), along with the actions identified in this LTCP, may further improve water quality in the Citywide/Open Waters waterbodies. For more information on the City's MS4 Program, please visit nyc.gov/dep/ms4.

DEP will also continue to monitor the water quality of the Harlem River, Hudson River, East River, New York Bay, Arthur Kill, and Kill Van Kull through its ongoing HSM and SM Programs, as discussed in Section 2.0. For example, if evidence of dry-weather sources of pollution is found, DEP will initiate investigations to identify the source. Such activities will continue to be reported to DEC on a quarterly basis, as is currently required under the SPDES permits for each of the WRRFs with permitted CSO outfalls that may discharge during wet-weather to the Open Waters waterbodies.

9.2 Implementation Schedule

The implementation schedules for the elements of the Citywide/Open Waters LTCP Recommended Plan are presented in Figure 9-2. The schedule presents the estimated time needed to conduct facility planning, procure design consultants, perform the engineering design, advertise and bid the construction contracts, and complete the construction of the actions identified in this LTCP. The schedules represent our best estimate at this conceptual level given the size, complexity, and access coordination needed to support the projects. In light of the 2020 COVID-19 pandemic and associated declarations of state and national emergencies (referred to hereinafter as "COVID-19"), the timing for LTCP schedules and initiation of the projected schedule proposed herein may ultimately be impacted. Pending DEC review and approval, DEP will seek to work with DEC to determine the appropriate start date for this recommended plan schedule as part of a balanced approach for capital investments to avoid unduly limiting DEP's ability to make sound investments in existing infrastructure. COVID-19 considerations and prioritization of future investments are further discussed in Section 9.8 and Section 9.9.

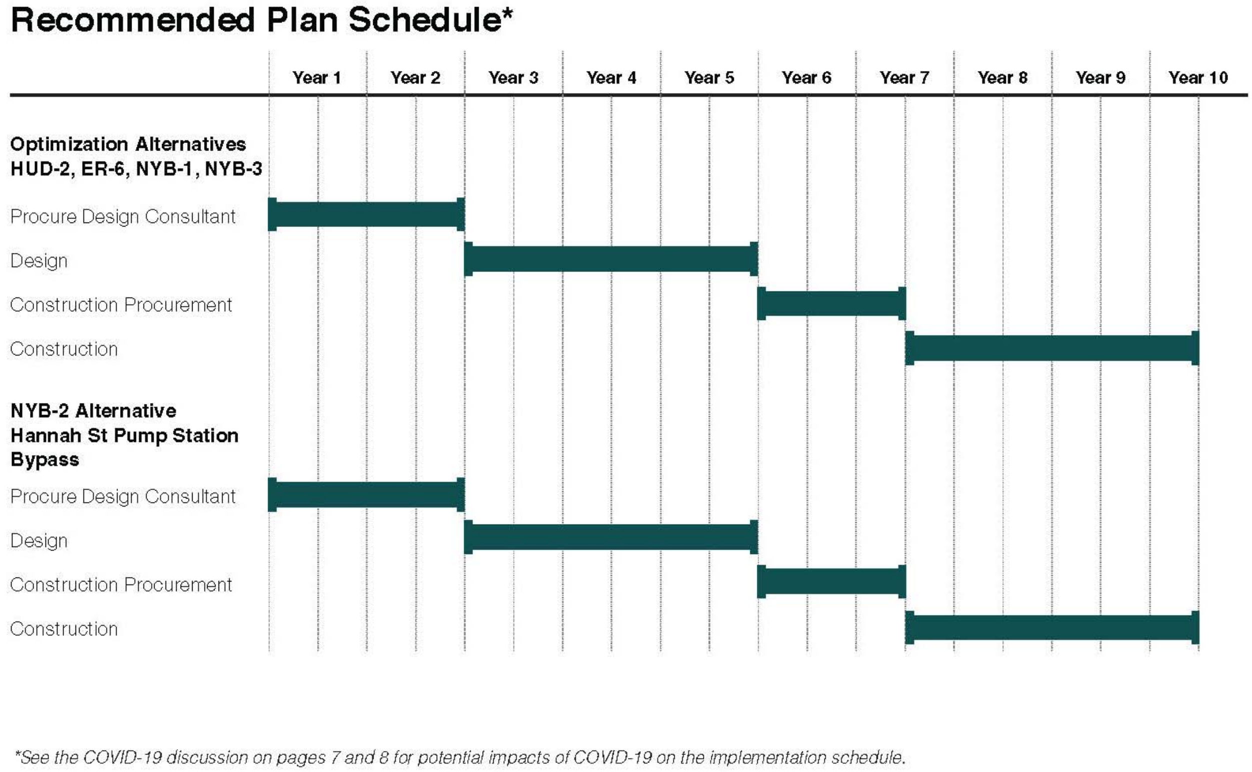


Figure 9-2. Implementation Schedule

9.3 Operational Plan/Operations & Maintenance (O&M)

DEP is committed to effectively incorporating Citywide/Open Waters LTCP components into the grey and green improvement projects currently built and planned under DEP's CSO Program. Program specific O&M plans will be developed for the proposed Citywide/Open waters LTCP Recommended Plan elements.

9.4 Projected Water Quality Improvements

As described in detail throughout Section 8 and summarized in Figure 9-3, the Recommended Plan will have a net reduction in CSO volume and activations, further improving water quality within the waterbodies of the Citywide/Open Waters LTCP.

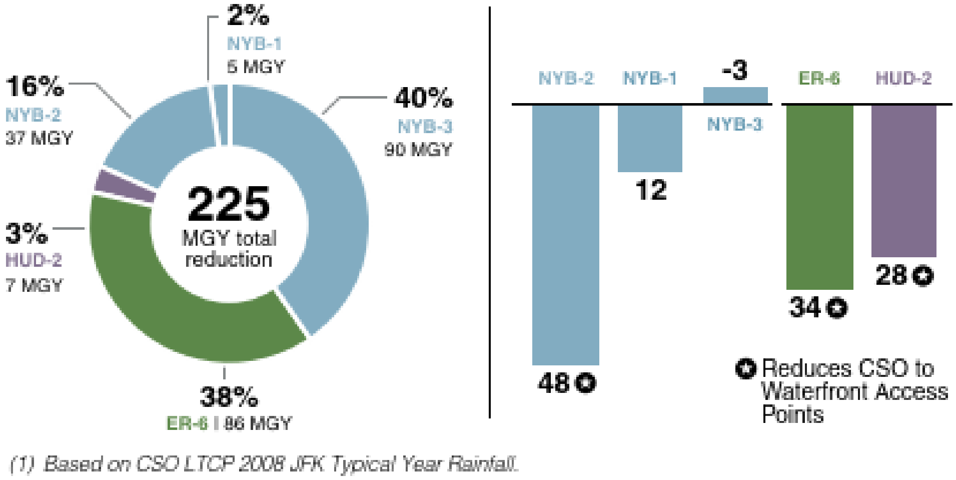


Figure 9-3. Benefits of the Recommended Plan

9.5 Post-Construction Monitoring Plan and Program Reassessment

Ongoing DEP monitoring programs such as the HSM and SM Programs will provide water quality data. DEP will conduct PCM for a period of time after the construction of the elements of the Recommended Plan is completed to assess effectiveness in terms of water quality improvements and CSO reductions.

9.6 Consistency with Federal CSO Control Policy

The Citywide/Open Waters LTCP was developed to comply with the requirements of the EPA CSO Control Policy and associated guidance documents, and the CWA.

The selection of the Recommended Plan was based on multiple considerations including public input, environmental benefits, cost effectiveness, community and societal impacts, and issues related to implementation and operation and maintenance. Table 9-1 presents the projected WQ Criteria attainment for the Citywide/Open Waters Recommended Plan.

Table 9-1. Summary of Water Quality Criteria Compliance with Recommended Plan

Waterbody	WQS Classification	Attainment with Criteria[1]				
		Fecal Coliform Monthly GM≤200 CFU/100mL		*Enterococci* 30-day GM≤35 cfu/100mL[3]	*Enterococci* 30-day STV≤130 cfu/100mL[3]	DO Annual Average Attainment[4]
		Annual	Recreational Season[2]	Recreational Season[2]	Recreational Season[2]	Annual
Harlem River	Class I	Yes	Yes	N/A	N/A	Yes
Hudson River (North of Harlem River)	Class SB	Yes	Yes	N/A	N/A	Yes
Hudson River (South of Harlem River)	Class I	Yes	Yes	N/A	N/A	Yes
Long Island Sound (East of Throgs Neck Bridge)	Class SB Coastal Primary Recreational	Yes	Yes	Yes	Yes	Yes
East River (between Whitestone Bridge and Throgs Neck Bridge)	Class SB	Yes	Yes	N/A	N/A	Yes
East River (West of Whitestone Bridge)	Class I	Yes	Yes	N/A	N/A	Yes
New York Bay	Class SB Coastal Primary Recreational	Yes	Yes	Yes	No	No[5]
Arthur Kill (South of Outerbridge Crossing Bridge)	Class I	No[6]	Yes	N/A	N/A	No[6]
Arthur Kill (North of Outerbridge Crossing Bridge)	Class SD	No[6]	No[6]	N/A	N/A	Yes
Kill Van Kull	Class SD	No[6]	Yes	N/A	N/A	Yes

Table 9-1. Summary of Water Quality Criteria Compliance with Recommended Plan

Waterbody	WQS Classification	Attainment with Criteria(1)				
		Fecal Coliform Monthly GM≤200 CFU/100mL		*Enterococci* 30-day GM≤35 cfu/100mL(3)	*Enterococci* 30-day STV≤130 cfu/100mL(3)	DO Annual Average Attainment(4)
		Annual	Recreational Season(2)	Recreational Season(2)	Recreational Season(2)	Annual

Notes:

(1) "**Yes**" means ≥95% attainment with the criteria. "**No**" means <95% attainment with the criteria. Attainment based on 10-year model simulation.

(2) Recreational season is May 1st through October 31st.

(3) *Enterococci* criteria apply only to coastal primary recreational waters; N/A = Not applicable.

(4) DO criteria:

   a. Class SB acute ≥3 mg/L; chronic ≥ range of 3 to 4.8 mg/L (see Section 6 for more details on Class SB chronic criteria)

   b. Class I ≥4 mg/L

   c. Class SD ≥3 mg/L

(5) Only the area around Station K5A in Raritan Bay off the southwest end of Staten Island is out of compliance with the Class SB DO criteria. No NYC CSOs are in the vicinity of this location, and 100% CSO control of NYC CSOs would not achieve attainment with the criteria.

(6) Additional loads outside of NYC prevent full attainment of WQS. 100% CSO control of NYC CSOs would not achieve attainment with the criteria.

9.6.a Introduction to Affordability and Financial Capability

DEP operates an approximately $4B annual budget to support our mission, which is almost entirely funded by our ratepayers. This section provides an overview of DEP historical and future spending, a background on our rate increases, and the socioeconomic challenges of our communities. As DEP plans future investments, it must balance many objectives and take affordability into consideration for our customers. This section includes application of existing EPA financial capability guidance and provides supplemental metrics to highlight affordability considerations in NYC including income inequality, high cost of living, and high prevalence of households living in poverty. Future investments must take these considerations into account as DEP prioritizes cost-effective projects to achieve clean water and public health objectives. This Section includes discussion of future capital spending plans, which may change in light of COVID-19. Section 9.8 discusses financial uncertainties associated with COVID-19.

9.6.b Background on Historical DEP Spending

As the largest combined water and wastewater utility in the nation, DEP provides over 1 billion gallons of drinking water daily to more than eight million NYC residents, visitors, and commuters, as well as to one million upstate customers. DEP maintains over 2,000 square miles of watershed comprised of 19 reservoirs, 3 controlled lakes, several aqueducts, and 6,600 miles of water mains and distribution pipes. DEP also collects and treats wastewater. Averaged across the year, the system treats approximately 1.3 billion gallons of wastewater per day collected through 7,500 miles of sewers, 96 pumping stations (PS) and 14 in-city WRRFs. During wet-weather conditions, the system can treat up to 3.5 billion gallons per day of combined storm and sanitary flow. In addition to its WRRFs, DEP also has four CSO storage facilities. In 2010, DEP launched a 20-year, $1.6B GI program with additional investments through private partnerships. A summary of historical spending is presented in Table 9-2. Additional details on the identified projects and programs are provided in the following sections.

Table 9-2. FY2009-2019 Historical DEP Spending Categories

<table>
<tr><th>Spending Category</th><th>Major Project or Program</th></tr>
<tr><td rowspan="4">Wastewater Mandated Programs</td><td>CSO Abatement and Stormwater Management Programs</td></tr>
<tr><td>MS4 Permit Compliance</td></tr>
<tr><td>Biological Nitrogen Removal</td></tr>
<tr><td>WRRF Upgrades</td></tr>
<tr><td rowspan="3">Drinking Water Mandated Programs</td><td>Croton Watershed - Croton Water Treatment Plant</td></tr>
<tr><td>Catskill/Delaware Watershed - Filtration Avoidance Determination</td></tr>
<tr><td>Catskill/Delaware Watershed - UV Disinfection Facility</td></tr>
<tr><td>State of Good Repair Projects</td><td>Multiple investments related to maintenance and repair of assets and infrastructure</td></tr>
</table>

9.6.b.1 Historical Capital and Operations and Maintenance Spending

Figure 9-4 identifies DEP's capital spending from FY2000 through FY2019. During this time, 51.4 percent of DEP's capital spending was for wastewater and water mandates. Figure 9-5 identifies associated historical wastewater and water operating expenses from FY2000 through FY2019, which have generally increased over time, reflecting the additional operational costs associated with NYC's investments. Many projects have been important investments that safeguard our water supply and improve the water quality of our receiving waters in the Harbor and its estuaries. These mandates and associated programs are described below.

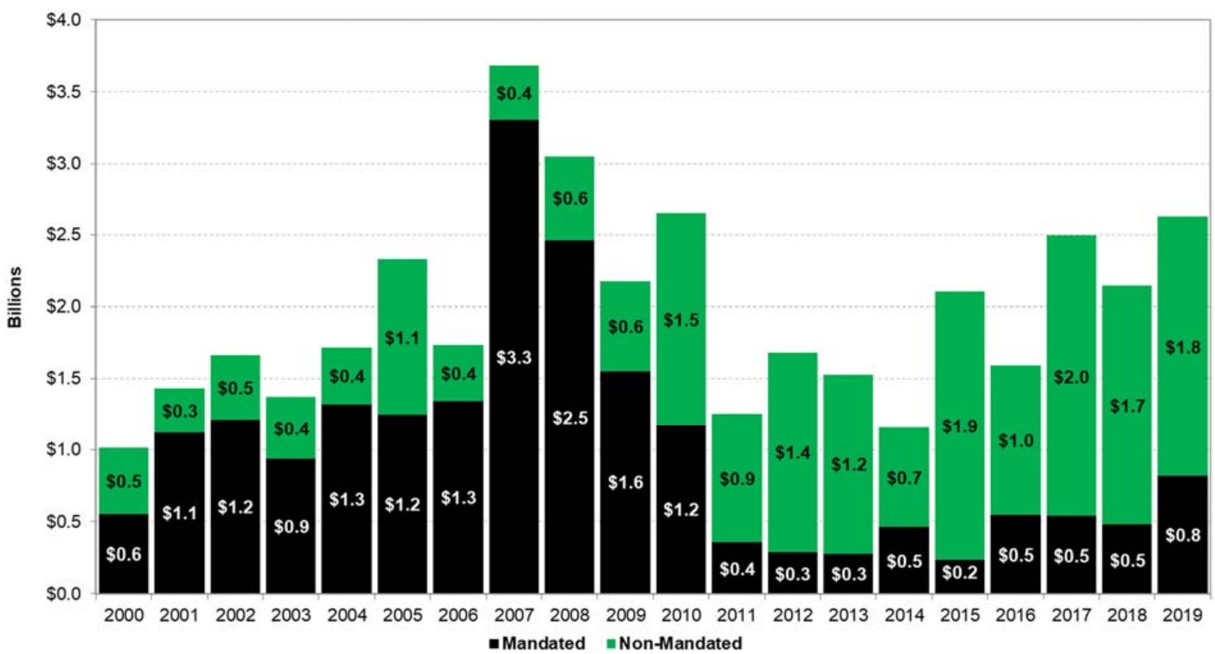


Figure 9-4. Historical Capital Commitments

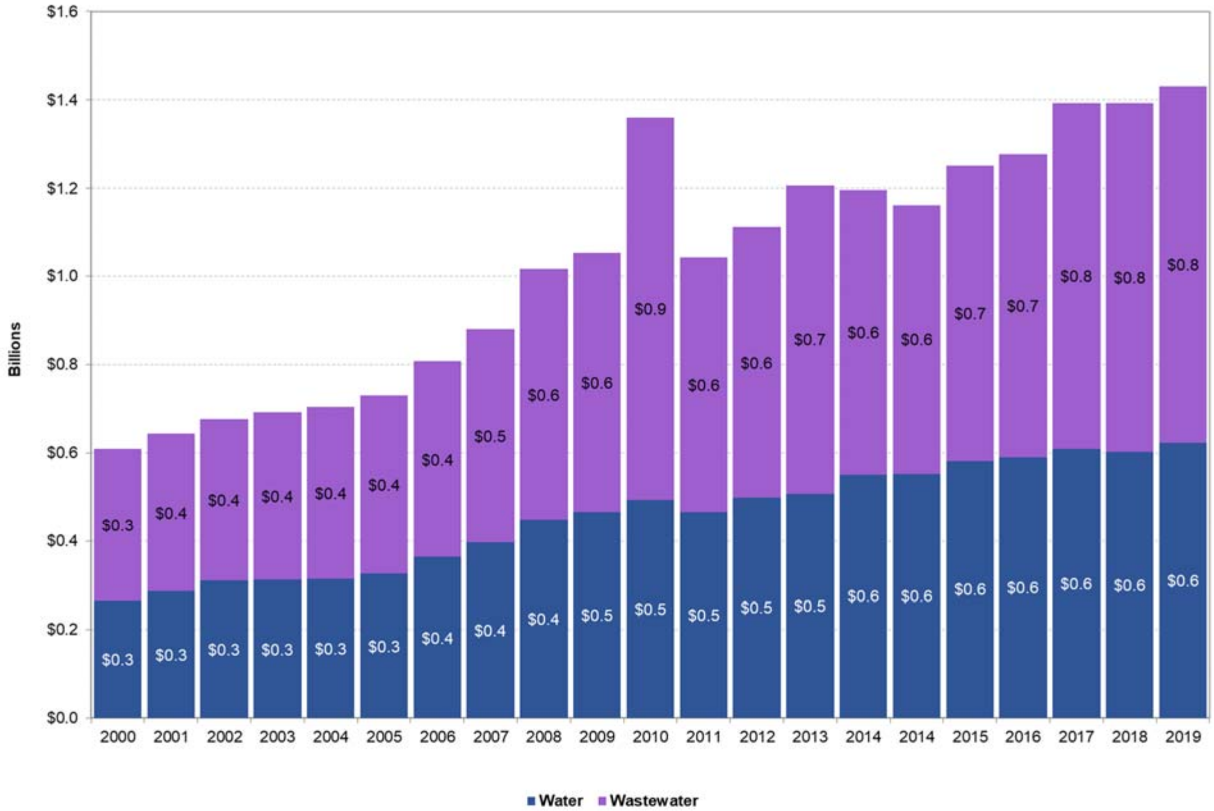


Figure 9-5. Historical Operating Expenses

9.6.b.2 Wastewater Mandated Programs

DEP is under multiple mandates to comply with federal and state laws and permits. The following wastewater programs and projects represent a few of the more significant projects that have been initiated, but do not represent an exhaustive list of all currently mandated projects:

- ***CSO Abatement and Stormwater Management Programs***

  DEP has initiated a number of projects to reduce CSOs, including construction of CSO abatement facilities, optimization of the wastewater system to reduce the volume of CSO discharge, controls to prevent discharge of floatables and debris that enters the combined wastewater system, dredging of CSO sediments that contribute to low DO and poor aesthetic conditions, and other water quality based enhancements to attain WQS. DEP also has invested in a robust Green Infrastructure Program for CSO control.

  These green and grey initiatives impact both the capital investments that DEP must make, and the agency's O&M expenses. Historical and existing commitments are estimated to be $4.3B ($2.7B in Waterbody Watershed Facility Plans and $1.6B for the GI program). Roughly $734M of GI costs has been incurred to-date. The costs associated with the CSO LTCP are discussed later in this section.

- ***Citywide MS4 Permit Compliance***

  DEC issued a citywide MS4 Permit to NYC for all City agencies, effective August 1, 2015, that covers NYC's municipal separate stormwater system.

  DEP coordinated efforts with other NYC agencies to develop a Stormwater Management Program (SWMP) plan for NYC to facilitate compliance with the permit. This plan includes the necessary legal authority to implement and enforce the SWMP, ensures adequate resources to comply with the MS4 Permit, and contains enforcement and tracking measures. Some of the stormwater pollution control measures identified through this plan may result in increased costs to DEP, and those costs will be more clearly defined over the course of ongoing implementation.

  The City completed its analysis of the resources needed to meet the MS4 Permit obligations during this permit term. The City estimates approximately $9.9M in capital spending and $87M in expense spending for the permit term (2015-2020).

- ***Biological Nitrogen Removal***

  In 2006, NYC entered into a Consent Judgment with DEC, which required DEP to upgrade five WRRFs to reduce nitrogen discharges. Pursuant to a modification and amendment to the Consent Judgment in 2011, DEP agreed to upgrade three additional WRRFs and to install additional nitrogen controls at one of the WRRFs included in the original Consent Judgment. To date, DEP has completed nitrogen upgrades at six WRRFs and expects to complete work on the remaining two WRRFs by the end of 2022. As in the case of CSOs and stormwater, these initiatives include capital investments made by DEP (over $1.2B to-date and an additional $22M in the 10-year capital plan), as well as O&M expenses (chemicals alone in FY2020 cost $11M).

- ***Wastewater Resource Recovery Facility Upgrades***

  The Newtown Creek WRRF was upgraded to provide secondary treatment pursuant to the terms of a Consent Judgment with DEC. The total cost of the upgrade was $5B. In 2011, DEP certified that the Newtown Creek WRRF met the effluent discharge requirements of the CWA, bringing all 14 WRRFs into compliance with the secondary treatment requirements.

- ***Total Residual Chlorine Order***

  In 2015, NYC entered into an Order on Consent, which required DEP to make improvements to their disinfection process to reduce effluent total residual chlorine discharges and if deemed necessary to construct dechlorination facilities. Pursuant to the Order on Consent in 2018, DEP and DEC made some refinements to their total residual chlorine program that include design and construction milestones for upgrades to the disinfection facilities at five WRRFs and to develop facility plans for nine WRRFs. To date, DEP has completed disinfection upgrades at three WRRFs and expects to complete work on the remaining two WRRFs by the end of 2022 with a total cost of about $100M associated with these five disinfection projects and have submitted the TRC facility plans.

9.6.b.3 Drinking Water Mandated Programs

Under the Federal Safe Drinking Water Act and the New York State Sanitary Code, water suppliers are required to either filter their surface water supplies or obtain and comply with a determination from EPA that allows them to avoid filtration. In addition, EPA promulgated a rule known as Long Term 2 (LT2) that required that unfiltered water supplies receive a second level of pathogen treatment (e.g., ultraviolet [UV] treatment in addition to chlorination) by April 2012. LT2 also requires water suppliers to cover or treat water from storage water reservoirs. The following DEP projects have been undertaken in response to these mandates:

- ***Croton Watershed - Croton Water Treatment Plant***

  Historically, NYC's water has not been filtered because of its good quality and long retention times in reservoirs. However, more stringent federal standards relating to surface water treatment resulted in a Federal Court Consent Decree, which mandated the construction of a full-scale water treatment facility to filter water from NYC's Croton watershed. Construction of the Croton Water Treatment Plant began in late 2004, and the facility began operating in 2015. To date, DEP has spent roughly $3.4B in capital costs on the Croton Water Treatment Plant. Since commencement of operations, DEP is also now incurring annual expenses for labor, power, chemicals, and other costs associated with plant O&M. For FY2020, O&M costs were about $21M.

- ***Catskill/Delaware Watershed - Filtration Avoidance Determination***

  The source water protection program is a key aspect of the City's Filtration Avoidance Determination (FAD) for the Catskill and Delaware water supplies. Since the early 1990s, federal and state regulators have issued the FAD as provided for under the Surface Water Treatment Rule based on the high quality of the City's source waters, treatment methods, extensive monitoring, and the effectiveness of the source water protection program. The FAD relieves the City of the multi-billion dollar capital and operational costs of filtering water from the Catskill and Delaware systems. Over this time, DEP has committed more than $2.7B in capital and expense funding to cover filtration avoidance costs, including $1B to meet its commitments under the 10-year 2017 FAD. Approximately $235M is committed in the current Capital Improvement Plan (CIP).

- ***UV Disinfection Facility***

  In January 2007, DEP entered into an Administrative Consent Order (UV Order) with EPA pursuant to EPA's authority under LT2 requiring DEP to construct a UV facility by 2012. Since late 2012, water from the Catskill and Delaware watersheds has been treated at DEP's new UV disinfection facility in order to achieve pathogen inactivation. To date, capital costs committed to the project amount to $1.6B. DEP is also incurring related annual expenses for property taxes, labor, power, and other costs related to plant O&M. FY2020 O&M costs were $34M, including taxes.

9.6.b.4 Other: State of Good Repair Projects

In addition to mandated water and wastewater programs, DEP has invested in critical projects related to maintenance and repair of its assets and infrastructure. State of good repair consisted of about 25 percent of historical capital spending from FY10 to FY19 totaling about $4.5B.

9.6.c On-going and Future System Investment

Over the next decade, the percentage of mandated project costs already identified in the Capital Improvement Plan is significant. In addition, DEP will devote significant funding to critical state of good repair projects and other projects needed to maintain NYC's infrastructure to deliver clean water and collect and treat wastewater. As of January 2020, DEP's capital budget for FY2020 through FY2029 is $20.5B. This plan did not take into account the potential impacts of COVID-19 on the capital budget. The financial uncertainties associated with COVID-19 are discussed in Section 9.8. This budget included projected capital commitments averaging $2.0B per year through FY2029, which is similar to the average spending from FY2009 through FY2019 shown in Figure 9-4 above. In addition, DEP anticipates that there will be additional mandated investments within and outside the January 2020 Plan (FY20-29) related to compliance with the City-wide MS4 SPDES Permit, potential modifications to DEP's in-city WRRF SPDES permits, Superfund remediation, and the Total Residual Chlorine (TRC) Order. DEP is also subject to a Consent Decree and Judgment with the United States and New York State, effective May 15, 2019, and will be required to construct a cover for Hillview Reservoir. DEP may in the future be subject to other additional wastewater and drinking water mandates. The inclusion of this additional spending is supported by the EPA financial capability assessment guidance in order to create a more accurate and complete picture of NYC's financial capability. A summary of anticipated future mandated and non-mandated projects and programs is presented in Table 9-3, and additional details on the identified projects and programs are provided in the following sections.

Table 9-3. Ongoing and Potential Future DEP Spending Categories[1]

Spending Category	Major Project or Program	
Wastewater	Future Wastewater Mandates	CSO LTCP Program
		MS4 Permit Compliance
		Total Residual Chlorine (TRC) Consent Order
		Superfund Remediation
		State of Good Repair Mandates
	Potential Wastewater Regulations	Expanded Nitrogen Discharge Limits
		WRRF SPDES Permit Compliance
	Other System Needs	Climate Resiliency
		Energy Projects at WRRFs
		Southeast Queens Flood Mitigation Plan
Water	Future Water Mandates	Filtration Avoidance Determination
		Hillview Reservoir Cover
		Kensico Eastview Connection 2
	Other System Needs	Water for the Future
		Activation of City Tunnel No. 3 Brooklyn/Queens
		Ashokan Century Program

Note:

(1) Some of these projects/programs have costs that extend beyond DEP's January 2020 Plan (FY20-29) or are potential costs pending regulatory updates.

9.6.c.1 Future Wastewater Mandates

- ***CSO Long Term Control Plans***

  Improving New York Harbor's water quality has been a City and DEP priority for decades. According to the City's most recent Harbor Survey Report, the Harbor is cleaner now than at any time in the last 100 years. Continued improvements to the City's 14 wastewater resource recovery facilities (WRRFs), and ongoing investments have resulted in an over 80 percent reduction in combined sewer overflows since the mid-1980s. With nine LTCPs approved, one pending, and this current LTCP being submitted in May 2020, current and planned infrastructure investments will result in even further water quality improvements.

  As summarized later in this section in Table 9-14, the total project costs for the Recommended Plans identified in the waterbody LTCPs and Superfund-mandated CSO control is approximately $6.3B. This does not include costs for land acquisition, which could be significant (hundreds of millions of dollars).

- ***Continued MS4 Permit Compliance***

  The City is currently negotiating its permit for the next five years, and the fiscal analysis associated with MS4 Permit for 2020-2025 is currently underway. DEP has estimated the need for $11M over the next 10 years for continued compliance.

- ***Total Residual Chlorine (TRC) Consent Order***

  In 2015, NYC entered into an Order on Consent, which required DEP to make improvements to their disinfection process to reduce effluent total residual chlorine discharges and if deemed necessary to construct dechlorination facilities. Pursuant to the Order on Consent in 2018, DEP and DEC made some refinements to their total residual chlorine program that include design and construction milestones for upgrades to the disinfection facilities at 5 WRRFs and to develop facility plans for nine WRRFs. Aside from the $100M encumbered to-date for disinfection upgrades, approximately $220M was included in the January 2020 Plan (FY20-29) for future effluent total residual chlorine discharge mitigation projects.

- ***Superfund Remediation***

  Two major Superfund sites in NYC are at different stages of the Superfund process. The EPA issued a Record of Decisions (ROD) for the Gowanus Canal Superfund Site in 2013, which requires an "in canal" remedy of dredging and capping sediments in the Canal by a group of responsible parties, including the City, and the construction of two CSO storage tanks by the City. The capping and dredging remedy is scheduled to begin in September 2020. The City has completed design for one of the CSO storage tanks, and construction of the tank is expected to begin in 2021. Remedial design work for the second tank work will take place in the next one to three years. Potential Superfund costs for the two Gowanus Canal retention tanks total approximately $1.3B.

  Completion of the Newtown Creek RI/FS is anticipated approximately in 2021 with issuance of a Record of Decision (ROD) projected by the end of 2023. However, in 2019 EPA released a

Proposed Remedial Action Plan for CSOs that recommends that DEP take no further action with respect to CSOs than what is required by the LTCP.

- ***State of Good Repair Mandates***

  In June 2016 DEP entered into an Omnibus Order with the DEC that requires the DEP to construct a number of projects at both the North River and Bowery Bay WRRFs along with some pumping station upgrades. To date, $326M have been encumbered for these projects and an additional $128 M is forecast in the next few years to comply with requirements of this Order.

9.6.c.2 Potential Wastewater Regulations on the Horizon

DEP is tracking potential future regulatory issues that may result in the need for additional projects. Insufficient detail is generally available at this time to define the cost risks associated with these potential regulations. Examples of these issues are described below.

- ***WRRF SPDES Permit Compliance***

  DEP has applied for renewal of the current SPDES permits issued for DEP's 14 WRRFs. While DEP continues to seek to comply with the current SPDES permit requirements, DEP anticipates that there will be additional requirements in any new SPDES permits. Existing and anticipated requirements include:

  – New effluent ammonia limits at many WRRFs – the current permits provide for a process to establish ammonia limits. Compliance with new effluent ammonia limits may require upgrades at the North River, 26th Ward, and Jamaica WRRFs.

  – Monthly sampling for free cyanide results will be submitted in report form to DEC. After review, DEC may seek to add a limit or action level for free cyanide.

  – Mercury Minimization Program (MMP) – DEP must develop, implement, and maintain an MMP. The MMP is required because the 50 nanograms/liter (ng/L) permit limit exceeds the statewide water quality based effluent limit (WQBEL) of 0.70 ng/L for Total Mercury. The goal of the MMP will be to reduce mercury effluent levels in pursuit of the WQBEL.

  – Inclusion of *Enterococci* WQ Criteria in the next SPDES permits may result in additional compliance costs for the WRRFs that discharge to the applicable waterbodies once a water quality based effluent limit is identified.

  – Ongoing monitoring of potential CSOs from regulators specified in the SPDES permit with related reporting.

- ***Nitrogen Discharge Limits***

  SPDES Permits for the East River WRRFs contain aggregate limits on the amount of total nitrogen that can be discharged from those WRRFs. If further reductions at the WRRFs are required, the potential cost impacts for NYC's four Upper East River WRRFs over the next 20 years could be significant for the East River WRRFs.

DEP continues to be subject to the First Amended Nitrogen Consent Judgment (FANCJ) whereby it is required to assess water quality improvement and ecological benefits associated with the completion of significant upgrades to all four of the Jamaica Bay WRRFs for nitrogen removal. Post-construction monitoring will be conducted for a three-year period following completion of nitrogen upgrade construction at the Coney Island WRRF in 2022.

9.6.c.3 Sustainability/Resiliency and Other Wastewater Initiatives

- ***Climate Resiliency***

  DEP continues to study climate change and to prepare for its impacts by modeling the potential effect of various climate scenarios on the City's water supply system through the Climate Change Integrated Modeling Project: protecting WRRFs from storm surge as part of the Wastewater Resiliency Program; and reducing urban flooding through cost-effective investments in grey and green infrastructure. Eight projects from DEP's Wastewater Resiliency Plan have been initiated as part of a $161M portfolio of strategies to flood-proof critical equipment at WRRFs. These projects will harden the infrastructure at the Bowery Bay, Hunts Point, Red Hook, Newtown Creek, Owl's Head, Port Richmond, Tallman Island, and Wards Island WRRFs. These investments enhance resiliency against future storms and include a buffer for sea level rise.

  Based on the initial success of the "Cloudburst Resiliency Planning Study" in Southeast Queens, which leveraged a partnership with the City of Copenhagen, DEP has also been working with partners at the Department of Transportation, Department of Design and Construction, and New York City Housing Authority (NYCHA) to initiate design of two pilot projects. These "cloudburst" projects will help manage extreme rainfall events in St. Albans and the South Jamaica Houses, both in Southeast Queens, by capturing rainfall of 2.3 inches per hour - a storm with a 10 percent chance of occurring in any given year by the middle of the century. In addition to providing a proof-of-concept for using green infrastructure to mitigate the effects of cloudbursts, the pilot projects will help reduce nuisance flooding in Southeast Queens and enhance the local landscape. As DEP continues to better understand future flood risk from extreme rain events, the Department will coordinate with its partner agencies to expand upon these initial cloudburst projects.

- ***Energy Projects at WRRFs***

  In April 2019, NYC launched OneNYC 2050, which calls for reducing NYC's greenhouse gas (GHG) emissions by 80 percent below 2005 levels and achieving carbon neutrality by 2050. NYC also passed the Climate Mobilization Act, which accelerated DEP's GHG reduction interim milestones to a 40 percent reduction by 2025 and a 50 percent reduction by 2030. In order to meet this and other OneNYC goals, DEP has implemented: Demand-Side Solutions, including on-site energy conservation and efficiency, on-site equipment and operational improvements, and citywide water demand management; Supply-Side Solutions, including on-site clean energy generation using anaerobic digester gas ("biogas"); Traditional Renewable Energy Solutions, including non-biogas renewable energies such as hydropower, solar photovoltaic systems, geothermal, and more; and Energy and Carbon Offsets, including offsite beneficial use of biosolids and biogas, as well as carbon sequestration by GI, restored wetlands, and DEP acquired forested lands. To-date, this four-pronged approach has resulted in a 17 percent reduction in GHG emissions from DEP facilities from 2006 to 2019. DEP has approximately $435M allocated in its January 2020 Plan to make additional system repairs to flares, digester domes, and digester gas piping, in order to maximize capture of fugitive emissions for beneficial use or flaring. DEP is currently diverting 170 tons per day of NYC's food scraps from landfills and digesting them to extract the available energy content to increase biogas production at the Newtown Creek WRRF. Biogas in excess of Newtown Creek WRRF's needs will be purified to natural gas standards, known as "renewable natural gas," and will be injected into the City's natural gas grid starting Spring 2020 through a partnership with National Grid. A 12-megawatt cogeneration system estimated at $179M is currently in construction for the North River WRRF and is estimated to be in operation in 2023. DEP recently kicked off a three-year Energy and Carbon Neutrality Plan to determine the most economically, operationally, and technologically feasible and innovative pathways forward to achieve the OneNYC goals, with a focus on how DEP can partner with sister agencies and its neighbors to help create "sustainability hubs" throughout the City that maximize resource recovery and sustainable practices going forward.

- ***Southeast Queens Flood Mitigation Plan***

  Southeast Queens (comprised of Queens Community Districts 12 and 13) experienced rapid residential and commercial growth from the 1920s through 1960s, and many of the natural watercourses that previously drained the area were paved over by developers, exacerbating flooding. The low-lying topography of the area and the enlargement of Idlewild/Kennedy Airport significantly complicated the installation of large storm sewers, making planned work extremely costly. Major projects had been deferred until Mayor de Blasio authorized $1.5B over ten years for the Southeast Queens Flood Mitigation Plan. This amount has since been increased to almost $2B.

9.6.c.4 Regulatory Mandated Drinking Water Projects on the Horizon

- ***Catskill/Delaware Watershed - Filtration Avoidance Determination***

  DEP has committed $1B to meet its commitments under the ten--year 2017 FAD. Approximately $235M is committed in the current CIP.

- ***Hillview Reservoir Cover***

  LT2 requires that uncovered finished water storage facilities, such as the Hillview Reservoir, be covered, or alternatively, any discharge from an uncovered water facility must be treated (40 C.F.R §141.714). The Hillview Reservoir is the final finished water source for the City's drinking water from the Catskill/Delaware System before it enters the City's distribution system. The City has determined it is not feasible to treat Hillview Reservoir's discharge and therefore, the City must cover the reservoir to comply with LT2. The City and DEP entered into a Consent Decree and Judgment with the United States and New York State, effective May 15, 2019, which sets forth a schedule of compliance for the City to cover the Hillview Reservoir as required by LT2. The most recent (2009) cost estimate for construction of the Hillview Cover was $1.6B. This cost estimate will be updated in the future as the Cover's design and planning progress in accordance with the Consent Decree's schedule of compliance. The Hillview Reservoir Improvements project, which is a precursor project to the Cover, is also governed by the Consent Decree and is estimated to cost an additional $580M.

- ***Kensico Eastview Connection 2***

  To ensure the resilience and provide critical redundancy of infrastructure in NYC's water supply system, DEP will be constructing a new tunnel between the Kensico Reservoir and the Ultraviolet Disinfection Facility. This project is also a precursor project to the Hillview Cover. The cost for this project is estimated at approximately $1.6B.

9.6.c.5 Other Drinking Water Initiatives

- ***Water for the Future***

  In 2011, DEP unveiled Water for the Future, a comprehensive program to permanently repair the leaks in the Delaware Aqueduct, which supplies half of New York's drinking water. Based on a 10-year investigation and more than $200M of preparatory construction work, DEP is designing a bypass for a section of the Delaware Aqueduct in Roseton and internal repairs for a tunnel section in Wawarsing. Since DEP must shut down the Aqueduct when it is ready to connect the bypass tunnel, DEP is also working on projects that will supplement NYC's drinking water supply during the shutdown, such as implementing demand reduction initiatives, including offering water conservation and water reuse grants to commercial, industrial, and multi-family residential property owners, offering a toilet replacement program, replacing municipal plumbing fixtures and providing demand management assistance to wholesale customers located north of NYC. The cost for this program is estimated to be approximately $1.7B.

- ***Activation of City Tunnel No. 3 Brooklyn/Queens***

  The Brooklyn/Queens leg of City Tunnel No. 3 is a 5.5-mile section in Brooklyn that connects to a 5-mile section in Queens. Two distribution shafts in Queens will be constructed, and are scheduled for completion in the 2020s. The Brooklyn/Queens leg will deliver water to Staten Island, Brooklyn, and Queens, and provide critical redundancy in the system. This project is estimated at $712M.

- ***Ashokan Century Program***

  The Ashokan Reservoir in the Catskill System is over 100 years old. DEP is embarking on a large program to upgrade dams, dikes, chambers, and other facilities around Ashokan Reservoir. This multi-year program is estimated to cost $980M.

9.6.d History of DEP Water and Sewer Rates

9.6.d.1 Background on DEP Rates

The NYC Water Board is responsible for setting water and wastewater rates sufficient to cover the costs of operating NYC's water supply and wastewater systems (the System). Water supply costs include those associated with water treatment, transmission, distribution, and maintaining a state of good repair. Wastewater service costs include those associated with wastewater conveyance and treatment, stormwater service, and maintaining a state of good repair. The NYC Municipal Water Finance Authority (MWFA) issues revenue bonds to finance NYC's water and wastewater capital programs, and the costs associated with debt service consume a significant portion of the system revenues. As shown in Figure 9-6, increases in capital expenditures have resulted in increased debt. Expenditures and total debt are projected to increase over the next several years.

For FY2020, most customers will be charged a proposed uniform water rate of $0.53 per 100 gallons of water. Wastewater charges are levied at 159 percent of water charges ($0.85 per 100 gallons). A small percentage of properties are billed a flat rate. Under the Multi-family Conservation Program (MCP), some properties are billed at a flat per--unit rate if they comply with certain conservation measures. Some non--profit institutions are also granted exemptions from water and wastewater charges on the condition that their consumption is metered and falls within specified consumption threshold levels. Select properties are also granted exemptions from wastewater charges (i.e., pay only for water services), if they can prove that they do not burden the wastewater system (e.g., they recycle wastewater for subsequent use on-site).

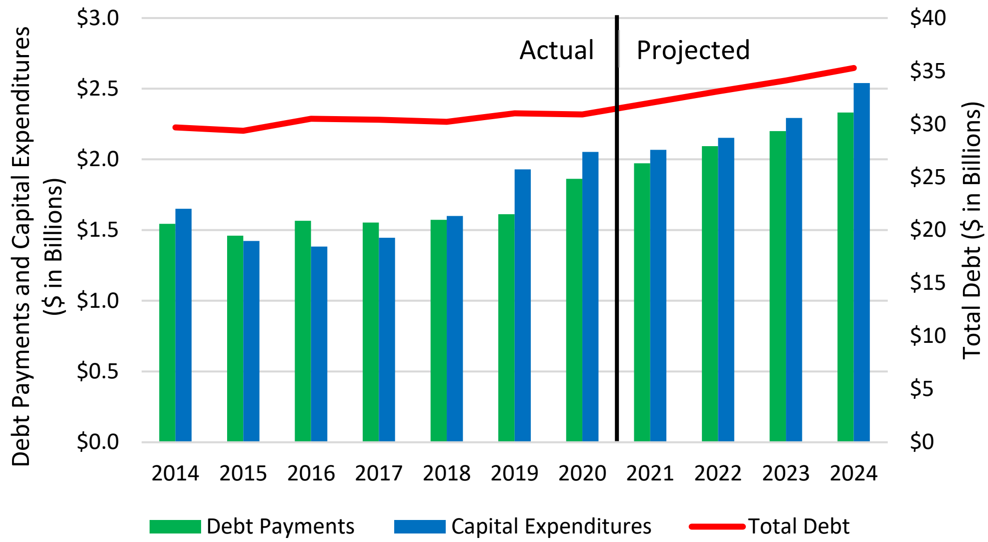


Figure 9-6. Past Costs and Total Debt

9.6.d.2 Historical Rate Increases to meet Cost of Service

Figure 9-7 shows how water and sewer rates have increased over time and how that compares with system demand and population. Despite a rise in population, water consumption rates have been falling since the 1990s due to metering and increases in water efficiency measures. The increase in population has not kept pace with the increase in the cost of service associated with DEP's capital commitments over the same time period. Furthermore, the total cost of service is spread across a smaller demand number due to the decline in consumption rates. As a result, DEP has had to increase its rates to meet the cost of service. DEP operations are funded almost entirely through rates paid by our customers. From FY2000 to FY2020, water and sewer rates have risen 207 percent, or approximately 108 percent when adjusted for inflation. This is despite the fact that DEP has diligently worked towards controlling operating costs and improving the efficiency of the agency's operations.

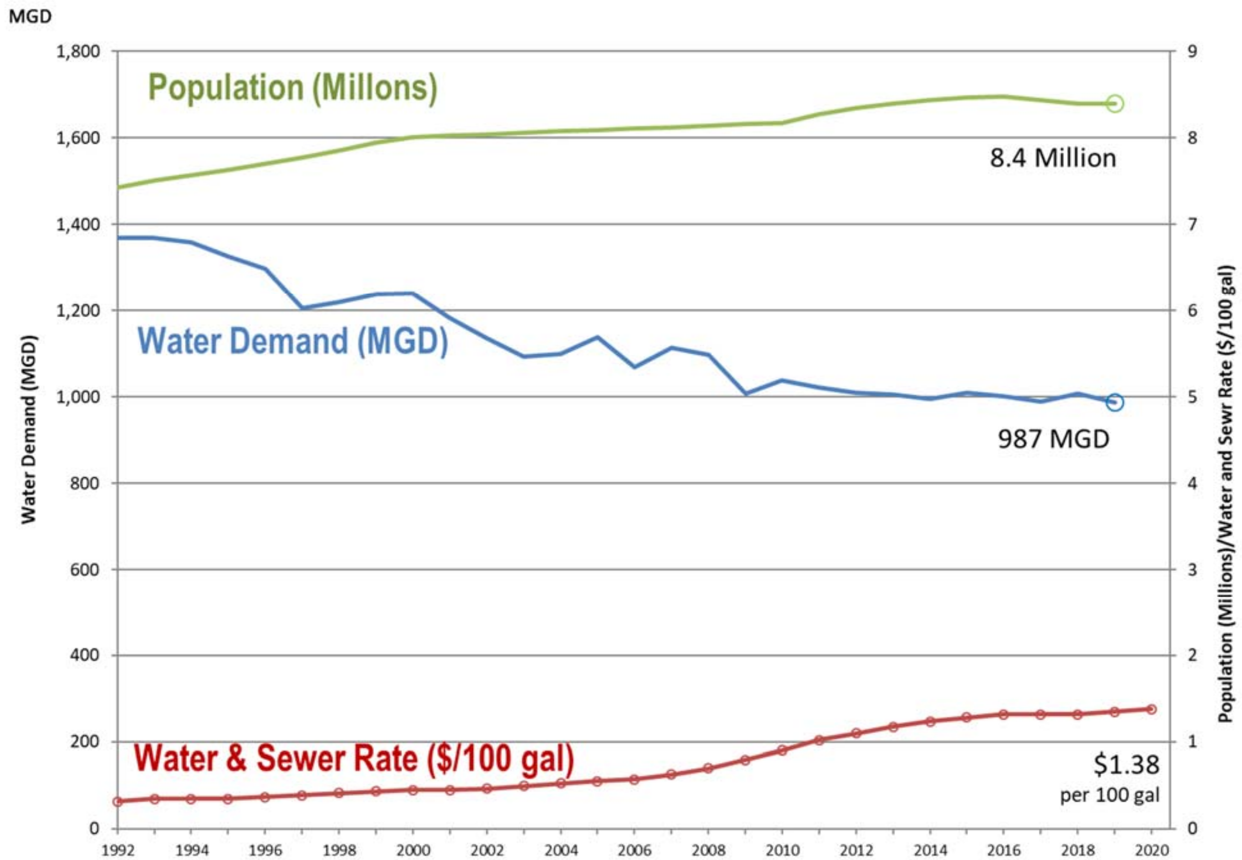


Figure 9-7. Population, Consumption Demand, and Water and Sewer Rates Over Time

9.6.d.3 Customer Assistance Programs

Several programs provide support and assistance for customers in financial distress, and DEP continues to expand these programs. The Safety Net Referral Program uses an existing network of NYC agency and not-for-profit programs to help customers with financial counseling, low-cost loans, and legal services. The Water Debt Assistance Program provides temporary water debt relief for qualified property owners who are at risk of mortgage foreclosure. While water and wastewater charges are a lien on the property served, and NYC has the authority to sell these liens to a third party (lienholder) in a process called a lien sale, DEP offers payment plans for customers who may have difficulty paying their entire bill at one time. DEP and the Water Board also created a Home Water Assistance Program to assist low-income homeowners. For this program, DEP partnered with the NYC Human Resources Administration, which administers the Federal Home Energy Assistance Program (HEAP), and the New York City Department of Finance, which provides tax exemptions to senior and disabled homeowners, to identify low-income homeowners who receive HEAP assistance and/or tax exemptions and, thus, are automatically eligible to receive a credit on their DEP bill.

There is also a Multi-family Water Assistance Program for Affordable Housing, where a $250 credit per housing unit would be issued for qualified projects identified by the NYC Housing Preservation and Development. The credit reflects 25 percent of the MCP rate, on which many of the eligible properties are billed. Up to 40,000 housing units will receive this credit, providing $10M of assistance.

9.6.e Affordability and Financial Capability Analyses

EPA has recognized the importance of taking a community's financial status into consideration, and, in 1997, issued "Combined Sewer Overflows: Guidance for Financial Capability Assessment and Schedule Development" (1997 EPA Guidance). The 1997 EPA Guidance contains a two-phased assessment approach. Phase I examines affordability in terms of impacts to residential households. This analysis applies the residential indicator (RI), which examines the average cost of household water pollution costs (wastewater and stormwater) relative to a benchmark of two percent of service area-wide Median Household Income (MHI).

The results of this preliminary screening analysis are assessed by placing the community in one of three categories:

- Low economic impact: average wastewater annual costs are less than one percent of MHI;
- Mid-range economic impact: average wastewater annual costs are between one percent and two percent of MHI; and
- High economic impact: average wastewater annual costs are greater than two percent of MHI.

The second phase develops the Permittee Financial Capability Indicators, which examine several metrics related to the financial health and capabilities of the impacted community. The indicators are compared to national benchmarks and are used to generate a score that is the average of six economic indicators: bond rating; net debt; MHI; local unemployment; property tax burden; and property tax collection rate within a service area. Lower Financial Capability Indicators (FCI) scores imply weaker economic conditions, and thus the increased likelihood that additional controls would cause substantial economic impact.

The results of the RI and the FCI are then combined in a Financial Capability Matrix to give an overall assessment of the permittee's financial capability. The result of this combined assessment can be used to establish an appropriate CSO control implementation schedule.

Significantly, EPA recognizes that the procedures set out in its guidance are not the only appropriate analyses to evaluate a community's ability to comply with CWA requirements. EPA's 2001 "Guidance: Coordinating CSO Long-term Planning with Water Quality Standards Reviews" emphasizes this by stating:

> *The 1997 Guidance "identifies the analyses States may use to support this determination [substantial and widespread impact] for water pollution control projects, including CSO LTCPs. States may also use alternative analyses and criteria to support this determination, provided they explain the basis for these alternative analyses and/or criteria* (U.S. EPA, 2001, p. 31)".

Likewise, EPA has recognized that its RI and FCI metrics are not the sole socioeconomic basis for considering an appropriate CSO compliance schedule. The 1997 EPA Guidance recognizes that there may be other important factors in determining an appropriate compliance schedule for a community, and contains the following statement that authorizes communities to submit information beyond that which is contained in the guidance:

> *It must be emphasized that the financial indicators found in this guidance might not present the most complete picture of a permittee's financial capability to fund the CSO controls. … Since flexibility is an important aspect of the CSO Policy, permittees are encouraged to*

> *submit any additional documentation that would create a more accurate and complete picture of their financial capability* (U.S. EPA, 1997, p. 7).

In November of 2014, EPA released its “Financial Capability Assessment Framework” (2014 EPA Framework) clarifying the flexibility within its CSO guidance. Although EPA did not modify the metrics established in the 1997 EPA Guidance, the 2014 EPA Framework reiterates that permittees are encouraged to supplement the core metrics with additional information that would “create a more accurate and complete picture of their financial capability” that may “affect the conclusion” of the analysis.

For example, EPA will consider:

- All CWA costs presented in the analysis described in the 1997 EPA Guidance; and
- Safe Drinking Water Act obligations as additional information about a permittee’s financial capability.

EPA will also consider alternative disaggregation of household income (e.g., quintiles), as well as economic indicators including, but not limited to:

- Actual poverty rates;
- Rate of home ownership;
- Absolute unemployment rates; and
- Projected, current, and historical wastewater (sewer and stormwater costs) as a percentage of household income, quintile, geography, or other breakdown.

The purpose of presenting these data is to demonstrate that the local conditions facing the municipality deviate from the national average to the extent that the metrics established in the 1997 EPA Guidance are inadequate for accurately assessing the municipality’s financial capacity for constructing, operating, and implementing its LTCP Program in compliance with its regulatory mandates.

In September 2020, EPA announced its' proposed 2020 Financial Capability Assessment Guidance (2020 EPA Proposed Guidance) that is anticipated to effectively replace the 1997 EPA Guidance. The 2020 EPA Proposed Guidance includes new metrics to inform a community’s implementation schedule, including indicators that more accurately reflect how much low-income communities can afford to pay for water infrastructure upgrades. The 2020 EPA Proposed Guidance reflects a departure from heavily relying on a percent of median household income as an indicator of affordability in the Clean Water Act context, a change that has been championed by water and wastewater utilities and their advocates to better account for impacts to economically disadvantaged communities.

This section begins to explore affordability and financial capability concerns as outlined in the 1997 and 2001 EPA guidance documents and the 2014 EPA Framework, and analyzes the financial capability of NYC to make additional investments in CSO control measures, in light of the relevant financial indicators, the overall socioeconomic conditions in NYC, and the need to continue spending on other water and sewer projects. The analysis is presented both in terms of the EPA’s Financial Capability Guidance Framework and by applying several additional factors that are relevant to NYC’s unique socioeconomic conditions. The methodology introduced in the 2020 EPA Proposed Guidance has not been applied since the guidance was still pending completion of a public comment period at the time of submittal of this LTCP, and it was not finalized or approved for use by EPA. However, some of the additional considerations (such as expanded consideration of costs, prevalence of poverty, and assessment of impacts at the lowest household income level) that are included in the 2020 EPA Proposed Guidance are explored in this section.

9.6.f Residential Indicator (RI)

As discussed above, the first economic test from the 1997 EPA Guidance is the RI, which compares the average annual household water pollution control cost (wastewater and stormwater related charges) to the MHI of the service area. Average household wastewater cost can be estimated by approximating the residential share of wastewater treatment and dividing it by total number of households. In NYC, the wastewater bill is a function of water consumption. Therefore, average household costs and the RI are estimated based on application of FY 2020 rates to consumption rates by household type, as shown in Table 9-4.

Table 9-4. Residential Water and Wastewater Costs Compared to Median Household Income (MHI)

	Average Annual Wastewater Cost ($/year)	Wastewater RI (Wastewater Cost/MHI[1]) (%)	Total Water and Wastewater Cost ($/Year)	Water and Wastewater RI (Water and Wastewater Cost/MHI) (%)
Single-family[2]	594	**0.89**	967	**1.45**
Multi-family[3]	441	**0.66**	718	**1.08**
Average Household Consumption[4]	556	**0.83**	905	**1.36**
MCP[5]	646	**0.95**	1,052	**1.54**

Notes:

(1) Latest MHI data is $63,799 based on 2018 ACS data, estimated MHI adjusted to 2020 is $66,620 using Bureau of Labor Statistics Consumer Price Index and U.S. Census Bureau data per the 1997 EPA Guidance.
(2) Based on 70,000 gallons/year consumption and FY2020 Rates.
(3) Based on 52,000 gallons/year consumption and FY2020 Rates.
(4) Based on average consumption across all metered residential units of 65,534 gallons/year and FY2020 Rates.
(5) Multi-family Conservation Plan (MCP) is a flat fee per unit for customers who will implement certain conservation measures.

As shown in Table 9-4, the RI for wastewater costs varies between 0.66 percent of MHI to 0.95 percent of MHI, depending on household type. Because DEP is a water and wastewater utility and ratepayers receive one bill for both charges, it is also appropriate to look at the total water and wastewater costs in considering the RI, which varies from 1.08 percent to 1.54 percent of MHI.

Based on this initial screen, current wastewater costs pose a low economic impact according to the 1997 EPA Guidance. Several factors, however, limit use of MHI as a financial indicator for a city like New York. NYC has a large population and more than three million households. Even if a relatively small percentage of households were facing unaffordable water and wastewater bills, there would still be a significant number of households experiencing this hardship. For example, more than 604,000 households in NYC (about 19 percent of NYC's total households) earn less than $20,000 per year and have estimated wastewater costs well above 2 percent of their household income. Therefore, there are several other socioeconomic indicators to consider in assessing residential affordability, as described later in this section.

9.6.g Financial Capability Indicators (FCI)

The second phase of the 1997 EPA Guidance develops the Permittee FCI, which examines several metrics related to the financial health and capabilities of the impacted community. The indicators are compared to national benchmarks and are used to generate a score that is the average of six economic indicators: bond rating, net debt, MHI, local unemployment, property tax burden, and property tax collection rate within a service area. Lower FCI scores imply weaker economic conditions and thus an increased likelihood that additional controls would cause substantial economic impact.

Table 9-5 summarizes the FCI scoring as presented in the 1997 EPA Guidance. NYC's FCI score based on this test is presented in Table 9-6 and is further described below.

Table 9-5. Financial Capability Indicator Scoring

Financial Capability Metric	Strong (Score = 3)	Mid-range (Score = 2)	Weak (Score = 1)
Debt Indicator			
Bond rating (G.O. bonds, revenue bonds)	AAA-A (S&P) Aaa-A (Moody's)	BBB (S&P) Baa (Moody's)	BB-D (S&P) Ba-C (Moody's)
Overall net debt as percentage of full market value	Below 2%	2–5%	Above 5%
Socioeconomic Indicator			
Unemployment rate	More than 1 percentage point below the national average	±1 percentage point of national average	More than 1 percentage point above the national average
MHI	More than 25% above adjusted national MHI	±25% of adjusted national MHI	More than 25% below adjusted national MHI
Financial Management Indicator			
Property tax revenues as percentage of Full Market Property Value (FMPV)	Below 2%	2–4%	Above 4%
Property tax revenue collection rate	Above 98%	94–98%	Below 94%

Table 9-6. NYC Financial Capability Indicator Score

Financial Capability Metric	Actual Value	Score
Debt Indicators		
Bond rating (G.O. bonds)	AA (S&P) AA (Fitch) Aa1 (Moody's)	Strong/3
Bond rating (Revenue bonds)	AA (S&P) AA (Fitch) Aa2 (Moody's)	
Overall net debt as percentage of FMPV	3.0%	Mid-range/2
G.O. Debt	$37.5B	
Market value	$1,250.7B	

Table 9-6. NYC Financial Capability Indicator Score

Financial Capability Metric	Actual Value	Score
Socioeconomic Indicators		
Unemployment rate (2019 annual average)	0.2% above the national average	Mid-range/2
NYC unemployment rate	4.0%	
United States unemployment rate	3.7%	
MHI as percentage of national average	+3.0%	Mid-range/2
Financial Management Indicators		
Property tax revenues as percentage of FMPV	2.4%	Mid-range/2
Property tax revenue collection rate	88.4%	Weak/1
Permittee Indicators Score		2.0

Notes:
Debt and Market Value Information as of November 20, 2019.
G.O. Debt and market value from 2019 CAFR.

9.6.g.1 Bond Rating

The first financial benchmark is NYC's bond rating for both general obligation (G.O.) and revenue bonds. A bond rating performs the isolated function of credit risk evaluation. While many factors go into the investment decision-making process, bond ratings can significantly affect the interest that the issuer is required to pay, and thus the cost of capital projects financed with bonds. According to EPA's criteria – based on the ratings NYC has received from all three rating agencies [Moody's, Standard & Poor's (S&P), and Fitch Ratings] – NYC's financing capability is considered "strong" for this category.

NYC's G.O. rating and Municipal Water Finance Authority's (MWFA) revenue bond ratings are high due to prudent fiscal management, the legal structure of the system, and the Water Board's historic ability to raise water and wastewater rates. However, mandates over the last decade have significantly increased the leverage of the system, and future bond ratings could be impacted by further increases to debt beyond what is currently forecasted.

9.6.g.2 Net Debt as a Percentage of Full Market Property Value (FMPV)

The second financial benchmark measures NYC's outstanding debt as a percentage of FMPV. At the end of FY2019, NYC had more than $37.5B in outstanding G.O. debt, and the FMPV within NYC was $1,250.7B. This results in a ratio of outstanding debt to FMPV of 3.0 percent and a "mid-range" rating for this indicator. If $24.9B of MWFA revenue bonds that support the system are included, net debt as a percentage of FMPV increases to 5.0 percent, which results in a "mid-range" rating for this indicator. Furthermore, if NYC's $52.5B of additional debt that is related to other services and infrastructure is also included, the ratio further increases to 9.2 percent.

9.6.g.3 Unemployment Rate

For the unemployment benchmark, the 2019 annual average unemployment rate for NYC was compared to that for the U.S. NYC's 2019 unemployment rate of 4.0 percent is 0.3 percentage points higher than the national average of 3.7 percent (U.S. Bureau of Labor Statistics). Based on the 1997 EPA Guidance, NYC's unemployment benchmark would be classified as "mid-range." It is important to note that over the past two decades, NYC's unemployment rate has generally been higher than the national average. Additionally, the unemployment rate measure identified in the 1997 financial guidance is a relative comparison based on a specific snapshot in time. It is difficult to predict whether the unemployment gap between the United States and NYC will widen, and it may be more relevant to look at longer term historical trends of the service area. Potential implications to NYC's unemployment rate as a result of COVID-19 are discussed in Section 9.8. For example, the average monthly unemployment rate from January 2020 through July 2020 has increased to 12.1 percent for NYC, which is 3.4 percentage points higher than the national average for this period of 8.7 percent (U.S. Bureau of Labor Statistics). Using this more recent data that reflects some of the hardships that have resulted from COVID-19, NYC's unemployment benchmark would be classified as "weak" per EPA's guidance.

9.6.g.4 Median Household Income (MHI)

The MHI benchmark compares the community's MHI to the national average. Using American Community Survey (ACS) 2018 single-year estimates, NYC's MHI is $63,799 and the nation's MHI is $61,937. Thus, NYC's MHI is approximately 103 percent of the national MHI, resulting in a "mid-range" rating for this indicator. However, as discussed above, MHI does not provide an adequate measure of affordability or financial capability. MHI is a poor indicator of economic distress and bears little relationship to poverty, or other measures of economic need. In addition, reliance on MHI alone can be a misleading indicator of the affordability impacts in large and diverse cities like NYC.

9.6.g.5 Tax Revenues as a Percentage of Full Market Property Value (FMPV)

This indicator, which EPA also refers to as the "property tax burden," attempts to measure "the funding capacity available to support debt based on the wealth of the community," as well as "the effectiveness of management in providing community services." According to the NYC Property Tax Annual Report issued for FY2019, NYC had billed $29.6B in real property taxes against a $1,250.7B FMPV, which amounts to 2.4 percent of FMPV. For this benchmark, NYC received a "mid-range" score. This figure does not include water and wastewater revenues. Including FY2019 system revenues ($3.8B) would increase the ratio to 2.7 percent of FMPV.

This indicator, whether including or excluding water and wastewater revenues, is misleading because NYC obtains about 45 percent of its tax revenues from property taxes, meaning that taxes other than property taxes (e.g., income taxes, sales taxes) accounted for 55 percent of the locally-borne NYC tax burden.

9.6.g.6 Property Tax Collection Rate

The property tax collection rate is a measure of "the efficiency of the tax collection system and the acceptability of tax levels to residents." The FY2019 NYC Property Tax Annual Report indicates NYC's total property tax levy was $29.6B, of which 88.4 percent was collected during FY2019, resulting in a "weak" rating for this indicator.

DEP notes, however, that the processes used to collect water and wastewater charges and the enforcement tools available differ from those used to collect and enforce real property taxes. In the case of DEP, property tax collection rate is an inappropriate measure of financial capability. The New York City Department of Finance (DOF), for example, can sell real property tax liens on all types of non--exempt properties to third parties, who can then take action against the delinquent property owners. DEP, in contrast, can sell liens on multi-family residential and commercial buildings whose owners have been delinquent on water bills for more than one year, but it cannot sell liens on single-family homes. Thus, the real property tax collection rate does not accurately reflect DEP's ability to collect the revenues used to support water supply and wastewater capital spending.

9.6.h Summary of the Phase 1 and Phase 2 Indicators

The results of the Phase 1 (Residential Indicator) and the Phase 2 (Permittee Financial Capability Indicators) evaluations are combined in the Financial Capability Matrix (see Table 9-7), to evaluate the level of financial burden the current CWA program costs may impose on NYC. Based on a RI score of 0.83 percent (using average household consumption), and a FCI score of 2.0, NYC's Financial Capability Matrix score is "Low Burden." The score also falls in the "Low Burden" category when considering the higher RI scores of 0.89 percent and 0.95 percent for single-family and multi-family conservation plan households, respectively.

Table 9-7. Financial Capability Matrix

Permittee Financial Capability Indicators Score (Socioeconomic, Debt, and Financial Indicators)	Residential Indicator (Cost Per Household as a % of MHI)		
	Low Impact (Below 1.0%)	**Mid-Range (Between 1.0 and 2.0%)**	**High Impact (Above 2.0%)**
Weak (Below 1.5)	Medium Burden	High Burden	High Burden
Mid-Range (Between 1.5 and 2.5)	**Low Burden**	Medium Burden	High Burden
Strong (Above 2.5)	Low Burden	Low Burden	Medium Burden

9.6.i Alternative Indicators: Household Burden and Poverty Prevalence

The American Water Works Association, National Association of Clean Water Agencies, and the Water Environment Federation commissioned the development of a new methodology and guideline for assessing household affordability and community financial capability. The resulting report, "Developing a New Framework for Household Affordability and Financial Capability Assessment in the Water Sector" was released in April 2019 (2019 Suggested Framework) and is intended to serve as a new framework that EPA can adopt that addresses some recognized shortcomings of the 1997 EPA Guidance. These shortcomings, which were identified in a National Academy of Public Administration report and literature review, include:

- MHI is a poor indicator of economic distress bearing little relationship to poverty or other measures of economic need within a community.
- The RI is not focused on the poor or the most economically vulnerable users, and MHI does not capture impacts across diverse populations.
- The RI is an incomplete water cost measure that only includes a limited set of wastewater costs and does not include the cost of drinking water or stormwater.
- The estimated costs included in the RI do not reflect the actual water bills that are paid by a residential customer.
- The RI focuses on average per household cost of water-related services rather than basic water use. Basic water use refers to water used for drinking, cooking, health, and sanitation.
- The RI provides a "snapshot" that does not account for the historical and future trends of a community's economic, demographic, and/or social conditions.

- The RI does not account for other non-discretionary household costs, such as the cost of housing or other utilities, which can exacerbate affordability challenges for low-income households (Raucher, et al. 2019).

The methodology recommended in the 2019 Suggested Framework for assessing housing affordability considers a combination of measures of household affordability as an alternative to the current RI. This includes the Household Burden Indicator (HBI) and the Poverty Prevalence Indicator (PPI). The HBI is defined as basic water service costs as a percent of the 20th percentile household income (the Lowest Quintile of Income (LQI) for the service area). This metric measures the economic burden that relatively low-income households in the community face in paying their water, wastewater, and stormwater bills. The PPI is defined as the percentage of community households at or below 200 percent of the Federal Poverty Level (FPL). PPI is a measure of the degree to which poverty is prevalent in the community. The 2019 Suggested Framework combines these measures in a matrix that indicates both a household-level burden and how water sector costs pose an affordability challenge at the community level.

The 2019 Suggested Framework was used to determine an alternative measurement of financial capability. With an annual basic water sector cost of $555.43 based on the average household consumption and an upper boundary of the LQI of $20,975, the HBI is 2.6 percent. Within the service area, the population below 200 percent of the FPL is 2.9 million, and the population for whom the poverty status is determined is 8.3 million. The resulting PPI is 35.4 percent.

According to the 2019 Suggested Framework, an HBI of less than 7 percent and a PPI greater than or equal to 35 percent is considered a "Moderate-High Burden" (see Table 9-8). In comparison, application of the 1997 EPA Guidance yielded a "Low Burden" result as detailed above. This indicates that the burden of water service is likely higher than that obtained using the 1997 EPA Guidance. Key elements of the 2019 Suggested Framework have been taken into consideration in development of the 2020 EPA Proposed Guidance introduced earlier.

Table 9-8. Benchmarks for Recommended Household Affordability Metrics

HBI (Water Costs as a Percent of Income at LQI)	PPI (Percent of Households Below 200% of FPL)		
	>=35%	20% to 35%	<20%
>=10%	Very High Burden	High Burden	Moderate-High Burden
7% to 10%	High Burden	Moderate-High Burden	Moderate-Low Burden
<7%	**Moderate-High Burden**	Moderate-Low Burden	Low Burden

9.6.j Socioeconomic Considerations in the New York City Context

As encouraged by the 1997 EPA Guidance and 2014 EPA Framework, several additional factors of particular relevance to NYC's unique socioeconomic character are provided in this section to aid in the evaluation of affordability implications of the costs associated with anticipated CWA compliance on households in NYC.

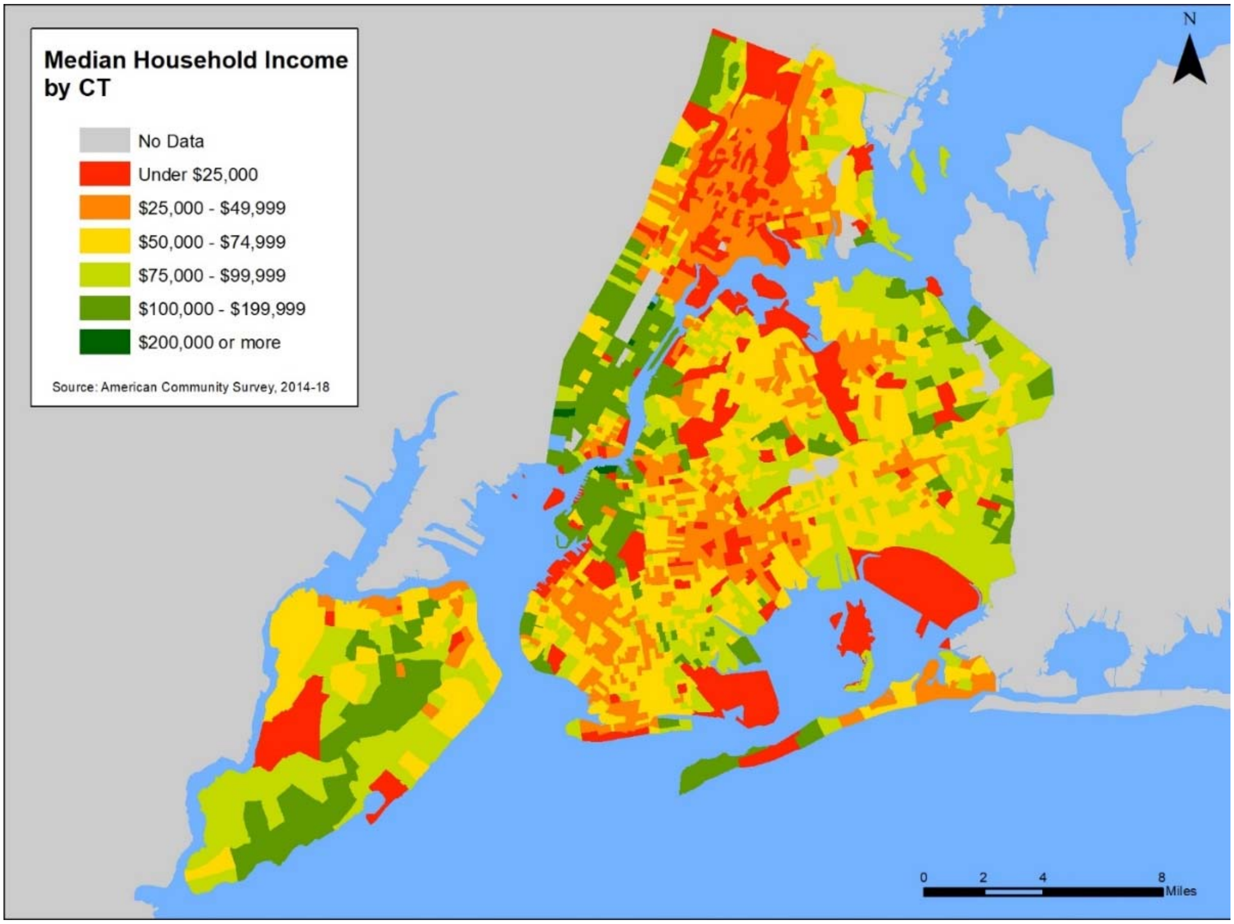
9.6.j.1 Income Levels

In 2018, the latest year for which Census data is available, the MHI in NYC was $63,799. As shown in Table 9-9, across the NYC boroughs, MHI ranged from $38,467 in the Bronx to $85,066 in Manhattan. Figure 9-8 shows that income levels also vary considerably across NYC neighborhoods, and there are several areas in NYC with high concentrations of low-income households.

Table 9-9. Median Household Income

Location	2018 (MHI)
United States	$61,937
New York City	$63,799
Bronx	$38,467
Brooklyn	$61,220
Manhattan	$85,066
Queens	$69,320
Staten Island	$82,166

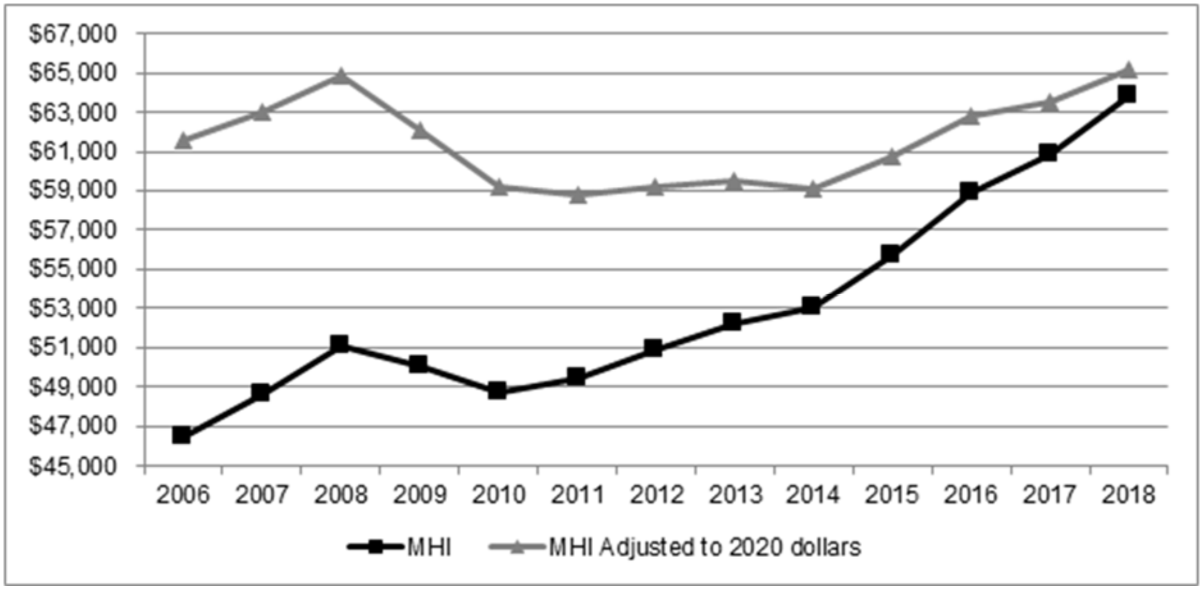
Source: U.S. Census Bureau 2018 ACS 1-Year Estimates.



Source: U.S. Census Bureau 2014-2018 ACS 5-Year Estimates.

Figure 9-8. Median Household Income by Census Tract

As shown in Figure 9-9, after 2008, MHI in NYC actually decreased for two years. In addition, the cost of living continued to increase during this period. When adjusting for inflation (2020 dollars) using the Bureau of Labor Statistics Consumer Price Index, MHI in NYC in 2018 was only 0.5 percent greater than MHI in 2008 (see Figure 9-9).



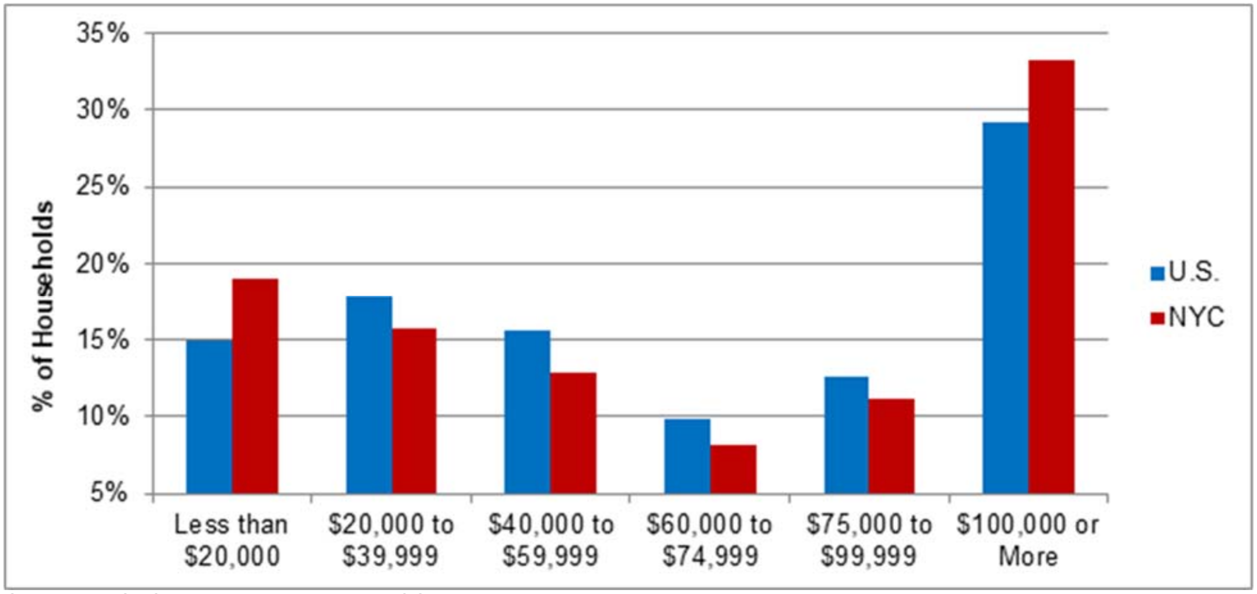
Source: U.S. Census Bureau 2006 through 2018 ACS 1-Year Estimates, Bureau of Labor Statistics Consumer Price Index.

Figure 9-9. NYC Median Household Income Over Time

9.6.j.2 Income Distribution

NYC currently ranks as one of the most unequal cities in the United States in terms of income distribution. NYC's income distribution highlights the need to focus on metrics other than citywide MHI to capture the disproportionate impact on households in the lowest income brackets. It is clear that MHI does not represent "the typical household" in NYC. As shown in Figure 9-10, incomes in NYC are not clustered around the median. Rather, a greater percentage of NYC households exist at either end of the economic spectrum. Also, the percentage of the population with middle-class incomes between $20,000 and $99,999 is 8.1 percent less in NYC than in the United States.

As shown in Table 9-10, the income level that defines the upper end of the Lowest Quintile (i.e., the lowest 20 percent of income earners) in NYC is $20,975, compared to $25,434 nationally. This further demonstrates that NYC has a particularly vulnerable, and sizable, lower income population. Table 9-11 compares the average household consumption wastewater RI and wastewater plus water RI for the Lowest Quintile, Second Quintile (i.e., the lowest 40 percent of income earners), and MHI for NYC using FY2020 rates. As shown in this table, households in the Lowest Quintile have a wastewater RI of approximately 2.54 percent, which easily exceeds EPA's "High Financial Impact" threshold of 2.0 percent, and the combined water and wastewater RI is approximately 4.13 percent.



Source: U.S. Census Bureau 2018 ACS 1-Year Estimates.

Figure 9-10. Income Distribution for NYC and U.S.

Table 9-10. Household Income Quintile Upper Limits in New York City and the United States (2018 Dollars)

Quintile	New York City	United States
20th Percentile	$20,975	$25,434
40th Percentile	$45,579	$48,836
60th Percentile	$83,191	$77,890
80th Percentile	$144,313	$125,322
95th Percentile	$250,000+	$238,883

Source: U.S. Census Bureau 2018 ACS 1-Year Estimates.

Table 9-11. Average Household Consumption Residential Indicator (RI) for Different Income Levels using FY2020Rates

Income Level	Wastewater RI(1)	Water and Wastewater RI(1)
Lowest 20 Percent Upper Limit	2.54%	4.13%
Lowest 40 Percent Upper Limit	1.12%	1.82%
MHI	0.83%	1.36%

Note:
(1) RI calculated by dividing average household consumption annual wastewater bill ($555 using FY2020 rates) and wastewater and water bill ($905 using FY2020 rates) by income level values adjusted to 2020 dollars.

Household affordability at the 20th income percentile was recently evaluated in an article by Manuel Teodoro for the 25 largest U.S. cities, including New York City (Teodoro, 2018). Teodoro's method aims to provide a more accurate and meaningful method for measuring the affordability of water and sewer service for low-income households by accounting for the following: essential household water needs; income disparities; and core non-water/sewer costs using an affordability ratio (AR). The AR is determined at the 20th income percentile rather than at median income to reflect the fact that determining affordability for low-income households is the primary concern. This metric (AR_{20}) is used in conjunction with basic household water and sewer cost, expressed in terms of hours of labor at minimum wage (HM).

For an individual or aggregated group of customers, AR_{20} is the ratio of number of persons in a household multiplied by the per capita cost of essential water and sewer services to LQI income less essential household expenses. Similarly, HM is calculated based on the number of persons in a household multiplied by the per capita cost of essential water and sewer services divided by minimum wage in the labor market. For both metrics, the essential expenditures are estimated at the 20th income percentile.

Using this approach, Teodoro determined that in NYC, the AR_{20} was 14.1 percent and the HM was 6.8 hours. The average AR_{20} for the 25 cities for which this metric was calculated was 11.4 percent and the range was 4.8 percent in Phoenix to 26.9 percent in San Francisco. NYC's HM of 6.8 hours fell below the average of 9.0 HM for the 25 largest cities and in the middle of the range of 4.0 to 13.6 HM. A higher AR_{20} value for NYC is indicative of the high cost of living and limited disposable income at low-income households, while the lower HM value reflects a higher minimum wage paired with lower water and sewer bills compared to some of the other cities included in the study. Cost of living in NYC and other socioeconomic factors are further discussed below.

9.6.j.3 Poverty Rates

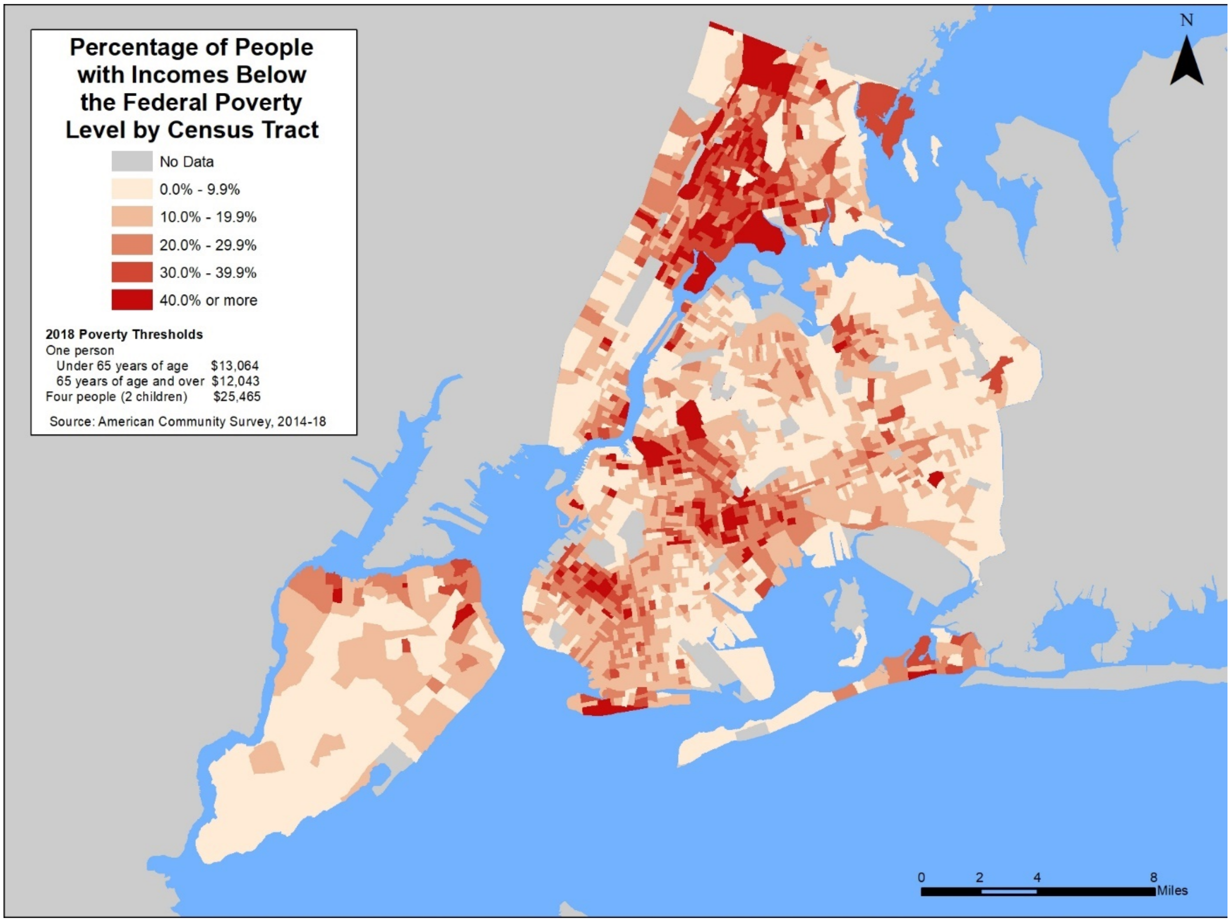
Based on the latest available Census data, 16.8 percent of NYC residents (over 1.4 million people, which, for reference, is roughly equivalent to the entire population of Philadelphia) are living below the federal poverty level. This is significantly higher than the national poverty rate of 13.1 percent, despite similar MHI levels for NYC and the U.S. as a whole. As shown in Table 9-12, across the NYC boroughs, poverty rates vary from 11.4 percent in Staten Island to 27.4 percent in the Bronx.

Table 9-12. NYC Poverty Rates

Location	Percentage of Residents Living Below the Federal Poverty Level
United States	13.1%
New York City	16.8%
Bronx	27.4%
Brooklyn	19.0%
Manhattan	15.5%
Queens	11.5%
Staten Island	11.4%

Source: U.S. Census Bureau 2018 ACS 1-Year Estimates.

Figure 9-11 shows that poverty rates also vary across neighborhoods, and Figure 9-12 shows several areas in NYC having a relatively high concentration of people living below the federal poverty level. Each green dot in Figure 9-12 represents 250 people living in poverty. While poverty levels are highly concentrated in some areas, smaller pockets of poverty exist throughout NYC. Because an RI that relies on MHI alone fails to capture these other indicators of economic distress, two cities with similar MHI could have disparate levels of poverty.



Source: U.S. Census Bureau 2014-2018 ACS 5-Year Estimates.

Figure 9-11. Poverty Rates in NYC

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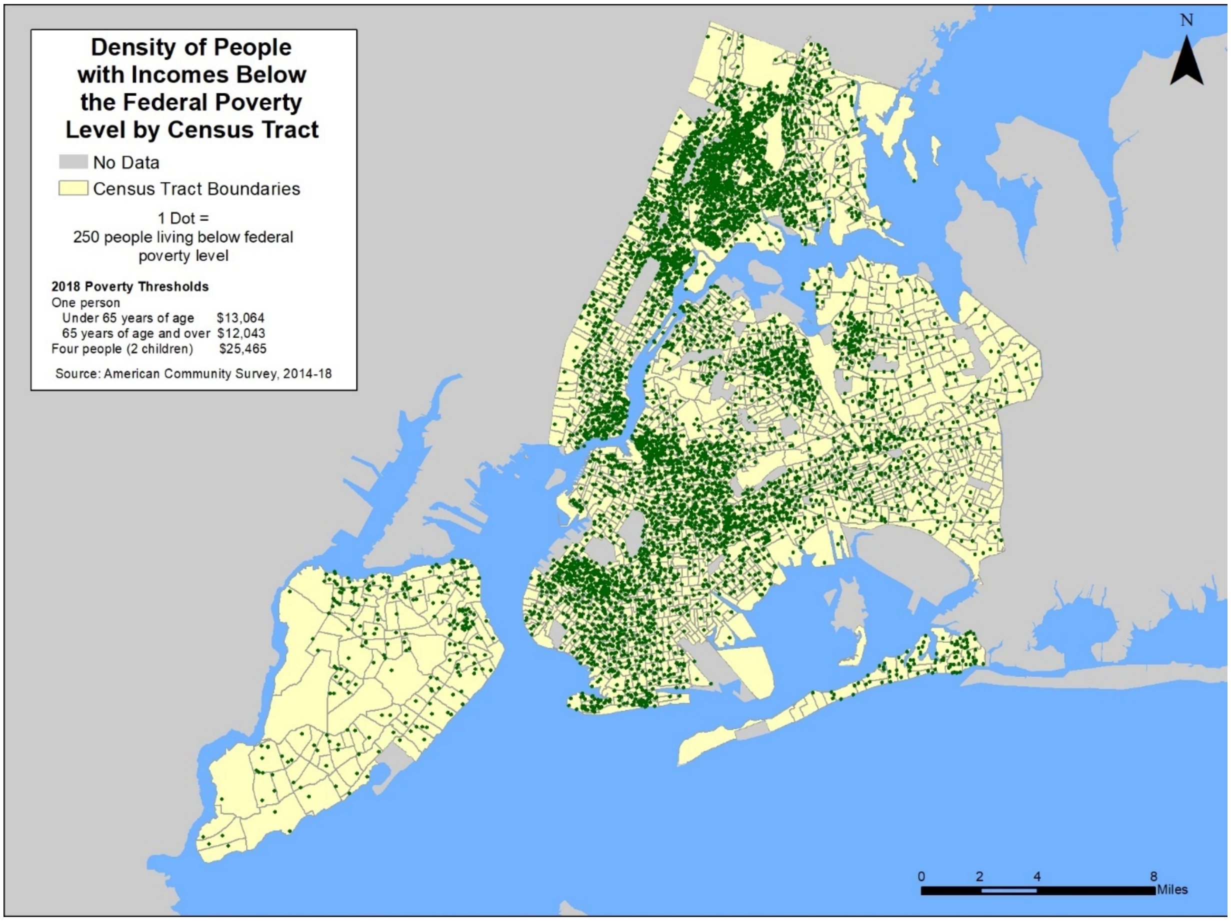


Source: U.S. Census Bureau 2014-2018 ACS 5-Year Estimates.

Figure 9-12. Poverty Clusters in NYC

9.6.j.4 Cost of Living and Housing Burden

NYC residents face relatively high costs for non-discretionary items (e.g., housing, utilities) compared to individuals living almost anywhere else in the nation, as shown in Figure 9-13. While water costs are slightly less than the average for other major United States cities, the housing burden is significantly higher.

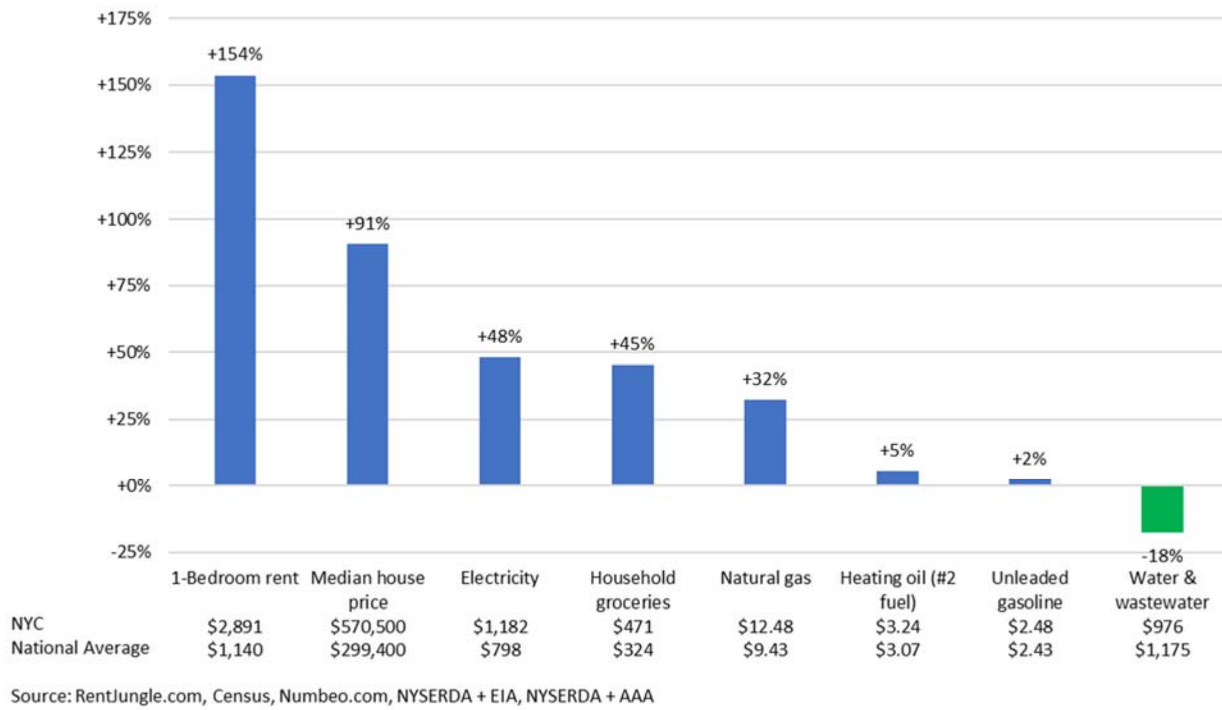


Figure 9-13. Comparison of Costs between NYC and other U.S. Cities

As noted above, the cost of living in NYC is high compared to the average cost of living of other cities in the U.S. In 2018, NYC's Cost of Living Index (COLI)[1] was 191, or 91 percent higher than the average cost of living of other cities. When adjusted for cost of living, the purchasing power of a MHI of $66,620 is reduced to $34,790 in NYC (2020 dollars) when compared to the national average. Adjusting MHI for cost of living increases the RI ranking from a low impact to a mid-range impact, resulting in an elevated Financial Capability Score from a Low Burden to a Medium Burden. For average household consumption, the RI increases from 0.83 to 1.60 for wastewater and 1.36 to 2.60 for water and wastewater. Table 9-13 displays the RI adjusted for 2020 dollars and cost of living in NYC.

[1] The Cost of Living Index (COLI) measures how urban areas compare in cost of maintaining a standard of living appropriate for moderately affluent professional and managerial households. The COLI measures relative price levels for consumer goods and services in over 300 participating areas. The COLI used here for NYC represents a weighted average of the COLI for the Bronx, Brooklyn, Manhattan, Queens, and Staten Island. The data was provided by the Center for Regional Economic Competitiveness (CREC) December 3, 2019.

Table 9-13. Residential Water and Wastewater Costs Compared to Median Household Income (MHI) and MHI with Cost of Living Adjustment (COLA)

	Wastewater RI (Wastewater Bill/MHI(1)) (%)		Water and Wastewater RI (Water and Wastewater Bill/MHI(1)) (%)	
	MHI	MHI COLA	MHI	MHI COLA
Single-family(2)	0.89	1.71	1.45	2.78
Multi-family(3)	0.66	1.27	1.08	2.06
Average Household Consumption(4)	0.83	1.60	1.36	2.60
MCP(5)	0.95	1.81	1.54	2.96

Notes:

(1) Latest MHI data is $63,799 based on 2018 ACS data. Estimated MHI adjusted to 2020 is $66,620. Adjusting 2020 MHI for cost of living, MHI is $34,790.
(2) Based on 70,000 gallons/year consumption and FY2020 Rates.
(3) Based on 52,000 gallons/year consumption and FY2020 Rates.
(4) Based on average consumption across all metered residential units of 65,534 gallons/year and FY2020 Rates.
(5) Multi-family Conservation Plan is a flat fee per unit for customers who will implement certain conservation measures.

Approximately 67 percent of all households in NYC are renter-occupied, compared to about 36 percent of households nationally. In recent years, affordability concerns have been compounded by the fact that gross median rents in NYC have increased, while median renter income has declined. Although renter households may not directly receive water and wastewater bills, these costs are often indirectly passed onto them in the form of rent increases. Increases in water and sewer costs that are borne by landlords and property owners could also indirectly impact tenants, as it may limit the ability to perform necessary maintenance. Although it can be difficult to discern precisely how much the water and sewer rates impact every household, particularly those in multi-family buildings and affordable housing units, the 1997 EPA Guidance requires that all households in the service area be identified and used to establish an average cost per household for use in financial capability and affordability analyses. This LTCP financial capability assessment applies a lower average annual wastewater cost for households in multi-family buildings, due to a lower annual consumption value as compared to single-family households, and also examines average consumption across the board.

Most government agencies consider housing costs of between 30 percent and 50 percent of household income to be a moderate burden in terms of affordability; costs greater than 50 percent of household income are considered a severe burden. A review of 2018 ACS Census data shows approximately 16 percent of NYC households (nearly 170,000 households) spent between 30 percent and 50 percent of their income on housing, while about 18 percent (over 182,000 households) spent more than 50 percent. This compares to 13 percent of households nationally that spent between 30 percent and 50 percent of their income on housing and 9 percent of households nationally that spent more than 50 percent. This means that 34 percent of households in NYC versus 22 percent of households nationally spent more than 30 percent of their income on housing costs.

New York City Housing Authority (NYCHA) provides public housing and Section 8 vouchers for 11.6 percent of the City's rental apartments, which account for 6.5 percent of NYC's population. NYCHA has 173,762 public housing apartments, representing approximately 8 percent of the City's rental apartments. NYCHA paid approximately $191M for water and wastewater in FY2019. This total represents approximately 5.7

percent of NYCHA's $3.51B operating budget. More than 90 percent of NYCHA billings are calculated under the Multi-family Conservation Program (MCP) rate. Even a small increase in rates could potentially impact the agency's ability to provide affordable housing and/or other programs and services, and in recent years, NYCHA has experienced funding cuts and operational shortfalls, further straining its operating budget.

In sum, the financial capability assessment for NYC must look beyond the 1997 EPA Guidance, and must additionally consider the socioeconomic conditions discussed in this section including NYC's income distribution, water and wastewater rate impacts on households with income below the median level, poverty rates, housing costs, and total tax burden. Because many utilities provide both drinking and wastewater services and households often pay one consolidated bill, financial capability and affordability must consider total water and wastewater spending. Scheduling and priorities for future spending should consider the data presented here and above with respect to historical and future commitments.

9.6.k Potential Impacts of CSO LTCPs to Future Household Costs

As previously discussed, DEP is facing significant future wastewater spending commitments associated with several regulatory compliance programs. This section presents the anticipated CSO LTCP implementation costs for NYC and describes the potential resulting impacts to future household costs for wastewater service, when coupled with DEP's current and future investments. As described below, estimating the future rate and income increases through 2045 based on the cumulative impacts of this investment and DEP's other future spending, up to 55 percent of households could pay two percent or more of their income for wastewater services.

9.6.k.1 Estimated Costs for Waterbody CSO Preferred Alternative

As discussed in Section 8.8, the selection of the Recommended Plan for the Citywide and Open Waters LTCP includes the following:

- Hudson River: Optimization of regulators associated with Outfalls NR-038, 040, and 046 within the Hudson River
- East River: Bending weir at Regulator TI-13 (TI-023) plus regulator optimization associated with TI-003
- New York Bay: Optimization of regulators associated with CSOs RH-005, 014
- New York Bay: Gravity flow connection from Victory Boulevard combined sewer directly to interceptor, bypassing Hannah Street PS, diverting dry- and wet-weather flow upstream of CSO PR-013
- New York Bay: RTC gate for Regulator 9C, Outfall OH-015

The estimated costs (in December 2019 dollars) for the Recommended Plan are: NPW of $61M, PBC of $42M, and annual O&M of $1.5M. The escalated design and construction costs for the LTCP Recommended Plan are estimated to be $84M (not including site acquisition).

9.6.k.2 Overall Estimated Citywide CSO Program Costs

In the early 2000s, DEP developed 11 CSO WWFPs that laid out a program of targeted grey infrastructure projects to reduce CSO impacts and to meet applicable WQS at that time. As part of the CSO Order between DEC and DEP, these grey infrastructure projects were incorporated in the Order with specific project design and construction milestones. Additionally, in the Order DEP committed to a $1.6B GI program with the goal of capturing the first inch of a rainfall on 10 percent of the impervious CSO areas in NYC. Capital costs associated with the WWFP projects and GI program are presented in Table 9-14, and resulting CSO volume reductions are presented in Table 9-15.

DEP's LTCP planning process was initiated in 2012 and has advanced pursuant to the CSO Order schedule. This Citywide and Open Waters LTCP represents the final waterbody LTCP developed as part of this process. Overall anticipated CSO program costs for NYC will be unknown until each LTCP is approved. Capital costs for the LTCP preferred alternatives are presented in Table 9-14, and resulting CSO volume reductions and treated/disinfected CSO volumes are presented in Table 9-15. Approximately $2.0B of LTCP and Superfund-mandated CSO control project costs were committed in the pre-COVID-19 January 2020 Plan (FY2020-2029). The remainder of LTCP costs will be committed beyond FY2029. However, DEP is currently evaluating realignment of priorities, which may result in revisions to the LTCP budget projections. See Sections 9.8 and 9.9 for additional considerations related to COVID-19 and prioritization of future spending.

9.6.k.3 Potential Impacts to Future Household Costs

The potential future rate impacts of the possible future CSO control capital costs were determined by considering capital investments in the January 2020 Plan (FY2020-2029) and applying estimated future DEP investments from 2030 to 2045 of $2.0B per year, assuming a CIP average of $2.0B per year (based on historic annual average CIP costs, anticipated needs, and investments) that was inflated by 3 percent per year beginning in 2029, In addition, $6.3B in LTCP and Superfund-mandated CSO control spending through 2045 was applied, a portion of which is included in the current CIP. This $6.3B in LTCP and Superfund-mandated CSO control spending is in addition to the $4.3B in existing commitments associated with the WWFP grey CSO control projects and the citywide GI program, resulting in a potential total CSO program financial commitment of $10.7B (see Table 9-16).

Table 9-14. Overall Estimated Citywide CSO Program Costs

Waterbody	Waterbody Watershed Facility Plan and Green Infrastructure Program		LTCP CSO Program		
	Projects	Total Project Costs (Design, CM, Construction) ($M)	Projects	Probable Bid Costs (Construction) ($M) – Current Estimate(1)	Total Project Costs (Design, CM, Construction) ($M) - Escalated to Midpoint of Construction(2)
Alley Creek	CSO Retention Facility	$141	Seasonal Disinfection at CSO Retention Facility	$8(5)	$25
Bergen and Thurston Basins(3)	Warnerville Pumping Station and Force Main + Bending Weirs + Parallel Interceptor + Lateral Sewer	$54	Included with Jamaica Bay and Tributaries	Included with Jamaica Bay and Tributaries	Included with Jamaica Bay and Tributaries
Bronx River	Maximize Flow to HP WRRF + Floatables Control	$46	New Regulator and Floatables Control at HP-011 + Hydraulic Relief at Outfalls HP-007/-009	$110(5)	$122
Coney Island Creek	Avenue V PS Expansion + Wet-Weather Force Main	$197	No Additional Projects	$0(5)	$0
Citywide/Open Waters	Multiple WRRF Headworks Projects + Port Richmond Throttling Facility + Tallman Island Conveyance + Outer Harbor CSO Regulator Improvements + Inner Harbor In-line Storage	$196	Regulator Optimizations and Hannah St PS Bypass	$42(6)	$84
Flushing Bay	Regulator Modifications to High Level Interceptor + Low-Lying Diversion Sewer + Environmental Dredging	$71	25 MG CSO Storage Tunnel (Outfalls BB-006 and BB-008)	$829(5)	$1,471
Flushing Creek	CSO Retention Facility + Vortex Facilities	$363	Floatables Control (Baffles) and seasonal disinfection at Diversion Chamber 3 (Outfall TI-010) and Regulator TI-09 (Outfall TI-011)	$56(5)	$89
Gowanus Canal	Gowanus PS Reconstruction + Flushing Tunnel	$198	8 MG Tank at RH-034 and 4 MG Tank at OH-007	$720(7)	$1,322
Hutchinson River	Hunts Point WRRF Headworks	$3	Diversion Structure with Floatables Control and seasonal disinfection at HP-024	$90(5)	$204
Jamaica Bay and Tributaries	Sewer Improvements in 26W + 26W HLSS + Hendrix Creek Canal Dredging + Shellbank Destratification + Spring Creek AWRRF Upgrade + 26 Ward Wet-Weather Improvements	$652	Additional GI, Shoreline Wetland Restoration, Environmental Dredging, and Ecological Restoration	$310(6)	$579
Newtown Creek	Floatables Control + Bending Weirs + Plant Expansion + Instream Aeration	$262	26 MGD BAPS Expansion and 39 MG Deep Tunnel	$597(5)	$2,401
Paerdegat Basin(3)	CSO Retention Facility	$394	Included with Jamaica Bay and Tributaries	Included with Jamaica Bay and Tributaries	Included with Jamaica Bay and Tributaries
Westchester Creek	Weir Modifications + Pugsley Creek Parallel Sewer	$126	No Additional Projects	$0(5)	$0
Green Infrastructure Program(4)	Citywide GI Program	$1,600			
Total Cost		***$4,303***		***$2,762***	***$6,297***

Notes:
1. (1) Costs reported in this column reflect current estimated construction costs only (i.e., probable bid cost).
2. (2) Costs reported in this column reflect total project costs (including design, construction management, and construction costs) escalated out to midpoint of construction and have been updated to be consistent with DEP's January 2020 Plan. Projected O&M costs are not included. Spending and costs may be impacted by COVID-19.
3. (3) LTCP Program costs for Bergen, Thurston, and Paerdegat Basins are included in the Jamaica Bay and Tributaries cost.
4. (4) GI Program costs are not part of the LTCP Program costs.
5. (5) Cost based on LTCP approved by DEC.
6. (6) Cost based on LTCP submitted to DEC, but not yet approved by DEC.
7. (7) Cost for project mandated by Superfund Program.

Table 9-15. Overall Estimated Citywide CSO Reductions

Waterbody	Waterbody Watershed Facility Plan				LTCP CSO Program			
	Pre-WWFP Baseline Volume (MGY)(1)	Baseline LTCP CSO Volume (MGY)(2)	CSO Reduction (MGY)	CSO Volume Reduction (%)	LTCP Recommended Plan (MGY)(3)	CSO Reduction (MGY)	CSO Volume Reduction (%)	Treated CSO Volume (MGY)
Alley Creek	330	132	198	60%	132	0	0%	78
Bergen & Thurston Basins	Included with Jamaica Bay	Included with Jamaica Bay	Included with Jamaica Bay	NA	Included with Jamaica Bay and Tributaries	Included with Jamaica Bay and Tributaries	NA	Included with Jamaica Bay and Tributaries
Bronx River	498	455	43	9%	285	170	37%	---
Coney Island Creek	235	75	160	68%	75	0	0%	---
Citywide/Open Waters(4)	12,207	11,160	1,047	8%	10,935	225	2%	---
Flushing Bay	1,800	1,453	347	19%	706	747	51%	---
Flushing Creek	2,413	1,201	1,212	50%	1,201	0	0%	584
Gowanus Canal	471	263	208	44%	115	148	56%	---
Hutchinson River	362	323	39	11%	323	0	0%	65
Jamaica Bay & Tribs	2,182	1,164	1,018	47%	1,156	8	1%	---
Newtown Creek	1,456	1,161	295	20%	455	706	61%	---
Paerdegat Basin	1,388	616	772	56%	616	0	0%	---
Westchester Creek	790	290	500	63%	290	0	0%	---
Total	***24,132***	***18,293***	***5,839***	***24%***	***16,289***	***2,004***	***11%***	***727***

Notes:
(1) “Pre-WWFP Baseline” volumes reflect conditions without Waterbody Watershed Facility Plan (WWFP) Projects, Green Infrastructure, and other sewer improvements using 2008 JFK rainfall data, CY2040 projected flows/loads and assuming WRRFs operating at permitted wet-weather capacities.
(2) “Baseline CSO LTCP” volumes are estimates of annual overflow volume based on WRRFs operating at permitted wet-weather capacities, all committed grey and green infrastructure online, 2008 JFK rainfall data (~46" of rainfall), and updated CY2040 projected flows and loads.
(3) “LTCP Recommended Plan” volumes are estimates of annual overflow volume based on WRRFs operating at permitted wet-weather capacities, all committed grey and green infrastructure online, 2008 JFK rainfall data (~46" of rainfall), updated CY2040 projected flows and loads, and the implementation of recommended plans for LTCPs submitted to-date (including this Citywide/Open Waters LTCP).
(4) The Citywide/Open waters baseline LTCP CSO Volume includes the reduction associated with the Tibbetts Brook Daylighting Project.

Table 9-16. Financial Commitment to CSO Reduction

New York City's CSO Program	Financial Commitment ($B)
Waterbody/Watershed Facility Plan and other CSO Projects	$2.7
Green Infrastructure Program	$1.6
LTCP Approved by DEC	$5.6(1)
LTCP Submitted, not yet Approved by DEC	0.84(1)
Total	**$10.74**

Note:

(1) Reflects costs escalated to midpoint construction for submitted and approved LTCP plans as shown in Table 9-14. $2.0B of LTCP and Superfund-mandated CSO control costs were in the January 2020 Plan; the remaining will be spent beyond.

A 4.5 percent interest rate was used to determine the estimated annual interest cost associated with the capital costs, and the annual debt service was divided by the anticipated FY2020 revenue to determine the resulting percent rate increase. This also assumes bonds are structured for a level debt service amortization over 32 years. Note that interest rates on debt could be significantly higher in the future. For illustration purposes, future annual O&M increases and other incremental costs were estimated based on historical data.

As Table 9-17 shows, implementation of the January 2020 Plan (FY2020-2029) would result in a 78 percent rate increase by 2029. Additional potential mandates and CIP investments from 2030 to 2045 (using an average of $2.0B per year, inflated by 3 percent per year), as well as the up to $6.3B in total LTCP and Superfund-mandated CSO control spending, could result in a cumulative rate increase of 265 percent compared to 2020 values.

Table 9-17. Potential Future Spending Incremental Additional Household Cost Impact

Analysis Year	Additional Annual Household Cost		
	Single-family Home	Multi-family Unit	Average Cost
2029(1)	$759	$564	$710
2045(1)	$2,565	$1,905	$2,400

Notes:

(1) Includes costs for the current $20.5B January 2020 Plan (FY2020-2029), which includes approximately $2.0B in LTCP and Superfund-mandated CSO control spending.

(2) Includes an estimated $2.0B per year in capital commitments based on DEP's historic annual average CIP costs anticipated needs and investments, inflated by 3.0 percent per year for 2030-2045. $6.3B in LTCP and Superfund-mandated CSO control spending from 2020 through 2045 is assumed.

Table 9-18 identifies the total projected annual household costs for the analysis years of 2020 (current conditions), 2029 (end of 10 year CIP), and 2045 (accounts for anticipated additional spending and an assumed commitment of the total $6.3B LTCP spending) for both water and wastewater combined, and wastewater only. Figure 9-14 shows the potential range of future spending and its impact on household cost (as presented in Table 9-18) compared to MHI for the analysis years. The projected MHI for the analysis years of 2029 and 2045 was estimated by applying an annual inflation rate of 1.3 percent. This rate is based on the average annual inflation rate from 2014 to 2018 according to Consumer Price Index data for the New York Metro Area, as obtained from the Bureau of Labor Statistics. While these estimates are preliminary, it should be noted (as discussed in detail earlier in this section), that comparing household cost to MHI alone does not tell the full story since a large percentage of households below the median could be paying a larger percentage of their income on these costs.

Table 9-18. Total Projected Annual Household Costs[1]

Year	Total Projected Annual Water and Wastewater Household Costs			Total Projected Annual Wastewater Household Costs Only		
	Single-family Home	Multi-family Unit	Average HH Cost	Single-family Home	Multi-family Unit	Average HH Cost
2020	$967	$718	$905	$593	$441	$556
2029	$1,726	$1,282	$1,615	$1,059	$787	$991
2045	$3,532	$2,623	$3,305	$2,168	$1,610	$2,029

Notes:
(1) Total projected household costs are estimated from rate increases presented in Table 9-17.
HH = Household

Table 9-19. Total Estimated Cumulative Future Household Costs / Median Household Income

Year	Projected MHI[1]	Total Water and Wastewater HH Cost / MHI			Total Wastewater HH Cost / MHI		
		Single-family Home	Multi-family Unit	Average HH Cost	Single-family Home	Multi-family Unit	Average HH Cost
2020	$66,620	1.45%	1.08%	1.36%	0.89%	0.66%	0.83%
2029	$73,364	2.35%	1.75%	2.20%	1.44%	1.07%	1.35%
2045	$89,894	3.93%	2.92%	3.68%	2.41%	1.79%	2.26%

Notes:
(1) Costs were compared to assumed MHI projection which was estimated using Census and Consumer Price Index data.
HH = Household

Figure 9-15 summarizes this range of future spending and impact on household cost accounting for the high cost of living in NYC using an Adjusted MHI based on the COLI value of 191, as discussed in Section 9.6.j.4. Based on this adjustment, total wastewater costs per average household account is projected to be 4.5 percent of MHI in 2045.

Table 9-20. Total Estimated Cumulative Future Household Costs/Median Household Income Adjusted for Cost of Living

Year	Projected MHI(1)	Total Water and Wastewater HH Cost / MHI			Total Wastewater HH Cost / MHI		
		Single-family Home	Multi-family Unit	Average HH Cost	Single-family Home	Multi-family Unit	Average HH Cost
2020	$34,790	2.78%	2.06%	2.60%	1.71%	1.27%	1.60%
2029	$38,312	4.50%	3.35%	4.22%	2.77%	2.05%	2.59%
2045	$46,945	7.74%	5.75%	7.25%	4.75%	3.53%	4.45%

Notes:

(1) Costs were compared to assumed MHI projection, which was estimated using Census and Consumer Price Index data and calculated based on Cost of Living Index value of 191.49 for NYC (Source: Center for Economic Competitiveness).

HH = Household

Figure 9-14 shows the average estimated household cost for wastewater services compared to household income, versus the percentage of households in various income brackets for 2020 (using FY2020 rates) and projected future rates for 2029 and 2045 (based on detail included in Table 9-16 and Table 9-17). As shown, roughly 25 percent of households are estimated to pay 2 percent or more of their income on wastewater service alone in 2020. Estimating the future rate and income increases to 2029 and 2045 (based on the projected costs in Table 9-17 and historic Consumer Price Index data), up to 55 percent of households could be paying more than 2 percent of their income on wastewater services when all future spending scenarios would be in place – the average wastewater annual cost is estimated to be about 2.3 percent of MHI in 2045. This is summarized in Table 9-21. As noted above, applying a cost of living adjustment to future incomes results in an even greater number of households paying more than 2 percent of their income.

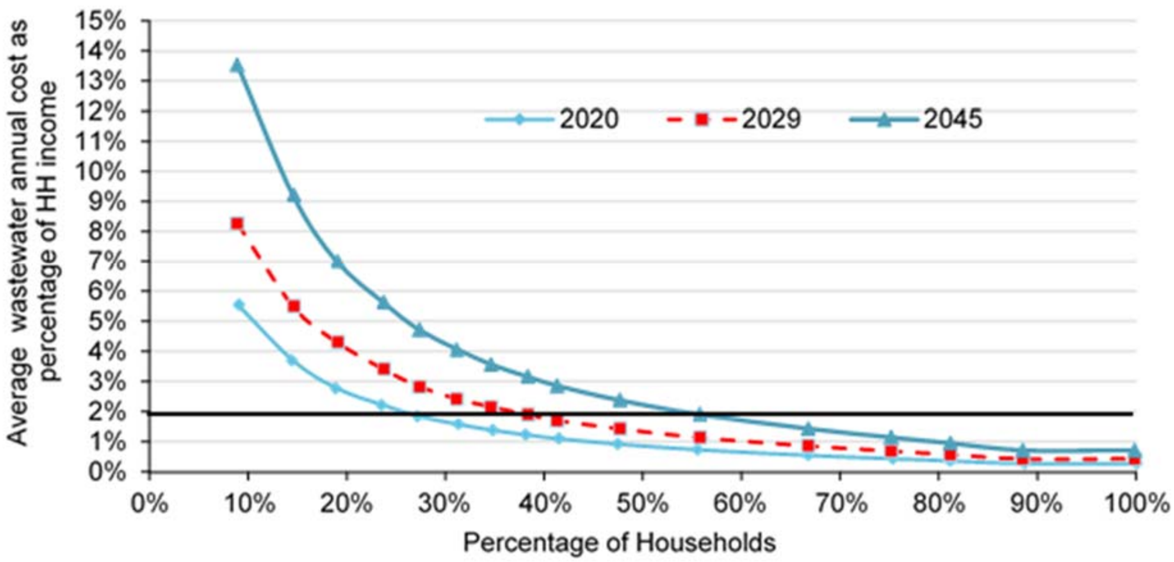


Figure 9-14. Estimated Average Wastewater Household Cost Compared to Household Income Projected Using CPI (2020, 2029, and 2045)

Table 9-21. Average Wastewater Annual Costs / Income Snapshot over Time

Year	RI using Average Wastewater Cost/MHI	RI using Average Wastewater Cost/Upper Limit of Lowest 20 Percent	RI using Average Wastewater Cost/Upper Limit of Lowest 40 Percent	Percent of HH estimated to be paying more than 2% of HH income on Wastewater Services
2020	0.8%	2.4%	1.1%	26%
2029	1.4%	3.9%	1.7%	37%
2045	2.3%	6.6%	2.9%	55%

DEP, like many utilities in the nation, provides both water and wastewater service, and its rate payers receive one bill. Currently, the average combined water and sewer annual cost is around 1.4 percent of MHI, but approximately 20 percent of households are estimated to be paying more than 4.5 percent of their income, and that could increase to about 42 percent of households by 2045, as shown in Figure 9-15.

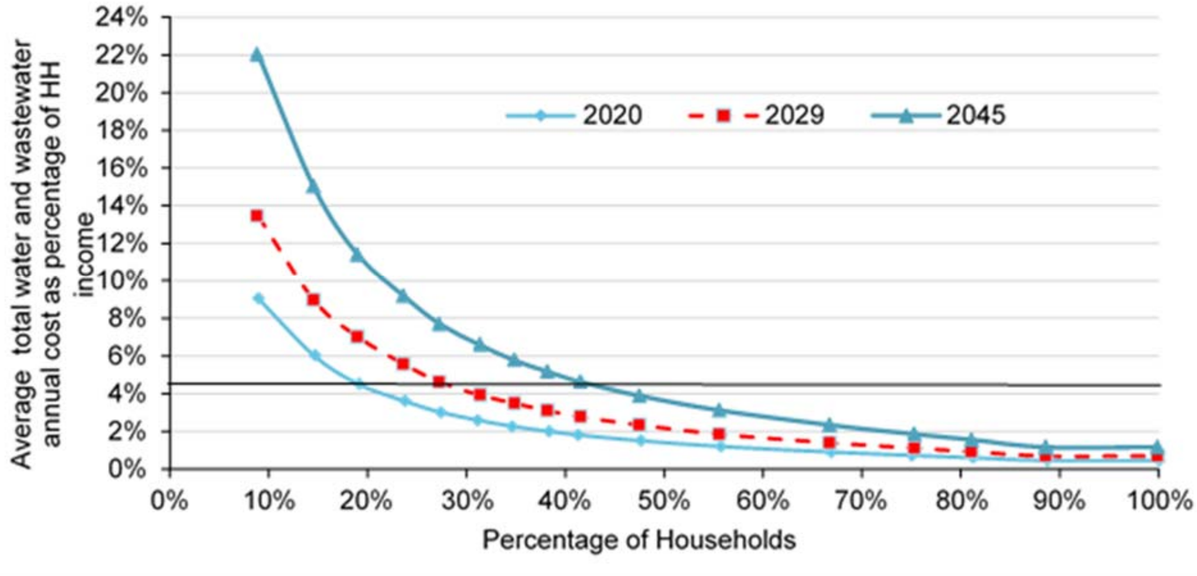


Figure 9-15. Estimated Average Total Water and Wastewater Household Cost Compared to Household Income Projected Using CPI (2020, 2029, and 2045)

9.6.I Benefits of Program Investments

DEP has been in the midst of a significant period of investment to improve water quality in the waters in and around New York City. Projects worth almost $10.7B have been completed or are underway since 2002 alone, including projects for nutrient removal, CSO abatement, marshland restoration in Jamaica Bay, and hundreds of other projects. In-city investments are improving water quality and restoring a world-class estuary while creating new public recreational opportunities and inviting people to return to NYC's 578 miles of waterfront. A description of citywide water quality benefits resulting from previous and ongoing programs is provided below, followed by the anticipated benefits of water quality improvements to the Citywide/Open Waters waterbodies resulting from implementation of the Recommended Plan.

9.6.I.1 Citywide Water Quality Benefits from Previous and Ongoing Programs and Anticipated Citywide and Open Waters Water Quality Benefits

Water quality benefits have been documented in New York Bay and its tributaries resulting from the almost $10.7B investment that NYC has already made or committed to in grey and green infrastructure since 2002 (assuming DEC approval of the Jamaica Bay and Tributaries, and Citywide/Open Waters LTCPs). Boating and kayaking are popular throughout the Harbor and tributaries, and 14 of NYC's beaches provide access to swimmable waters in the Bronx, Brooklyn, Queens, and Staten Island.

Figure 9-16 shows the historical timeline of DEP's investments in wastewater infrastructure since the CWA of 1972. Of the $10.7B invested or to be invested since 2002, almost 90 percent has been dedicated to controlling CSOs and stormwater. That investment has resulted in NYC capturing and treating over 80 percent of the combined stormwater and wastewater that otherwise would be directly discharged to our waterways during periods of heavy rain or runoff. Projects that have already been completed include:

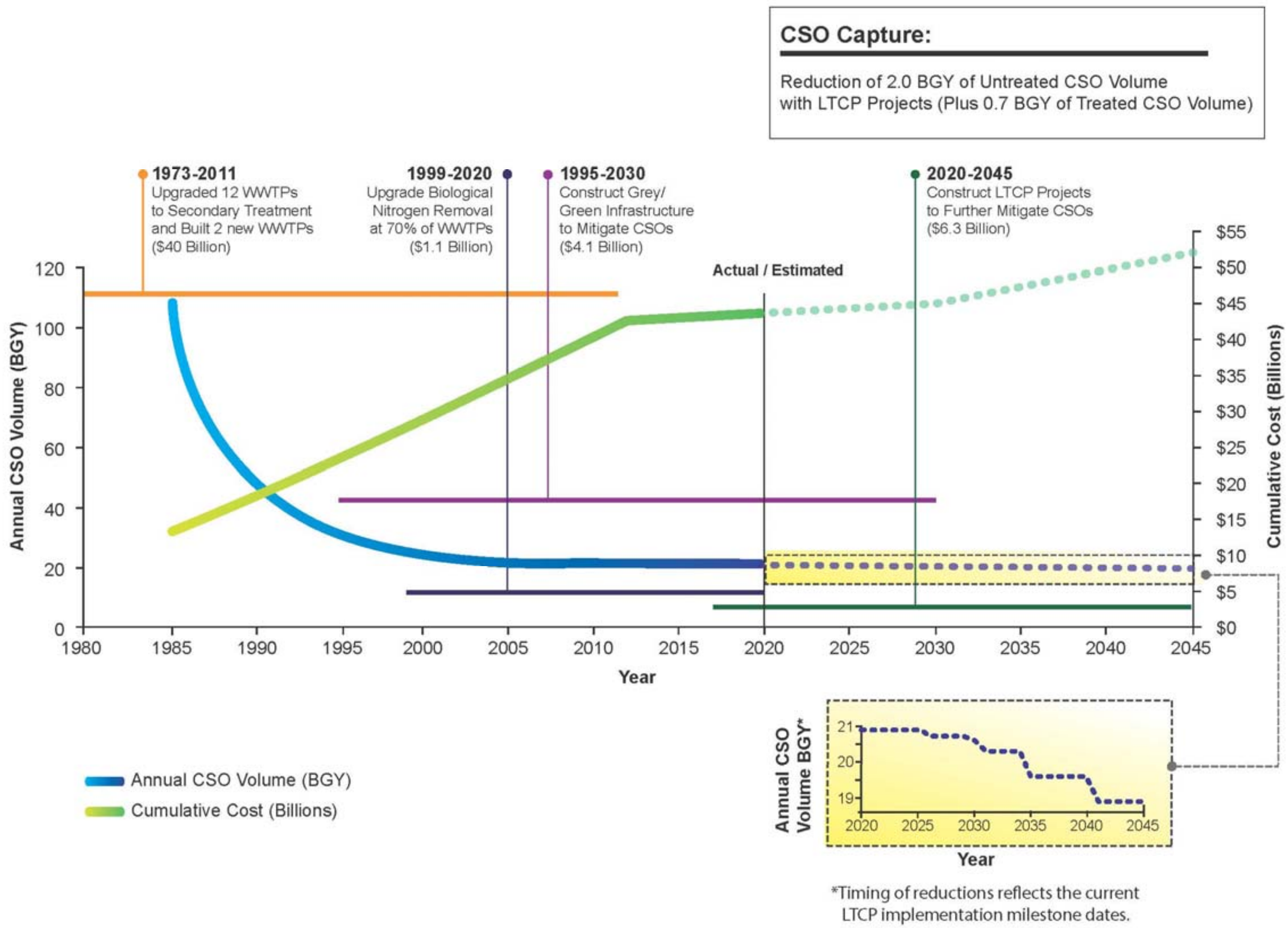


Figure 9-16. Historical Timeline for Wastewater Infrastructure Investments and CSO Reduction over Time

GI projects in 26th Ward, Hutchinson River, and Newtown Creek watersheds; area-wide GI contracts; CSO storage tanks for Alley Creek, Flushing Creek and Paerdegat Basin; the Avenue V Pumping Station and Force Main; the Gowanus Pumping Station and Flushing Tunnel Upgrade; the Bronx River Floatables Control projects; dredging and restoration of the Flushing Bay shoreline; bending weirs, floatables control and an aeration system for Newtown Creek, regulator improvements and miscellaneous other projects for Jamaica Bay; and static weir adjustments for Bowery Bay. Several other major projects are in active construction or design. The water quality improvements already achieved have allowed greater access of the waterways and shorelines for recreation, as well as enhanced environmental habitat and aesthetic conditions in many of NYC's neighborhoods.

Although significant investments were made for water quality improvements Harbor-wide through the Waterbody/Watershed Facilities Planning process, it was recognized that more work was needed. DEP remains committed to both further reducing CSOs and making other cost-effective infrastructure improvements to achieve additional water quality improvements. The CSO Order between DEP and DEC outlined a combined grey and green approach to reduce CSOs through development of 11 individual LTCPs for waters in and around New York City. This LTCP for Citywide and Open Waters is the last of the 11 detailed plans that DEP has prepared to evaluate and identify additional control measures for reducing CSOs and improving water quality in the City's waterways. DEP is also committed to extensive water quality monitoring throughout the City's waterways which will allow better assessment of the effectiveness of the controls implemented.

As noted above, GI stormwater control measures and the program developed by DEP and DEC are a major component of the CSO Order. DEP is targeting implementing GI in priority combined sewer areas citywide. GI will take multiple forms, including green or blue roofs, bioinfiltration systems, right-of-way rain gardens, rain barrels, and porous pavement. These measures provide benefits beyond their associated water quality improvements. Depending on the measure installed, they can recharge groundwater, provide localized flood attenuation, provide sources of water for non-potable use (such as watering lawns or gardens), reduce heat island effect, improve air quality, enhance aesthetic quality, and provide recreational opportunities. These benefits contribute to the overall quality of life for residents of NYC.

A detailed discussion of anticipated water quality improvements is included in Section 8.0.

9.6.m Conclusions

DEP has a robust water and wastewater spending plan to serve its mission, and we must continue to spend wisely to maintain existing infrastructure while also looking forward to achieve expanded water quality objectives by being mindful of the burden on ratepayers. In addition to what is outlined in the current Federal CSO guidance on financial capability, DEP has presented in this section a number of additional socioeconomic factors for consideration in the context of affordability and assessing potential impacts to our ratepayers. A summary of key findings and takeaways is provided below.

- DEP spending has increased to support both mandated projects and other critical investments in our water and wastewater infrastructure. As a result, water and sewer rates have increased by almost 108 percent (adjusted for inflation) since 2000 to meet the increasing cost of service.
- While the cost of NYC water is less than the national average, New Yorkers are burdened by a high overall cost of living in a city with one of the largest income gaps in the nation.

- Application of EPA's current guidance results in a RI value of 0.83 percent of MHI for current wastewater costs for the average household, which represents a "low economic impact" according to EPA. However, as detailed in this section, MHI is a poor indicator of economic distress and bears little relationship to poverty, or other measures of economic need. In addition, reliance on MHI alone can be a misleading indicator of the affordability impacts in large and diverse cities like NYC.
- The RI value increases to 2.54 percent for households in the Lowest Quintile (i.e., lowest 20 percent of income earners). This falls well above EPA's "high economic impact" designation.
- Using alternative Household Burden and Poverty Prevalence Indicators results in a "Moderate-High Burden," suggesting the burden of water service is likely higher than that obtained using the current EPA methodology. Also, when applying a cost of living adjustment, the current RI increases to 1.6 percent for the average household.
- Future estimates predict wastewater costs will exceed 2 percent of MHI by 2045, which represents a "high economic impact" according to EPA's current guidance.
- DEP's historical and future investments in CSO reduction total nearly $10.7B. DEP continues to balance these investments with other regulatory mandates, State of Good Repair, Drinking Water investments, and Climate Resiliency, while taking into consideration the socioeconomic challenges of our communities.

DEP is fully focused on making critical investments to support our mission of protecting the health and safety of New Yorkers and improving water quality, while being mindful of rates. DEP seeks to prioritize smart investments that produce the greatest social, economic, and environmental benefits without putting undue financial burden on our rate payers. See Sections 9.8 and 9.9 below for further discussion.

9.7 Compliance with Water Quality Goals

The water quality in the Open Waters waterbodies addressed in this LTCP can be improved through the implementation of the Recommended Plan projects from the approved and pending LTCPs, constructed and planned GI projects in combined sewer areas including the Tibbetts Brook Daylighting Project, programmatic floatables control activities, and implementation of this LTCP. The Harlem River, Hudson River, and East River/Long Island Sound are in full attainment with applicable bacteria and DO WQ Criteria, and can support existing uses: swimming (where applicable), kayaking, boating, and fish, shellfish, and wildlife propagation and survival. New York Bay Arthur Kill and Kill Van Kull have segments where applicable bacteria and DO WQ Criteria cannot be attained. For Arthur Kill, Kill Van Kull, and the area of New York Bay off the southwestern tip of Staten Island, non-attainment of the WQ Criteria is due to sources other than NYC CSOs. 100% CSO control would not result in attainment of the WQ Criteria in those locations. Attainment with the Class SB Coastal Primary Recreational *Enterococci* 30-day STV criteria in New York Bay would require at least 50 percent control of the CSO volume to New York Bay, at an un-escalated PBC of $3,000M, and the feasibility of constructing such a project is unclear.

The CSO Order Goal Statement stipulates that, in situations where the proposed alternatives presented in the LTCP will not achieve existing WQS or the CWA Section 101(a)(2) goals, the LTCP will include a UAA. Because the analyses developed indicate that New York Bay, Arthur Kill, and Kill Van Kull have segments which are not projected to fully meet applicable WQ Criteria for bacteria and DO, a UAA for each of those waterbodies is included in this LTCP.

9.8 COVID-19 Considerations

On March 7, 2020, New York State Governor Andrew Cuomo declared a State of Emergency in New York through Executive Order No. 202. On March 13, 2020, the Federal government declared a nationwide emergency pursuant to Sec. 501(b) of the Robert T. Stafford Disaster Relief and Emergency Assistance Act, 42 U.S.C. 5121-5207, Release number HG-20-017. DEP gave timely notice to DEC of this Force Majeure on March 19, 2020 pursuant to the terms of the CSO Order and will keep DEC informed of any additional impacts from the Force Majeure. In light of COVID-19 and the uncertainty posed by this ongoing pandemic, DEP has initiated re-evaluation of budgets and schedules for its spending portfolio.

COVID-19 has disrupted travel, commerce, and financial markets globally, resulting in a worldwide economic recession adversely affecting almost all the world's major economies. While the long-term impact on New York City cannot be predicted, the initial economic and financial impacts have been substantial.

Personal incomes and tax receipts have been correspondingly lower, due to job losses, wage reductions, and the loss of available work hours. The City's already difficult housing conditions are under greater stress, as the non-payment of rent and mortgages grows. The reduction in cashflow for both residential and commercial renters has placed some landlords under financial pressure, contributing to additional non-payment of taxes and utility bills.

The city has been amongst the most severely affected during the first six months of the pandemic in terms of increased unemployment. According to the New York Department of Labor, New York City initial unemployment claims for the period of March 14 to August 22, 2020 totaled 3,555,580 compared to 357,980 during the same period in 2019; an increase of 3,192,600 or 892 percent.[1] The largest numbers of initial claims were in the lower wage sectors including accommodation, food services, and retail trade. Healthcare and social assistance employment was also substantially impacted. NYC unemployment was 19.8 percent in July 2020 compared to 3.9 percent in July 2019. Figure 9-17 shows NYC's unemployment rate since 2000. For greater context, the average monthly unemployment rate in NYC since mid-March is more than twice as much as what occurred during the "Dot-Com" crash and September 11, 2001, and the Great Recession.

[1] https://labor.ny.gov/stats/PDFs/Research-Notes-Initial-Claims-WE-8222020.pdf

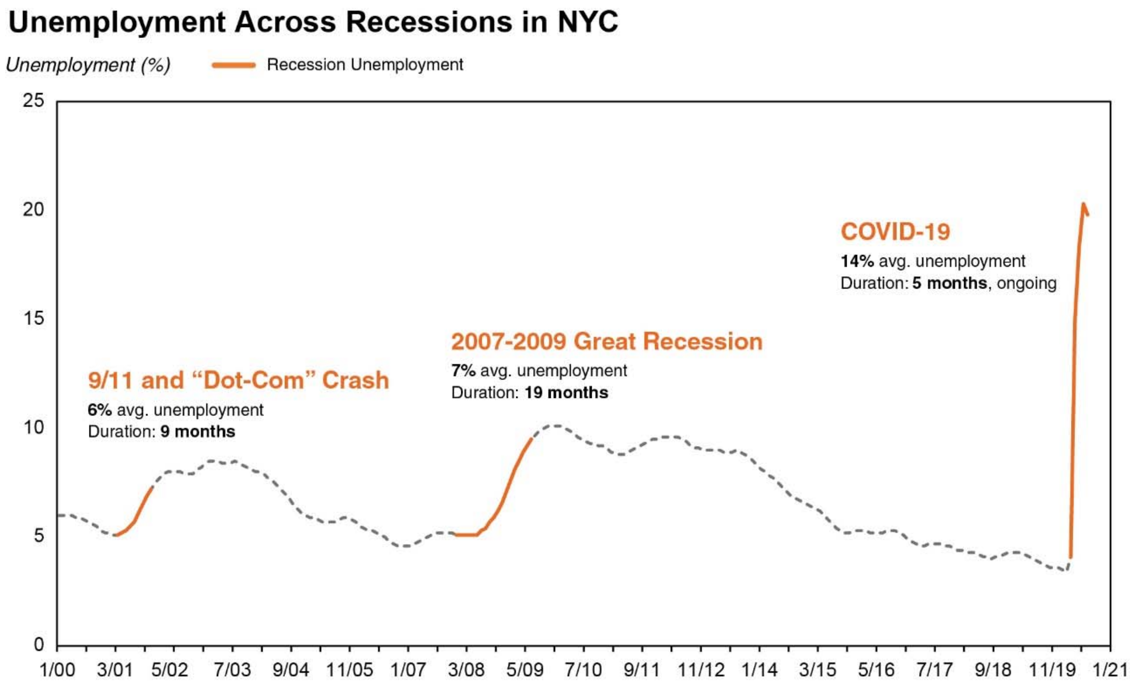


Figure 9-17: NYC Unemployment Rates over Time (Source: NYS Department of Labor)

On April 14, 2020, the American Water Works Association (AWWA) and Association of Metropolitan Water Agencies published a report on the impacts of COVID-19 on water utilities, "The Financial Impact of the COVID-19 Crisis on U.S. Drinking Water Utilities." The implications cited in this report include potential increase in customer delinquencies, reduction in demand and corresponding reductions in revenue, delayed and reduced capital expenditures, increases in personnel expenses, and deferral of water rate increases.

The City's Water Board acknowledged the stark economic realities of COVID-19 and did not propose a rate increase for the fiscal year beginning July 1, 2020. The Board further adopted a budget for its fiscal year 2021 that was 12 percent smaller than the budget it had previously adopted for fiscal year 2020, reflecting a fiscal year 2021 budget of $3.32B compared to $3.82B the year before. Over two months into fiscal year 2021, as of mid-September, Water Board revenues are 8 percent lower than for the same period last year. DEP financial projections shared with the investor community, covering fiscal years 2020 through 2024, reflect a potential cumulative reduction of more than $1B of revenues, compared to DEP's multi-year revenue forecast in place prior to the start of the pandemic.

Adding to the future fiscal uncertainty, in response to the ongoing economic hardship that has been caused by COVID-19, in September 2020 the City postponed the closing of its annual sale of liens against unpaid water and sewer charges and property taxes. The City's postponement is consistent with actions taken by New York State to provide temporary public relief from lien sales during the ongoing pandemic.

The AWWA report further states that on average, utilities across the country are experiencing decreases in Non-Residential demand and increases in Residential demand. Citywide water demand in New York City declined about 5 percent (nearly 50 million gallons per day) from mid-March 2020 through April 30, 2020, following City, State, and Federal emergency declarations due to COVID-19. Citywide demand began rebounding in June, consistent with the phased reopening of New York State (see Figure 9-18 for these demand trends).

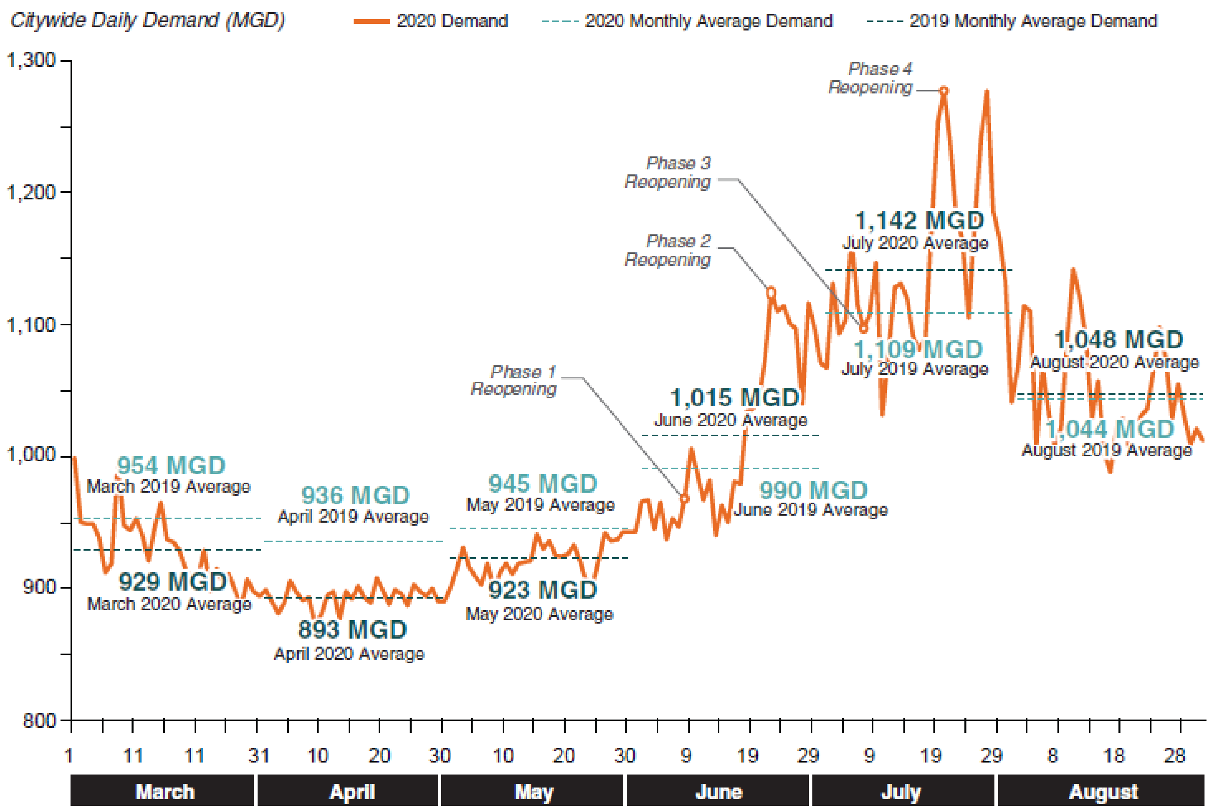


Figure 9-18. Citywide Daily Demand Comparison, March 1 to August 31, 2020 versus Same Period in 2019

Volumetrically, citywide water demand in 2020 is consistent with 2019. Demand from March 1 through August 31, 2020 was about 0.5 percent less (about 5 million gallons per day) versus the same period in 2019. Demand by customer type, however, has shifted due to COVID-19: Residential demand has increased, and Non-Residential demand has decreased. Between March 1 and August 28, 2020, the decrease in citywide Non-Residential demand was largely offset by a similar increase in citywide Residential demand, particularly in June and August. This is consistent with COVID-19-related trends and policies: New Yorkers are spending more time in their homes for work, recreation, and school, thus driving up Residential demand. Residential demand may return to average levels if work, school, and travel policies shift to pre-COVID-19 conditions. Additionally, neighborhood-specific demand trends may indicate further takeaways regarding COVID-19 demand shifts, customer affordability, socioeconomics, and public health.

The COVID-19 crisis dramatically underlines the urgency for sound investment planning to maximize environmental and community benefits and minimize affordability concerns. Depending on the magnitude and duration of these COVID-19-related economic impacts, DEP could be compelled to implement a more holistic adaptive asset management approach to implementing its LTCP to ensure expenditures are financially sustainable and balanced with operational needs and maintaining existing infrastructure.

9.9 Holistic Adaptive Planning Framework and Prioritization of Future Investments

DEP recognizes the need to both prioritize short-term needs due to COVID-19-related financial disruptions, plus facilitate long-term planning and budget prioritization. DEP believes that taking a holistic adaptive planning approach will help to streamline DEP's efforts across all departments to maximize environmental and community benefits and achieve water quality goals as efficiently as possible, while maintaining sustainable rates.

A holistic planning approach can:

- Provide an approach to evaluate opportunities to do more with less, that is, consider LTCP commitments as the baseline and determine whether other investments can achieve the equivalent or greater benefits with less spending;

- Offer a balanced approach to meet operational needs and regulatory requirements, while considering affordability;

- Provide a sound approach to prioritize capital projects that yield the highest benefits as efficiently as possible.

Many municipalities have taken a similar approach to developing integrated plans as the basis to reprioritize their capital programs, or to evaluate Consent Decree and Consent Order modifications. A holistic planning approach can be tailored to the needs and constraints of individual cities.

DEP always looks to balance investments and approaches that are environmentally, socially, and financially responsible. As DEP balances priorities, DEP will continue to be conscientious of affordability concerns of its rate payers.

DEP has historically had to balance several competing priorities between mandated and non-mandated programs. Although DEP has made substantial investments in meeting mandated commitments, other non-mandated priorities needed to be deferred to keep the capital budget affordable. Historically, capital spending was driven by state and federal mandates including Croton Water Filtration Plant, CAT/DEL UV, and Newtown Creek upgrades, which left limited resources for other critical needs like State of Good Repair. As shown in Figure 9-19 from 2000 to 2009, DEP's capital commitments were primarily driven by mandates (ranging from 54 percent in 2000 to as high as 90 percent in 2007). Operational and State of Good Repair (SOGR) needs were significantly deferred until the early 2010's. DEP continues to work to complete deferred State of Good Repair, and additional deferral of State of Good Repair in order to fund consent order mandates could exacerbate aging infrastructure and operational issues in the future1#Thus, DEP is pursuing a more balanced approach with DEC to meet operational needs and regulatory requirements, while considering affordability.

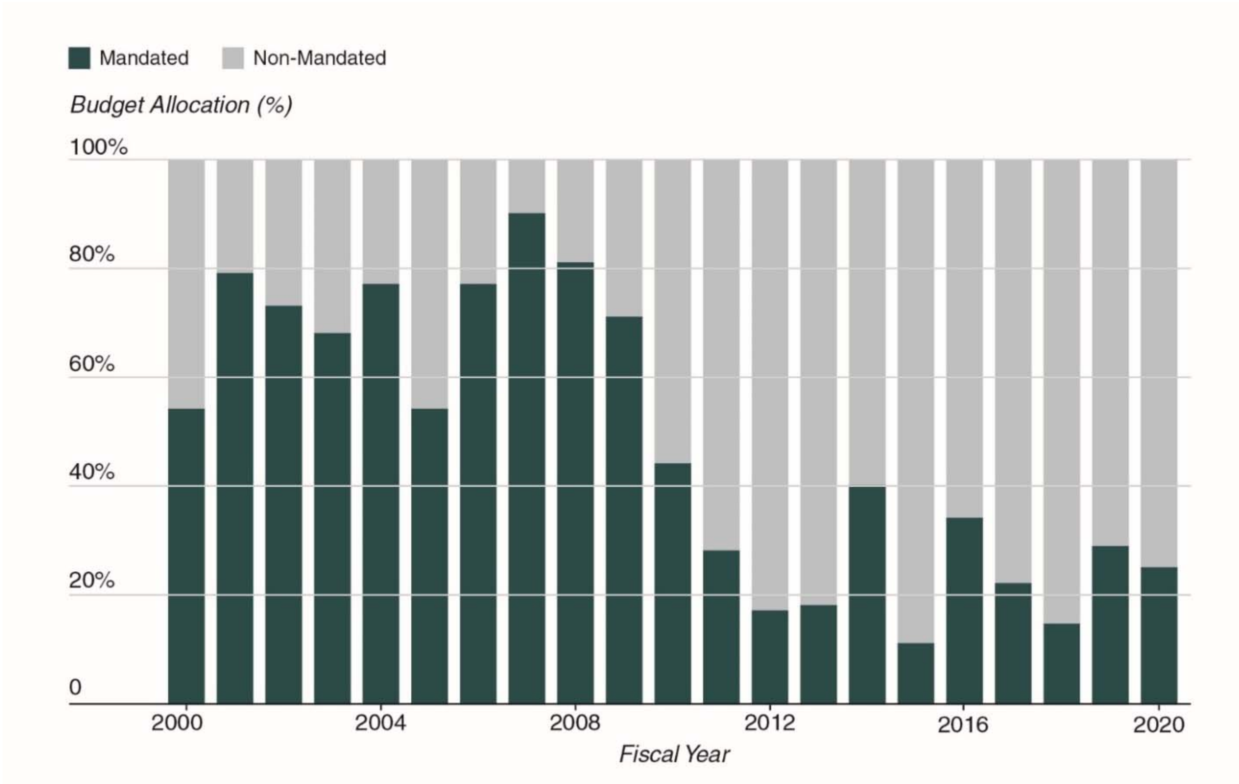


Figure 9-19. Historical Capital Commitments

Looking ahead, DEP's significant future capital commitments will need to be balanced with these SOGR and operational priorities, while also efficiently achieving water quality goals, enhancing resilience to climate change, and maintaining sustainable rates for all New Yorkers. Although DEP is currently balancing fiscal needs, COVID-19 is adding additional strain not previously accounted for. Figure 9-20 shows historical expenditures (2000 to 2019) and the pre-COVID-19 CIP expenditure forecast (2020 to 2029) for non-mandated and mandated projects. As a direct result of COVID-19, DEP was only able to register $1 billion of $2.3 billion in planned investments. The resulting $1.3 billion backlog of work will need to be redistributed into the FY 2021 and subsequent fiscal years. COVID-19 has created uncertainties for DEP, including uncertainty concerning the revenues likely to be available to the system in the coming years. DEP is currently forecasting that revenues across fiscal years 2020 to 2024 will be more than $1B less than expected prior to the COVID-19 pandemic. Forecasted budgets and timing for projected future expenditures depicted herein are subject to change.

A holistic adaptive planning process will facilitate DEP's goal in evaluating the best strategies and the pace of capital investments to maximize benefits efficiently. Multiple scenarios will be considered, including the possibility of extending mandated deadlines. Under all evaluation scenarios, DEP is committed to achieving the LTCP objectives, maintaining transparency, and continuing robust coordination with stakeholders to demonstrate viability and benefits of any potential alternatives.

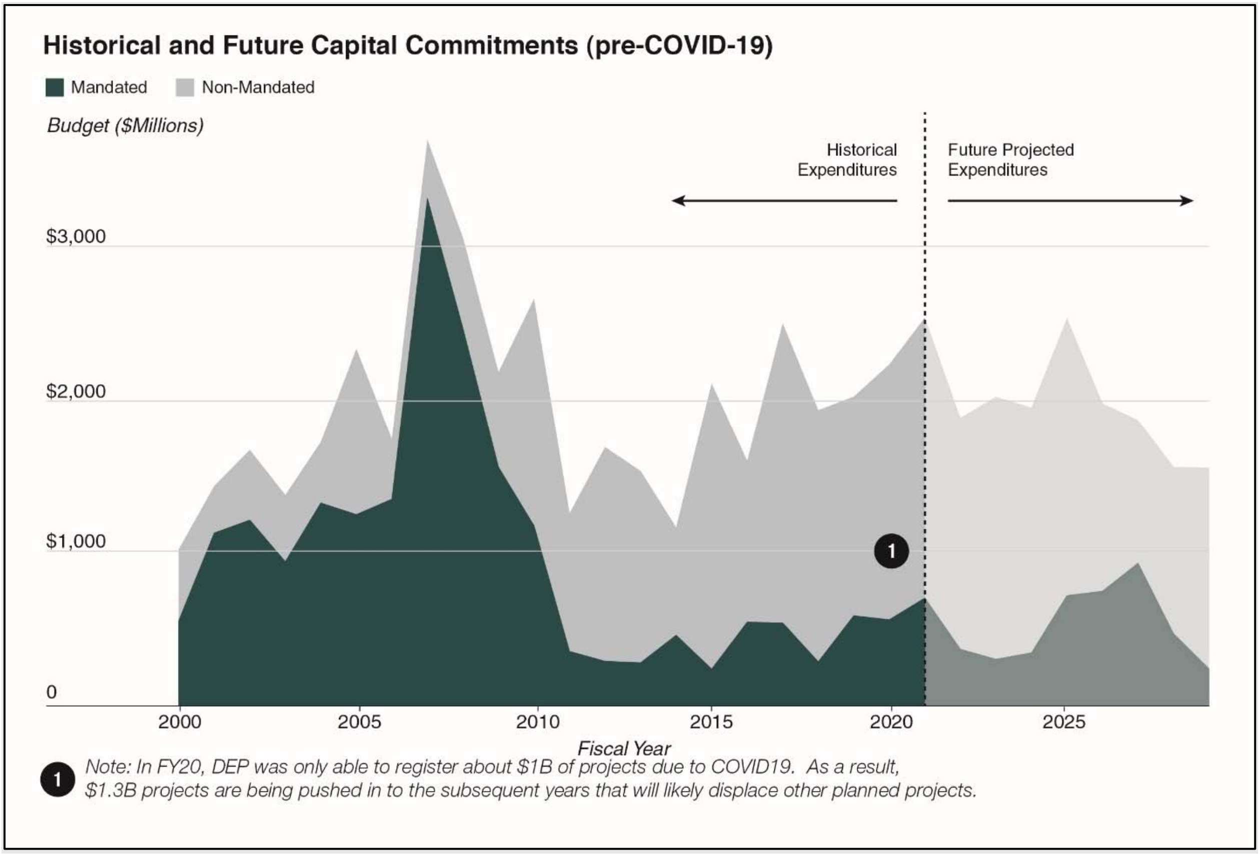


Figure 9-20. Historical and Future Capital Commitments (pre-COVID-19)

10. REFERENCES

American Water Works Association, National Association of Clean Water Agencies, and the Water Environment Federation. 2019. Developing a New Framework for Household Affordability and Financial Capability Assessment in the Water Sector. April 2019.

Cerrato, R. M 1986. The Benthic Fauna of Newark Bay. U.S. Fish and Wildlife Service Special Report 68(86-3). Marine Sciences Research Center, State University of New York. Stony Brook, New York.

City of New York, NY. 2010. Rules of the City of New York Governing House/Site Connections to the Sewer System. www.nyc.gov/html/gbee/.../dep_rule_title15_ch.31.pdf.

City of New York. 2013. Special Initiative for Rebuilding and Resiliency. A Stronger, More Resilient New York.

City of Philadelphia. 2016. FY16 Combined Sewer and Stormwater Management Program Annual Reports.

HydroQual Environmental Engineers and Scientists, P.C., 2003. Use and Standards Attainment Project, Year 2003 Subtidal Benthos and Ichthyoplankton Characterization Field Sampling and Analysis Program. Prepared for The City of New York Department of Environmental Protection, Bureau of Environmental Engineering, April 2003.

HydroQual Environmental Engineers & Scientists, P.C. 2005a. NY/NJ Harbor Estuary Program Model Applications of Stormwater Sampling Results, Memorandum to C. Villari, NYCDEP from C. Dujardin and W. Leo. May 4, 2005.

HydroQual Environmental Engineers & Scientists, P.C. in Association with Greeley and Hansen/O'Brien & Gere/Hazen and Sawyer Joint Venture. 2005b. Facility Plan for Delivery of Wet Weather Flow to the Tallman Island WPCP for the New York City Department of Environmental Protection, Bureau of Environmental Engineering. August 2005.

Manuel P. Teodoro. 2018. Measuring Household Affordability for Water and Sewer Utilities. https://awwa.onlinelibrary.wiley.com/doi/full/10.5942/jawwa.2018.110.0002

New York City Department of City Planning. 1993. DCP Plan for the Manhattan and Bronx Waterfronts.

New York City Department of City Planning. 2010c. Vision 2020 Comprehensive Waterfront Plan.

New York City Department of Environmental Protection. YouTube page: https://www.youtube.com/user/nycwater.

New York City Department of Environmental Protection. Green Infrastructure Annual Reports. http://www.nyc.gov/dep/greeninfrastructure.

New York City Department of Environmental Protection. Long Term Control Plan Quarterly Progress Reports. http://www.nyc.gov/ html/dep/html/cso_long_term_control_plan/index.shtml.

New York City Department of Environmental Protection. Harbor Survey Monitoring Program. http://www.nyc.gov/html/dep/html/harborwater/harbor_water_sampling_results.shtml.

New York City Department of Environmental Protection. Sentinel Monitoring Program. http://www.nyc.gov/html/dep/html/wastewater/wwsystem-control.shtml.

New York City Department of Environmental Protection. NYCDEP Website. www.nyc.gov/dep.

New York City Department of Environmental Protection. NYCDEP LTCP Program Website. www.nyc.gov/dep/ltcp.

New York City Department of Environmental Protection. 1994. Inner Harbor CSO Facility Planning Project. Facilities Planning Report: prepared for NYCDEP by Hazen and Sawyer, P.C. and HydroQual Environmental Engineers and Scientists, P.C.

New York City Department of Environmental Protection. 2005. Combined Sewer Overflow (CSO) Order on Consent (DEC Case No. CO2-20000107-8).

New York City Department of Environmental Protection, 2007. The City of New York PlaNYC 2030: A Greener, Greater New York Report. http://www.nyc.gov/html/planyc/downloads/pdf/publications/full_report_2007.pdf.

New York City Department of Environmental Protection. 2009. CSO Pilot Monitoring Program. http://www.nyc.gov/html/dep/html/press_releases/12-12pr.shtml#.V3RdkU0UXcs.

New York City Department of Environmental Protection. Combined Sewer Overflow Best Management Practices (BMP): Annual Reports. https://www1.nyc.gov/html/dep/water/combined-sewer-overfows.page.

New York City Department of Environmental Protection. 2010. NYC Green Infrastructure Program. http://www.nyc.gov/html/dep/html/stormwater/using_green_infra_to_manage_stormwater.shtml.

New York City Department of Environmental Protection. 2010b. NYC Green Infrastructure Plan, A Sustainable Strategy for Clean Waterways. September 2010.

New York City Department of Environmental Protection, 2011. Water for the Future. http://www.nyc.gov/html/waterforthefuture/index.shtml.

New York City Department of Environmental Protection. 2011. Green Infrastructure Grant Program. http://www.nyc.gov/html/dep/html/stormwater/nyc_green_infrastructure_grant_program.shtml.

New York City Department of Environmental Protection. 2012. Public Participation Plan. http://www.nyc.gov/html/dep/pdf/cso_long_term_control_plan/ltcp_public_participation_plan.pdf.

New York City Department of Environmental Protection. 2012. Combined Sewer Overflow (CSO) Order on Consent (DEC Case No. CO2-20110512-25). March 8 2012. http://www.dec.ny.gov/docs/water_pdf/csosum2012.pdf.

New York City Department of Environmental Protection. 2012 Long Term Control Plan (LTCP) Program. http://www.nyc.gov/dep/ltcp.

New York City Department of Environmental Protection. 2012a. InfoWorks Citywide Model Recalibration Report. June 2012.

New York City Department of Environmental Protection. 2012b. Citywide Hydraulic Analysis Report. December 2012.

New York City Department of Environmental Protection. 2012. NYC Green Infrastructure Plan: 2012 Green Infrastructure Pilot Monitoring Report.

New York City Department of Environmental Protection in consultation with the New York City Department of Buildings. 2012d. Guidelines for the Design and Construction of Stormwater Management Systems. http://www.nyc.gov/html/dep/pdf/green_infrastructure/stormwater_guidelines_2012_final.pdf.

New York City Department of Environmental Protection. 2013.NYC Wastewater Resiliency Plan Climate Risk Assessment and Adaptation Study. http://www.nyc.gov/html/dep/html/about_dep/wastewater_resiliency_plan.shtml.

New York City Department of Environmental Protection. 2014. Post-Construction Compliance Monitoring Green Infrastructure Neighborhood Demonstration Areas. August 2014, Resubmitted January 2015.

New York City Department of Environmental Protection. 2014. Combined Sewer Overflow Long Term Control Plan for Alley Creek and Little Neck Bay.

New York City Department of Environmental Protection. 2014. Combined Sewer Overflow Long Term Control Plan for Westchester Creek.

New York City Department of Environmental Protection. 2014. Combined Sewer Overflow Long Term Control Plan for Hutchison River.

New York City Department of Environmental Protection. 2014. Combined Sewer Overflow Long Term Control Plan for Flushing Creek.

New York City Department of Environmental Protection. 2015. Combined Sewer Overflow Long Term Control Plan for Bronx River.

New York City Department of Environmental Protection. 2015. Combined Sewer Overflow Long Term Control Plan for Gowanus Canal.

New York City Department of Environmental Protection. 2015. Municipal Separate Storm Sewer Systems “MS4” Permit. http://www.nyc.gov/html/dep/pdf/water_sewer/spdes-ms4-permit.pdf.

New York City Department of Environmental Protection. 2015. One New York: The Plan for a Strong and Just City (OneNYC). http://www1.nyc.gov/html/onenyc/index.html.

New York City Department of Finance, 2015. NYC Property Tax Annual Report. https://www1.nyc.gov/site/finance/taxes/property-reports/property-reports-annual-property-tax.page.

New York City Department of Environmental Protection. 2016. Regulator(s) with CSO Monitoring Equipment Identification Program Report. February 1, 2016.

New York City Department of Environmental Protection. 2016. Combined Sewer Overflow Long Term Control Plan for Coney Island Creek.

New York City Department of Environmental Protection. 2016. Combined Sewer Overflow Long Term Control Plan for Flushing Bay.

New York City Department of Environmental Protection. 2017. Combined Sewer Overflow Long Term Control Plan for Newtown Creek.

New York City Department of Environmental Protection. 2018. Combined Sewer Overflow Long Term Control Plan for Jamaica Bay and Tributaries.

New York City Department of Environmental Protection. FY2020 Revenue Plan. http://www1.nyc.gov/assets/ omb/ downloads/pdf/erc4-19.pdf.

New York City Department of Environmental Protection. 2019. OneNYC 2050. http://onenyc.cityofnewyork.us/.

New York State Environmental Conservation Law. http://www.dec.ny.gov/regulations/regulations.html.

New York State Department of Environmental Conservation. National Pollutant Discharge Elimination System (NPDES). https://www.epa.gov/npdes.

New York State Department of Environmental Conservation. 2010. 2010 CSO BMP Order on Consent.

New York State Department of Environmental Conservation. 2010. State Pollution Discharge Elimination System Discharge Permit (SPDES): NY0026191. November 2010 http://www.dec.ny.gov/docs/permits_ ej_operations_pdf/huntsptspdes.pdf.

New York State Department of Environmental Conservation. Wet Weather Operating Practices for POTWs with Combined Sewers. http://www.dec.ny.gov/chemical/48980.html.

New York State Department of Environmental Conservation. 2012. 2012 Section 303(d) List of Impaired Waters Requiring a TMDL/Other Strategy. Revised February 2013. http://www.dec.ny.gov/docs/ water_pdf/303dlistfinal12.pdf.

New York State Department of Environmental Conservation. 2014. 2014 CSO BMP Order on Consent. http://www.dec.ny.gov/docs/water_pdf/csobmp2014.pdf.

New York State Department of Health. 2000. New York State Sanitary Code, Section 6-2.15-Bathing Beach Design Standards.

R. Raucher, J. Clements, E. Rothstein, G.R. Group, J. Mastracchio, Z. Green. 2019 Developing a New Framework for Household Affordability and Financial Capability Assessment in the Water Sector The American Water Works Association (2019)

Nicholas K. Coch, Meagan Lenna, Aislinn Deely. 2017. School of Earth and Environmental Sciences, Queens College, City University of New York, Flushing. 2017. Anthropogenic Land Changes and Sedimentation Response in the Tidal Straits of New York City.

U.S. Census Bureau 2014. http://www.census.gov/population/projections/data/national/2014.html.

U.S. Congress. 1972. Clean Water Act. http://cfpub.epa.gov/npdes/cwa.cfm?program_id=45**.**

U.S. Congress. 1974. Safe Drinking Water Act. Amended 1996. https://www.epa.gov/environmental-topics/water-topics.

U.S. Environmental Protection Agency. 1994. Combined Sewer Overflow (CSO) Control Policy. EPA 830-B-94-001. April 1994.

U.S Environmental Protection Agency. 1995. Combined Sewer Overflows: Guidance for Nine Minimum Controls. 1995. http://www.epa.gov/npdes/pubs/owm0030.pdf.

U.S. Environmental Protection Agency. 1995a. Combined Sewer Overflows - Guidance for Long-Term Control Plan. EPA 832-B-95-002. September 1995.

U.S. Environmental Protection Agency. 1995b. Combined Sewer Overflows - Guidance for Permit Writers. EPA 832-B-95-008. September 1995.

U.S Environmental Protection Agency. 1997. Combined Sewer Overflows-Guidance for Financial Capability Assessment and Schedule Development.

U.S. Environmental Protection Agency. 2000. Beaches Environmental Assessment and Coastal Health (BEACH) Act of 2000.

U.S. Environmental Protection Agency. 2001. Guidance: Coordinating CSO Long-Term Planning With Water Quality Standards Reviews. EPA-833-R-01-002, July 31, 2001.

U.S. Environmental Protection Agency, 2007. Filtration Avoidance Determinations. http://www.epa.gov/region02/water/nycshed/filtad.htm

U.S Environmental Protection Agency. 2012. Integrated Municipal Stormwater and Wastewater Planning Approach Framework. June 5, 2012. http://www.wefnet.org/CleanWaterActIPF/Integrated%20Planning%20%20Framework%20(06.05.12).pdf

U.S Environmental Protection Agency. 2012. 2012 Recreational Water Quality Criteria (RWQC). http://water.epa. gov/scitech/swguidance/standards/criteria/health/recreation/upload/factsheet2012.pdf.

U.S. Environmental Protection Agency, 2014. Financial Capability Assessment Framework. http://www.epa.gov.

U.S Environmental Protection Agency. 2014. Greening CSO Plans: Planning and Modeling Green Infrastructure for Combined Sewer Overflow (CSO) Control. March 2014.

Vogel, 2005. Letter from Leigh Vogel (NYCDEP) to Gary Kline (NYSDEC), DEC Region 2 Natural Resources' Response to Request for Input Regarding Sensitive Areas Identified in the NYC Long-Term CSO Control Plan. New York, June 17, 2005.

Washington D.C., District Department of the Environment. 2015. 2014 DC MS4 Annual Report. http://doee.dc.gov/sites/default/files/dc/sites/ddoe/publication/attachments/2014%20Annual%20Report%20Final.pdf.

11.0 GLOSSARY

1.5xDDWF:	One and One-half Times Design Dry Weather Flow
2xDDWF:	Two Times Design Dry Weather Flow
AACE:	Association for the Advancement of Cost Engineering
AAOV:	Annual Average Overflow Volumes
AK:	Arthur Kill
AMP:	Asset Management Plan
AR:	Affordability Ratio
AWRRF:	Auxiliary Wastewater Resource Recovery Facility
AWWA:	American Water Works Association
BCEQ:	Bronx Council for Environmental Quality
BEACH:	Beaches Environmental Assessment and Coastal Health
BGY:	Billion Gallons per Year
BMP:	Best Management Practice
BNR:	Biological Nutrient Removal
BOD:	Biochemical Oxygen Demand
BODR:	Basis of Design Report
BYO:	Bring Your Own
CEG:	Cost Effective Grey
CIP:	Capital Improvement Plan
COLI:	Cost of Living Index
CPK:	Central Park
CREC:	Center for Regional Economic Competitiveness
CSO:	Combined Sewer Overflow
CSS:	Combined Sewer System

CWA:	Clean Water Act
DCIA:	Directly Connected Impervious Areas
DCP:	New York City Department of City Planning
DDC:	New York City Department of Design and Construction
DDWF:	Design Dry Weather Flow
DEC:	New York State Department of Environmental Conservation
DEP:	New York City Department of Environmental Protection
DMA:	Douglaston Manor Association
DO:	Dissolved Oxygen
DOF:	New York City Department of Finance
DOHMH:	New York City Department of Health and Mental Hygiene
DOT:	New York City Department of Transportation
DPR:	New York City Department of Parks & Recreation
DSNY:	New York City Department of Sanitation
EDC:	New York City Economic Development Corporation
EO:	Executive Order
EPA:	United States Environmental Protection Agency
ER:	East River
ESMIA:	Ecologically Sensitive Maritime and Industrial Area
EWR:	Newark Liberty International Airport
FAD:	Filtration Avoidance Determination
FANCJ:	First Amended Nitrogen Consent Judgement
FCI:	Financial Capability Indicators
FMPV:	Full Market Property Value
FPL:	Federal Poverty Level
FS:	Feasibility Study

FT:	Abbreviation for “Feet”
FY:	Fiscal Year
GHG:	Greenhouse Gases
GI:	Green Infrastructure
GIS:	Geographical Information System
GM:	Geometric Mean
G.O.:	General Obligation
GoFB:	Guardians of Flushing Bay
GRTA:	NYC Green Roof Tax Abatement
HBI:	Household Burden Indicator
HEAP:	Home Energy Assistance Program
HGL:	Hydraulic Grade Line
HH:	Household
HLI:	High Level Interceptor
HLSS:	High Level Storm Sewers
HSM:	Harbor Survey Monitoring Program
HVAC:	Heating, Ventilation and Air Conditioning
IEC:	Interstate Environmental Commission
in.:	Abbreviation for “Inches”.
in/hr:	Inches per hour
IW:	InfoWorks CS™
JEM:	Jamaica Eutrophication Model
JFK:	John F. Kennedy International Airport
KOTC:	Knee-of-the-Curve
KVK:	Kill Van Kull
lbs/day	pounds per day

LF:	linear feet
LGA:	LaGuardia Airport
LIRR:	Long Island Rail Road
LIS:	Long Island Sound
LLI:	Low Level Interceptor
LQI:	Lowest Quintile of Income
LT2:	Long Term 2
LTCP:	Long Term Control Plan
LTCPRM:	Long Term Control Plan Regional Model
MCP:	Multifamily Conservation Program
MEG:	Model Evaluation Groups
mg/L:	milligrams per liter
MG:	Million Gallons
MGD:	Million Gallons Per Day
MGY:	Million Gallons Per Year
MHI:	Median Household Income
MIH:	Mandatory Inclusionary Housing
MMP:	Mercury Minimization Program
MOU:	Memorandum of Understanding
MPN:	Most Probable Number
MS4:	Municipal separate storm sewer systems
MSP:	Main Sewage Pump
MTA:	Metropolitan Transportation Authority
MWFA:	New York City Municipal Water Finance Authority
NCA:	Newtown Creek Alliance
ng/L:	Nanograms per Liter

NMC:	Nine Minimum Control
NOAA:	National Oceanic and Atmospheric Administration
NPDES:	National Pollutant Discharge Elimination System
NPW:	Net Present Worth
NWI:	National Wetlands Inventory
NYB:	New York Bay
NYC:	New York City
NYCHA:	New York City Housing Authority
NYCRR:	New York State Code of Rules and Regulations
NYNHP:	New York Natural Heritage Program
NYPD:	New York City Police Department
NYS:	New York State
NYSDOH:	New York State Department of Health
O&M:	Operation and Maintenance
PANYNJ:	Port Authority of New York and New Jersey
PATH:	Port Authority Trans-Hudson
PBC:	Probable Bid Cost
PCM:	Post-Construction Compliance Monitoring
PMAZ:	Priority Marine Activity Zones
POTW:	Publicly Owned Treatment Works
PPI:	Poverty Prevalence Indicator
PS:	Pump Station or Pumping Station
PVSC:	Passaic Valley Sewerage Commission
Q:	Symbol for Flow (designation when used in equations)
REC:	Recognized Ecological Complexes
RI:	Remedial Investigation

ROD:	Record of Decision
ROW:	Right-of-Way
RTC:	Real Time Control
RWQC:	Recreational Water Quality Criteria
S&P:	Standard and Poor
SAFE:	Solvents, Automotive, Flammables, and Electronics
SCADA:	Supervisory Control and Data Acquisition
SDWA:	Safe Drinking Water Act
sf:	square feet
SM:	Sentinel Monitoring
SMIA:	Significant Maritime and Industrial Areas
SNWA:	Significant Natural Waterfront Area
SOGR:	State of Good Repair
SPDES:	State Pollutant Discharge Elimination System
STEM:	Science, Technology, Engineering, and Mathematics
STV:	Statistical Threshold Value
SW:	Stormwater
SWEM:	System-Wide Eutrophication Model
S.W.I.M.:	Stormwater Infrastructure Matters Coalition
SWMP:	Stormwater Management Program
TBD:	To Be Determined
TBM:	Tunnel Boring Machine
TMDL:	Total Maximum Daily Load
TRC:	Total Residual Chlorine
UAA:	Use Attainability Analysis
ug/L:	Micrograms Per Liter

U.S.:	United States
USFWS:	U.S. Fish & Wildlife Service
UV:	Ultraviolet Light
VCPA:	Van Cortlandt Park Alliance
WDAP:	Water Debt Assistance Program
WQ:	Water Quality
WQBEL:	Water Quality Based Effluent Limitations
WQS:	Water Quality Standards
WRP:	Waterfront Revitalization Program
WRRF:	Wastewater Resource Recovery Facilities
WWFP:	Waterbody/Watershed Facility Plan
WWOP:	Wet Weather Operating Plan
WWTP:	Wastewater Treatment Plant

Appendix A: Supplemental Tables

Combined Sewer Outfalls - Volume		
Waterbody	**Outfall**	**Total Discharge (MG/Yr)**
East River and Open Waters	BB-002	13
East River and Open Waters	BB-003	53
East River and Open Waters	BB-005	732
East River and Open Waters	BB-016	2
East River and Open Waters	BB-017	2
East River and Open Waters	BB-018	1
East River and Open Waters	BB-021	21
East River and Open Waters	BB-022	1
East River and Open Waters	BB-023	16
East River and Open Waters	BB-024	32
East River and Open Waters	BB-025	10
East River and Open Waters	BB-027	5
East River and Open Waters	BB-028	317
East River and Open Waters	BB-029	90
East River and Open Waters	BB-030	25
East River and Open Waters	BB-031	3
East River and Open Waters	BB-032	2
East River and Open Waters	BB-033	6
East River and Open Waters	BB-034	186
East River and Open Waters	BB-035	4
East River and Open Waters	BB-036	8
East River and Open Waters	BB-037	1
East River and Open Waters	BB-041	85
East River and Open Waters	BB-045	0
East River and Open Waters	BB-046	7
East River and Open Waters	BB-047	2
East River and Open Waters	HP-002	48
East River and Open Waters	HP-003	138
East River and Open Waters	HP-011	665
East River and Open Waters	HP-017	39
East River and Open Waters	HP-018	3
East River and Open Waters	HP-019	15
East River and Open Waters	HP-020	84
East River and Open Waters	HP-021	202
East River and Open Waters	HP-022	29

Combined Sewer Outfalls - Volume		
Waterbody	**Outfall**	**Total Discharge (MG/Yr)**
East River and Open Waters	HP-025	96
East River and Open Waters	HP-026	49
East River and Open Waters	HP-029	3
East River and Open Waters	NC-003	0
East River and Open Waters	NC-004	18
East River and Open Waters	NC-005	50
East River and Open Waters	NC-006	113
East River and Open Waters	NC-007	9
East River and Open Waters	NC-008	23
East River and Open Waters	NC-010	0
East River and Open Waters	NC-011	0
East River and Open Waters	NC-012	16
East River and Open Waters	NC-013	98
East River and Open Waters	NC-014	727
East River and Open Waters	NC-016	3
East River and Open Waters	NC-017	1
East River and Open Waters	NC-018	12
East River and Open Waters	NC-020	8
East River and Open Waters	NC-024	0
East River and Open Waters	NC-025	1
East River and Open Waters	NC-026	0
East River and Open Waters	NC-027	19
East River and Open Waters	NC-028	0
East River and Open Waters	NC-030	0
East River and Open Waters	NC-031	4
East River and Open Waters	NC-032	6
East River and Open Waters	NC-033	0
East River and Open Waters	NC-034	2
East River and Open Waters	NC-035	4
East River and Open Waters	NC-036	80
East River and Open Waters	NC-037	1
East River and Open Waters	NC-038	10
East River and Open Waters	NC-039	1
East River and Open Waters	NC-040	0
East River and Open Waters	NC-041	29
East River and Open Waters	NC-042	2
East River and Open Waters	NC-043	4

Combined Sewer Outfalls - Volume		
Waterbody	**Outfall**	**Total Discharge (MG/Yr)**
East River and Open Waters	NC-044	0
East River and Open Waters	NC-045	22
East River and Open Waters	NC-046	3
East River and Open Waters	NC-047	2
East River and Open Waters	NC-048	5
East River and Open Waters	NC-049	18
East River and Open Waters	NC-050	35
East River and Open Waters	NC-051	1
East River and Open Waters	NC-052	24
East River and Open Waters	NC-053	10
East River and Open Waters	NC-054	3
East River and Open Waters	NC-055	1
East River and Open Waters	NC-056	22
East River and Open Waters	NC-057	4
East River and Open Waters	NC-058	16
East River and Open Waters	NC-059	8
East River and Open Waters	NC-060	1
East River and Open Waters	NC-061	3
East River and Open Waters	NC-062	13
East River and Open Waters	NC-063	16
East River and Open Waters	NC-064	10
East River and Open Waters	NC-065	0
East River and Open Waters	NC-066	5
East River and Open Waters	NC-067	7
East River and Open Waters	NC-068	0
East River and Open Waters	NC-069	9
East River and Open Waters	NC-078	1
East River and Open Waters	NC-082	1
East River and Open Waters	NC-087	5
East River and Open Waters	RH-002	0
East River and Open Waters	RH-003	1
East River and Open Waters	RH-005	134
East River and Open Waters	RH-006	8
East River and Open Waters	RH-007	1
East River and Open Waters	RH-008	3
East River and Open Waters	RH-009	3
East River and Open Waters	RH-010	0

Combined Sewer Outfalls - Volume		
Waterbody	**Outfall**	**Total Discharge (MG/Yr)**
East River and Open Waters	RH-011	5
East River and Open Waters	RH-012	10
East River and Open Waters	RH-013	0
East River and Open Waters	RH-040	24
East River and Open Waters	TI-003	71
East River and Open Waters	TI-004	4
East River and Open Waters	TI-005	0
East River and Open Waters	TI-019	0
East River and Open Waters	TI-020	0
East River and Open Waters	TI-023	138
East River and Open Waters	WI-002	6
East River and Open Waters	WI-003	90
East River and Open Waters	WI-004	6
East River and Open Waters	WI-005	4
East River and Open Waters	WI-006	5
East River and Open Waters	WI-007	4
East River and Open Waters	WI-008	115
East River and Open Waters	WI-009	0
East River and Open Waters	WI-010	0
East River and Open Waters	WI-011	3
East River and Open Waters	WI-012	8
East River and Open Waters	WI-013	0
East River and Open Waters	WI-014	0
East River and Open Waters	WI-015	1
East River and Open Waters	WI-016	13
East River and Open Waters	WI-017	2
East River and Open Waters	WI-070	9
East River and Open Waters	WI-071	13
East River and Open Waters	WI-072	32
Harlem River	NR-007	1
Harlem River	NR-008	19
Harlem River	NR-009	2
Harlem River	NR-010	9
Harlem River	NR-011	1
Harlem River	NR-012	1
Harlem River	NR-013	0
Harlem River	NR-014	1

Combined Sewer Outfalls - Volume		
Waterbody	**Outfall**	**Total Discharge (MG/Yr)**
Harlem River	NR-016	1
Harlem River	NR-017	26
Harlem River	NR-018	0
Harlem River	NR-045	12
Harlem River	NR-055	1
Harlem River	WI-018	0
Harlem River	WI-019	0
Harlem River	WI-020	0
Harlem River	WI-021	0
Harlem River	WI-022	0
Harlem River	WI-023	23
Harlem River	WI-024	10
Harlem River	WI-025	24
Harlem River	WI-026	0
Harlem River	WI-027	0
Harlem River	WI-028	0
Harlem River	WI-029	1
Harlem River	WI-030	0
Harlem River	WI-031	1
Harlem River	WI-032	0
Harlem River	WI-033	1
Harlem River	WI-034	0
Harlem River	WI-035	3
Harlem River	WI-036	1
Harlem River	WI-037	2
Harlem River	WI-038	11
Harlem River	WI-039	1
Harlem River	WI-040	1
Harlem River	WI-041	4
Harlem River	WI-042	0
Harlem River	WI-043	0
Harlem River	WI-044	2
Harlem River	WI-045	34
Harlem River	WI-046	123
Harlem River	WI-047	18
Harlem River	WI-048	11
Harlem River	WI-050	16

Combined Sewer Outfalls - Volume		
Waterbody	**Outfall**	**Total Discharge (MG/Yr)**
Harlem River	WI-051	22
Harlem River	WI-052	45
Harlem River	WI-056	582
Harlem River	WI-057	124
Harlem River	WI-058	31
Harlem River	WI-059	7
Harlem River	WI-060	285
Harlem River	WI-061	4
Harlem River	WI-062	147
Harlem River	WI-063	5
Harlem River	WI-064	17
Harlem River	WI-065	0
Harlem River	WI-066	1
Harlem River	WI-067	6
Harlem River	WI-068	17
Harlem River	WI-069	0
Harlem River	WI-073	0
Harlem River	WI-075	68
Harlem River	WI-076	58
Harlem River	WI-077	81
Harlem River	WI-078	34
Hudson River	NC-070	8
Hudson River	NC-071	8
Hudson River	NC-072	9
Hudson River	NC-073	29
Hudson River	NC-074	11
Hudson River	NC-075	78
Hudson River	NC-076	225
Hudson River	NC-080	1
Hudson River	NC-081	0
Hudson River	NR-002	1
Hudson River	NR-003	4
Hudson River	NR-004	5
Hudson River	NR-005	0
Hudson River	NR-006	36
Hudson River	NR-019	4
Hudson River	NR-020	12

Combined Sewer Outfalls - Volume		
Waterbody	**Outfall**	**Total Discharge (MG/Yr)**
Hudson River	NR-021	4
Hudson River	NR-022	7
Hudson River	NR-023	20
Hudson River	NR-024	9
Hudson River	NR-025	8
Hudson River	NR-026	14
Hudson River	NR-027	70
Hudson River	NR-028	3
Hudson River	NR-029	4
Hudson River	NR-030	5
Hudson River	NR-031	2
Hudson River	NR-032	1
Hudson River	NR-033	19
Hudson River	NR-034	5
Hudson River	NR-035	6
Hudson River	NR-036	10
Hudson River	NR-037	1
Hudson River	NR-038	6
Hudson River	NR-039	0
Hudson River	NR-040	45
Hudson River	NR-041	1
Hudson River	NR-042	2
Hudson River	NR-043	45
Hudson River	NR-044	1
Hudson River	NR-046	7
Hudson River	NR-047	0
Hudson River	NR-048	0
Hudson River	NR-049	8
Hudson River	NR-050	0
Hudson River	NR-052	0
Hudson River	NR-056	4
Hudson River	WI-053	46
Hudson River	WI-054	32
Hudson River	WI-055	20
Hudson River	WI-079	0
Kill Van Kull	PR-002	0
Kill Van Kull	PR-003	0

Combined Sewer Outfalls - Volume		
Waterbody	**Outfall**	**Total Discharge (MG/Yr)**
Kill Van Kull	PR-004	0
Kill Van Kull	PR-005	0
Kill Van Kull	PR-006	6
Kill Van Kull	PR-007	0
Kill Van Kull	PR-008	0
Kill Van Kull	PR-009	0
Kill Van Kull	PR-024	0
Kill Van Kull	PR-025	0
Kill Van Kull	PR-026	1
Kill Van Kull	PR-027	2
Kill Van Kull	PR-028	15
Kill Van Kull	PR-029	146
Kill Van Kull	PR-033	0
Kill Van Kull	PR-034	0
Kill Van Kull	PR-035	0
Kill Van Kull	PR-036	0
Kill Van Kull	PR-037	3
New York Bay	OH-002	407
New York Bay	OH-003	374
New York Bay	OH-004	9
New York Bay	OH-015	1105
New York Bay	OH-017	449
New York Bay	OH-018	121
New York Bay	OH-019	23
New York Bay	OH-020	1
New York Bay	OH-022	0
New York Bay	OH-025	0
New York Bay	PR-010	1
New York Bay	PR-011	0
New York Bay	PR-013	41
New York Bay	PR-014	28
New York Bay	PR-015	2
New York Bay	PR-016	2
New York Bay	PR-017	13
New York Bay	PR-018	3
New York Bay	PR-019	67
New York Bay	PR-020	25

Combined Sewer Outfalls - Volume		
Waterbody	**Outfall**	**Total Discharge (MG/Yr)**
New York Bay	PR-021	7
New York Bay	PR-023A	42
New York Bay	PR-030	9
New York Bay	PR-031	183
New York Bay	PR-032	7
New York Bay	RH-014	33
New York Bay	RH-016	34
New York Bay	RH-018	10
New York Bay	RH-019	15
New York Bay	RH-020	1
New York Bay	RH-021	3
New York Bay	RH-022	4
New York Bay	RH-023	4
New York Bay	RH-024	4
New York Bay	RH-025	6
New York Bay	RH-028	28
New York Bay	RH-029	2
	Total CSO	**11,164**

MS-4 Outfalls - Volumes		
Waterbody	**Outfall**	**Total Discharge, (MG/Yr)**
Arthur Kill	PR-612	590
Arthur Kill	PR-621_ms4	278
East River and Open Waters	BB-603	2
East River and Open Waters	BB-606	5
East River and Open Waters	BB-607	2
East River and Open Waters	HP-631	35
East River and Open Waters	RH-1204	11
East River and Open Waters	TI-609_BWSO	9
East River and Open Waters	TI-610_BWSO	33
East River and Open Waters	TI-615_BWSO	26
East River and Open Waters	TI-616_BWSO	4
East River and Open Waters	TI-617_BWSO	4
East River and Open Waters	TI-618_BWSO	18
East River and Open Waters	TI-619_BWSO	2
East River and Open Waters	TI-634_BWSO	16
East River and Open Waters	TI-646_BWSO	5
East River and Open Waters	TI-661_BWSO	22
East River and Open Waters	TI-665	0
East River and Open Waters	TI-666_BWSO	18
East River and Open Waters	TI-671_BWSO	3
East River and Open Waters	TI-674_BWSO	3
East River and Open Waters	TI-675_BWSO	72
East River and Open Waters	TI-676_BWSO	8
East River and Open Waters	TI-1208_BWSO	14
Kill Van Kull	PR-603	29
Kill Van Kull	PR-613	365
New York Bay	CI-603	33
New York Bay	CI-604	2
New York Bay	CI-605_CI-659	291
New York Bay	CI-605_CI-666	25
New York Bay	CI-607	1
New York Bay	CI-608	2
New York Bay	CI-609	1
New York Bay	CI-610	359
New York Bay	CI-654	45
New York Bay	CI-655	94
New York Bay	CI-656	0

MS-4 Outfalls - Volumes		
Waterbody	**Outfall**	**Total Discharge, (MG/Yr)**
New York Bay	CI-657	19
New York Bay	CI-662	40
New York Bay	CI-663	42
New York Bay	CI-668	13
New York Bay	CI-669	13
New York Bay	CI-670	12
New York Bay	CI-671	10
New York Bay	CI-672	8
New York Bay	CI-673	6
New York Bay	CI-674	15
New York Bay	CI-677	357
New York Bay	CI-678	16
New York Bay	CI-682	2
	Total MS-4	**2,979**

Stormwater Outfalls - Volumes		
Waterbody	**Waterbody**	**Waterbody**
Arthur Kill	OB-351	335
Arthur Kill	OB-359	155
Arthur Kill	OB-362	70
Arthur Kill	OB-364	112
Arthur Kill	OB-366	436
Arthur Kill	OB-367	134
Arthur Kill	OB-368	79
Arthur Kill	OB-372	454
Arthur Kill	PR-149	422
Arthur Kill	PR-503	66
Arthur Kill	PR-621_sw	53
East River and Open Waters	BB--61	24
East River and Open Waters	HP--37	25
East River and Open Waters	HP--40	15
East River and Open Waters	HP--42	24
East River and Open Waters	HP--43	14
East River and Open Waters	HP--44	34
East River and Open Waters	HP-506	47
East River and Open Waters	HP-507	8
East River and Open Waters	HP-623	27
East River and Open Waters	HP-630	85
East River and Open Waters	HP-633	15
East River and Open Waters	HP-643	13
East River and Open Waters	HP-644	38
East River and Open Waters	HP--66	23
East River and Open Waters	NC-004M	5
East River and Open Waters	NC-005M	5
East River and Open Waters	RH-614	72
East River and Open Waters	TI--60	11
East River and Open Waters	TI--61_sw	6
East River and Open Waters	TI-610_sw	17
East River and Open Waters	TI-611	83
East River and Open Waters	TI-615	1
East River and Open Waters	TI-619	5
East River and Open Waters	TI-621_sw	49
East River and Open Waters	TI-634	5
East River and Open Waters	TI-649_sw	5

Stormwater Outfalls - Volumes		
Waterbody	**Waterbody**	**Waterbody**
East River and Open Waters	TI-662_sw	2
East River and Open Waters	TI--68_sw	6
East River and Open Waters	TI--69_sw	5
East River and Open Waters	TI--70	13
East River and Open Waters	WI-821	6
Hudson River	NR--79	20
Kill Van Kull	OB-373	964
Kill Van Kull	PR-133	25
Kill Van Kull	PR-134	1
Kill Van Kull	PR-135	154
Kill Van Kull	PR-137	37
Kill Van Kull	PR-140	16
Kill Van Kull	PR-141	36
Kill Van Kull	PR-145	39
Kill Van Kull	PR-181	64
Kill Van Kull	PR-187	25
Kill Van Kull	PR-189	18
Kill Van Kull	PR-190	151
Kill Van Kull	OB-356	392
Kill Van Kull	OB-369	494
New York Bay	CI-446	1
New York Bay	CI-455	7
New York Bay	OB-352	726
New York Bay	OB-353	880
New York Bay	OB-354	572
New York Bay	OB-355	893
New York Bay	OB-358	233
New York Bay	OB-360	141
New York Bay	OB-361	154
New York Bay	OB-363	575
New York Bay	OB-365	128
New York Bay	OB-370	30
New York Bay	OB-371	529
New York Bay	OB-357	33
New York Bay	OH-015_OF	48
New York Bay	OH--64	15
New York Bay	OH--65	38

Stormwater Outfalls - Volumes		
Waterbody	**Waterbody**	**Waterbody**
New York Bay	OH--88	7
New York Bay	OH--89	14
New York Bay	OH-875	33
New York Bay	PR-104	5
New York Bay	PR-162	27
New York Bay	PR-180	3
	Total Stormwater	**10,528**

Direct Runoff Outfalls - Volumes		
Waterbody	**Outfall**	**Total Discharge, (MG/Yr)**
East River and Open Waters	BB--49	38
East River and Open Waters	BB--58	3
East River and Open Waters	BB--59	11
East River and Open Waters	BB--60	0
East River and Open Waters	BB--62	2
East River and Open Waters	BB--63	11
East River and Open Waters	BB--64	13
East River and Open Waters	BB--65	0
East River and Open Waters	BB--66	4
East River and Open Waters	BB--67	15
East River and Open Waters	BB--68	27
East River and Open Waters	BB--69	21
East River and Open Waters	BB--70	17
East River and Open Waters	BB--71	2
East River and Open Waters	BB--72	22
East River and Open Waters	BB--82	20
East River and Open Waters	BB--83	27
East River and Open Waters	BB--84	42
East River and Open Waters	BB--85	50
East River and Open Waters	BB--87	16
East River and Open Waters	BB--88	17
East River and Open Waters	BB--89	16
East River and Open Waters	BB-103	25
East River and Open Waters	BB-200	53
East River and Open Waters	BB-202	13
East River and Open Waters	BB-370	25
East River and Open Waters	BB-502	19
East River and Open Waters	BB-503	27
East River and Open Waters	BB-506	18
East River and Open Waters	BB-532	28
East River and Open Waters	BB-537	6
East River and Open Waters	HP--38	82
East River and Open Waters	HP--39	9
East River and Open Waters	HP--45	60
East River and Open Waters	HP--46	51
East River and Open Waters	HP--47	13
East River and Open Waters	HP--48	16

Direct Runoff Outfalls - Volumes		
Waterbody	**Outfall**	**Total Discharge, (MG/Yr)**
East River and Open Waters	HP--62	11
East River and Open Waters	HP--63	23
East River and Open Waters	HP--64	6
East River and Open Waters	HP--65	9
East River and Open Waters	HP--67	6
East River and Open Waters	HP--68	3
East River and Open Waters	HP--69	8
East River and Open Waters	HP--70	10
East River and Open Waters	HP--71	22
East River and Open Waters	HP--72	9
East River and Open Waters	HP--81	9
East River and Open Waters	HP--88	33
East River and Open Waters	HP--89	35
East River and Open Waters	HP--90	72
East River and Open Waters	HP--91	10
East River and Open Waters	HP--92	57
East River and Open Waters	HP--93	8
East River and Open Waters	HP--94	5
East River and Open Waters	HP--95	36
East River and Open Waters	HP-105	4
East River and Open Waters	HP-205	36
East River and Open Waters	HP-502	16
East River and Open Waters	HP-511	9
East River and Open Waters	HP-645	15
East River and Open Waters	NC--48	5
East River and Open Waters	NC--49	3
East River and Open Waters	NC--50	5
East River and Open Waters	NC--51	9
East River and Open Waters	NC--52	9
East River and Open Waters	NC--53	14
East River and Open Waters	NC--54	7
East River and Open Waters	NC--55	6
East River and Open Waters	NC--56	8
East River and Open Waters	NC--57	9
East River and Open Waters	NC--58	8
East River and Open Waters	NC--59	7
East River and Open Waters	NC--60	12

Direct Runoff Outfalls - Volumes		
Waterbody	**Outfall**	**Total Discharge, (MG/Yr)**
East River and Open Waters	NC--61	6
East River and Open Waters	NC--62	16
East River and Open Waters	NC--63	36
East River and Open Waters	NC--64	18
East River and Open Waters	NC--65	6
East River and Open Waters	NC--89	27
East River and Open Waters	NC--90	7
East River and Open Waters	NC--93	14
East River and Open Waters	NC--94	18
East River and Open Waters	NC--95	15
East River and Open Waters	RH--60	18
East River and Open Waters	RH--61	17
East River and Open Waters	RH-501	29
East River and Open Waters	RH-505	30
East River and Open Waters	RH-508	72
East River and Open Waters	RH-510	6
East River and Open Waters	RH-511	25
East River and Open Waters	RH-610	14
East River and Open Waters	RH-611	6
East River and Open Waters	TI--61_dd	2
East River and Open Waters	TI--62	3
East River and Open Waters	TI--63	6
East River and Open Waters	TI--67	1
East River and Open Waters	TI--68_dd	3
East River and Open Waters	TI--69_dd	14
East River and Open Waters	TI-501	2
East River and Open Waters	TI-505	4
East River and Open Waters	TI-516	8
East River and Open Waters	TI-545	32
East River and Open Waters	TI-551	7
East River and Open Waters	TI-561	3
East River and Open Waters	TI-562	23
East River and Open Waters	TI-567	1
East River and Open Waters	TI-609	8
East River and Open Waters	TI-610_dd	4
East River and Open Waters	TI-614	1
East River and Open Waters	TI-621_dd	6

Direct Runoff Outfalls - Volumes		
Waterbody	**Outfall**	**Total Discharge, (MG/Yr)**
East River and Open Waters	TI-649_dd	5
East River and Open Waters	TI-662_dd	1
East River and Open Waters	WI-102	6
East River and Open Waters	WI-105	19
East River and Open Waters	WI-184	54
East River and Open Waters	WI-977	137
Harlem River	NR--75	28
Harlem River	NR--76	7
Harlem River	NR--77	12
Harlem River	NR--78	32
Harlem River	WI-189	28
Harlem River	WI-207	137
Harlem River	WI-507	156
Harlem River	WI-609	1
Harlem River	WI-610	1
Harlem River	WI-614	14
Harlem River	WI-826	1
Harlem River	WI-832	5
Harlem River	WI-840	7
Harlem River	WI-870	32
Harlem River	WI-883	8
Harlem River	WI-887	1
Harlem River	WI-908	90
Hudson River	NC--85	42
Hudson River	NC--86	19
Hudson River	NC--87	44
Hudson River	NC--91	36
Hudson River	NC--92	16
Hudson River	NR--60	11
Hudson River	NR--61	17
Hudson River	NR--62	29
Hudson River	NR--63	67
Hudson River	NR--64	42
Hudson River	NR--65	35
Hudson River	NR--66	35
Hudson River	NR--67	41
Hudson River	NR--68	51

Direct Runoff Outfalls - Volumes		
Waterbody	**Outfall**	**Total Discharge, (MG/Yr)**
Hudson River	NR--69	23
Hudson River	NR--70	39
Hudson River	NR--71	16
Hudson River	NR--72	29
Hudson River	NR--73	36
Hudson River	NR--74	26
Hudson River	NR-501	21
Hudson River	WI-936	13
Hudson River	WI-950	7
Hudson River	WI-951	5
Hudson River	WI-982	14
Hudson River	WI-984	18
New York Bay	CI--61	38
New York Bay	CI--62	15
New York Bay	CI--63	15
New York Bay	CI--64	19
New York Bay	CI--65	3
New York Bay	CI--66	14
New York Bay	CI--68	36
New York Bay	CI--69	6
New York Bay	CI--70	6
New York Bay	CI--71	3
New York Bay	CI--72	5
New York Bay	CI--73	22
New York Bay	CI--74	7
New York Bay	CI--75	3
New York Bay	CI--76	7
New York Bay	CI--77	13
New York Bay	CI--78	31
New York Bay	CI--79	42
New York Bay	CI--80	85
New York Bay	CI-425	30
New York Bay	CI-428	23
New York Bay	CI-430	2
New York Bay	CI-431	21
New York Bay	CI-432	3
New York Bay	NC--88	13

Direct Runoff Outfalls - Volumes		
Waterbody	**Outfall**	**Total Discharge, (MG/Yr)**
New York Bay	OH--12	1
New York Bay	OH--61	16
New York Bay	OH--67	7
New York Bay	OH--75	21
New York Bay	OH--77	20
New York Bay	OH--78	52
New York Bay	OH--79	30
New York Bay	OH--80	21
New York Bay	OH--81	17
New York Bay	OH--82	17
New York Bay	OH--83	80
New York Bay	OH--84	48
New York Bay	OH--85	36
New York Bay	OH--86	9
New York Bay	OH--87	21
New York Bay	OH--90	7
New York Bay	OH-344	19
New York Bay	OH-415	7
New York Bay	OH-419	20
New York Bay	OH--U1	3
New York Bay	OH--U2	7
New York Bay	OH--U3	4
New York Bay	OH--U4	1
New York Bay	OH--U5	9
New York Bay	RH--62	21
New York Bay	RH--63	21
New York Bay	RH--64	25
New York Bay	RH--65	20
New York Bay	RH--66	30
New York Bay	RH--67	27
New York Bay	RH--71	10
	Total Direct Runoff	**4,484**

Airport/Transport Outfalls - Volumes		
Waterbody	**Outfall**	**Total Discharge, (MG/Yr)**
East River and Open Waters	BB-LG01	17
East River and Open Waters	BB-LG02	7
East River and Open Waters	BB-LG03	0
East River and Open Waters	BB-LG04	1
East River and Open Waters	BB-LG05	43
East River and Open Waters	BB-LG06	35
East River and Open Waters	BB-LG07	8
East River and Open Waters	BB-LG08	4
East River and Open Waters	BB-LG1A	0
East River and Open Waters	BB-LG5A	36
East River and Open Waters	BB-LG6A	3
East River and Open Waters	BB-LKD	35
	Total Airport/Transport	**189**

WRRF Discharges - Volumes		
Waterbody	**Outfall**	**Total Discharge (MG/Yr)**
Kill Van Kull	PRWPCP	10,600
East River and Open Waters	BBWPCP	46,844
East River and Open Waters	HPWPCP	45,889
East River and Open Waters	NCWPCP	92,034
East River and Open Waters	RHWPCP	12,329
East River and Open Waters	TIWPCP	24,289
East River and Open Waters	WIWPCP	76,199
Hudson River	NRWPCP	46,855
New York Bay	CIWPCP	32,216
New York Bay	OBWPCP	11,115
New York Bay	OHWPCP	35,417
	Total WRRF	**433,786**

Totals by Waterbody - Volumes		
Waterbody	**Outfall**	**Total Discharge (MG/Yr)**
Harlem River	NA	2,460
Hudson River	NA	48,437
East River and Open Waters	NA	306,068
New York Bay	NA	89,401
Arthur Kill	NA	3,183
Kill Van Kull	NA	13,581

Totals by Source - Volumes		
Source	**Outfall**	**Total Discharge (MG/Yr)**
Airport/Transport	NA	189
CSO	NA	11,164
Direct Runoff	NA	4,484
MS4	NA	2,979
Storm	NA	10,528
WRRF	NA	433,786

Totals by Source by Waterbody - Volumes		
Waterbody	**Source**	**Total Discharge (MG/Yr)**
Arthur Kill	CSO	0
	MS4	868
	Storm	2315
	Direct Runoff	0
	Airport/Transport	0
	WRRF	0
Total		3,183
East River and Open Waters	CSO	5,192
	MS4	312
	Storm	688
	Direct Runoff	2,103

Totals by Source by Waterbody - Volumes		
Waterbody	**Source**	**Total Discharge (MG/Yr)**
	Airport/Transport	189
	WRRF	297,584
Total		306,068
Harlem River	CSO	1,899
	MS4	0
	Storm	0
	Direct Runoff	561
	Airport/Transport	0
	WRRF	0
Total		2,460
Hudson River	CSO	833
	MS4	0
	Storm	20
	Direct Runoff	729
	Airport/Transport	0
	WRRF	46,855
Total		48,437
Kill Van Kull	CSO	173
	MS4	395
	Storm	2,414
	Direct Runoff	0
	Airport/Transport	0
	WRRF	10,600
Total		13,581
New York Bay	CSO	3,066
	MS4	1,404
	Storm	5,092
	Direct Runoff	1,091
	Airport/Transport	0
	WRRF	78,748
Total		89,401

Combined Sewer Outfalls – Fecal Coliform		
Waterbody	**Outfall**	**Total Load (10^{12} cfu/Yr)**
East River and Open Waters	BB-002	514
East River and Open Waters	BB-003	732
East River and Open Waters	BB-005	16,966
East River and Open Waters	BB-016	14
East River and Open Waters	BB-017	24
East River and Open Waters	BB-018	17
East River and Open Waters	BB-021	176
East River and Open Waters	BB-022	4
East River and Open Waters	BB-023	64
East River and Open Waters	BB-024	123
East River and Open Waters	BB-025	172
East River and Open Waters	BB-027	13
East River and Open Waters	BB-028	6,255
East River and Open Waters	BB-029	1,754
East River and Open Waters	BB-030	768
East River and Open Waters	BB-031	137
East River and Open Waters	BB-032	9
East River and Open Waters	BB-033	24
East River and Open Waters	BB-034	5,040
East River and Open Waters	BB-035	53
East River and Open Waters	BB-036	96
East River and Open Waters	BB-037	3
East River and Open Waters	BB-041	2,406
East River and Open Waters	BB-045	0
East River and Open Waters	BB-046	49
East River and Open Waters	BB-047	41
East River and Open Waters	HP-002	572
East River and Open Waters	HP-003	4,563
East River and Open Waters	HP-011	10,810
East River and Open Waters	HP-017	599
East River and Open Waters	HP-018	24
East River and Open Waters	HP-019	119
East River and Open Waters	HP-020	58
East River and Open Waters	HP-021	324
East River and Open Waters	HP-022	252
East River and Open Waters	HP-025	4,081
East River and Open Waters	HP-026	33

Combined Sewer Outfalls – Fecal Coliform		
Waterbody	**Outfall**	**Total Load (10^{12} cfu/Yr)**
East River and Open Waters	HP-029	2
East River and Open Waters	NC-003	1
East River and Open Waters	NC-004	157
East River and Open Waters	NC-005	2,341
East River and Open Waters	NC-006	1,871
East River and Open Waters	NC-007	39
East River and Open Waters	NC-008	284
East River and Open Waters	NC-010	0
East River and Open Waters	NC-011	0
East River and Open Waters	NC-012	175
East River and Open Waters	NC-013	2,214
East River and Open Waters	NC-014	22,508
East River and Open Waters	NC-016	80
East River and Open Waters	NC-017	5
East River and Open Waters	NC-018	241
East River and Open Waters	NC-020	209
East River and Open Waters	NC-024	0
East River and Open Waters	NC-025	4
East River and Open Waters	NC-026	4
East River and Open Waters	NC-027	172
East River and Open Waters	NC-028	0
East River and Open Waters	NC-030	0
East River and Open Waters	NC-031	136
East River and Open Waters	NC-032	121
East River and Open Waters	NC-033	6
East River and Open Waters	NC-034	59
East River and Open Waters	NC-035	233
East River and Open Waters	NC-036	1,923
East River and Open Waters	NC-037	2
East River and Open Waters	NC-038	374
East River and Open Waters	NC-039	46
East River and Open Waters	NC-040	4
East River and Open Waters	NC-041	1,439
East River and Open Waters	NC-042	24
East River and Open Waters	NC-043	92
East River and Open Waters	NC-044	5
East River and Open Waters	NC-045	802

Combined Sewer Outfalls – Fecal Coliform		
Waterbody	**Outfall**	**Total Load (10^{12} cfu/Yr)**
East River and Open Waters	NC-046	120
East River and Open Waters	NC-047	39
East River and Open Waters	NC-048	300
East River and Open Waters	NC-049	784
East River and Open Waters	NC-050	1,624
East River and Open Waters	NC-051	32
East River and Open Waters	NC-052	1,347
East River and Open Waters	NC-053	242
East River and Open Waters	NC-054	70
East River and Open Waters	NC-055	42
East River and Open Waters	NC-056	1,224
East River and Open Waters	NC-057	148
East River and Open Waters	NC-058	737
East River and Open Waters	NC-059	264
East River and Open Waters	NC-060	20
East River and Open Waters	NC-061	58
East River and Open Waters	NC-062	404
East River and Open Waters	NC-063	831
East River and Open Waters	NC-064	388
East River and Open Waters	NC-065	4
East River and Open Waters	NC-066	214
East River and Open Waters	NC-067	268
East River and Open Waters	NC-068	9
East River and Open Waters	NC-069	198
East River and Open Waters	NC-078	12
East River and Open Waters	NC-082	2
East River and Open Waters	NC-087	96
East River and Open Waters	RH-002	0
East River and Open Waters	RH-003	8
East River and Open Waters	RH-005	2,271
East River and Open Waters	RH-006	50
East River and Open Waters	RH-007	9
East River and Open Waters	RH-008	18
East River and Open Waters	RH-009	26
East River and Open Waters	RH-010	1
East River and Open Waters	RH-011	88
East River and Open Waters	RH-012	148

Combined Sewer Outfalls – Fecal Coliform		
Waterbody	**Outfall**	**Total Load (10^{12} cfu/Yr)**
East River and Open Waters	RH-013	1
East River and Open Waters	RH-040	17
East River and Open Waters	TI-003	1,238
East River and Open Waters	TI-004	17
East River and Open Waters	TI-005	1
East River and Open Waters	TI-019	0
East River and Open Waters	TI-020	0
East River and Open Waters	TI-023	1,594
East River and Open Waters	WI-002	232
East River and Open Waters	WI-003	2,966
East River and Open Waters	WI-004	200
East River and Open Waters	WI-005	121
East River and Open Waters	WI-006	143
East River and Open Waters	WI-007	104
East River and Open Waters	WI-008	3,258
East River and Open Waters	WI-009	0
East River and Open Waters	WI-010	0
East River and Open Waters	WI-011	63
East River and Open Waters	WI-012	142
East River and Open Waters	WI-013	2
East River and Open Waters	WI-014	0
East River and Open Waters	WI-015	15
East River and Open Waters	WI-016	342
East River and Open Waters	WI-017	40
East River and Open Waters	WI-070	17
East River and Open Waters	WI-071	147
East River and Open Waters	WI-072	449
Harlem River	NR-007	9
Harlem River	NR-008	162
Harlem River	NR-009	9
Harlem River	NR-010	75
Harlem River	NR-011	8
Harlem River	NR-012	8
Harlem River	NR-013	8
Harlem River	NR-014	21
Harlem River	NR-016	15
Harlem River	NR-017	710

Combined Sewer Outfalls – Fecal Coliform		
Waterbody	**Outfall**	**Total Load (10^{12} cfu/Yr)**
Harlem River	NR-018	0
Harlem River	NR-045	244
Harlem River	NR-055	3
Harlem River	WI-018	2
Harlem River	WI-019	0
Harlem River	WI-020	0
Harlem River	WI-021	0
Harlem River	WI-022	1
Harlem River	WI-023	835
Harlem River	WI-024	641
Harlem River	WI-025	127
Harlem River	WI-026	1
Harlem River	WI-027	0
Harlem River	WI-028	1
Harlem River	WI-029	8
Harlem River	WI-030	0
Harlem River	WI-031	6
Harlem River	WI-032	0
Harlem River	WI-033	9
Harlem River	WI-034	0
Harlem River	WI-035	23
Harlem River	WI-036	45
Harlem River	WI-037	15
Harlem River	WI-038	152
Harlem River	WI-039	20
Harlem River	WI-040	6
Harlem River	WI-041	100
Harlem River	WI-042	14
Harlem River	WI-043	2
Harlem River	WI-044	45
Harlem River	WI-045	712
Harlem River	WI-046	3,859
Harlem River	WI-047	594
Harlem River	WI-048	356
Harlem River	WI-050	899
Harlem River	WI-051	223
Harlem River	WI-052	1,262

Combined Sewer Outfalls – Fecal Coliform		
Waterbody	**Outfall**	**Total Load (10^{12} cfu/Yr)**
Harlem River	WI-056	46,803
Harlem River	WI-057	6,418
Harlem River	WI-058	992
Harlem River	WI-059	131
Harlem River	WI-060	9,863
Harlem River	WI-061	52
Harlem River	WI-062	2,822
Harlem River	WI-063	46
Harlem River	WI-064	336
Harlem River	WI-065	0
Harlem River	WI-066	1
Harlem River	WI-067	67
Harlem River	WI-068	602
Harlem River	WI-069	0
Harlem River	WI-073	1
Harlem River	WI-075	1,436
Harlem River	WI-076	2,052
Harlem River	WI-077	3,024
Harlem River	WI-078	1,718
Hudson River	NC-070	448
Hudson River	NC-071	248
Hudson River	NC-072	167
Hudson River	NC-073	1,136
Hudson River	NC-074	236
Hudson River	NC-075	1,643
Hudson River	NC-076	10,749
Hudson River	NC-080	3
Hudson River	NC-081	23
Hudson River	NR-002	9
Hudson River	NR-003	50
Hudson River	NR-004	41
Hudson River	NR-005	0
Hudson River	NR-006	640
Hudson River	NR-019	61
Hudson River	NR-020	197
Hudson River	NR-021	23
Hudson River	NR-022	87

Combined Sewer Outfalls – Fecal Coliform		
Waterbody	**Outfall**	**Total Load (10^{12} cfu/Yr)**
Hudson River	NR-023	445
Hudson River	NR-024	81
Hudson River	NR-025	144
Hudson River	NR-026	169
Hudson River	NR-027	1,813
Hudson River	NR-028	38
Hudson River	NR-029	14
Hudson River	NR-030	226
Hudson River	NR-031	16
Hudson River	NR-032	8
Hudson River	NR-033	346
Hudson River	NR-034	25
Hudson River	NR-035	77
Hudson River	NR-036	176
Hudson River	NR-037	6
Hudson River	NR-038	73
Hudson River	NR-039	0
Hudson River	NR-040	956
Hudson River	NR-041	18
Hudson River	NR-042	22
Hudson River	NR-043	1,779
Hudson River	NR-044	15
Hudson River	NR-046	88
Hudson River	NR-047	0
Hudson River	NR-048	17
Hudson River	NR-049	121
Hudson River	NR-050	0
Hudson River	NR-052	5
Hudson River	NR-056	23
Hudson River	WI-053	415
Hudson River	WI-054	245
Hudson River	WI-055	307
Hudson River	WI-079	0
Kill Van Kull	PR-002	0
Kill Van Kull	PR-003	0
Kill Van Kull	PR-004	0
Kill Van Kull	PR-005	0

Combined Sewer Outfalls – Fecal Coliform		
Waterbody	**Outfall**	**Total Load (10^{12} cfu/Yr)**
Kill Van Kull	PR-006	37
Kill Van Kull	PR-007	0
Kill Van Kull	PR-008	0
Kill Van Kull	PR-009	0
Kill Van Kull	PR-024	0
Kill Van Kull	PR-025	0
Kill Van Kull	PR-026	5
Kill Van Kull	PR-027	7
Kill Van Kull	PR-028	83
Kill Van Kull	PR-029	1,843
Kill Van Kull	PR-033	0
Kill Van Kull	PR-034	0
Kill Van Kull	PR-035	0
Kill Van Kull	PR-036	0
Kill Van Kull	PR-037	13
New York Bay	OH-002	3,917
New York Bay	OH-003	38,713
New York Bay	OH-004	124
New York Bay	OH-015	131,130
New York Bay	OH-017	92,494
New York Bay	OH-018	5,396
New York Bay	OH-019	883
New York Bay	OH-020	22
New York Bay	OH-022	0
New York Bay	OH-025	0
New York Bay	PR-010	3
New York Bay	PR-011	0
New York Bay	PR-013	272
New York Bay	PR-014	213
New York Bay	PR-015	7
New York Bay	PR-016	10
New York Bay	PR-017	165
New York Bay	PR-018	62
New York Bay	PR-019	564
New York Bay	PR-020	335
New York Bay	PR-021	79
New York Bay	PR-023A	27

Combined Sewer Outfalls – Fecal Coliform		
Waterbody	**Outfall**	**Total Load (10^{12} cfu/Yr)**
New York Bay	PR-030	79
New York Bay	PR-031	1,755
New York Bay	PR-032	55
New York Bay	RH-014	753
New York Bay	RH-016	592
New York Bay	RH-018	109
New York Bay	RH-019	158
New York Bay	RH-020	2
New York Bay	RH-021	23
New York Bay	RH-022	32
New York Bay	RH-023	39
New York Bay	RH-024	40
New York Bay	RH-025	61
New York Bay	RH-028	264
New York Bay	RH-029	5
	Total CSO	**507,055**

MS-4 Outfalls – Fecal Coliform		
Waterbody	**Outfall**	**Total Load (10^{12} cfu/Yr)**
Arthur Kill	PR-612	406
Arthur Kill	PR-621_ms4	192
East River and Open Waters	BB-603	2
East River and Open Waters	BB-606	3
East River and Open Waters	BB-607	2
East River and Open Waters	HP-631	24
East River and Open Waters	RH-1204	8
East River and Open Waters	TI-609_BWSO	6
East River and Open Waters	TI-610_BWSO	23
East River and Open Waters	TI-615_BWSO	18
East River and Open Waters	TI-616_BWSO	3
East River and Open Waters	TI-617_BWSO	3
East River and Open Waters	TI-618_BWSO	12
East River and Open Waters	TI-619_BWSO	2
East River and Open Waters	TI-634_BWSO	11
East River and Open Waters	TI-646_BWSO	3
East River and Open Waters	TI-661_BWSO	15
East River and Open Waters	TI-665	0
East River and Open Waters	TI-666_BWSO	12
East River and Open Waters	TI-671_BWSO	2
East River and Open Waters	TI-674_BWSO	2
East River and Open Waters	TI-675_BWSO	49
East River and Open Waters	TI-676_BWSO	6
East River and Open Waters	TI-1208_BWSO	10
Kill Van Kull	PR-603	20
Kill Van Kull	PR-613	252
New York Bay	CI-603	23
New York Bay	CI-604	2
New York Bay	CI-605_CI-659	200
New York Bay	CI-605_CI-666	18
New York Bay	CI-607	1
New York Bay	CI-608	1
New York Bay	CI-609	1
New York Bay	CI-610	247
New York Bay	CI-654	31
New York Bay	CI-655	65
New York Bay	CI-656	0

MS-4 Outfalls – Fecal Coliform		
Waterbody	**Outfall**	**Total Load (10^{12} cfu/Yr)**
New York Bay	CI-657	13
New York Bay	CI-662	28
New York Bay	CI-663	29
New York Bay	CI-668	9
New York Bay	CI-669	9
New York Bay	CI-670	8
New York Bay	CI-671	7
New York Bay	CI-672	6
New York Bay	CI-673	4
New York Bay	CI-674	10
New York Bay	CI-677	246
New York Bay	CI-678	11
New York Bay	CI-682	2
	Total MS-4	**2,056**

Stormwater Outfalls – Fecal Coliform		
Waterbody	**Outfall**	**Total Load (10^{12} cfu/Yr)**
Arthur Kill	OB-351	231
Arthur Kill	OB-359	107
Arthur Kill	OB-362	48
Arthur Kill	OB-364	77
Arthur Kill	OB-366	300
Arthur Kill	OB-367	92
Arthur Kill	OB-368	55
Arthur Kill	OB-372	313
Arthur Kill	PR-149	291
Arthur Kill	PR-503	46
Arthur Kill	PR-621_sw	37
East River and Open Waters	BB--61	16
East River and Open Waters	HP--37	17
East River and Open Waters	HP--40	10
East River and Open Waters	HP--42	16
East River and Open Waters	HP--43	10
East River and Open Waters	HP--44	24
East River and Open Waters	HP-506	33
East River and Open Waters	HP-507	6
East River and Open Waters	HP-623	19
East River and Open Waters	HP-630	58
East River and Open Waters	HP-633	10
East River and Open Waters	HP-643	9
East River and Open Waters	HP-644	26
East River and Open Waters	HP--66	16
East River and Open Waters	NC-004M	4
East River and Open Waters	NC-005M	4
East River and Open Waters	RH-614	50
East River and Open Waters	TI--60	8
East River and Open Waters	TI--61_sw	4
East River and Open Waters	TI-610_sw	12
East River and Open Waters	TI-611	57
East River and Open Waters	TI-615	1
East River and Open Waters	TI-619	4
East River and Open Waters	TI-621_sw	34
East River and Open Waters	TI-634	4
East River and Open Waters	TI-649_sw	4

Stormwater Outfalls – Fecal Coliform		
Waterbody	**Outfall**	**Total Load (10^{12} cfu/Yr)**
East River and Open Waters	TI-662_sw	2
East River and Open Waters	TI--68_sw	4
East River and Open Waters	TI--69_sw	4
East River and Open Waters	TI--70	9
East River and Open Waters	WI-821	4
Hudson River	NR--79	14
Kill Van Kull	OB-373	664
Kill Van Kull	PR-133	17
Kill Van Kull	PR-134	1
Kill Van Kull	PR-135	106
Kill Van Kull	PR-137	26
Kill Van Kull	PR-140	11
Kill Van Kull	PR-141	25
Kill Van Kull	PR-145	27
Kill Van Kull	PR-181	44
Kill Van Kull	PR-187	17
Kill Van Kull	PR-189	13
Kill Van Kull	PR-190	104
Kill Van Kull	OB-356	270
Kill Van Kull	OB-369	340
New York Bay	CI-446	1
New York Bay	CI-455	5
New York Bay	OB-352	500
New York Bay	OB-353	606
New York Bay	OB-354	394
New York Bay	OB-355	615
New York Bay	OB-358	161
New York Bay	OB-360	97
New York Bay	OB-361	106
New York Bay	OB-363	396
New York Bay	OB-365	88
New York Bay	OB-370	21
New York Bay	OB-371	365
New York Bay	OB-357	23
New York Bay	OH-015_OF	33
New York Bay	OH--64	10
New York Bay	OH--65	26

Stormwater Outfalls – Fecal Coliform		
Waterbody	**Outfall**	**Total Load (10^{12} cfu/Yr)**
New York Bay	OH--88	5
New York Bay	OH--89	10
New York Bay	OH-875	23
New York Bay	PR-104	3
New York Bay	PR-162	18
New York Bay	PR-180	2
	Total Stormwater	**7,260**

Direct Runoff Outfalls – Fecal Coliform		
Waterbody	**Outfall**	**Total Load (10^{12} cfu/Yr)**
East River and Open Waters	BB--49	6
East River and Open Waters	BB--58	1
East River and Open Waters	BB--59	2
East River and Open Waters	BB--60	0
East River and Open Waters	BB--62	0
East River and Open Waters	BB--63	2
East River and Open Waters	BB--64	2
East River and Open Waters	BB--65	0
East River and Open Waters	BB--66	1
East River and Open Waters	BB--67	2
East River and Open Waters	BB--68	4
East River and Open Waters	BB--69	3
East River and Open Waters	BB--70	3
East River and Open Waters	BB--71	0
East River and Open Waters	BB--72	3
East River and Open Waters	BB--82	3
East River and Open Waters	BB--83	4
East River and Open Waters	BB--84	6
East River and Open Waters	BB--85	8
East River and Open Waters	BB--87	2
East River and Open Waters	BB--88	3
East River and Open Waters	BB--89	2
East River and Open Waters	BB-103	4
East River and Open Waters	BB-200	8
East River and Open Waters	BB-202	2
East River and Open Waters	BB-370	4
East River and Open Waters	BB-502	3
East River and Open Waters	BB-503	4
East River and Open Waters	BB-506	3
East River and Open Waters	BB-532	4
East River and Open Waters	BB-537	1
East River and Open Waters	HP--38	12
East River and Open Waters	HP--39	1
East River and Open Waters	HP--45	9
East River and Open Waters	HP--46	8
East River and Open Waters	HP--47	2
East River and Open Waters	HP--48	3

Direct Runoff Outfalls – Fecal Coliform		
Waterbody	**Outfall**	**Total Load (10^{12} cfu/Yr)**
East River and Open Waters	HP--62	2
East River and Open Waters	HP--63	3
East River and Open Waters	HP--64	1
East River and Open Waters	HP--65	1
East River and Open Waters	HP--67	1
East River and Open Waters	HP--68	0
East River and Open Waters	HP--69	1
East River and Open Waters	HP--70	2
East River and Open Waters	HP--71	3
East River and Open Waters	HP--72	1
East River and Open Waters	HP--81	1
East River and Open Waters	HP--88	5
East River and Open Waters	HP--89	5
East River and Open Waters	HP--90	11
East River and Open Waters	HP--91	2
East River and Open Waters	HP--92	9
East River and Open Waters	HP--93	1
East River and Open Waters	HP--94	1
East River and Open Waters	HP--95	5
East River and Open Waters	HP-105	1
East River and Open Waters	HP-205	5
East River and Open Waters	HP-502	2
East River and Open Waters	HP-511	1
East River and Open Waters	HP-645	2
East River and Open Waters	NC--48	1
East River and Open Waters	NC--49	1
East River and Open Waters	NC--50	1
East River and Open Waters	NC--51	1
East River and Open Waters	NC--52	1
East River and Open Waters	NC--53	2
East River and Open Waters	NC--54	1
East River and Open Waters	NC--55	1
East River and Open Waters	NC--56	1
East River and Open Waters	NC--57	1
East River and Open Waters	NC--58	1
East River and Open Waters	NC--59	1
East River and Open Waters	NC--60	2

Direct Runoff Outfalls – Fecal Coliform		
Waterbody	**Outfall**	**Total Load (10^{12} cfu/Yr)**
East River and Open Waters	NC--61	1
East River and Open Waters	NC--62	2
East River and Open Waters	NC--63	5
East River and Open Waters	NC--64	3
East River and Open Waters	NC--65	1
East River and Open Waters	NC--89	4
East River and Open Waters	NC--90	1
East River and Open Waters	NC--93	10
East River and Open Waters	NC--94	13
East River and Open Waters	NC--95	10
East River and Open Waters	RH--60	3
East River and Open Waters	RH--61	3
East River and Open Waters	RH-501	4
East River and Open Waters	RH-505	5
East River and Open Waters	RH-508	11
East River and Open Waters	RH-510	1
East River and Open Waters	RH-511	4
East River and Open Waters	RH-610	2
East River and Open Waters	RH-611	1
East River and Open Waters	TI--61_dd	0
East River and Open Waters	TI--62	0
East River and Open Waters	TI--63	1
East River and Open Waters	TI--67	0
East River and Open Waters	TI--68_dd	0
East River and Open Waters	TI--69_dd	2
East River and Open Waters	TI-501	0
East River and Open Waters	TI-505	1
East River and Open Waters	TI-516	1
East River and Open Waters	TI-545	5
East River and Open Waters	TI-551	1
East River and Open Waters	TI-561	0
East River and Open Waters	TI-562	4
East River and Open Waters	TI-567	0
East River and Open Waters	TI-609	1
East River and Open Waters	TI-610_dd	1
East River and Open Waters	TI-614	0
East River and Open Waters	TI-621_dd	1

Direct Runoff Outfalls – Fecal Coliform		
Waterbody	**Outfall**	**Total Load (10^{12} cfu/Yr)**
East River and Open Waters	TI-649_dd	1
East River and Open Waters	TI-662_dd	0
East River and Open Waters	WI-102	1
East River and Open Waters	WI-105	3
East River and Open Waters	WI-184	8
East River and Open Waters	WI-977	21
Harlem River	NR--75	4
Harlem River	NR--76	1
Harlem River	NR--77	2
Harlem River	NR--78	5
Harlem River	WI-189	4
Harlem River	WI-207	21
Harlem River	WI-507	24
Harlem River	WI-609	0
Harlem River	WI-610	0
Harlem River	WI-614	2
Harlem River	WI-826	0
Harlem River	WI-832	1
Harlem River	WI-840	1
Harlem River	WI-870	5
Harlem River	WI-883	1
Harlem River	WI-887	0
Harlem River	WI-908	14
Hudson River	NC--85	6
Hudson River	NC--86	3
Hudson River	NC--87	7
Hudson River	NC--91	5
Hudson River	NC--92	2
Hudson River	NR--60	2
Hudson River	NR--61	3
Hudson River	NR--62	4
Hudson River	NR--63	10
Hudson River	NR--64	6
Hudson River	NR--65	5
Hudson River	NR--66	5
Hudson River	NR--67	6
Hudson River	NR--68	8

Direct Runoff Outfalls – Fecal Coliform		
Waterbody	**Outfall**	**Total Load (10^{12} cfu/Yr)**
Hudson River	NR--69	3
Hudson River	NR--70	6
Hudson River	NR--71	2
Hudson River	NR--72	4
Hudson River	NR--73	6
Hudson River	NR--74	4
Hudson River	NR-501	3
Hudson River	WI-936	2
Hudson River	WI-950	1
Hudson River	WI-951	1
Hudson River	WI-982	2
Hudson River	WI-984	3
New York Bay	CI--61	6
New York Bay	CI--62	2
New York Bay	CI--63	2
New York Bay	CI--64	3
New York Bay	CI--65	0
New York Bay	CI--66	2
New York Bay	CI--68	5
New York Bay	CI--69	1
New York Bay	CI--70	1
New York Bay	CI--71	1
New York Bay	CI--72	1
New York Bay	CI--73	3
New York Bay	CI--74	1
New York Bay	CI--75	1
New York Bay	CI--76	1
New York Bay	CI--77	2
New York Bay	CI--78	5
New York Bay	CI--79	6
New York Bay	CI--80	13
New York Bay	CI-425	21
New York Bay	CI-428	4
New York Bay	CI-430	2
New York Bay	CI-431	14
New York Bay	CI-432	2
New York Bay	NC--88	2

Direct Runoff Outfalls – Fecal Coliform		
Waterbody	**Outfall**	**Total Load (10^{12} cfu/Yr)**
New York Bay	OH--12	0
New York Bay	OH--61	2
New York Bay	OH--67	1
New York Bay	OH--75	3
New York Bay	OH--77	3
New York Bay	OH--78	8
New York Bay	OH--79	5
New York Bay	OH--80	3
New York Bay	OH--81	3
New York Bay	OH--82	3
New York Bay	OH--83	12
New York Bay	OH--84	7
New York Bay	OH--85	5
New York Bay	OH--86	1
New York Bay	OH--87	3
New York Bay	OH--90	1
New York Bay	OH-344	3
New York Bay	OH-415	1
New York Bay	OH-419	3
New York Bay	OH--U1	0
New York Bay	OH--U2	1
New York Bay	OH--U3	1
New York Bay	OH--U4	0
New York Bay	OH--U5	1
New York Bay	RH--62	3
New York Bay	RH--63	3
New York Bay	RH--64	4
New York Bay	RH--65	3
New York Bay	RH--66	5
New York Bay	RH--67	4
New York Bay	RH--71	2
	Total Direct Runoff	**740**

Airport/Transport Outfalls – Fecal Coliform		
Waterbody	**Outfall**	**Total Load (10^{12} cfu/Yr)**
East River and Open Waters	BB-LG01	13
East River and Open Waters	BB-LG02	5
East River and Open Waters	BB-LG03	1
East River and Open Waters	BB-LG04	1
East River and Open Waters	BB-LG05	33
East River and Open Waters	BB-LG06	26
East River and Open Waters	BB-LG07	6
East River and Open Waters	BB-LG08	3
East River and Open Waters	BB-LG1A	1
East River and Open Waters	BB-LG5A	27
East River and Open Waters	BB-LG6A	2
East River and Open Waters	BB-LKD	26
	Total Airport/Transport	**145**

WRRF Discharges – Fecal Coliform		
Waterbody	**Outfall**	**Total Load (10^{12} cfu/Yr)**
Kill Van Kull	PRWPCP	20
East River and Open Waters	BBWPCP	44
East River and Open Waters	HPWPCP	87
East River and Open Waters	NCWPCP	174
East River and Open Waters	RHWPCP	23
East River and Open Waters	TIWPCP	46
East River and Open Waters	WIWPCP	150
Hudson River	NRWPCP	89
New York Bay	CIWPCP	132
New York Bay	OBWPCP	21
New York Bay	OHWPCP	67
	Total WRRF	**853**

Totals by Waterbody		
Waterbody	**Outfall**	**Total Load (10^{12} cfu/Yr)**
Harlem River	NA	87,676
Hudson River	NA	23,639
East River and Open Waters	NA	117,372
New York Bay	NA	283,284
Arthur Kill	NA	2,194
Kill Van Kull	NA	3,944

Load Totals from Outside NYC by Waterbody		
Waterbody	**Source**	**Total Load (10^{12} cfu/Yr)**
Arthur Kill	Loads from Outside NYC	20,585
Hudson River	Loads from Outside NYC	49,242
Kill Van Kull	Loads from Outside NYC	6,145
Upper New York Bay	Loads from Outside NYC	4,688

Totals by Source		
Source	**Outfall**	**Total Load (10^{12} cfu/Yr)**
Airport/Transport	NA	145
CSO	NA	507,055
Direct Runoff	NA	740
MS4	NA	2,056
Storm	NA	7,260
WRRF	NA	854
Outside of NYC	NA	80,660

Totals by Source by Waterbody		
Waterbody	**Source**	**Total Load (10^{12} cfu/Yr)**
Arthur Kill	CSO	0
	MS4	598
	Storm	1,596
	Direct Runoff	0
	Airport/Transport	0
	WRRF	0
	Outside of NYC	20,585
Total		22,779
East River and Open Waters	CSO	115,665
	MS4	216
	Storm	476
	Direct Runoff	346
	Airport/Transport	145
	WRRF	524
	Outside of NYC	0
Total		117,372
Harlem River	CSO	87,591
	MS4	0
	Storm	0
	Direct Runoff	85
	Airport/Transport	0
	WRRF	0
	Outside of NYC	0
Total		87,676
Hudson River	CSO	23,426
	MS4	0
	Storm	14
	Direct Runoff	111
	Airport/Transport	0
	WRRF	89
	Outside of NYC	49,242
Total		72,881
Kill Van Kull	CSO	1,988
	MS4	272
	Storm	1,664
	Direct Runoff	0
	Airport/Transport	0

Totals by Source by Waterbody		
Waterbody	**Source**	**Total Load (10^{12} cfu/Yr)**
	WRRF	20
	Outside of NYC	6,145
Total		10,089
New York Bay	CSO	278,386
	MS4	970
	Storm	3,510
	Direct Runoff	198
	Airport/Transport	0
	WRRF	220
	Outside of NYC	4,688
Total		283,284

Combined Sewer Outfalls - *Enterococci*		
Waterbody	**Outfall**	**Total Load (10^{12} cfu/Yr)**
East River and Open Waters	BB-002	137
East River and Open Waters	BB-003	227
East River and Open Waters	BB-005	4,809
East River and Open Waters	BB-016	5
East River and Open Waters	BB-017	7
East River and Open Waters	BB-018	5
East River and Open Waters	BB-021	62
East River and Open Waters	BB-022	2
East River and Open Waters	BB-023	30
East River and Open Waters	BB-024	59
East River and Open Waters	BB-025	51
East River and Open Waters	BB-027	8
East River and Open Waters	BB-028	1,816
East River and Open Waters	BB-029	510
East River and Open Waters	BB-030	210
East River and Open Waters	BB-031	36
East River and Open Waters	BB-032	4
East River and Open Waters	BB-033	11
East River and Open Waters	BB-034	1,400
East River and Open Waters	BB-035	16
East River and Open Waters	BB-036	31
East River and Open Waters	BB-037	1
East River and Open Waters	BB-041	665
East River and Open Waters	BB-045	0
East River and Open Waters	BB-046	18
East River and Open Waters	BB-047	12
East River and Open Waters	HP-002	183
East River and Open Waters	HP-003	1,240
East River and Open Waters	HP-011	3,245
East River and Open Waters	HP-017	181
East River and Open Waters	HP-018	9
East River and Open Waters	HP-019	43
East River and Open Waters	HP-020	91
East River and Open Waters	HP-021	264
East River and Open Waters	HP-022	88
East River and Open Waters	HP-025	1,083
East River and Open Waters	HP-026	53

Combined Sewer Outfalls - *Enterococci*		
Waterbody	**Outfall**	**Total Load (10^{12} cfu/Yr)**
East River and Open Waters	HP-029	3
East River and Open Waters	NC-003	1
East River and Open Waters	NC-004	55
East River and Open Waters	NC-005	617
East River and Open Waters	NC-006	560
East River and Open Waters	NC-007	17
East River and Open Waters	NC-008	91
East River and Open Waters	NC-010	0
East River and Open Waters	NC-011	0
East River and Open Waters	NC-012	58
East River and Open Waters	NC-013	630
East River and Open Waters	NC-014	6,156
East River and Open Waters	NC-016	23
East River and Open Waters	NC-017	2
East River and Open Waters	NC-018	70
East River and Open Waters	NC-020	59
East River and Open Waters	NC-024	0
East River and Open Waters	NC-025	2
East River and Open Waters	NC-026	1
East River and Open Waters	NC-027	60
East River and Open Waters	NC-028	0
East River and Open Waters	NC-030	0
East River and Open Waters	NC-031	37
East River and Open Waters	NC-032	35
East River and Open Waters	NC-033	2
East River and Open Waters	NC-034	16
East River and Open Waters	NC-035	61
East River and Open Waters	NC-036	542
East River and Open Waters	NC-037	1
East River and Open Waters	NC-038	101
East River and Open Waters	NC-039	13
East River and Open Waters	NC-040	1
East River and Open Waters	NC-041	378
East River and Open Waters	NC-042	7
East River and Open Waters	NC-043	26
East River and Open Waters	NC-044	1
East River and Open Waters	NC-045	216

Combined Sewer Outfalls - *Enterococci*		
Waterbody	**Outfall**	**Total Load (10^{12} cfu/Yr)**
East River and Open Waters	NC-046	32
East River and Open Waters	NC-047	12
East River and Open Waters	NC-048	78
East River and Open Waters	NC-049	207
East River and Open Waters	NC-050	428
East River and Open Waters	NC-051	9
East River and Open Waters	NC-052	351
East River and Open Waters	NC-053	68
East River and Open Waters	NC-054	19
East River and Open Waters	NC-055	11
East River and Open Waters	NC-056	319
East River and Open Waters	NC-057	40
East River and Open Waters	NC-058	195
East River and Open Waters	NC-059	71
East River and Open Waters	NC-060	5
East River and Open Waters	NC-061	17
East River and Open Waters	NC-062	111
East River and Open Waters	NC-063	218
East River and Open Waters	NC-064	104
East River and Open Waters	NC-065	1
East River and Open Waters	NC-066	57
East River and Open Waters	NC-067	72
East River and Open Waters	NC-068	3
East River and Open Waters	NC-069	57
East River and Open Waters	NC-078	4
East River and Open Waters	NC-082	1
East River and Open Waters	NC-087	28
East River and Open Waters	RH-002	0
East River and Open Waters	RH-003	3
East River and Open Waters	RH-005	676
East River and Open Waters	RH-006	20
East River and Open Waters	RH-007	3
East River and Open Waters	RH-008	7
East River and Open Waters	RH-009	9
East River and Open Waters	RH-010	0
East River and Open Waters	RH-011	25
East River and Open Waters	RH-012	45

Combined Sewer Outfalls - *Enterococci*		
Waterbody	**Outfall**	**Total Load (10^{12} cfu/Yr)**
East River and Open Waters	RH-013	1
East River and Open Waters	RH-040	27
East River and Open Waters	TI-003	349
East River and Open Waters	TI-004	6
East River and Open Waters	TI-005	0
East River and Open Waters	TI-019	0
East River and Open Waters	TI-020	0
East River and Open Waters	TI-023	479
East River and Open Waters	WI-002	62
East River and Open Waters	WI-003	805
East River and Open Waters	WI-004	54
East River and Open Waters	WI-005	33
East River and Open Waters	WI-006	39
East River and Open Waters	WI-007	29
East River and Open Waters	WI-008	900
East River and Open Waters	WI-009	0
East River and Open Waters	WI-010	0
East River and Open Waters	WI-011	18
East River and Open Waters	WI-012	42
East River and Open Waters	WI-013	1
East River and Open Waters	WI-014	0
East River and Open Waters	WI-015	4
East River and Open Waters	WI-016	96
East River and Open Waters	WI-017	11
East River and Open Waters	WI-070	12
East River and Open Waters	WI-071	48
East River and Open Waters	WI-072	139
Harlem River	NR-007	3
Harlem River	NR-008	57
Harlem River	NR-009	4
Harlem River	NR-010	27
Harlem River	NR-011	3
Harlem River	NR-012	2
Harlem River	NR-013	2
Harlem River	NR-014	6
Harlem River	NR-016	5
Harlem River	NR-017	196

Combined Sewer Outfalls - *Enterococci*		
Waterbody	**Outfall**	**Total Load (10^{12} cfu/Yr)**
Harlem River	NR-018	0
Harlem River	NR-045	71
Harlem River	NR-055	1
Harlem River	WI-018	1
Harlem River	WI-019	0
Harlem River	WI-020	0
Harlem River	WI-021	0
Harlem River	WI-022	1
Harlem River	WI-023	225
Harlem River	WI-024	166
Harlem River	WI-025	53
Harlem River	WI-026	0
Harlem River	WI-027	0
Harlem River	WI-028	0
Harlem River	WI-029	3
Harlem River	WI-030	0
Harlem River	WI-031	2
Harlem River	WI-032	0
Harlem River	WI-033	3
Harlem River	WI-034	0
Harlem River	WI-035	8
Harlem River	WI-036	12
Harlem River	WI-037	5
Harlem River	WI-038	47
Harlem River	WI-039	6
Harlem River	WI-040	2
Harlem River	WI-041	28
Harlem River	WI-042	4
Harlem River	WI-043	1
Harlem River	WI-044	12
Harlem River	WI-045	205
Harlem River	WI-046	1,054
Harlem River	WI-047	162
Harlem River	WI-048	97
Harlem River	WI-050	234
Harlem River	WI-051	74
Harlem River	WI-052	349

Combined Sewer Outfalls - *Enterococci*		
Waterbody	**Outfall**	**Total Load (10^{12} cfu/Yr)**
Harlem River	WI-056	23,496
Harlem River	WI-057	1,688
Harlem River	WI-058	272
Harlem River	WI-059	38
Harlem River	WI-060	6,183
Harlem River	WI-061	16
Harlem River	WI-062	787
Harlem River	WI-063	16
Harlem River	WI-064	98
Harlem River	WI-065	0
Harlem River	WI-066	1
Harlem River	WI-067	22
Harlem River	WI-068	162
Harlem River	WI-069	0
Harlem River	WI-073	0
Harlem River	WI-075	413
Harlem River	WI-076	554
Harlem River	WI-077	812
Harlem River	WI-078	451
Hudson River	NC-070	117
Hudson River	NC-071	68
Hudson River	NC-072	49
Hudson River	NC-073	304
Hudson River	NC-074	67
Hudson River	NC-075	472
Hudson River	NC-076	2,829
Hudson River	NC-080	1
Hudson River	NC-081	6
Hudson River	NR-002	3
Hudson River	NR-003	16
Hudson River	NR-004	14
Hudson River	NR-005	0
Hudson River	NR-006	189
Hudson River	NR-019	18
Hudson River	NR-020	59
Hudson River	NR-021	9
Hudson River	NR-022	27

Combined Sewer Outfalls - *Enterococci*		
Waterbody	**Outfall**	**Total Load (10^{12} cfu/Yr)**
Hudson River	NR-023	127
Hudson River	NR-024	28
Hudson River	NR-025	43
Hudson River	NR-026	54
Hudson River	NR-027	506
Hudson River	NR-028	12
Hudson River	NR-029	7
Hudson River	NR-030	60
Hudson River	NR-031	6
Hudson River	NR-032	3
Hudson River	NR-033	102
Hudson River	NR-034	10
Hudson River	NR-035	25
Hudson River	NR-036	52
Hudson River	NR-037	2
Hudson River	NR-038	23
Hudson River	NR-039	0
Hudson River	NR-040	274
Hudson River	NR-041	6
Hudson River	NR-042	7
Hudson River	NR-043	476
Hudson River	NR-044	5
Hudson River	NR-046	28
Hudson River	NR-047	0
Hudson River	NR-048	4
Hudson River	NR-049	37
Hudson River	NR-050	0
Hudson River	NR-052	2
Hudson River	NR-056	9
Hudson River	WI-053	144
Hudson River	WI-054	89
Hudson River	WI-055	93
Hudson River	WI-079	0
Kill Van Kull	PR-002	0
Kill Van Kull	PR-003	0
Kill Van Kull	PR-004	0
Kill Van Kull	PR-005	0

Combined Sewer Outfalls - *Enterococci*		
Waterbody	**Outfall**	**Total Load (10^{12} cfu/Yr)**
Kill Van Kull	PR-006	13
Kill Van Kull	PR-007	0
Kill Van Kull	PR-008	0
Kill Van Kull	PR-009	0
Kill Van Kull	PR-024	0
Kill Van Kull	PR-025	0
Kill Van Kull	PR-026	2
Kill Van Kull	PR-027	3
Kill Van Kull	PR-028	30
Kill Van Kull	PR-029	545
Kill Van Kull	PR-033	0
Kill Van Kull	PR-034	0
Kill Van Kull	PR-035	0
Kill Van Kull	PR-036	0
Kill Van Kull	PR-037	5
New York Bay	OH-002	1,328
New York Bay	OH-003	8,982
New York Bay	OH-004	39
New York Bay	OH-015	33,692
New York Bay	OH-017	21,219
New York Bay	OH-018	1,427
New York Bay	OH-019	236
New York Bay	OH-020	7
New York Bay	OH-022	0
New York Bay	OH-025	0
New York Bay	PR-010	1
New York Bay	PR-011	0
New York Bay	PR-013	93
New York Bay	PR-014	70
New York Bay	PR-015	3
New York Bay	PR-016	4
New York Bay	PR-017	49
New York Bay	PR-018	17
New York Bay	PR-019	181
New York Bay	PR-020	98
New York Bay	PR-021	24
New York Bay	PR-023A	43

Combined Sewer Outfalls - *Enterococci*		
Waterbody	**Outfall**	**Total Load (10^{12} cfu/Yr)**
New York Bay	PR-030	25
New York Bay	PR-031	547
New York Bay	PR-032	18
New York Bay	RH-014	214
New York Bay	RH-016	176
New York Bay	RH-018	36
New York Bay	RH-019	52
New York Bay	RH-020	2
New York Bay	RH-021	9
New York Bay	RH-022	12
New York Bay	RH-023	13
New York Bay	RH-024	14
New York Bay	RH-025	21
New York Bay	RH-028	90
New York Bay	RH-029	3
	Total CSO	**146,876**

MS-4 Outfalls - *Enterococci*		
Waterbody	**Outfall**	**Total Load (10^{12} cfu/Yr)**
Arthur Kill	PR-612	471
Arthur Kill	PR-621_ms4	222
East River and Open Waters	BB-603	3
East River and Open Waters	BB-606	5
East River and Open Waters	BB-607	3
East River and Open Waters	HP-631	38
East River and Open Waters	RH-1204	9
East River and Open Waters	TI-609_BWSO	7
East River and Open Waters	TI-610_BWSO	26
East River and Open Waters	TI-615_BWSO	21
East River and Open Waters	TI-616_BWSO	3
East River and Open Waters	TI-617_BWSO	3
East River and Open Waters	TI-618_BWSO	14
East River and Open Waters	TI-619_BWSO	2
East River and Open Waters	TI-634_BWSO	13
East River and Open Waters	TI-646_BWSO	4
East River and Open Waters	TI-661_BWSO	18
East River and Open Waters	TI-665	0
East River and Open Waters	TI-666_BWSO	14
East River and Open Waters	TI-671_BWSO	2
East River and Open Waters	TI-674_BWSO	2
East River and Open Waters	TI-675_BWSO	57
East River and Open Waters	TI-676_BWSO	7
East River and Open Waters	TI-1208_BWSO	11
Kill Van Kull	PR-603	24
Kill Van Kull	PR-613	292
New York Bay	CI-603	36
New York Bay	CI-604	2
New York Bay	CI-605_CI-659	315
New York Bay	CI-605_CI-666	28
New York Bay	CI-607	1
New York Bay	CI-608	2
New York Bay	CI-609	2
New York Bay	CI-610	389
New York Bay	CI-654	49
New York Bay	CI-655	102
New York Bay	CI-656	1

MS-4 Outfalls - *Enterococci*		
Waterbody	**Outfall**	**Total Load (10^{12} cfu/Yr)**
New York Bay	CI-657	21
New York Bay	CI-662	43
New York Bay	CI-663	45
New York Bay	CI-668	14
New York Bay	CI-669	14
New York Bay	CI-670	13
New York Bay	CI-671	11
New York Bay	CI-672	9
New York Bay	CI-673	6
New York Bay	CI-674	16
New York Bay	CI-677	387
New York Bay	CI-678	17
New York Bay	CI-682	3
	Total MS-4	**2,797**

Stormwater Outfalls - *Enterococci*		
Waterbody	**Outfall**	**Total Load (10^{12} cfu/Yr)**
Arthur Kill	OB-351	267
Arthur Kill	OB-359	124
Arthur Kill	OB-362	56
Arthur Kill	OB-364	89
Arthur Kill	OB-366	348
Arthur Kill	OB-367	107
Arthur Kill	OB-368	64
Arthur Kill	OB-372	363
Arthur Kill	PR-149	337
Arthur Kill	PR-503	53
Arthur Kill	PR-621_sw	42
East River and Open Waters	BB--61	26
East River and Open Waters	HP--37	27
East River and Open Waters	HP--40	16
East River and Open Waters	HP--42	25
East River and Open Waters	HP--43	16
East River and Open Waters	HP--44	37
East River and Open Waters	HP-506	51
East River and Open Waters	HP-507	9
East River and Open Waters	HP-623	29
East River and Open Waters	HP-630	92
East River and Open Waters	HP-633	16
East River and Open Waters	HP-643	14
East River and Open Waters	HP-644	42
East River and Open Waters	HP--66	25
East River and Open Waters	NC-004M	4
East River and Open Waters	NC-005M	4
East River and Open Waters	RH-614	79
East River and Open Waters	TI--60	9
East River and Open Waters	TI--61_sw	4
East River and Open Waters	TI-610_sw	14
East River and Open Waters	TI-611	66
East River and Open Waters	TI-615	1
East River and Open Waters	TI-619	4
East River and Open Waters	TI-621_sw	40
East River and Open Waters	TI-634	4
East River and Open Waters	TI-649_sw	4

Stormwater Outfalls - *Enterococci*		
Waterbody	**Outfall**	**Total Load (10^{12} cfu/Yr)**
East River and Open Waters	TI-662_sw	2
East River and Open Waters	TI--68_sw	5
East River and Open Waters	TI--69_sw	4
East River and Open Waters	TI--70	10
East River and Open Waters	WI-821	6
Hudson River	NR--79	16
Kill Van Kull	OB-373	770
Kill Van Kull	PR-133	20
Kill Van Kull	PR-134	1
Kill Van Kull	PR-135	123
Kill Van Kull	PR-137	30
Kill Van Kull	PR-140	13
Kill Van Kull	PR-141	29
Kill Van Kull	PR-145	31
Kill Van Kull	PR-181	51
Kill Van Kull	PR-187	20
Kill Van Kull	PR-189	15
Kill Van Kull	PR-190	120
Kill Van Kull	OB-356	313
Kill Van Kull	OB-369	395
New York Bay	CI-446	2
New York Bay	CI-455	8
New York Bay	OB-352	580
New York Bay	OB-353	703
New York Bay	OB-354	457
New York Bay	OB-355	713
New York Bay	OB-358	186
New York Bay	OB-360	113
New York Bay	OB-361	123
New York Bay	OB-363	459
New York Bay	OB-365	102
New York Bay	OB-370	24
New York Bay	OB-371	423
New York Bay	OB-357	27
New York Bay	OH-015_OF	52
New York Bay	OH--64	16
New York Bay	OH--65	41

Stormwater Outfalls - *Enterococci*		
Waterbody	**Outfall**	**Total Load (10^{12} cfu/Yr)**
New York Bay	OH--88	8
New York Bay	OH--89	15
New York Bay	OH-875	36
New York Bay	PR-104	4
New York Bay	PR-162	21
New York Bay	PR-180	3
	Total Stormwater	**8,598**

Direct Runoff Outfalls - *Enterococci*		
Waterbody	**Outfall**	**Total Load (10^{12} cfu/Yr)**
East River and Open Waters	BB--49	9
East River and Open Waters	BB--58	1
East River and Open Waters	BB--59	2
East River and Open Waters	BB--60	0
East River and Open Waters	BB--62	0
East River and Open Waters	BB--63	2
East River and Open Waters	BB--64	3
East River and Open Waters	BB--65	0
East River and Open Waters	BB--66	1
East River and Open Waters	BB--67	3
East River and Open Waters	BB--68	6
East River and Open Waters	BB--69	5
East River and Open Waters	BB--70	4
East River and Open Waters	BB--71	1
East River and Open Waters	BB--72	5
East River and Open Waters	BB--82	5
East River and Open Waters	BB--83	6
East River and Open Waters	BB--84	10
East River and Open Waters	BB--85	11
East River and Open Waters	BB--87	4
East River and Open Waters	BB--88	4
East River and Open Waters	BB--89	4
East River and Open Waters	BB-103	6
East River and Open Waters	BB-200	12
East River and Open Waters	BB-202	3
East River and Open Waters	BB-370	6
East River and Open Waters	BB-502	4
East River and Open Waters	BB-503	6
East River and Open Waters	BB-506	4
East River and Open Waters	BB-532	6
East River and Open Waters	BB-537	1
East River and Open Waters	HP--38	19
East River and Open Waters	HP--39	2
East River and Open Waters	HP--45	14
East River and Open Waters	HP--46	12
East River and Open Waters	HP--47	3
East River and Open Waters	HP--48	4

Direct Runoff Outfalls - *Enterococci*		
Waterbody	**Outfall**	**Total Load (10^{12} cfu/Yr)**
East River and Open Waters	HP--62	3
East River and Open Waters	HP--63	5
East River and Open Waters	HP--64	2
East River and Open Waters	HP--65	2
East River and Open Waters	HP--67	1
East River and Open Waters	HP--68	1
East River and Open Waters	HP--69	2
East River and Open Waters	HP--70	2
East River and Open Waters	HP--71	5
East River and Open Waters	HP--72	2
East River and Open Waters	HP--81	2
East River and Open Waters	HP--88	8
East River and Open Waters	HP--89	8
East River and Open Waters	HP--90	16
East River and Open Waters	HP--91	2
East River and Open Waters	HP--92	13
East River and Open Waters	HP--93	2
East River and Open Waters	HP--94	1
East River and Open Waters	HP--95	8
East River and Open Waters	HP-105	1
East River and Open Waters	HP-205	8
East River and Open Waters	HP-502	4
East River and Open Waters	HP-511	2
East River and Open Waters	HP-645	3
East River and Open Waters	NC--48	1
East River and Open Waters	NC--49	1
East River and Open Waters	NC--50	1
East River and Open Waters	NC--51	2
East River and Open Waters	NC--52	2
East River and Open Waters	NC--53	3
East River and Open Waters	NC--54	2
East River and Open Waters	NC--55	1
East River and Open Waters	NC--56	2
East River and Open Waters	NC--57	2
East River and Open Waters	NC--58	2
East River and Open Waters	NC--59	2
East River and Open Waters	NC--60	3

Direct Runoff Outfalls - *Enterococci*		
Waterbody	**Outfall**	**Total Load (10^{12} cfu/Yr)**
East River and Open Waters	NC--61	1
East River and Open Waters	NC--62	4
East River and Open Waters	NC--63	8
East River and Open Waters	NC--64	4
East River and Open Waters	NC--65	1
East River and Open Waters	NC--89	6
East River and Open Waters	NC--90	2
East River and Open Waters	NC--93	11
East River and Open Waters	NC--94	15
East River and Open Waters	NC--95	12
East River and Open Waters	RH--60	4
East River and Open Waters	RH--61	4
East River and Open Waters	RH-501	7
East River and Open Waters	RH-505	7
East River and Open Waters	RH-508	16
East River and Open Waters	RH-510	1
East River and Open Waters	RH-511	6
East River and Open Waters	RH-610	3
East River and Open Waters	RH-611	1
East River and Open Waters	TI--61_dd	1
East River and Open Waters	TI--62	1
East River and Open Waters	TI--63	1
East River and Open Waters	TI--67	0
East River and Open Waters	TI--68_dd	1
East River and Open Waters	TI--69_dd	3
East River and Open Waters	TI-501	0
East River and Open Waters	TI-505	1
East River and Open Waters	TI-516	2
East River and Open Waters	TI-545	7
East River and Open Waters	TI-551	2
East River and Open Waters	TI-561	1
East River and Open Waters	TI-562	5
East River and Open Waters	TI-567	0
East River and Open Waters	TI-609	2
East River and Open Waters	TI-610_dd	1
East River and Open Waters	TI-614	0
East River and Open Waters	TI-621_dd	1

Direct Runoff Outfalls - *Enterococci*		
Waterbody	**Outfall**	**Total Load (10^{12} cfu/Yr)**
East River and Open Waters	TI-649_dd	1
East River and Open Waters	TI-662_dd	0
East River and Open Waters	WI-102	1
East River and Open Waters	WI-105	4
East River and Open Waters	WI-184	12
East River and Open Waters	WI-977	31
Harlem River	NR--75	6
Harlem River	NR--76	2
Harlem River	NR--77	3
Harlem River	NR--78	7
Harlem River	WI-189	6
Harlem River	WI-207	31
Harlem River	WI-507	35
Harlem River	WI-609	0
Harlem River	WI-610	0
Harlem River	WI-614	3
Harlem River	WI-826	0
Harlem River	WI-832	1
Harlem River	WI-840	2
Harlem River	WI-870	7
Harlem River	WI-883	2
Harlem River	WI-887	0
Harlem River	WI-908	21
Hudson River	NC--85	10
Hudson River	NC--86	4
Hudson River	NC--87	10
Hudson River	NC--91	8
Hudson River	NC--92	4
Hudson River	NR--60	3
Hudson River	NR--61	4
Hudson River	NR--62	7
Hudson River	NR--63	15
Hudson River	NR--64	10
Hudson River	NR--65	8
Hudson River	NR--66	8
Hudson River	NR--67	9
Hudson River	NR--68	12

Direct Runoff Outfalls - *Enterococci*		
Waterbody	**Outfall**	**Total Load (10^{12} cfu/Yr)**
Hudson River	NR--69	5
Hudson River	NR--70	9
Hudson River	NR--71	4
Hudson River	NR--72	7
Hudson River	NR--73	8
Hudson River	NR--74	6
Hudson River	NR-501	5
Hudson River	WI-936	3
Hudson River	WI-950	2
Hudson River	WI-951	1
Hudson River	WI-982	3
Hudson River	WI-984	4
New York Bay	CI--61	9
New York Bay	CI--62	4
New York Bay	CI--63	4
New York Bay	CI--64	4
New York Bay	CI--65	1
New York Bay	CI--66	3
New York Bay	CI--68	8
New York Bay	CI--69	1
New York Bay	CI--70	2
New York Bay	CI--71	1
New York Bay	CI--72	1
New York Bay	CI--73	5
New York Bay	CI--74	2
New York Bay	CI--75	1
New York Bay	CI--76	2
New York Bay	CI--77	3
New York Bay	CI--78	7
New York Bay	CI--79	9
New York Bay	CI--80	19
New York Bay	CI-425	33
New York Bay	CI-428	5
New York Bay	CI-430	3
New York Bay	CI-431	23
New York Bay	CI-432	4
New York Bay	NC--88	3

Direct Runoff Outfalls - *Enterococci*		
Waterbody	**Outfall**	**Total Load (10^{12} cfu/Yr)**
New York Bay	OH--12	0
New York Bay	OH--61	4
New York Bay	OH--67	2
New York Bay	OH--75	5
New York Bay	OH--77	5
New York Bay	OH--78	12
New York Bay	OH--79	7
New York Bay	OH--80	5
New York Bay	OH--81	4
New York Bay	OH--82	4
New York Bay	OH--83	18
New York Bay	OH--84	11
New York Bay	OH--85	8
New York Bay	OH--86	2
New York Bay	OH--87	5
New York Bay	OH--90	2
New York Bay	OH-344	4
New York Bay	OH-415	2
New York Bay	OH-419	4
New York Bay	OH--U1	1
New York Bay	OH--U2	2
New York Bay	OH--U3	1
New York Bay	OH--U4	0
New York Bay	OH--U5	2
New York Bay	RH--62	5
New York Bay	RH--63	5
New York Bay	RH--64	6
New York Bay	RH--65	5
New York Bay	RH--66	7
New York Bay	RH--67	6
New York Bay	RH--71	2
	Total Direct Runoff	**1,102**

Airport/Transport Outfalls - *Enterococci*		
Waterbody	**Outfall**	**Total Load (10^{12} cfu/Yr)**
East River and Open Waters	BB-LG01	5
East River and Open Waters	BB-LG02	2
East River and Open Waters	BB-LG03	0
East River and Open Waters	BB-LG04	0
East River and Open Waters	BB-LG05	13
East River and Open Waters	BB-LG06	11
East River and Open Waters	BB-LG07	2
East River and Open Waters	BB-LG08	1
East River and Open Waters	BB-LG1A	0
East River and Open Waters	BB-LG5A	11
East River and Open Waters	BB-LG6A	1
East River and Open Waters	BB-LKD	11
	Total Airport/Transport	**58**

WRRF Discharges - *Enterococci*		
Waterbody	**Outfall**	**Total Load (10^{12} cfu/Yr)**
Kill Van Kull	PRWPCP	4
East River and Open Waters	BBWPCP	9
East River and Open Waters	HPWPCP	17
East River and Open Waters	NCWPCP	35
East River and Open Waters	RHWPCP	5
East River and Open Waters	TIWPCP	9
East River and Open Waters	WIWPCP	30
Hudson River	NRWPCP	18
New York Bay	CIWPCP	66
New York Bay	OBWPCP	4
New York Bay	OHWPCP	13
	Total WRRF	**210**

AECOM with Hazen

Totals by Waterbody - *Enterococci*		
Waterbody	**Outfall**	**Total Load (10^{12} cfu/Yr)**
Harlem River	NA	38,270
Hudson River	NA	6,679
East River and Open Waters	NA	34,533
New York Bay	NA	74,768
Arthur Kill	NA	2,544
Kill Van Kull	NA	2,847

Load Totals from Outside NYC by Waterbody - *Enterococci*		
Waterbody	**Source**	**Total Load (10^{12} cfu/Yr)**
Arthur Kill	Loads from Outside of NYC	29,636
Hudson River	Loads from Outside of NYC	30,060
Kill Van Kull	Loads from Outside of NYC	2,536
Upper New York Bay	Loads from Outside of NYC	2,524

Totals by Source - *Enterococci*		
Source	**Outfall**	**Total Load (10^{12} cfu/Yr)**
Airport/Transport	NA	58
CSO	NA	146,876
Direct Runoff	NA	1,102
MS4	NA	2,797
Storm	NA	8,598
WRRF	NA	210
Outside of NYC	NA	64,756

Totals by Source by Waterbody - *Enterococci*		
Waterbody	**Source**	**Total Load (10^{12} cfu/Yr)**
Arthur Kill	CSO	0
	MS4	693
	Storm	1,850
	Direct Runoff	0
	Airport/Transport	0
	WRRF	0
	Outside of NYC	29,636
Total		32,180
East River and Open Waters	CSO	32,913
	MS4	263
	Storm	686
	Direct Runoff	508
	Airport/Transport	58
	WRRF	105
	Outside of NYC	0
Total		34,533
Harlem River	CSO	38,142
	MS4	0
	Storm	0
	Direct Runoff	128
	Airport/Transport	0
	WRRF	0
	Outside of NYC	0
Total		38,270
Hudson River	CSO	6,479
	MS4	0
	Storm	16
	Direct Runoff	166
	Airport/Transport	0
	WRRF	18
	Outside of NYC	30,060
Total		36,739
Kill Van Kull	CSO	598
	MS4	316
	Storm	1,930
	Direct Runoff	0
	Airport/Transport	0

Totals by Source by Waterbody - *Enterococci*		
Waterbody	**Source**	**Total Load (10^{12} cfu/Yr)**
	WRRF	4
	Outside of NYC	2,536
Total		5,383
New York Bay	CSO	68,745
	MS4	1,525
	Storm	4,116
	Direct Runoff	299
	Airport/Transport	0
	WRRF	84
	Outside of NYC	2,523
Total		74,768

Combined Sewer Outfalls - BOD		
Waterbody	**Outfall**	**Total Load (Lbs/Yr)**
East River and Open Waters	BB-002	5,108
East River and Open Waters	BB-003	11,523
East River and Open Waters	BB-005	194,806
East River and Open Waters	BB-016	303
East River and Open Waters	BB-017	367
East River and Open Waters	BB-018	259
East River and Open Waters	BB-021	3,782
East River and Open Waters	BB-022	140
East River and Open Waters	BB-023	2,302
East River and Open Waters	BB-024	4,661
East River and Open Waters	BB-025	2,469
East River and Open Waters	BB-027	741
East River and Open Waters	BB-028	72,154
East River and Open Waters	BB-029	21,449
East River and Open Waters	BB-030	8,169
East River and Open Waters	BB-031	1,231
East River and Open Waters	BB-032	306
East River and Open Waters	BB-033	853
East River and Open Waters	BB-034	54,170
East River and Open Waters	BB-035	884
East River and Open Waters	BB-036	1,784
East River and Open Waters	BB-037	109
East River and Open Waters	BB-041	26,543
East River and Open Waters	BB-045	5
East River and Open Waters	BB-046	1,187
East River and Open Waters	BB-047	521
East River and Open Waters	HP-002	8,902
East River and Open Waters	HP-003	35,789
East River and Open Waters	HP-011	134,212
East River and Open Waters	HP-017	7,237
East River and Open Waters	HP-018	555
East River and Open Waters	HP-019	2,515
East River and Open Waters	HP-020	10,503
East River and Open Waters	HP-021	26,107
East River and Open Waters	HP-022	4,747
East River and Open Waters	HP-025	30,143
East River and Open Waters	HP-026	6,076

Combined Sewer Outfalls - BOD		
Waterbody	**Outfall**	**Total Load (Lbs/Yr)**
East River and Open Waters	HP-029	403
East River and Open Waters	NC-003	68
East River and Open Waters	NC-004	3,183
East River and Open Waters	NC-005	20,154
East River and Open Waters	NC-006	24,178
East River and Open Waters	NC-007	1,318
East River and Open Waters	NC-008	4,160
East River and Open Waters	NC-010	19
East River and Open Waters	NC-011	0
East River and Open Waters	NC-012	3,013
East River and Open Waters	NC-013	22,801
East River and Open Waters	NC-014	209,808
East River and Open Waters	NC-016	912
East River and Open Waters	NC-017	119
East River and Open Waters	NC-018	2,908
East River and Open Waters	NC-020	2,337
East River and Open Waters	NC-024	2
East River and Open Waters	NC-025	112
East River and Open Waters	NC-026	87
East River and Open Waters	NC-027	3,285
East River and Open Waters	NC-028	2
East River and Open Waters	NC-030	36
East River and Open Waters	NC-031	1,345
East River and Open Waters	NC-032	1,510
East River and Open Waters	NC-033	94
East River and Open Waters	NC-034	611
East River and Open Waters	NC-035	2,043
East River and Open Waters	NC-036	20,909
East River and Open Waters	NC-037	131
East River and Open Waters	NC-038	3,366
East River and Open Waters	NC-039	444
East River and Open Waters	NC-040	41
East River and Open Waters	NC-041	10,607
East River and Open Waters	NC-042	378
East River and Open Waters	NC-043	1,108
East River and Open Waters	NC-044	49
East River and Open Waters	NC-045	6,722

Combined Sewer Outfalls - BOD		
Waterbody	**Outfall**	**Total Load (Lbs/Yr)**
East River and Open Waters	NC-046	1,035
East River and Open Waters	NC-047	548
East River and Open Waters	NC-048	2,181
East River and Open Waters	NC-049	5,849
East River and Open Waters	NC-050	11,787
East River and Open Waters	NC-051	242
East River and Open Waters	NC-052	9,182
East River and Open Waters	NC-053	2,627
East River and Open Waters	NC-054	741
East River and Open Waters	NC-055	402
East River and Open Waters	NC-056	9,030
East River and Open Waters	NC-057	1,264
East River and Open Waters	NC-058	5,984
East River and Open Waters	NC-059	2,227
East River and Open Waters	NC-060	193
East River and Open Waters	NC-061	699
East River and Open Waters	NC-062	4,208
East River and Open Waters	NC-063	6,460
East River and Open Waters	NC-064	3,554
East River and Open Waters	NC-065	54
East River and Open Waters	NC-066	1,478
East River and Open Waters	NC-067	2,464
East River and Open Waters	NC-068	101
East River and Open Waters	NC-069	1,985
East River and Open Waters	NC-078	193
East River and Open Waters	NC-082	90
East River and Open Waters	NC-087	1,173
East River and Open Waters	RH-002	0
East River and Open Waters	RH-003	169
East River and Open Waters	RH-005	29,887
East River and Open Waters	RH-006	1,278
East River and Open Waters	RH-007	215
East River and Open Waters	RH-008	499
East River and Open Waters	RH-009	480
East River and Open Waters	RH-010	31
East River and Open Waters	RH-011	1,119
East River and Open Waters	RH-012	1,994

Combined Sewer Outfalls - BOD		
Waterbody	**Outfall**	**Total Load (Lbs/Yr)**
East River and Open Waters	RH-013	54
East River and Open Waters	RH-040	3,064
East River and Open Waters	TI-003	16,746
East River and Open Waters	TI-004	568
East River and Open Waters	TI-005	14
East River and Open Waters	TI-019	0
East River and Open Waters	TI-020	0
East River and Open Waters	TI-023	26,658
East River and Open Waters	WI-002	1,956
East River and Open Waters	WI-003	26,101
East River and Open Waters	WI-004	1,721
East River and Open Waters	WI-005	1,137
East River and Open Waters	WI-006	1,281
East River and Open Waters	WI-007	1,047
East River and Open Waters	WI-008	28,577
East River and Open Waters	WI-009	0
East River and Open Waters	WI-010	0
East River and Open Waters	WI-011	785
East River and Open Waters	WI-012	1,724
East River and Open Waters	WI-013	25
East River and Open Waters	WI-014	3
East River and Open Waters	WI-015	189
East River and Open Waters	WI-016	3,311
East River and Open Waters	WI-017	460
East River and Open Waters	WI-070	1,137
East River and Open Waters	WI-071	2,232
East River and Open Waters	WI-072	6,291
Harlem River	NR-007	217
Harlem River	NR-008	3,886
Harlem River	NR-009	302
Harlem River	NR-010	1,923
Harlem River	NR-011	254
Harlem River	NR-012	157
Harlem River	NR-013	138
Harlem River	NR-014	392
Harlem River	NR-016	282
Harlem River	NR-017	9,335

Combined Sewer Outfalls - BOD		
Waterbody	**Outfall**	**Total Load (Lbs/Yr)**
Harlem River	NR-018	9
Harlem River	NR-045	3,876
Harlem River	NR-055	118
Harlem River	WI-018	23
Harlem River	WI-019	5
Harlem River	WI-020	0
Harlem River	WI-021	10
Harlem River	WI-022	35
Harlem River	WI-023	6,551
Harlem River	WI-024	3,714
Harlem River	WI-025	3,545
Harlem River	WI-026	13
Harlem River	WI-027	9
Harlem River	WI-028	20
Harlem River	WI-029	139
Harlem River	WI-030	11
Harlem River	WI-031	127
Harlem River	WI-032	1
Harlem River	WI-033	178
Harlem River	WI-034	16
Harlem River	WI-035	467
Harlem River	WI-036	354
Harlem River	WI-037	299
Harlem River	WI-038	2,155
Harlem River	WI-039	270
Harlem River	WI-040	124
Harlem River	WI-041	1,024
Harlem River	WI-042	136
Harlem River	WI-043	57
Harlem River	WI-044	412
Harlem River	WI-045	7,710
Harlem River	WI-046	32,628
Harlem River	WI-047	5,197
Harlem River	WI-048	3,199
Harlem River	WI-050	6,625
Harlem River	WI-051	3,850
Harlem River	WI-052	11,976

Combined Sewer Outfalls - BOD		
Waterbody	**Outfall**	**Total Load (Lbs/Yr)**
Harlem River	WI-056	493,747
Harlem River	WI-057	45,422
Harlem River	WI-058	8,616
Harlem River	WI-059	1,512
Harlem River	WI-060	71,488
Harlem River	WI-061	840
Harlem River	WI-062	26,205
Harlem River	WI-063	961
Harlem River	WI-064	3,561
Harlem River	WI-065	21
Harlem River	WI-066	79
Harlem River	WI-067	1,110
Harlem River	WI-068	4,449
Harlem River	WI-069	6
Harlem River	WI-073	7
Harlem River	WI-075	15,022
Harlem River	WI-076	16,731
Harlem River	WI-077	23,043
Harlem River	WI-078	13,029
Hudson River	NC-070	3,956
Hudson River	NC-071	2,507
Hudson River	NC-072	1,921
Hudson River	NC-073	9,538
Hudson River	NC-074	2,447
Hudson River	NC-075	18,563
Hudson River	NC-076	86,702
Hudson River	NC-080	100
Hudson River	NC-081	187
Hudson River	NR-002	245
Hudson River	NR-003	1,017
Hudson River	NR-004	1,057
Hudson River	NR-005	2
Hudson River	NR-006	10,489
Hudson River	NR-019	1,068
Hudson River	NR-020	3,413
Hudson River	NR-021	665
Hudson River	NR-022	1,617

Combined Sewer Outfalls - BOD		
Waterbody	**Outfall**	**Total Load (Lbs/Yr)**
Hudson River	NR-023	6,578
Hudson River	NR-024	1,909
Hudson River	NR-025	2,328
Hudson River	NR-026	3,303
Hudson River	NR-027	25,652
Hudson River	NR-028	680
Hudson River	NR-029	575
Hudson River	NR-030	2,800
Hudson River	NR-031	412
Hudson River	NR-032	168
Hudson River	NR-033	5,732
Hudson River	NR-034	798
Hudson River	NR-035	1,582
Hudson River	NR-036	3,012
Hudson River	NR-037	193
Hudson River	NR-038	1,492
Hudson River	NR-039	0
Hudson River	NR-040	15,134
Hudson River	NR-041	414
Hudson River	NR-042	553
Hudson River	NR-043	19,487
Hudson River	NR-044	341
Hudson River	NR-046	1,956
Hudson River	NR-047	9
Hudson River	NR-048	220
Hudson River	NR-049	2,000
Hudson River	NR-050	9
Hudson River	NR-052	107
Hudson River	NR-056	665
Hudson River	WI-053	7,514
Hudson River	WI-054	4,978
Hudson River	WI-055	3,889
Hudson River	WI-079	0
Kill Van Kull	PR-002	0
Kill Van Kull	PR-003	0
Kill Van Kull	PR-004	0
Kill Van Kull	PR-005	4

Combined Sewer Outfalls - BOD		
Waterbody	**Outfall**	**Total Load (Lbs/Yr)**
Kill Van Kull	PR-006	1,086
Kill Van Kull	PR-007	0
Kill Van Kull	PR-008	0
Kill Van Kull	PR-009	0
Kill Van Kull	PR-024	3
Kill Van Kull	PR-025	0
Kill Van Kull	PR-026	213
Kill Van Kull	PR-027	264
Kill Van Kull	PR-028	2,449
Kill Van Kull	PR-029	30,393
Kill Van Kull	PR-033	0
Kill Van Kull	PR-034	0
Kill Van Kull	PR-035	0
Kill Van Kull	PR-036	0
Kill Van Kull	PR-037	470
New York Bay	OH-002	68,359
New York Bay	OH-003	91,133
New York Bay	OH-004	1,849
New York Bay	OH-015	263,452
New York Bay	OH-017	98,479
New York Bay	OH-018	42,305
New York Bay	OH-019	7,250
New York Bay	OH-020	340
New York Bay	OH-022	0
New York Bay	OH-025	0
New York Bay	PR-010	156
New York Bay	PR-011	31
New York Bay	PR-013	7,231
New York Bay	PR-014	5,026
New York Bay	PR-015	324
New York Bay	PR-016	306
New York Bay	PR-017	2,862
New York Bay	PR-018	897
New York Bay	PR-019	12,490
New York Bay	PR-020	5,737
New York Bay	PR-021	1,578
New York Bay	PR-023A	7,752

Combined Sewer Outfalls - BOD		
Waterbody	**Outfall**	**Total Load (Lbs/Yr)**
New York Bay	PR-030	1,738
New York Bay	PR-031	35,562
New York Bay	PR-032	1,379
New York Bay	RH-014	8,400
New York Bay	RH-016	7,584
New York Bay	RH-018	1,877
New York Bay	RH-019	2,663
New York Bay	RH-020	189
New York Bay	RH-021	576
New York Bay	RH-022	705
New York Bay	RH-023	733
New York Bay	RH-024	756
New York Bay	RH-025	1,178
New York Bay	RH-028	5,023
New York Bay	RH-029	340
	Total CSO	**3,086,112**

MS-4 Outfalls - BOD		
Waterbody	**Outfall**	**Total Load (Lbs/Yr)**
Arthur Kill	PR-612	73,854
Arthur Kill	PR-621_ms4	34,815
East River and Open Waters	BB-603	299
East River and Open Waters	BB-606	630
East River and Open Waters	BB-607	338
East River and Open Waters	HP-631	4,355
East River and Open Waters	RH-1204	1,410
East River and Open Waters	TI-609_BWSO	1,134
East River and Open Waters	TI-610_BWSO	4,140
East River and Open Waters	TI-615_BWSO	3,309
East River and Open Waters	TI-616_BWSO	469
East River and Open Waters	TI-617_BWSO	501
East River and Open Waters	TI-618_BWSO	2,193
East River and Open Waters	TI-619_BWSO	309
East River and Open Waters	TI-634_BWSO	1,978
East River and Open Waters	TI-646_BWSO	584
East River and Open Waters	TI-661_BWSO	2,779
East River and Open Waters	TI-665	0
East River and Open Waters	TI-666_BWSO	2,240
East River and Open Waters	TI-671_BWSO	335
East River and Open Waters	TI-674_BWSO	360
East River and Open Waters	TI-675_BWSO	8,993
East River and Open Waters	TI-676_BWSO	1,063
East River and Open Waters	TI-1208_BWSO	1,797
Kill Van Kull	PR-603	3,703
Kill Van Kull	PR-613	45,757
New York Bay	CI-603	4,145
New York Bay	CI-604	274
New York Bay	CI-605_CI-659	36,398
New York Bay	CI-605_CI-666	3,207
New York Bay	CI-607	157
New York Bay	CI-608	232
New York Bay	CI-609	194
New York Bay	CI-610	44,931
New York Bay	CI-654	5,651
New York Bay	CI-655	11,770
New York Bay	CI-656	80

MS-4 Outfalls - BOD		
Waterbody	**Outfall**	**Total Load (Lbs/Yr)**
New York Bay	CI-657	2,413
New York Bay	CI-662	5,012
New York Bay	CI-663	5,249
New York Bay	CI-668	1,593
New York Bay	CI-669	1,598
New York Bay	CI-670	1,504
New York Bay	CI-671	1,248
New York Bay	CI-672	1,026
New York Bay	CI-673	721
New York Bay	CI-674	1,880
New York Bay	CI-677	44,727
New York Bay	CI-678	1,975
New York Bay	CI-682	298
	Total MS4	**373,626**

Stormwater Outfalls - BOD		
Waterbody	**Outfall**	**Total Load (Lbs/Yr)**
Arthur Kill	OB-351	41,863
Arthur Kill	OB-359	19,346
Arthur Kill	OB-362	8,787
Arthur Kill	OB-364	13,994
Arthur Kill	OB-366	54,465
Arthur Kill	OB-367	16,772
Arthur Kill	OB-368	9,946
Arthur Kill	OB-372	56,763
Arthur Kill	PR-149	52,851
Arthur Kill	PR-503	8,291
Arthur Kill	PR-621_sw	6,644
East River and Open Waters	BB--61	2,989
East River and Open Waters	HP--37	3,180
East River and Open Waters	HP--40	1,861
East River and Open Waters	HP--42	2,961
East River and Open Waters	HP--43	1,832
East River and Open Waters	HP--44	4,290
East River and Open Waters	HP-506	5,911
East River and Open Waters	HP-507	1,042
East River and Open Waters	HP-623	3,402
East River and Open Waters	HP-630	10,610
East River and Open Waters	HP-633	1,884
East River and Open Waters	HP-643	1,660
East River and Open Waters	HP-644	4,809
East River and Open Waters	HP--66	2,939
East River and Open Waters	NC-004M	653
East River and Open Waters	NC-005M	645
East River and Open Waters	RH-614	9,105
East River and Open Waters	TI--60	1,395
East River and Open Waters	TI--61_sw	1,072
East River and Open Waters	TI-610_sw	2,143
East River and Open Waters	TI-611	10,359
East River and Open Waters	TI-615	107
East River and Open Waters	TI-619	641
East River and Open Waters	TI-621_sw	6,193
East River and Open Waters	TI-634	651
East River and Open Waters	TI-649_sw	681

Stormwater Outfalls - BOD		
Waterbody	**Outfall**	**Total Load (Lbs/Yr)**
East River and Open Waters	TI-662_sw	308
East River and Open Waters	TI--68_sw	732
East River and Open Waters	TI--69_sw	650
East River and Open Waters	TI--70	1,655
East River and Open Waters	WI-821	719
Hudson River	NR--79	2,503
Kill Van Kull	OB-373	120,531
Kill Van Kull	PR-133	3,089
Kill Van Kull	PR-134	120
Kill Van Kull	PR-135	19,259
Kill Van Kull	PR-137	4,670
Kill Van Kull	PR-140	1,978
Kill Van Kull	PR-141	4,506
Kill Van Kull	PR-145	4850
Kill Van Kull	PR-181	8,066
Kill Van Kull	PR-187	3,132
Kill Van Kull	PR-189	2,309
Kill Van Kull	PR-190	18,876
Kill Van Kull	OB-356	48,992
Kill Van Kull	OB-369	61,794
New York Bay	CI-446	205
New York Bay	CI-455	897
New York Bay	OB-352	90,736
New York Bay	OB-353	110,062
New York Bay	OB-354	71,549
New York Bay	OB-355	111,639
New York Bay	OB-358	29,148
New York Bay	OB-360	17,626
New York Bay	OB-361	19,263
New York Bay	OB-363	71,868
New York Bay	OB-365	16,013
New York Bay	OB-370	3,755
New York Bay	OB-371	66,212
New York Bay	OB-357	4,179
New York Bay	OH-015_OF	6,036
New York Bay	OH--64	1,925
New York Bay	OH--65	4,759

Stormwater Outfalls - BOD		
Waterbody	**Outfall**	**Total Load (Lbs/Yr)**
New York Bay	OH--88	955
New York Bay	OH--89	1,781
New York Bay	OH-875	4,169
New York Bay	PR-104	611
New York Bay	PR-162	3,351
New York Bay	PR-180	452
	Total Stormwater	**1,318,666**

Direct Runoff Outfalls - BOD		
Waterbody	**Outfall**	**Total Load (Lbs/Yr)**
East River and Open Waters	BB--49	4,787
East River and Open Waters	BB--58	421
East River and Open Waters	BB--59	1,364
East River and Open Waters	BB--60	85
East River and Open Waters	BB--62	258
East River and Open Waters	BB--63	1,347
East River and Open Waters	BB--64	1,715
East River and Open Waters	BB--65	87
East River and Open Waters	BB--66	573
East River and Open Waters	BB--67	1,843
East River and Open Waters	BB--68	3,417
East River and Open Waters	BB--69	2,617
East River and Open Waters	BB--70	2,204
East River and Open Waters	BB--71	332
East River and Open Waters	BB--72	2,820
East River and Open Waters	BB--82	2,587
East River and Open Waters	BB--83	3,381
East River and Open Waters	BB--84	5,251
East River and Open Waters	BB--85	6,222
East River and Open Waters	BB--87	2,059
East River and Open Waters	BB--88	2,186
East River and Open Waters	BB--89	2,019
East River and Open Waters	BB-103	3,127
East River and Open Waters	BB-200	6,627
East River and Open Waters	BB-202	1,603
East River and Open Waters	BB-370	3,178
East River and Open Waters	BB-502	2,358
East River and Open Waters	BB-503	3,443
East River and Open Waters	BB-506	2,258
East River and Open Waters	BB-532	3,556
East River and Open Waters	BB-537	829
East River and Open Waters	HP--38	10,263
East River and Open Waters	HP--39	1,193
East River and Open Waters	HP--45	7,493
East River and Open Waters	HP--46	6,415
East River and Open Waters	HP--47	1,717
East River and Open Waters	HP--48	2,077

Direct Runoff Outfalls - BOD		
Waterbody	**Outfall**	**Total Load (Lbs/Yr)**
East River and Open Waters	HP--62	1,411
East River and Open Waters	HP--63	2,891
East River and Open Waters	HP--64	834
East River and Open Waters	HP--65	1,178
East River and Open Waters	HP--67	817
East River and Open Waters	HP--68	349
East River and Open Waters	HP--69	1,001
East River and Open Waters	HP--70	1,305
East River and Open Waters	HP--71	2,737
East River and Open Waters	HP--72	1,185
East River and Open Waters	HP--81	1,178
East River and Open Waters	HP--88	4,206
East River and Open Waters	HP--89	4,346
East River and Open Waters	HP--90	8,968
East River and Open Waters	HP--91	1,289
East River and Open Waters	HP--92	7,200
East River and Open Waters	HP--93	1,020
East River and Open Waters	HP--94	660
East River and Open Waters	HP--95	4,483
East River and Open Waters	HP-105	490
East River and Open Waters	HP-205	4,491
East River and Open Waters	HP-502	2,001
East River and Open Waters	HP-511	1,101
East River and Open Waters	HP-645	1,880
East River and Open Waters	NC--48	656
East River and Open Waters	NC--49	445
East River and Open Waters	NC--50	692
East River and Open Waters	NC--51	1,128
East River and Open Waters	NC--52	1,110
East River and Open Waters	NC--53	1,811
East River and Open Waters	NC--54	890
East River and Open Waters	NC--55	767
East River and Open Waters	NC--56	1,043
East River and Open Waters	NC--57	1,131
East River and Open Waters	NC--58	976
East River and Open Waters	NC--59	904
East River and Open Waters	NC--60	1,500

Direct Runoff Outfalls - BOD		
Waterbody	**Outfall**	**Total Load (Lbs/Yr)**
East River and Open Waters	NC--61	826
East River and Open Waters	NC--62	2,015
East River and Open Waters	NC--63	4,536
East River and Open Waters	NC--64	2,305
East River and Open Waters	NC--65	761
East River and Open Waters	NC--89	3,413
East River and Open Waters	NC--90	882
East River and Open Waters	NC--93	1,732
East River and Open Waters	NC--94	2,312
East River and Open Waters	NC--95	1,896
East River and Open Waters	RH--60	2,266
East River and Open Waters	RH--61	2,120
East River and Open Waters	RH-501	3,680
East River and Open Waters	RH-505	3,777
East River and Open Waters	RH-508	9,052
East River and Open Waters	RH-510	761
East River and Open Waters	RH-511	3,102
East River and Open Waters	RH-610	1,779
East River and Open Waters	RH-611	789
East River and Open Waters	TI--61_dd	306
East River and Open Waters	TI--62	408
East River and Open Waters	TI--63	758
East River and Open Waters	TI--67	159
East River and Open Waters	TI--68_dd	373
East River and Open Waters	TI--69_dd	1,695
East River and Open Waters	TI-501	226
East River and Open Waters	TI-505	505
East River and Open Waters	TI-516	973
East River and Open Waters	TI-545	3,998
East River and Open Waters	TI-551	897
East River and Open Waters	TI-561	403
East River and Open Waters	TI-562	2,930
East River and Open Waters	TI-567	206
East River and Open Waters	TI-609	1,063
East River and Open Waters	TI-610_dd	505
East River and Open Waters	TI-614	180
East River and Open Waters	TI-621_dd	783

Direct Runoff Outfalls - BOD		
Waterbody	**Outfall**	**Total Load (Lbs/Yr)**
East River and Open Waters	TI-649_dd	642
East River and Open Waters	TI-662_dd	133
East River and Open Waters	WI-102	707
East River and Open Waters	WI-105	2,346
East River and Open Waters	WI-184	6,784
East River and Open Waters	WI-977	17,157
Harlem River	NR--75	3,501
Harlem River	NR--76	884
Harlem River	NR--77	1,495
Harlem River	NR--78	4,028
Harlem River	WI-189	3,479
Harlem River	WI-207	17,100
Harlem River	WI-507	19,530
Harlem River	WI-609	191
Harlem River	WI-610	115
Harlem River	WI-614	1,816
Harlem River	WI-826	168
Harlem River	WI-832	620
Harlem River	WI-840	910
Harlem River	WI-870	4,045
Harlem River	WI-883	987
Harlem River	WI-887	164
Harlem River	WI-908	11,326
Hudson River	NC--85	5,292
Hudson River	NC--86	2,456
Hudson River	NC--87	5,504
Hudson River	NC--91	4,525
Hudson River	NC--92	2,019
Hudson River	NR--60	1,383
Hudson River	NR--61	2,105
Hudson River	NR--62	3,589
Hudson River	NR--63	8,389
Hudson River	NR--64	5,251
Hudson River	NR--65	4,374
Hudson River	NR--66	4,367
Hudson River	NR--67	5,159
Hudson River	NR--68	6,353

Direct Runoff Outfalls - BOD		
Waterbody	**Outfall**	**Total Load (Lbs/Yr)**
Hudson River	NR--69	2,887
Hudson River	NR--70	4,878
Hudson River	NR--71	2,028
Hudson River	NR--72	3,629
Hudson River	NR--73	4,556
Hudson River	NR--74	3,233
Hudson River	NR-501	2,609
Hudson River	WI-936	1,589
Hudson River	WI-950	929
Hudson River	WI-951	660
Hudson River	WI-982	1,781
Hudson River	WI-984	2,239
New York Bay	CI--61	4,784
New York Bay	CI--62	1,959
New York Bay	CI--63	1,936
New York Bay	CI--64	2,422
New York Bay	CI--65	368
New York Bay	CI--66	1,746
New York Bay	CI--68	4,519
New York Bay	CI--69	769
New York Bay	CI--70	838
New York Bay	CI--71	446
New York Bay	CI--72	681
New York Bay	CI--73	2,751
New York Bay	CI--74	926
New York Bay	CI--75	449
New York Bay	CI--76	939
New York Bay	CI--77	1,597
New York Bay	CI--78	3,932
New York Bay	CI--79	5,216
New York Bay	CI--80	10,699
New York Bay	CI-425	3,821
New York Bay	CI-428	2,913
New York Bay	CI-430	315
New York Bay	CI-431	2,633
New York Bay	CI-432	447
New York Bay	NC--88	1,610

Direct Runoff Outfalls - BOD		
Waterbody	**Outfall**	**Total Load (Lbs/Yr)**
New York Bay	OH--12	200
New York Bay	OH--61	2,051
New York Bay	OH--67	853
New York Bay	OH--75	2,702
New York Bay	OH--77	2,493
New York Bay	OH--78	6,555
New York Bay	OH--79	3,754
New York Bay	OH--80	2,678
New York Bay	OH--81	2,074
New York Bay	OH--82	2,096
New York Bay	OH--83	9,998
New York Bay	OH--84	6,024
New York Bay	OH--85	4,523
New York Bay	OH--86	1,180
New York Bay	OH--87	2,648
New York Bay	OH--90	844
New York Bay	OH-344	2,457
New York Bay	OH-415	880
New York Bay	OH-419	2,473
New York Bay	OH--U1	380
New York Bay	OH--U2	961
New York Bay	OH--U3	533
New York Bay	OH--U4	169
New York Bay	OH--U5	1,113
New York Bay	RH--62	2,709
New York Bay	RH--63	2,595
New York Bay	RH--64	3,091
New York Bay	RH--65	2,572
New York Bay	RH--66	3,793
New York Bay	RH--67	3,424
New York Bay	RH--71	1,338
	Total Direct Runoff	**565,941**

Airport/Transport Outfalls		
Waterbody	**Outfall**	**Total Load (Lbs/Yr)**
East River and Open Waters	BB-LG01	2181
East River and Open Waters	BB-LG02	903
East River and Open Waters	BB-LG03	88
East River and Open Waters	BB-LG04	120
East River and Open Waters	BB-LG05	5426
East River and Open Waters	BB-LG06	4354
East River and Open Waters	BB-LG07	1008
East River and Open Waters	BB-LG08	499
East River and Open Waters	BB-LG1A	95
East River and Open Waters	BB-LG5A	4520
East River and Open Waters	BB-LG6A	383
East River and Open Waters	BB-LKD	4373
	Total Airport/Transport	**23,949**

WRRF Discharges		
Waterbody	**Outfall**	**Total Load (Lbs/Yr)**
Kill Van Kull	PRWPCP	751,393
East River and Open Waters	BBWPCP	828,097
East River and Open Waters	HPWPCP	1,343,022
East River and Open Waters	NCWPCP	8,967,003
East River and Open Waters	RHWPCP	574,375
East River and Open Waters	TIWPCP	1,159,376
East River and Open Waters	WIWPCP	2,503,091
Hudson River	NRWPCP	3,113,058
New York Bay	CIWPCP	2,687,728
New York Bay	OBWPCP	674,634
New York Bay	OHWPCP	4,069,313
	Total WRRF	**26,671,091**

Totals by Waterbody		
Waterbody	**Outfall**	**Total Load (Lbs/Yr)**
Harlem River	NA	907,973
Hudson River	NA	3,467,331
East River and Open Waters	NA	17,058,499
New York Bay	NA	9,069,284
Arthur Kill	NA	398,389
Kill Van Kull	NA	1,137,908

Totals by Source		
Source	**Outfall**	**Total Load (Lbs/Yr)**
Airport/Transport	NA	23,949
CSO	NA	3,086,112
Direct Runoff	NA	565,941
MS4	NA	373,626
Storm	NA	1,318,666
WRRF	NA	26,671,091

Totals by Source by Waterbody		
Waterbody	**Source**	**Total Load (Lbs/Yr)**
Arthur Kill	CSO	0
	MS4	108,669
	Storm	289,720
	Direct Runoff	0
	Airport/Transport	0
	WRRF	0
Total		398,389
East River and Open Waters	CSO	1,267,369
	MS4	39,214
	Storm	87,081
	Direct Runoff	265,921
	Airport/Transport	23,949
	WRRF	15,374,964
Total		17,058,499
Harlem River	CSO	837,615
	MS4	0
	Storm	0
	Direct Runoff	70,359
	Airport/Transport	0
	WRRF	0
Total		907,973
Hudson River	CSO	259,985
	MS4	0
	Storm	2,503
	Direct Runoff	91,785
	Airport/Transport	0
	WRRF	3,113,058
Total		3,467,331
Kill Van Kull	CSO	34,883
	MS4	49,460
	Storm	302,171
	Direct Runoff	0
	Airport/Transport	0
	WRRF	751,393
Total		1,137,908
New York Bay	CSO	686,260
	MS4	176,283

Totals by Source by Waterbody		
Waterbody	**Source**	**Total Load (Lbs/Yr)**
	Storm	637,191
	Direct Runoff	137,876
	Airport/Transport	0
	WRRF	7,431,675
Total		9,069,284

APPENDIX B: RECOMMENDED PLAN PUBLIC COMMENT RESPONSE SUMMARY

PUBLIC COMMENTS RECEIVED

1. Karen Argenti of Bronx Council for Environmental Quality (BCEQ), March 2, 2020. RE: NYCDEP Proposed Recommendations for the Citywide/Open Waters CSO LTCP.
2. Rob Buchanan (avironvoile@gmail.com) of New York City Water Trail Association (NYCWTA) March 3, 2020. NYCWTA comments on the proposed East River/Open Waters LTCP
3. Linda Cohen (lindashoob@aol.com), March 3, 2020. RE: NYC Department of Environmental Protection Proposed Recommendations for the Citywide/Open Waters CSO Long Term Control Plan.
4. Pro Bono Water Quality Associates (PBWQA), March 2, 2020. Re: Comments NYCDEP Citywide and Open Waters CSO LTCP (water quality modeling).
5. Amy Motzny of Gowanus Canal Conservancy (GCC), March 2, 2020. RE: NYC Department of Environmental Protection Proposed Recommendations for the Citywide/Open Waters CSO Long Term Control Plan.
6. Roger Reynolds of Save the Sound (STS), March 2, 2020. RE: Comments on DEP's Combined Sewer Overflow (CSO) Long Term Control Plan (LTCP) for Citywide/Open Waters Recommended Plan Summary.
7. Kalra Raji, Bronx River Alliance (BRA), March 2, 2020. RE: NYC Department of Environmental Protection Proposed Recommendations for the Citywide/Open Waters CSO Long Term Control Plan.
8. Bob Alpern, January 30, 2020. RE: Citywide/Open Waters LTCP.
9. Kate Mc Letchie of Waterfront Alliance (WA), January 17, 2020. RE: Citywide and East River/Open Waters Recommended Plan Meeting.
10. Kellan Stanner of Lower East Side Ecology (LESEC), March 2, 2020. RE: NYC Department of Environmental Protection Proposed Recommendations for the Citywide/Open Waters CSO Long Term Control Plan.
11. Alan P. Berger of Alliance for a Human Scale City, February 24, 2020, RE: NYC Department of Environmental Protection Proposed Recommendations for the Citywide/Open Waters CSO Long Term Control Plan.
12. Vasos Panagiotopoulos, February 12, 2020, Re: Flushing River (Creek).
13. Ira Gershenhorn (ira@gershenhorn.com), February 3, 2020, RE: Citywide/Open Waters CSO Long Term Control Plan.
14. National Resource Defense Council (NRDC), March 2, 2020, RE: Citywide/Open Waters CSO Long Term Control Plan (form letter submitted by 1670 additional individuals.)
15. Riverkeeper, February 25, 2020, RE: DEP's "Citywide/Open Waters CSO Long Term Control Plan" must go further to protect public health (form letter submitted by 282 additional individuals).
16. NYC Department of Parks and Recreation (DPR), December 12, 2019. RE: Comments on Citywide/Open Water LTCP Retained Alternatives Summary submitted via email to ltcp@dep.ny.gov

WATER QUALITY SAMPLING AND MODELING

Comment #1: **At a minimum, DEP needs to make good on the data mapping and analytical commitments they made last year in response to public comments:**

1. **Water quality modeling results by specific location (grid cell) throughout the open waters:**
   a. **In DEP's 1/27/2020, response to comments on the retained alternatives summary, DEP stated (in Response #1c): "The modeled attainment results for the open waters will include mosaics that show attainment across all of the model cells against the applicable standard."**
   b. **DEP's 10/10/2019, response to comments from April/May 2019 stated (Response 2b): "In addition to presenting levels of WQS attainment in the form of color-coded, waterbody-wide mosaics, the Citywide/Open Waters LTCP will also provide WQS attainment at selected discrete grid cell locations throughout the open waters. The discrete grid cells added to the water quality model will include locations near public access points based on feedback received at the public meetings and in subsequent comments."**
2. **Results of "time to recovery" analysis:**

DEP's 10/10/2019, response to comments that were submitted in April/May 2019 stated (Response 2a): "DEP acknowledges that the geometric mean criteria upon which the WQS are based do not necessarily portray the short-term impacts of wet-weather events. However, the previous LTCPs approved by DEC have included an analysis of time to recovery, where the magnitude and duration of wet-weather impacts are assessed in more detail. The Citywide/Open Waters LTCP will include similar analyses of time to recovery at locations near recreational beaches and other public access points." (Letters: NYCWTA)

Response #1: Sections 6 and 8 of the Citywide/Open Waters LTCP include figures/mosaics with color-coded grid cells that identify the water quality attainment at points of public access to the Hudson River, Harlem River, East River, Long Island Sound, New York Bay, Kill Van Kull and Arthur Kill. These points of public access include multiple categories of public access including public and private beaches, City identified access points and access points identified during the public comment period. Section 6 includes the mosaics for Baseline Conditions and 100% CSO Control, while Section 8 includes mosaics for the Recommended Plan.

The Citywide LTCP mosaics are also available online at nyc.gov/dep/ltcp.

Comment #2: The proposed LTCP fails to outline a strategy for better and more detailed CSO monitoring and notification, so that all interested residents can be promptly informed of the precise locations, times and amounts of sewage and stormwater releases. In place of the current (and hopelessly vague) 'waterbody advisories' based on presumed water quality, the plan should mandate real-time flow monitors at all major outfalls, and create a robust modeling program to predict overflow times and amounts at all other outfalls. (Letters: NYCWTA)

Response #2: New York City maintains multiple websites that are good resources for members of the public who may have concerns about wet-weather impacts on water quality. DEP's waterbody advisory system is *based on a statistical correlation between historical rainfall volumes and corresponding water quality model outputs. The derived correlations are then used to issue water quality advisories.*

Waterbody advisories can be accessed using the following web-link: https://www1.nyc.gov/site/dep/water/waterbody-advisories.page.

To sign-up for waterbody alerts use the following web-link: https://a858-nycnotify.nyc.gov/notifynyc.

Considering the large number of CSO outfalls throughout the City, it is impractical to institute a real-time CSO monitoring program that provides instantaneous public advisories about individual CSO discharges due to the high level of maintenance and response times necessary to minimize the risk of false advisories due to equipment malfunctions and tidal influence. Real-time metering of tidally influenced CSO outfalls is very complex and requires multiple meters for each CSO site, particularly in New York City where many of the larger outfalls include multiple sewer barrels and contributing regulators. Due to the characteristics of the collection system configuration, highly variable flow conditions and debris within the combined sewage, instruments are subject to frequent malfunction or misreporting of overflow events. To maintain a real-time monitoring system of this size, the metering equipment must be frequently accessed for maintenance and re-calibration. The vast majority of the sites are located in busy road intersections, highways, private properties or other locations which require traffic plans, coordination with property owners or advance notice to access these sites. Other sites are limited to access only during low tide or low sewage flow conditions. The small window of opportunity to access these sites can delay troubleshooting and completion of the necessary repairs. The delays in maintenance response times result in a higher risk of misreporting and subjecting the public to unsafe water quality conditions. Another challenge at some sites is the lack of availability of a permanent power source. Flow meters need a power source to operate, and long-term metering installations cannot reliably operate on battery power.

The current waterbody advisory system provides regular updates on water quality impacts from potential CSO discharges based upon historical monitoring of water quality conditions and validated modeling of collection system responses to a wide range of rainfall events. This is an industry-wide accepted approach that protects public health and minimizes the risk of false advisories caused by real-time equipment malfunctions and misreporting of data.

DEP appreciates the public feedback and will continue to evaluate and institute improvements to the current advisory programs to expand available information, particularly for recreational access points, and to make these web-based sites more user-friendly.

Comment #3: DEP's representations on Page 46 of the Recommended Plan Summary that the East River/Long Island Sound area is meeting Water Quality Standards for dissolved oxygen is transparently, and demonstrably, false. (Letters: STS)

Comment #3a: By way of example, we have attached the Long Island Sound monitoring survey maps demonstrating extreme hypoxic, and even anoxic, conditions from this last summer. This survey is compiled annually and monthly by CT Department of Energy and Environmental Protection and the Long Island Sound Study. (Resource page available at https://www.ct.gov/deep/cwp/view.asp?a=2719&q=325532&depNav_GID=1654). The July 15 – 17 map shows that there was a 46.1 square kilometer area that fell below 3.0 mg/l. Much of this area is within the area impacted by sewage overflows. (Dissolved Oxygen in Long Island Sound Bottom Waters, CT DEEP and Long Island Sound Study, available at https://www.ct.gov/deep/lib/deep/water/lis_water_quality/monitoring/currentyear/lis- narrativemap_4-july-hy.pdf). The August 12 – 14, 2019 map shows a 38.2 square kilometer area actually fell below 1% during that period, becoming not only hypoxic but anoxic. (Dissolved Oxygen in Long Island Sound Bottom Waters, CT DEEP and Long Island Sound Study, August 13 – 15, available at https://www.ct.gov/deep/lib/deep/water/lis_water_quality/monitoring/currentyear/lis-narrativemap_6- august-hy.pdf)

Again, this is the area of Long Island Sound furthest west and most impacted by the sewage overflows in question. We have also attached the 2018 Long Island Sound Hypoxia Review report that documents that between 1994 and 2018 dissolved oxygen levels in the vast majority East River Long Island Sound area fell under the 3.0 mg/l standard 90%–100% of the years (There was a small portion that fell below 3.0 mg/l standard 70%-100% of the years). (2018 Long Island Sound Hypoxia Review, CT DEEP, IEC, and EPA, p. 8 available at http://www.iec- nynjct.org/sites/default/files/ 2019-08/2018-Combined-Report_Final.pdf)

Moreover, New York City's own New York Harbor Water Quality Data demonstrates numerous times each year from 2006 to the present that dissolved oxygen in the East River/Long Island Sound violated Water Quality Standards. In 2019 alone, there are 46 documented instances of Class SB waters falling below 3.0 mg/l or Class I waters falling below 4 mg/l.

Response #3a: The presentation of attainment with WQ Criteria for DO in this LTCP has been consistent with the approach used in all 10 previously-submitted LTCPs under this program. Consistent with direction from DEC, the level of attainment with WQ Criteria for DO has been presented on an annual average basis, calculated as follows:

- *The water quality model is a three-dimensional model set up as a grid system, with each grid cell having 10 layers scaled to the depth of the water. The top layer represents the surface of the water, and the bottom layer represents the layer of water along the bottom of the waterbody.*
- *Within each layer of each grid cell, the model computes the annual percent attainment with the applicable DO criteria.*
- *The overall annual attainment for the grid cell is then computed as the average of the annual attainment of each layer in the grid cell.*

DEP acknowledges that available data have shown periods when measured DO levels have fallen below 3.0 mg/L in certain Class SB waters, or below 4.0 mg/L in certain Class I waters. LTCP sampling data initially presented by DEP at the May 10, 2018 Public Kick-off Meeting for the East River/Long Island Sound waterbodies showed some DO measurements below the applicable Class I or Class SB criteria.

These data are also presented in Section 2 of the Citywide/Open Water CSO LTCP, specifically the data from sampling conducted as part of the LTCP program, and by DEP's HSM program. For example, Figure 1 illustrates the location of the eight HSM stations, designated as E2, E4, E6, E7, E8, E12, E13, and E14. Figure 2 (included in Section 2 of the LTCP) shows the arithmetic mean, minimum, maximum, 25th *percentile, and 75th percentile values for DO from the HSM dataset measured for 2015, 2016 and 2017. The average DO concentrations at all stations were above 6.0 mg/L, but the data show minimum DO concentrations at some Class I East River Stations dropped below 4.0 mg/L, and some Class SB East River/Long Island Sound stations dropped below 3.0 mg/L. The water quality model was therefore calibrated to data that is generally consistent with data from the other sampling sources noted.*

Additional data from HSM for 2018 and 2019 indicate that low seasonal DO conditions continue to persist from late July to early September annually. These conditions exist for varying periods annually and are more prevalent in bottom sample data, particularly at East River stations located nearest Long Island Sound. These data are again generally consistent with the data from the references noted in the comment, which showed generally lower DO levels in the western end of Long Island Sound compared to other parts of the Sound.

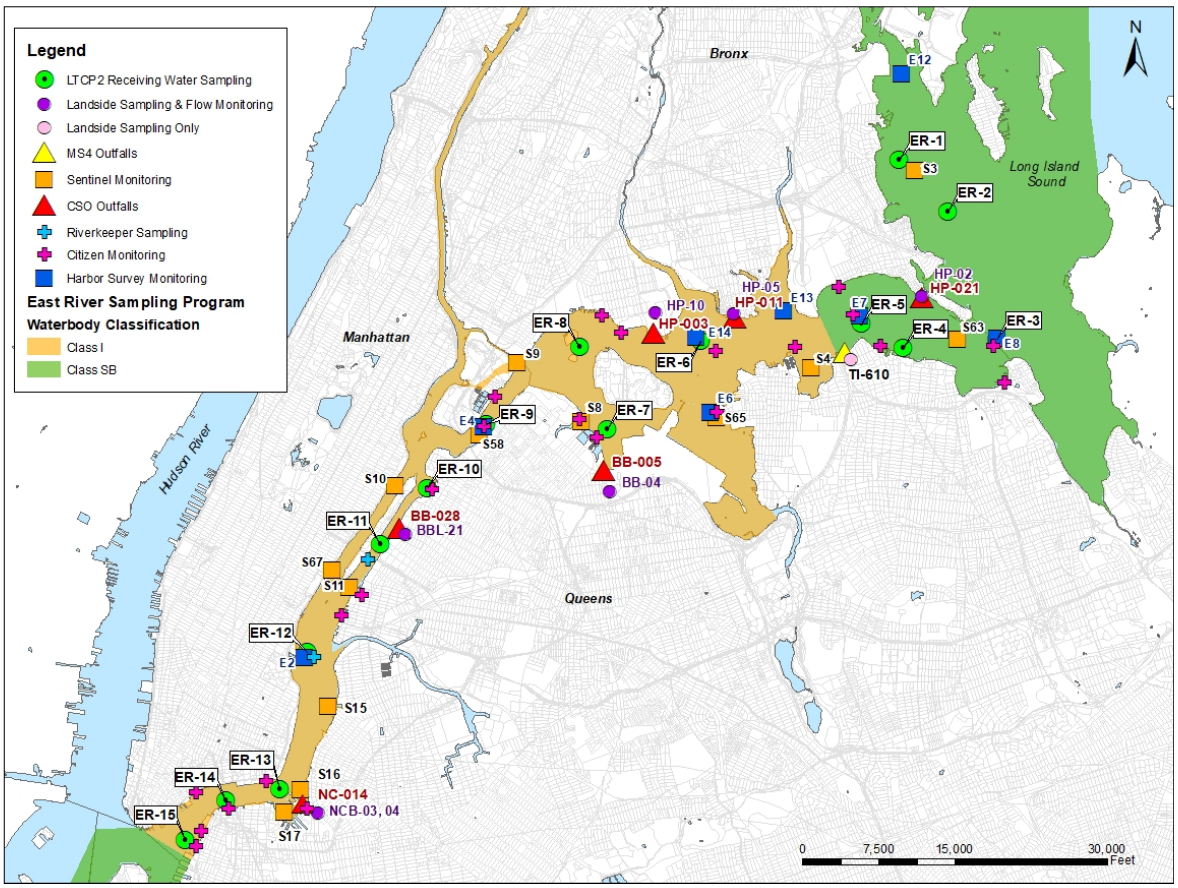
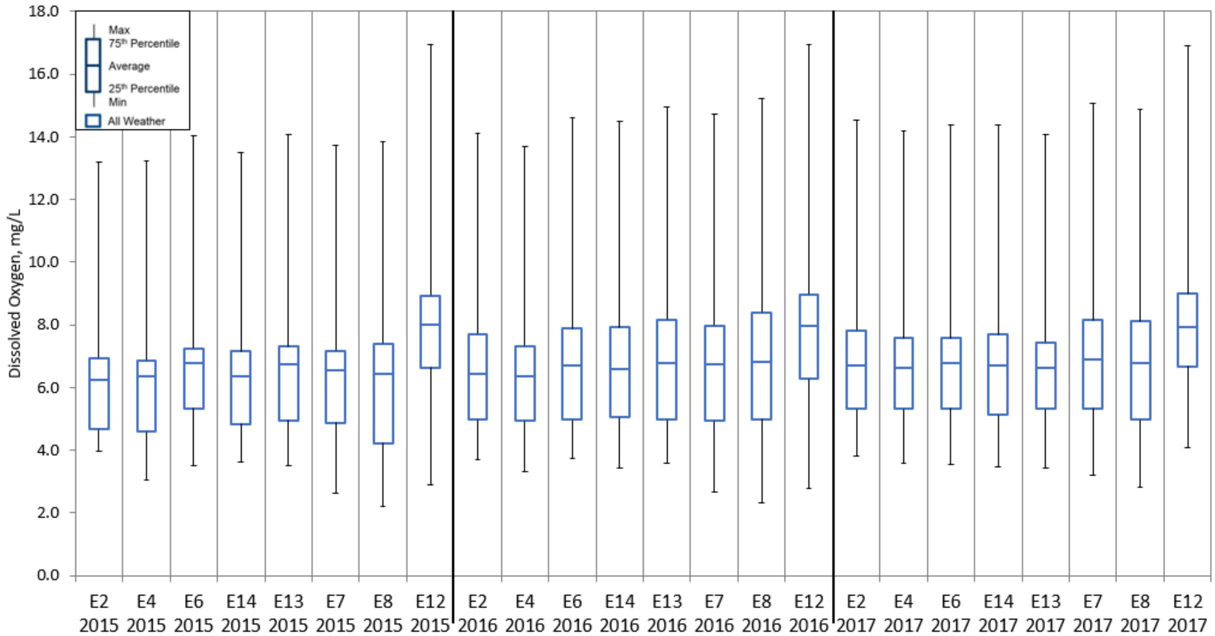


Figure 1. Water Quality Monitoring Sampling Locations for the East River and Long Island Sound

Figure 2. HSM DO Data for East River/Long Island Sound



However, the critical point identified in the review of the data for this LTCP is that controlling CSOs is not predicted to result in a significant improvement in DO levels in the Open Waters waterbodies. The periodic discharges of CSOs are not a major source of pollutant constituents that would contribute to low DO levels (biochemical oxygen demand and nutrients), compared to other, more constant sources in the Open Waters (wastewater resource recovery facility [WRRF] effluent and upstream boundary sources such as non-NYC WRRFs, CSOs and SSOs, failed septic systems, illicit connections, sewer system exfiltration, stormwater sources, fertilizer application, farm runoff, etc.). Particularly in the western end of Long Island Sound, the shoreline is more highly urbanized, and the hydrodynamics of the waters in this area are affected by tidal conditions, the narrower width of the waterway, and other factors resulting in reduced mixing and low DO levels.

Using data from Appendix A of the 2018 Long Island Sound Hypoxia Season Review Report as an example, DO levels are shown at IEC Stations A1 and A2M, located along the East River near the Whitestone Bridge (A1) and Throgs Neck Bridge (A2M), where CSOs discharge. As indicated by the figures in Appendix A, the DO levels at these stations are consistently higher than those at Stations A3, A4 and A5 which are located to the east between Westchester County and Long Island. The water quality at Stations A3, A4 and A5 is impacted by municipal WRRFs and other sources which contribute nutrients. These additional sources include sanitary sewer overflows, malfunctioning septic systems, agricultural runoff, and stormwater runoff.

DEP continues to work with EPA, DEC and other agencies to evaluate and implement measures to improve DO levels in these waters. However, as noted above and discussed in the response to Comment #3d below, CSO control is not a cost-effective approach to reducing the nutrient loads that affect DO levels in these waterways.

Comment #3b: In response to a question at the public meeting, DEP explained that their conclusion that the East River and Long Island Sound were in compliance with Water Quality Standards was based upon annual averaging. Water Quality Standards for dissolved oxygen, however, include

daily averages and acute standards – not annual averages. That reality must be reflected in the study and in the alternatives that are chosen. While DEP justifies their use of the methodology as approved by DEC, even if that is the case, that agency has no authority to modify the Water Quality Standards without going through a formal regulatory process to do so. If it is the case that DEC, the agency charged with protecting New York water quality, in fact approved a methodology that is completely inconsistent with and unrelated to the Water Quality Standard itself, that is an even greater cause for concern for clean water and responsible government action to protect it.

Response#3b: Consistent with DEC approved methodology and previously submitted and approved LTCPs, DO model results are depth averaged. Attainment is calculated in the 10 equal vertical layers of the model, and then the attainment of all 10 layers is averaged (see response to Comment #3a above).

Comment #3c: As pointed out in previous comments from the SWIM Coalition,

1. **(1) DEP uses different rainfall models for the same period,**
2. **(2) DEP inappropriately uses depth averaging rather than sampling bottom waters,**
3. **(3) DEP failed to sample waters in the maximum hypoxia season from July to September, and**
4. **(4) DEP inappropriately combined seasonal LTCP sampling data with year round harbor monitoring data.**

Response #3c:

(1) The DEP performs 10-year continuous simulations of the InfoWorks collection system models to provide input to 10-year continuous simulations of the water quality model to assess attainment with the WQ Criteria for bacteria under Baseline Conditions and 100% CSO reduction as part of the gap analysis in Section 6 of the LTCP. The same 10-year bacterial attainment assessment is conducted for the recommend plan as part of Section 8. The 1-year simulations using the 2008 Typical Year are used for the initial evaluation of alternatives, since it is not practical to assess multiple alternatives using a 10-year simulation. Similarly, the assessment of attainment with WQ Criteria for DO is conducted using the 1-year (2008) simulation because the dissolved oxygen water quality modeling is much more complicated than bacterial water quality modeling and attainment with the dissolved oxygen WQ Criteria is much less sensitive to intermittent wet-weather discharges. The results of the 10-year model runs assessing attainment with WQ Criteria for bacteria, and the 1-year runs assessing attainment with WQ Criteria for DO will be included in Sections 6 and 8 of the LTCP.

(2) Consistent with DEC approved methodology and previously submitted and approved LTCPs, DO model results are depth averaged. Attainment is calculated in the 10 equal vertical layers of the model, and then the attainment of all 10 layers is averaged (see response to Comment #3a, above).

(3) Over the course of the sampling effort for the LTCP, DEP performed an extremely extensive sampling program that targeted wet-weather and collected samples for four consecutive days after a significant storm event during both low tide and high tide conditions, resulting in the collection of a total of 1,886 LTCP ambient water quality samples. These data were also supplemented with data from DEP's Harbor Survey Monitoring Program and were used to calibrate/validate the existing water quality model. The water quality model was then used to project the level of attainment with WQ Criteria for bacteria and DO both annually and seasonally, including the warmer late summer and early fall months when DO levels tend to be at their lowest.

(4) The model calibration process looked at specific sampling data collected on specific days and compared that data to the model predictions for those locations on those days. The bar charts of the Harbor Survey Monitoring, Sentinel Monitoring and LTCP Sampling Program data are presented to provide a general sense of water quality conditions and show that the data correlated to one

another. The projected attainment with Water Quality Standards was based on a calibrated/validated water quality model and as previously mentioned both baseline and recommended plan attainment was evaluated using a comprehensive 10-year period that includes some higher than average wet periods.

Comment #3d: Regarding the criticism that DEP did not adequately account for nitrogen pollution and dissolved oxygen impairments, DEC refers to its own data which has allegedly shown that the total portion of nitrogen load to the Open Waters waterbodies attributable to CSOs is so low that reductions in it would not have an actual impact on receiving water quality. First of all, this does not address the misrepresentation regarding compliance with Water Quality Standards within the waterbody. Moreover, DEP fails to provide any data or modeling to back up this claim. The first thing DEP must do is to accurately characterize the natures of the water as severely hypoxic in the summer season and out of compliance with Water Quality Standards. Subsequently, DEP must evaluate CSO's to determine whether they are causing or contributing to this impairment. To date, DEP has done neither.

Response #3d: The western end of Long Island Sound is funneled into a narrow area bounded by lower Westchester County, Connecticut, western Nassau County, the Bronx and northern Queens, and flows into the Upper East River. WRRFs that serve more than a dozen municipalities along the Connecticut and New York coasts are one of the many sources of nitrogen in the Sound. Coastal watersheds that drain directly into the Sound and those that drain into tributaries to the Sound are also major contributors. High levels of nitrogen in the Sound over the last few decades have led to periodic algae blooms that reduce the amount of dissolved oxygen in the water and impair the survival of fish and other marine organisms. Algae colonies can flourish with an ample supply of sunlight and nutrients, such as nitrogen.

On April 5, 2001, the U.S. Environmental Protection Agency approved a nitrogen reduction plan for Long Island Sound which had been established by New York and Connecticut. The plan mandated a 58.5 percent reduction of nitrogen from the 1994 baseline, for dischargers to Long Island Sound, including New York City's Upper East River WRRFs (Hunts Point, Bowery Bay, Wards Island and Tallman Island), the City's Lower East River WRRFs (Newtown Creek and Red Hook), as well as WRRFs serving Long Island, Westchester and Connecticut, through a phased approach over 15 years. DEC imposed nitrogen limits reflecting the approved plan on all the New York WRRFs through the process of renewing required operating permits, also known as the State Pollution Discharge Elimination System.

As part of an agreement with the New York State Department of Environmental Conservation (DEC) and the New York State Attorney General, DEP committed to reducing the combined nitrogen discharges from its WRRFs located along the East River by 58.5 percent by January 2017. And, as of September 2016, nitrogen discharges from New York City WRRFs to the East River have been reduced by approximately 61 percent.

The capital investments included:

1) *$277 million at the Hunts Point WRRF completed December 30, 2016*
2) *$388 million at the Wards Island WRRF completed November 10, 2014*
3) *$209 million at the Tallman Island WRRF completed March 31, 2017*
4) *$161 million at the Bowery Bay WRRF completed December 30, 2016*

The nitrogen reductions associated with these WRRF upgrades are beginning to be reflected in the dissolved oxygen levels in the East River and Long Island Sound. Dissolved oxygen levels will continue to improve with the reduction in this primary nutrient source for algae growth. DEP will continue to monitor DO and report water quality improvements in accordance with the agreement and current water quality monitoring programs.

Table 1. **Annual Loads to East River and Long Island Sound for Baseline Conditions** *provides a summary of model-predicted fecal coliform, Enterococcus, and Biochemical Oxygen Demand (BOD) loads discharged to East River and Long Island Sound from NYC WRRFs and CSO Outfalls under Baseline Conditions for the 2008 typical year. Total Nitrogen (TN) loads for the WRRFs and CSO Outfalls are provided for 2017 DMR and CSO TN Reporting. The table illustrates that fecal coliform and Enterococcus loads are predominantly from CSOs making pathogens the primary focus of the CSO LTCP, while BOD and TN are primarily associated with WRRF effluent discharges.*

The annual nitrogen loading data in Table 1. **Annual Loads to East River and Long Island Sound for Baseline Conditions** *are presented graphically in* ***Error! Reference source not found.****. This figure illustrates that the model-predicted load from all East River CSOs is significantly less than the annual TN contribution from each of the six WRRFs. The relative level of TN loading shown is consistent with the findings of other LTCPs which indicate that CSOs typically contribute negligible nutrient loads to receiving waters relative to other sources.*

Considering the extremely small TN loads contributed by CSOs to the East River and Long Island Sound, it is not cost-effective to address TN related water quality issues through CSO control. Reduction of TN loads related to non-CSO sources is outside the scope of this LTCP and continues to be addressed through the nitrogen management program and the SPDES Permit for each WRRF.

Table 1. Annual Loads to East River and Long Island Sound for Baseline Conditions

Parameter	Bowery Bay WRRF (1)	Tallman Island WRRF (2)	Hunts Point WRRF (1)	Red Hook WRRF (3)	Wards Island WRRF (1)	Newtown Creek WRRF (3)	CSOs
Fecal Coliform ($x10^{12}$ cfu /100mL) (4)	44	46	87	23	150	174	590,085
Enterococci **($x10^{12}$ cfu /100mL) (4)**	9	9	17	5	30	35	173,491
BOD (lbs/yr) (4)	828,097	1,159,376	1,343,022	574,375	2,503,091	8,697,003	4,717,748
TN (lbs/day) (5)	10,474	3,821	7,872	4,443	13,306	32,148	2,205
TN (lbs/yr) (5)	9,866,815	3,599,558	7,415,624	4,185,477	12,533,797	30,282,962	804,788

Notes:
(1) BNR upgrades with carbon addition are fully operational.
(2) BNR upgrades are under construction.
(3) No BNR upgrades (RH and NC).
(4) Based on LTCP model-predicted loads for typical 2008 rainfall year.
(5) Based on 2017 DMR data and 2017 CSO TN report.

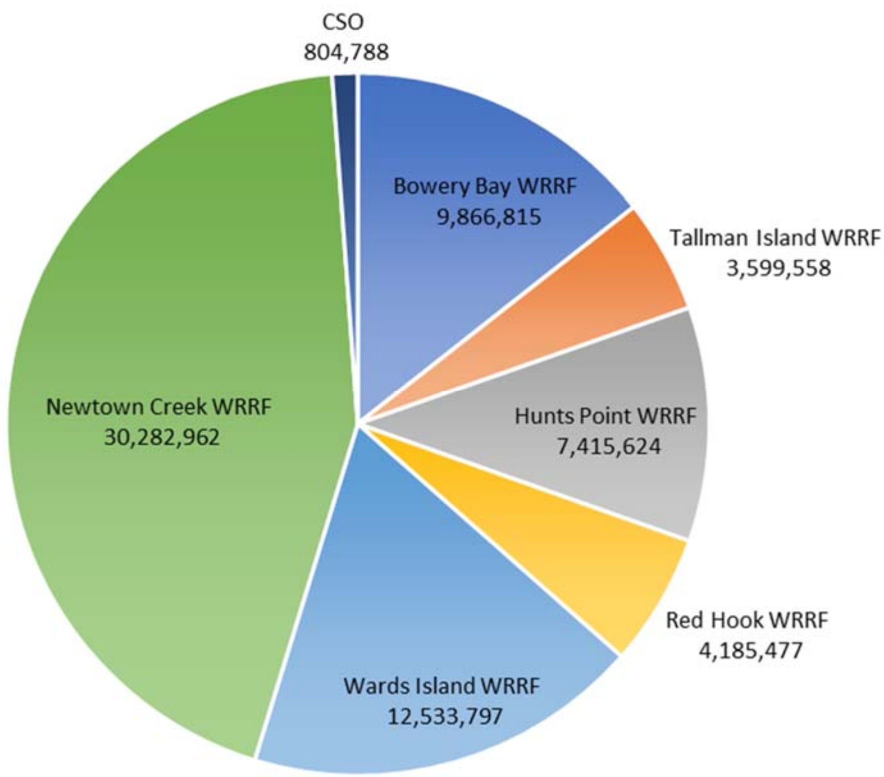


Figure 3. Annual Nitrogen Loading to the East River and Long Island Sound (2008 Typical Year)

Comment #4: DEP's statement regarding East River/Long Island Sound's compliance with Water Quality Standards are demonstrably false and there is extensive, readily available, data to the contrary. (Letters: STS)

Response #4: Please refer to Response #3a above.

Comment #5: Additionally, DEP's data directly contradicts the water quality results that we and our partner organizations report annually. Our longitudinal studies show that the Bronx River and East River are in very poor health, with severely low dissolved oxygen levels and extremely high counts of *Enterococcus*, typically several orders of magnitude above the EPA's safety threshold. (Letters: BRA)

Response #5: As indicated in Section 2 of the Citywide/Open Waters CSO LTCP, HSM dissolved oxygen sampling results appear to be consistent with data reported at overlapping IEC sampling stations in the East River and westernmost potion of the Long Island Sound. As discussed in the above responses, the IEC monitoring stations with the worst DO conditions are located within the Long Island Sound between Westchester and Nassau Counties. Please refer to the responses to Comments 3a, 3b, and 3c for additional information.

The Enterococci criteria only apply to Class SB Coastal Primary Contact Recreational Waters. The freshwater portion of the Bronx River in NYC is classified as Class B. The saline portion of the Bronx River and the majority of the East River are classified as Class I waters. A small portion of the East River between the Whitestone and Throgs Neck Bridges is classified as Class SB non-coastal waters. The fecal coliform monthly geometric mean criteria apply to these waterbodies. The monthly geometric mean standard considers variations in fecal coliform concentrations over the period of a month. During that period, there may be instances where instantaneous fecal coliform concentrations may exceed 200 cfu/100mL but the geometric mean WQ Criteria are still attained.

Comment #6: DEP's use of 95% attainment of Water Quality Standards is inconsistent with the Clean Water Act, the EPA 1994 Combined Sewer Overflow Control Policy and DEP's Consent Order. (Letters: STS)

Comment #6a: In response to concerns that DEP was only modeling 95% compliance with Water Quality Standards, DEP simply explained that that was the methodology they proposed to DEC and was accepted. Yet, that methodology is inconsistent with EPA's CSO Control Policy and fails to meet the standard of actual compliance with Water Quality Standards. DEP uses this 95% criteria throughout the LTCPs to predict future bacteria and DO concentrations. But nowhere in the CWA is attainment based on only 95% attainment and there is no authority that we are aware of to support such an interpretation. By definition, 95% attainment is 5% non-attainment. While percent attainment is not generally a metric used (actual compliance is), countless Clean Water Act cases have been brought to enforce violations that were less than 5%. In a case like sewer overflows, where we are concerned with the acute impacts of periodic but intense pollution events, 5% non-compliance is more than enough to cause substantial harm to human health and the environment.

Response #6a: The LTCP utilizes landside and receiving waters models as predictive tools for assessing collection system responses to precipitation and the impacts on water quality attainment. The models were initially developed to replicate existing conditions and were then modified to represent future Baseline Conditions, evaluate CSO control alternatives and predict performance of the Recommended Plan. In developing these models, many assumptions were made relating to various parameters that impact runoff, collection system performance, receiving water dynamics and other characteristics. DEP's approach to collection system and water quality modeling, interpretation of model output, and determining water quality standards attainment has been developed in coordination with DEC. The approach used for the Citywide/Open Waters LTCP was consistent with the approach used in the prior LTCPs that have been approved by DEC.

For consistency, this same standard was applied to all of the submitted and approved LTCPs and the same metric will also be applied for determining water quality attainment under the Citywide/Open Waters LTCP.

Upon implementation and operation of the Recommended Plans for each of the LTCPs, DEP will be required to perform a Post-Construction Compliance Monitoring (PCM) Program in compliance with the USEPA CSO Policy to "verify compliance with water standards and protection of designated uses as well as ascertain the effectiveness of CSO controls."

Comment #6b: The regulatory backdrop for this LTCP establishes the need to comport with actual regulatory standards, rather than statistical models developed by DEP and accepted by DEC yet not meeting such standards. Section 402(q) of the CWA and DEP's permit both require compliance with the CSO Control Policy. The Demonstration Approach of the CSO Control Policy requires that the LTCP be "in compliance with the requirements of the CWA" and be "adequate to meet WQS and protect designated uses." There is no indication in the CSO Policy, the Clean Water Act or other guidance that 95 percent of compliance with Water Quality Standards is adequate.

Response #6b: As discussed in the response to Comment #6a, the model is a predictive tool used for assessment of CSO control alternatives. Ultimately, a PCM Program will be performed upon implementation of the Recommended Plan to verify the effectiveness of CSO controls.

Comment #6c: At the public hearing on the Citywide LTCP, DEP explained that it chose 95% because it was within the margin of error of their methodology. Yet, margins of error do not go solely in one direction. The risk that the model could require measures that might exceed Water Quality Standards is accompanied by the risk that they could fall short. In other words, while it might be reasonable to suspect that 95% modeled compliance might represent 100% compliance, by that same reasoning it could also represent 90% or less compliance. Allowing DEP a 5% cushion in only one direction is unjustified and constitutes an unjustified dilution of the Water Quality Standards.

Response #6c: As discussed in the response to Comment #6a, DEP has taken a conservative approach in developing the landside and receiving water models and believes that these models over-predict CSO frequency and volume and their water quality impacts. Ultimately, a PCM Program will be performed upon implementation of the Recommended Plan to verify the effectiveness of CSO controls.

Comment #7: DEP has failed to adequately analyze or address floatables and enterococcus.
(Letters: STS)

Comment #7a: In addition to the issues set forth above, the summary document and the public hearings failed to address either floatables or enterococcus. Floatables are part of the Water Quality Standards. While EPA states they will address them in the actual Long Term Control Plan, they have given no indication why they could not, or did not, address them in the summary. Moreover, DEP's past practice has been not to have a public comment period on the actual LTCP which would eliminate meaningful input from the public on this issue altogether.

Response #7a: Slides 51 through 57 of the January 29, 2020 public presentation addressed floatables controls. Data collected under the Citywide Integrated Floatables Program indicate that 96% of citywide floatables emanating from CSOs are captured through street sweeping, catch basin hoods, netting, booms and the WRRFs. (Source: NYC Stormwater Management Program, NYCDEP, August 2018.)

Despite the strong performance of these technologies, the City continues is efforts through public education and outreach through its "Clean Streets = Clean Beaches" campaign, online surveys and focus groups. The City has also implemented the following regulatory measures to reduce floatables at the source:

(1) Prohibitions and fines for littering and illegal dumping
(2) Regulations for Alternate Side Parking to conduct street sweeping

(3) Requirements to for property owners to keep sidewalks, gutters, backyard areaways and alleys clean
(4) Styrofoam Ban in effect on January 1, 2019
(5) Single-use plastic bags ban (NYS) with five cent fee for paper bag (NYC) in effect on May 15, 2020
(6) Executive Order banning City Agencies from purchasing single-use plastic foodware

A subsection has been included in Section 8 of the LTCP that provides additional details on the above programs, as well as others DEP is implementing to address floatables from combined and storm sewer systems.

Comment #7b: **With respect to enterococcus, by letter of May 19, 2016, EPA has notified DEC that they will be expected to modify their current Water Quality Standards to set levels for enterococcus that will be protective of public health pursuant to the Clean Water Act "as soon as possible." Given this, DEP must not only consider compliance with Water Quality Standards that are in place today, but must consider the Standards that should be in place at the time the LTCP is put into effect. Failing to address these pollutants is another way in which the LTCP falls woefully short of, and is inconsistent with, the requirements of the CSO Control Policy and the CWA.**

Response #7b: DEC adopted amendments to 6 NYCRR 700, 703, 890 in their BEACH Act standards and reclassification rule (BEACH Act Rule) that established in New York City Enterococci WQ Criteria for Class SB (primary contact) coastal recreational marine waters, which went into effect on November 1, 2019. The Enterococci WQ Criteria includes a 30-day rolling geometric mean (GM) for Enterococci of 35 cfu/100mL with a 90th percentile statistical threshold value (STV) of 130 cfu/100mL. In New York City, these criteria apply to Upper/Lower New York Bay and the Long Island Sound. As defined by DEC in 6 NYCRR 700.1(73), Coastal recreation waters mean the Great Lakes and marine coastal waters (including coastal estuaries) that are designated under Section 303(c) of the federal Clean Water Act by the State for use for swimming, bathing, surfing, or similar water-contact activities. Coastal recreation waters do not include inland waters or waters upstream of the mouth of a river or stream having an unimpeded natural connection with the Great Lakes or open marine waters.

As established by DEC in their BEACH ACT Rule, the Enterococci criteria do not apply to the Hudson River, Harlem River, Kill Van Kull, Arthur Kill, or the East River, nor do they apply to the tributaries. While DEP has evaluated the implications of applying these standards to these Class I and Class SD waterbodies and presented the gap analysis in prior public meetings and presentation materials for informational purposes, the alternatives evaluations and development of the Recommended Plan are based upon attainment of Existing WQ Criteria as established by DEC for the waterbodies covered by this LTCP.

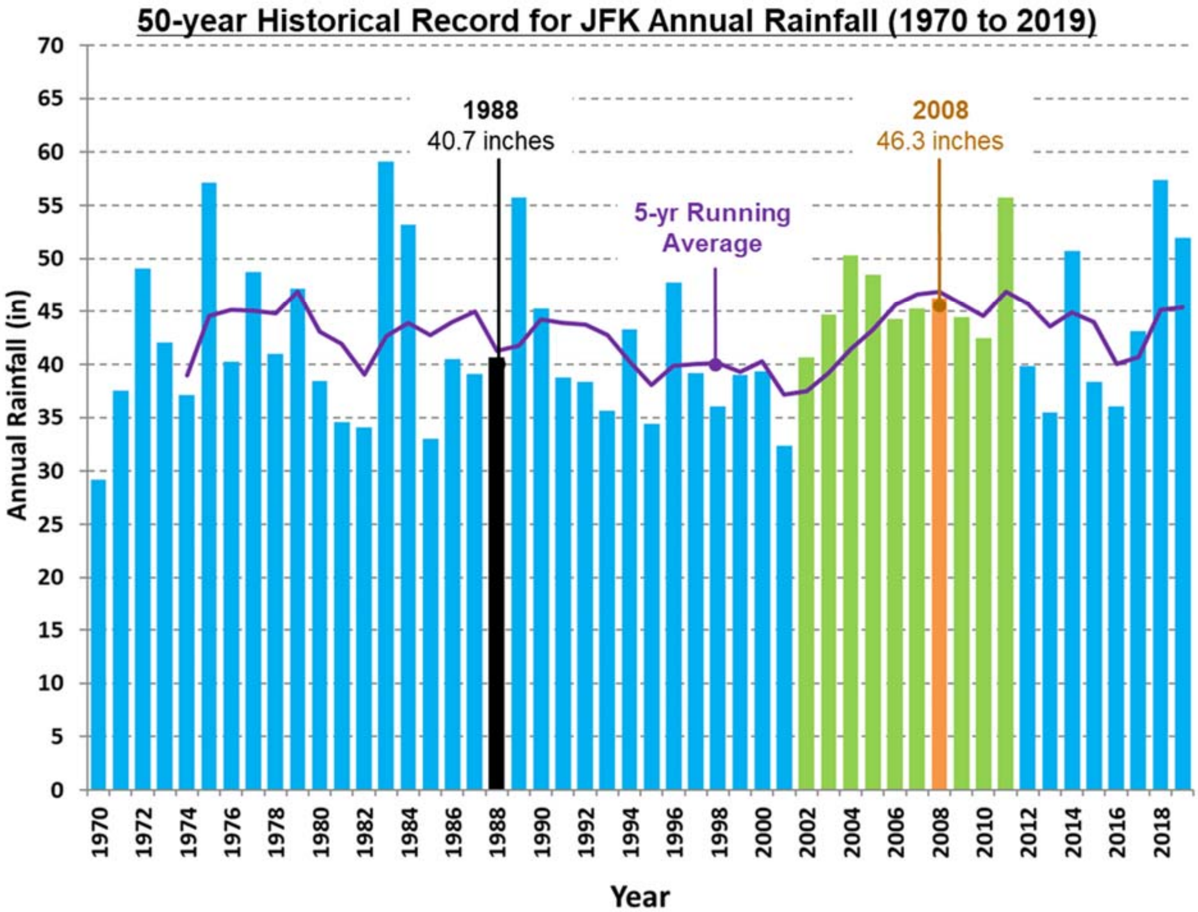
Comment #8: **Review of NYCDEP's Modeling Approach for the NYC CSO LTCP Evaluations.**

Since copies of NYCDEP's CSO LTCP Open Water - water quality modeling reports were not available to conduct an engineering review, the following Flushing Bay work was used as a surrogate. (At the January 29, 2020 NYCDEP " Combined Sewer Overflow Long Term Control Plan: Citywide/Open Waters LTCP - Recommended Plan Public Meeting", NRDC commented that providing the supporting engineering documents is a fundamental requirement for stakeholders to develop a full understanding of the proposed planning approach.) "City-Wide Long Term CSO Control Planning Project - Flushing Bay LTCP Sewer System and Water Quality Modeling" ***(April 2016 REVISED January 2017)*** **The six water quality modeling issues identified below were based on that report.** (Letters: PBWQA)

Comment #8a: **ISSUE 1: Design Life / Design Conditions - The model, as applied, does not take into account the reality of climate change; Precipitation records for Central Park go back to 1869, and as can be seen, the 53.6 inches that fell in 2008 makes it an above-average year, when looked at on a probability basis. But going back to the temporal plot – one notices that precipitation over the past 50 or so years seem to have more variability and higher volumes than the those of the previous century.**

NYC's use of 2008 for 'Baseline' ignores the reality of climate change and the '2008 Baseline' should be scaled and then used to estimate anticipated increasing precipitation? If we design and install a 20' pipe and then realize it should have been 24', because we're experiencing greater rainfall – then – "Houston, we have a problem" or one might say – we've not optimally invested our public funds for maximum benefit.

Response #8a: Meteorology input was based on the NOAA's weather station at JFK International Airport (USAF 744860 WBAN_ID 94789). The following figure summarizes the annual rainfall for the past 50 years from 1970 through 2019. The black bar identifies the 1988 typical rainfall year used as the basis for the development of the Waterbody Watershed Facilities Plans (WWFPs). Upon initiating the modeling for the Long Term Control Plans (LTCPs), DEP reevaluated the historical rainfall data. The 5-year average was plotted (purple line) to illustrate variations in total annual rainfall.



A ten-year period of rainfall was selected between 2002 and 2011, representing a wetter period as indicated by the two peaks in the 5-year average. Each of the years during this period exceeded 40 inches of rainfall, while all other consecutive 10-year periods since 1970 included multiple years with annual rainfall less than 40 inches. To select the "Typical Year", a comprehensive range of historical rainfall data were evaluated from 1970 to 2019 at four rainfall gauges (Central Park, and LaGuardia, JFK, and Newark Airports). The 2008 JFK rainfall was determined to be the most representative of average annual rainfall across all four gauges for that period. The total rainfall in 2008 was 46.3 inches, ranking 14th out of the most recent 50 years of data. Based upon this analysis, the period from 2002 through 2011 is the wettest continuous period over the past 50 years and provides a high level of conservatism to the LTCP analyses.

The LTCP is the first phase of CSO planning and is focused on identifying a cost-effective, constructible recommended plan that addresses CSO impacts on water quality. It is the initial step in the process and does not fully define the facilities to be constructed. As DEP proceeds with implementation of the Recommended Plan, additional planning is performed before advancing to design and construction to evaluate and incorporate other projects with synergies, assess risk and constructability, consider opportunities for future expansion and develop the basis of design that among other details addresses climate change and resiliency. Any modifications to the Recommended Plans, as a result of the planning and design processes, are coordinated with DEC so that any material changes to the LTCP projects are incorporated into the CSO Order.

As each of the LTCP recommended plans are advanced, the DEP will follow a similar process to consider future expandability for the purposes of addressing stricter regulatory requirements, higher levels of CSO control, climate change, sea level rise and resiliency.

Comment #8b: ISSUE 2: Pathogen Kinetics: No site-specific nor pathogen-specific die-off rates were measured. The literature is replete with studies that found the need to perform such measurements to determine die-off rates. The second issue that we identified is that the Pathogen Kinetics were not assigned on a site-specific basis, nor on a pathogen-specific basis. As can be seen by this table, there is no one-size-fits-all disappearance rate. Also, review of Lomardo and Lantrip's work indicate that not all indicators 'decay' at the same rates.

Response #8b: Water quality was sampled during wet-weather events over three-day periods. These data provided information for the loss rate of bacteria. Part of the process of model calibration is fitting the data by modifying the bacteria die-off rates.

The approach to modeling is to start with a simple approach, using a base die-off rate affected by temperature and salinity, and then add additional complexity if the data indicates that additional complexity is warranted. In the case of Flushing Bay, settling appeared to be a major mechanism based on the available data, so a settling factor was incorporated into the die-off rates. In the Open Waters, solar radiation appeared to be a factor, so a factor to account for losses due to solar radiation was added to the die-off rates.

The water quality model did use different die-off rates for fecal coliform and Enterococci. The base temperature-dependent die-off rate for fecal coliform was a little less than the value for fecal coliform in the Lantrip table, and the base temperature-dependent die-off rate for Enterococci was slightly higher. In both cases, the die-off rates applied in the model were consistent with other literature values.

Lantrip (1983)				
Indicator	Decay Rates (1/day)			
	n	Median	Minimum	Maximum
Total Coliform	16	0.722	-	-
Fecal Coliform	13	0.732	-	-
Fecal Step	5	0.706	-	-

Lantrip, B.M., 1983. The Decay of Enteric Bacteria in an Estuary, Doctor of Science Dissertation, School of Hygiene and Public Health, The Johns Hopkins

Comment #8c: ISSUE 3: Impact of solar radiation on pathogen die-off was not considered. The literature is replete with studies that found that the effect of solar radiation had to be considered to adequately represent the fate of pathogens in natural systems. The third issue identified is that the impact of solar radiation was not included in the model. Solar radiation loss has consistently been included in engineering models since at least the 1970's. Given the reality of climate change and its associated impact on water clarity, etc. we believe it should have been included, as does Dr. Steven C. Chapra of Tufts, who conducted a NYCDEP funded review.

Response #8c: Die-off associated with solar radiation was applied in the model used for the Open Waters analysis.

Comment #8d: ISSUE 4: Settling rates were assigned yet TSS was not measured or modeled. The notion that the major 'loss' mechanism was defined as settling, yet no Total Suspended Solids measurements (TSS) were made to assist in model calibration, is not currently acceptable practice. The fourth issue identified was that Total Suspended Solids were neither measured nor included as a state variable in the model, even though settling was described as the major loss mechanism. Not only should TSS have been measured and modeled – but we also agree with Dr. Chapra that the potential importance of resuspension and sediment load should be evaluated. Given that the overall 'loss' rate is greater than 1/day, that both the concentration and wastewater flow vary hour-to-hour, and that the onset and termination of precipitation events is random pathogen loads and concentrations should be input into the model hourly, not as a steady-state constant. As can be seen from this Newtown Creek Plant graph, concentrations of Total Coliform varied by factors of 10 to 20 times on a minimum to maximum basis.

Response #8d: Settling was not included as part of the bacteria loss mechanisms in the Open Waters modeling, which can be considered a conservative approach. In Flushing Bay, the settling approach was discussed with and signed off by Steve Chapra from Tufts University, and literature was available on the settling characteristics of TSS in Flushing Bay from the two references below as listed in the modeling report reference section. (City-Wide Long Term CSO Control Planning Project - Flushing Bay LTCP Sewer System and Water Quality Modeling)

- Fugate, D. and B. Chant. Aggregate settling velocity of combined sewage overflow Marine Pollution Bulletin Volume 52, Issue 4, April 2006, Pages 427–432.

- Lawler, Matusky & Skelly Engineers, LLP. April 2005. Solids Reactivity and Settling Characteristics Study. Phase I CSO Solids. For the New York City Department of Environmental Protection CSO Long-Term Control Plan. Under subcontract to Joint Venture: Hazen and Sawyer, Greeley and Hansen LLC and O'Brien and Gere.

As described in the Flushing Bay report, CSO concentrations were assigned randomly based on a Monte Carlo distribution of sampling data, where data were available. Figure 4 shows the frequency distribution plots of the modeled concentrations of fecal coliform and Enterococci at Outfalls BB-006 and BB-008 compared to the measured concentrations from the LTCP sampling program. This approach was not practical for the 314 Open Waters CSOs. Sampling was performed for 14 representative CSO outfalls and 20 stormwater outfalls, while water quality samples were collected at over 150 locations. For the Open Waters waterbodies, a mass balance approach was used, where the CSO concentration is computed by the InfoWorks model based on the relative proportions of sanitary sewage and stormwater in the CSO. This approach which still results in a time-variable loading, but with generally a smaller range of concentrations.

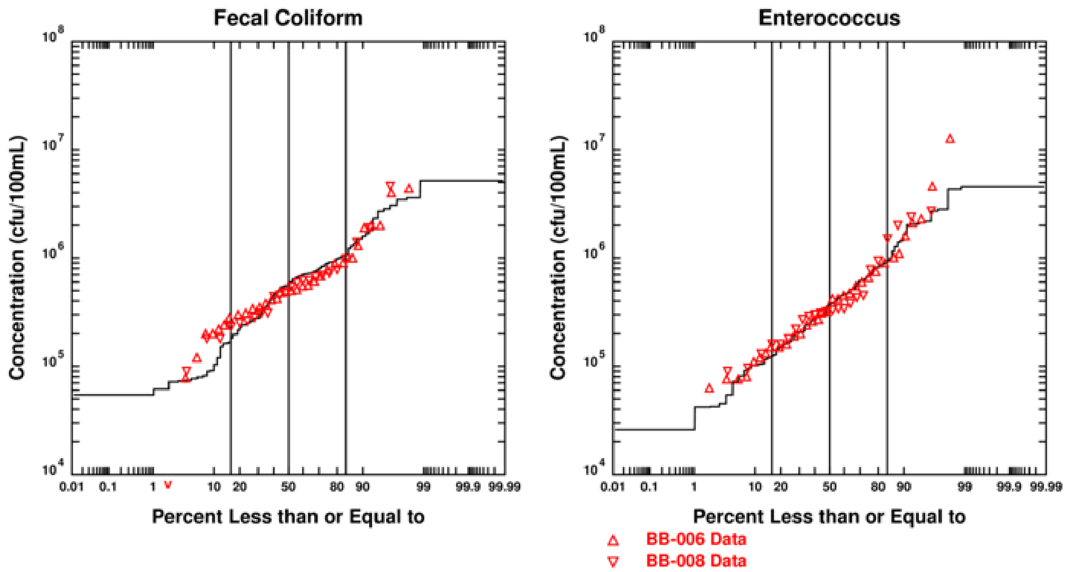


Figure 4. Probability Distribution Comparison between Observed CSO BB-006 and BB-008 Bacteria Concentrations and Estimated Concentrations from the Monte Carlo Analysis

Comment #8e: ISSUE 5: Diurnal variability of pathogen load was ignored. Given that the 'loss' rates are on the order of per day, assigning steady-state loads is inappropriate. Observed hourly loads should have been used given observed diurnal variability. Given that the overall 'loss' rate is greater than 1/day, that both the concentration and wastewater flow vary hour-to-hour, and that the onset and termination of precipitation events is random pathogen loads and concentrations should be input into the model hourly, not as a steady-state constant. As can be seen from this Newtown Creek Plant graph, concentrations of Total Coliform varied by factors of 10 to 20 times on a minimum to maximum basis. Likewise, Kim et al found significant minimum to maximum variation for both concentration and loads.

Response #8e: Steady-state loads were not applied in this model. Time-variable loads were assigned based on output from InfoWorks that was assigned on an hourly basis. CSO, stormwater, and WRRF flows were assigned from the InfoWorks models based on time-variable precipitation.

CSO concentrations were not assigned as constant concentrations, but were based on sanitary and stormwater concentrations and a time-variable fraction of each based on InfoWorks model output. The diurnal variation of flow is assigned in the InfoWorks model.

Comment #8f: ISSUE 6: Supplemental special rate studies and field data needs to be collected. The last model issue identified is that the data collection effort had significant gaps. For example, there was apparently no measurement of Secchi Depth or Light Extinction in the program. Also, a review of the analytical summary table indicates that necessary components of forcing functions were not measured (e.g., fecal coliform and enterococci for both the sanitary and stormwater discharges). As discussed above, TSS (Total Suspended Solids) were not measured at all. Also, we recommend

that both temperature, conductivity, and salinity be measured for in the sanitary and stormwater discharges.

Response #8f: Water quality data has been collected over the course of developing the 11prior NYCDEP CSO LTCPs. For the Citywide/Open Waters LTCP, sampling was performed for an additional 14 representative CSO outfalls and 20 stormwater outfalls. In addition, water quality samples were collected at over 150 locations. These data provide insight into the loss-rates, and die-off rates of bacteria in the waters of New York. The LTCP sampling data was also supplemented with available historical data and literature sources. Through the combination of hydrodynamics, base die-off rates, and time-variable changes to the influence of temperature, salinity, solar radiation the measured bacteria loss-rates are reasonably reproduced.

Comment #9: Better Data Collection and Analysis (Letter: WA)

***Comment #9a:* The rainfall totals for the long-term plan, which are from 2008, are outdated and do not consider the City's growth or the increasing number and strength of rainstorms each year.**

Response #9a: Please refer to the Response #8a relating to the selection of 2008 as the typical rainfall year and the period of 2002 through 2011 for 10-year continuous model simulations. Consistent with previous studies, the dry-weather sanitary sewage flows used in the baseline modeling were escalated to reflect anticipated growth in the City. The updated analyses use 2010 census data to reassign population values to the watersheds in the model and project up to 2040 sanitary flows. These projections also reflect water conservation measures that have already significantly reduced flows to the WRRFs.

Comment #9b: Furthermore, water quality results presented by DEP do not align with the years of water quality testing conducted by citizen science programs in these same waters.

Response#9b: Please refer to the response to Comment #3a.

TIBBETTS BROOK

Comment #10: The support was BCEQ's support for the Tibbetts Brook Daylighting Project, which included the Van Cortlandt Lake Improvements, that and an additional enhancements would be to include the proposed by the Living Shoreline Design proposed by Dr. Paul Mankiewicz and BCEQ. By capturing the upland runoff along the sloping edge on the south end of the grassy edge on the north contributes to the quantity of water in the sewer. A project such as this will clean the lake and lower the input to WI-056. Kindly reconsider that response (to prior Comment #27a) and add that enhancement to the Green Infrastructure Project. (Letter: BCEQ)

Response #10: The goals of the Tibbetts Brook Daylighting Project are consistent with the Living Shoreline goals of improving water quality and reducing runoff. Minimizing disturbance to both the shoreline and the park is another key objective of the project. The project would therefore promote biodiversity through targeted plantings and invasive species removal.

GREEN INFRASTRUCTURE (GI)

Comment #11: Green Infrastructure Maintenance Staff should be established and funded in accordance with the New York City Charter of one team for each community district. Green Infrastructure Funding for participating agencies, such as Parks, Transportation, Police, Fire, Libraries, Schools, etc. Trees and Wetlands. Due to the loss of trees, we suggest that we have a LTCP with Trees, or actually one million trees per decade. We believe wetlands should be funded in the capital improvement project that allows restoration at a year and decade pace. (Letter: BCEQ)

Response #11: A robust Green Infrastructure Maintenance Team has been established and is growing as construction of new assets is completed, as documented in the 2018 annual GI report. There are ongoing programs to install GI on other City properties, in particular, on parks, schools and NYCHA housing complexes, as well as to fund GI portions of capital projects by other City agencies. The City has invested millions in its MillionTrees Program, and GI further supports that initiative by incorporating trees where feasible. DEP is also supportive of expanding tree planting and wetland restoration and improvements. However, while there are a number of benefits of wetland expansion on the waterways, they would have limited impact to reducing combined sewer overflows, which is the primary focus of the current efforts.

Comment #12: We have prepared two documents which are online at the following links. The first is a story map proposing a next phase of Green Infrastructure -- https://bceq.org/2020/02/07/phase-ii-green- infrastructure-and-short-circuits/. Just as the DEP searched through their underground pipes and connectors, we suggest that the City look to open fields of grass. This is a large segment of the landscape, as identified in our report. If properly treated and cared for, fields of grass can absorb more rain before it gets to the pipe. Grass is a good carbon sink, as well. The second link is to a power point and other links on our web page that are examples of where this work can take place -- https://bceq.org/2020/02/07/short-circuits-for-cso-reduction/ (Letter: BCEQ)

Response #12: Large scale GI projects are continuously being evaluated for feasibility on public and private properties to meet the 2030 green infrastructure commitments. DEP also formed an in-house design team that strategically targets building GI in large medians that are owned by Department of Transportation or Department of Parks. We will continue to look for opportunities at these areas to become more effective at management of not just the immediate area, but surrounding impervious surfaces to maximize runoff reduction.

Comment #13: We encourage the City to maximize the use of green infrastructure to reduce overflows. Several plans allocate a decade or more to complete the system upgrades. These Low Impact Development (LID) technologies include conservation easements, on-site source controls (e.g., green roofs, rain gardens, rain barrels, etc.), stream buffers, urban redevelopment technologies, decentralized wastewater treatment, water reuse, and wetlands restoration. LID options can be effectively used separately from, or in combination with, end-of-pipe CSO solutions.

Response #13: DEP will continue to evaluate opportunities for green infrastructure in the public right-of-way, on City-owned properties, and on private properties through Green Infrastructure Private Incentives programs both on retrofits as well as on new developments, to the best extent possible, to help reduce CSOs. For more information on the NYC Green Infrastructure Program visit www.nyc.gov/dep/greeninfrastructure to review the latest Annual Report.

Comment #14: **Widespread green infrastructure will help mitigate storm surge effects by increasing the infiltration rate of floodwaters in coastal areas and because green infrastructure utilizes natural processes to manage stormwater, it has the potential to be more resilient than traditional grey infrastructure. In this way, green infrastructure can be used to build a more resilient City, capable of handling both influxes of sewage and urban runoff and excess stormwater without polluting the surrounding waterways.** (Letters: WA)

Response #14: DEP agrees that green infrastructure offers additional benefits to make the City's infrastructure more resilient and serves as part of an adaptive management plan in coastal areas in particular. DEP will continue to look for opportunities to maximize green infrastructure that can serve multiple benefits.

DEP continues to develop and encourage incentives for GI projects within privately owned property, primarily through the Green Infrastructure Grant Program. DEP is launching a new, innovative Private Incentive Retrofit Program in 2020 that will substantially scale-up investments in GI on private property. The Program utilizes a third-party administrator who is responsible for identifying the most cost-effective properties, 50,000 square feet or larger, to retrofit with GI and retrofitting them for a flat-rate incentive payment. This approach allows the administrator the flexibility to aggregate and bid projects in the most cost-effective manner. The goal for this program is 200 greened acres in five years. More information on the grant program and future private incentive program can be found in the Green Infrastructure Annual Reports on DEP's website (www.nyc.gov/dep/greeninfrastructure).

CLIMATE CHANGE AND RESILIENCY

Comment #15: **An important and pressing issue facing New York City in parallel to CSO outflows is climate adaptation and storm resiliency. Climate change is expected to shift the intensity, frequency, and cumulative annual amount of precipitation, affecting precipitation-based flooding potential and drought. Our region can expect to see up to an 11% increase in precipitation by the 2050s.This is particularly important in urban areas. Broader strategies will be needed to ensure safety, and exemplary stormwater management can contribute to cumulative improvements.** (Letters: WA)

Response #15: Further to the response provided to Comment #10a, DEP is working in parallel with the CSO program in developing strategies for addressing impacts of climate adaptation and storm resiliency on its stormwater and wastewater collection and treatment systems. These issues are particularly complex and the science/modeling of projected precipitation changes and sea level rise continues to evolve. Sea levels have risen since 1900 by about 1 foot. The sea level rise is attributed to a combination of warming of waters due to temperature increases and sinking of coastal lands. Projected variations through the end of this century range significantly (from one to four feet for sea level rise and 4% to 13% for annual precipitation) and will play a major impact on the design of the Recommended Plans.

As previously noted, the LTCP is the first phase of CSO planning and is focused on identifying a cost-effective, constructible recommended plan that addresses CSO impacts on water quality. It is the initial step in the process and does not fully define the facilities to be constructed. As DEP proceeds with *implementation of the Recommended Plan, additional planning is performed before advancing to design and construction to evaluate and incorporate other projects with synergies, assess risk and constructability, consider opportunities for future expansion and develop the basis of design that among other details addresses climate change and resiliency. Any modifications to the Recommended Plans, as a result of the planning and design processes, are coordinated with DEC so that any material changes to the LTCP projects are incorporated into the CSO Order.*

Comment #16: DEP has not justified its failure to use appropriate precipitation data for climate change for future years DEP has not responded adequately to the critique of failing to consider the increased precipitation caused by climate change and its challenges for the water system. Instead of taking the New York City Panel on Climate Change forecast of an increase of 4%-11% by 2050 and 5%-13% by 2080, (N Y City Panel on Climate Change, 2015 Report Executive Summary (2015), available at https://nyaspubs.onlinelibrary.wiley.com/doi/full/10.1111/nyas.12591) **DEP still bases its calculations on the rainfall average at JFK in 2008. DEP, in response to comments, states that the "average annual rainfall depth from 2010 to 2018 was less than the total annual rainfall from the 2008", and therefore "remains a good representation of *current* average rainfall conditions. (DEP Public Comment Response, p.5; emphasis added.) However, this is a random statistic that fails to take into account the best projections of the rainfall for the appropriate future period. To imagine that this would remain at the 2008 level flouts sound science and real world conditions and constitutes another example of skewing data to mask the extent of the problem.** (Letters: STS)

Response #16: Please refer to the responses to Comments 8a and 15.

RETAINED ALTERNATIVES SUMMARY

Comment #18: Provide a commitment that Alternative Analysis will be completed on major projects (with certain criteria) and based on SEQR and CEQR, to provide Environmental Assessments Statement Type I, and list exclusions. (Letters: BCEQ)

Response #18: The LTCP is the first phase of CSO planning and design which focuses on the review and assessment of CSO control alternatives primarily based upon cost-performance and constructability. Upon approval of the LTCP by DEC, DEP will perform additional planning level evaluations to address SEQR, CEQR and other applicable environmental requirements and socio-economic impacts of implementing the Recommended Plan. In subsequent phases, a basis of design report is developed and the project moves towards design with the development of construction documents for solicitation of bids for construction.

Comment #19: DEP fails to consider a meaningful range of alternatives that are (a) viable and (b) not cost-prohibitive. The list of potential alternatives for LTCPs were only analyzed in terms of their cost-effectiveness, with no regard to the water quality impacts associated with these alternatives. While DEP purports to have considered nine alternatives, four of those were not viable alternatives in the first place as they would increase CSO discharges to other tributaries (e.g. the Bronx River, Westchester Creek or Flushing Creek). Of the five viable options, three cost at least $4,700 M. It remains unexplained why DEP did not consider any solutions ranging between ER-6 (86 MGY net CSO volume reduction; $6M Bid Cost) and ER-7 (2,699 MGY net CSO volume reduction; $4,700M Bid

Cost) both in terms of the reduction result and the cost. A reduction to 86 MGY is a tiny portion of the total amount of sewage overflows and is facially insufficient to improve the water quality and address the substantial problems New York City waters are still facing. We urge DEP to consider a meaningful range of storage options that will significantly reduce CSOs and improve water quality. (Letters: STS)

Response #19: The evaluation of CSO control alternatives begins with the assessment of Baseline Conditions and performance of a gap analysis to identify the potential impact CSO controls will have on improving water quality. These analyses provide insight as to the locations where implementation of CSO controls will provide water quality benefits. Under Baseline Conditions, the Open Waters were found to be in compliance with current water quality standards for pathogens and dissolved oxygen, with the exception of the Kill Van Kull, Arthur Kill, and a segment of the Upper New York Bay near Gravesend Bay. The gap analysis indicates that control of NYC CSOs does not provide for water quality standards attainment in the Kill Van Kull or the Arthur Kill. Considering the wide range of City programs competing for financial support, improvement to water quality standards attainment must be the first and foremost consideration in determining the cost-effectiveness of CSO control measures.

Consistent with the approach used for the previous LTCPs submitted to DEC under this program, the alternatives development and evaluation process started with a range of different potential CSO control technologies. This initial "toolbox" was organized into categories that included Source Control, System Optimization, CSO Relocation, Water Quality/Ecological Enhancement, Treatment, and Storage.

Figure 5 presents a graphical representation of the CSO control alternatives toolbox. Technologies are color-coded to indicate whether the technology was considered for ongoing implementation under other programs or prior approved LTCPs, was screened out based on various levels of evaluation, or was carried forward as a retained alternative for evaluation using the cost/performance curves. Further detailed discussion of the technologies within each of these categories is presented in Section 8 of the Citywide/Open Waters CSO LTCP.

<table>
<tr><td>Source Control</td><td colspan="2">Green Infrastructure</td><td colspan="3">Storm Sewers</td></tr>
<tr><td>System Optimization</td><td>Regulator Modifications</td><td>Parallel Interceptor / Sewer</td><td>Bending Weirs Control Gates</td><td>Pump Station Optimization</td><td>Pump Station Expansion</td></tr>
<tr><td>CSO Relocation</td><td>Gravity Flow Tipping to Other Watersheds</td><td>Pumping Station Modification</td><td colspan="3">Flow Tipping with Conduit/Tunnel and Pumping</td></tr>
<tr><td>Water Quality / Ecological Enhancement</td><td>Floatables Control</td><td>Environmental Dredging</td><td colspan="3">Wetland Restoration & Daylighting</td></tr>
<tr><td>Satellite Treatment</td><td>Outfall Disinfection</td><td colspan="3">Retention Treatment Basin (RTB)</td><td>High Rate Clarification (HRC)</td></tr>
<tr><td>Centralized Treatment</td><td colspan="5">WRRF Expansion</td></tr>
<tr><td>Storage</td><td colspan="2">In-System</td><td>Tank</td><td colspan="2">Tunnel</td></tr>
</table>

Ongoing Projects | Evaluated but Screened Out | Retained Alternatives

Figure 5. CSO Control Alternatives Toolbox

As a result of the generally high level of attainment with applicable WQ Criteria under Baseline Conditions, the CSO control alternatives evaluations initially focused on relatively low-cost system optimization measures to improve collection system performance and maximize flow to the WRRFs. These optimization measures prioritized high-frequency CSO discharges and CSOs located near public access points along the waterbodies. While over 65,000 alternatives were evaluated for each system, the majority of these alternatives resulted in the transfer of CSO to other outfalls or increased the risk of flooding.

The alternatives evaluations also considered the level of control necessary to achieve the DEC goal for a time to recovery of less than 24 hours after a wet-weather event. Consistent with the CSO Policy, alternatives to provide a range of 25, 50, 75, and 100 percent CSO control were also evaluated. Given the extremely high cost of these alternatives and the limited potential benefit in terms of improvement in attainment of WQS, these alternatives were only developed to a conceptual level, sufficient to assess general dimensions and order-of-magnitude costs.

The following table provides a summary of the storage volume required to achieve 25, 50, 75, and 100 percent CSO capture for each of the Citywide/Open Waters waterbodies. For each case, the percent CSO control was estimated based upon the 2008 Typical Year.

Summary of Storage Volume Required for 25, 50, 75 and 100 Percent CSO Control for Citywide/Open Waters Waterbodies

Waterbody	Storage Volume Required (MG)			
	25% CSO Control	50% CSO Control	75% CSO Control	100% CSO Control
Harlem River	21	130	197	277
Hudson River	14	79	114	142
East River/Long Island Sound	52	367	526	740
Upper/Lower New York Bay	22	156	253	361
Kill Van Kull	2.5	6.8	15	30
Total	**112**	**739**	**1,105**	**1,550**

Considering the limited improvement in water quality, the number of outfalls and the large volumes of CSO capture necessary to achieve high levels of CSO control, it is not practical in a highly urbanized city to redevelop public recreational or institutional properties or take private residential, commercial, or industrial properties by eminent domain for the purposes of installing storage tanks or remote treatment facilities. CSO storage tunnels are the most viable approach to achieving these system-wide levels of control while minimizing neighborhood and other socio-economic impacts. Section 8 of the LTCP further details the findings of the CSO control alternatives evaluations and recommendations.

LTCP Report Content

Comment #20: **Report Standards. The January presentation handouts lacked sufficient information to evaluate their proposals. It would be preferable if each of the LTCPs were written with the same format for the other LTCP. For the Harlem River this would mean, existing conditions on the land and the water for the Bronx and New York Counties. Each outfall history, catchment areas, discharge volume, wet-weather violations, and more should be provided and analyzed. The purpose would be to find out # volume for each side of the watershed. It should also provide the speed of the Harlem River, and list all other general permit for new projects, direct discharges and MS4s.** (Letters: BCEQ)

Response #20: The structure of the Citywide/Open Waters CSO LTCP is consistent with the past LTCP submissions. Much like the Jamaica Bay and Tributaries CSO LTCP, the report text is structured by waterbody. As multiple sewersheds contribute CSO to many of the respective waterbodies, the optimization evaluations discussed in Section 8 were further segregated by sewershed. The comparison of retained alternatives, the cost-performance considerations, and the selection of the Recommended Plan are then summarized at the end of the subsection for each waterbody.

Section 2 of the report characterizes the sewer system, land use, and planned projects within the sewersheds tributary to each waterbody. Section 6 presents the annual CSO volume and activations for each CSO Outfall by waterbody under Baseline Conditions for the 2008 typical year. Tables summarizing baseline loading for fecal coliform, Enterococci, and BOD by source (CSO, MS4 SW, Non-MS4 SW, direct drainage, and WRRFs) are also provided.

The speed and direction of the currents in the Harlem River, as well as the other Open Waters waterbodies, are constantly changing with tide. The WQ model considers tidal impacts, currents, and other parameters in predicting WQS attainment. Figures and tables for model-predicted attainment of WQS as well as projections for time to recovery following a wet-weather event are presented in Section 6 for Baseline Conditions and 100-percent CSO control. Similar information is provided for the Recommended Plan in Section 8. The figures showing color-coded mosaics of the water quality attainment also include the locations of kayak launches, marinas, and beaches, in addition to the CSO outfalls.

RECOMMENDED PLAN

Comment #21: DEP's "recommended plan" to reduce the 11 billion gallons per year of CSO pollution that discharge into the City's largest water bodies by a mere 2% over the next decade is shockingly insufficient. The fact that this plan would invest only $42 million (in 2019 dollars) of new funds to clean up these vital waterways, which literally surround every borough and collectively account for half of all CSO discharges citywide, is inexplicable. As City Council Member Brad Lander put it, this sewage pollution reduction plan is a "drop in the bucket." This approach does not honor New York State and City commitments to achieving environmental justice, nor do they put our waters on course for public access and usability. It also hinders conservation and restoration efforts that support species that are key to the economy and ecosystem of the New York Harbor. (Letters: BCEQ, Berger, GCC, BRA, LESEC, NRDC, Riverkeeper)

Response #21: New York State DEC established use classifications for the marine and fresh waters in and around New York City along with water quality standards for each defined use classification. Water quality modeling indicates that the Class I and Class SB portions of the Hudson River, Harlem River, and East River are in attainment of the applicable WQS for fecal coliform and dissolved oxygen. As shown in the cost-performance curves presented in Section 8 of the LTCP, higher levels of CSO control do not cost-effectively result in improvements to attainment of current WQS. DEP's analysis indicated that the sewer system is functioning as designed and performance is already optimized in most locations such that the full capacity of the interceptor system is being utilized to deliver flow to the WRRFs during rain events and thus DEP has limited recommendations to further optimize system performance.

The selection of the preferred alternative for New York Bay is based on multiple considerations including environmental and water quality benefits, and cost effectiveness. However, New York Bay is achieving Class SB fecal coliform WQ criteria, and Class SB Coastal Primary Contact Recreational Enterococci WQ 30-day geometric mean criteria greater than 95 percent of the time under Baseline Conditions. The CSO storage tunnel alternatives would provide a range of levels of CSO reduction to New York Bay, but the costs associated with those alternatives are very high. The 50 percent control tunnel would generally achieve attainment with the Class SB Coastal Primary Contact Recreational Enterococci WQ 30-day STV criteria throughout New York Bay, but at an un-escalated Probable Bid Cost (PBC) of $3.0 billion. Those high-cost alternatives would not substantially change the level of the other applicable WQ Criteria for bacteria that are already being achieved. Section 9 presents affordability issues and impacts on disadvantaged communities that would come into play if the CSO program costs were to further significantly increase. Also, the time to recovery or duration of impacts of wet-weather events in New York Bay is relatively short. For these reasons, the CSO storage tunnel alternatives are not recommended.

As described in Section 6 of the LTCP, the reach of Kill Van Kull east of Newark Bay is achieving Class SD fecal coliform WQ criteria greater than 95 percent of the time under Baseline Conditions. For the reach *along Newark Bay, attainment with the Class SD fecal coliform WQ criteria falls into the 80 to 95 percent range under both Baseline Conditions and 100% CSO control. Thus, the non-attainment in this reach is not due to NYC CSOs. Similarly, Baseline Conditions and 100% CSO control attainment of the Class SD fecal coliform criteria in Arthur Kill north of the Outerbridge Crossing Bridge is in the less than 70 to less than 95 percent range. Baseline Conditions and 100% CSO control attainment of the Class I fecal coliform criteria in Arthur Kill south of the Outerbridge Crossing Bridge is in the 90 to greater than 95 percent range. Therefore, the non-attainment in Arthur Kill is also not due to NYC CSOs.*

As described in Section 8 of the LTCP, none of the optimization alternatives evaluated for the CSOs discharging to Kill Van Kull from the Port Richmond WRRF system were found to either provide more than nominal CSO reduction, or to be hydraulically feasible. The CSO storage alternatives would provide a range of levels of CSO reduction to Kill Van Kull, but the costs associated with those alternatives are very high, and none of the CSO storage alternatives would change the level of attainment with the applicable WQ Criteria for fecal coliform. This is further supported by the gap analysis performed in Section 6 of the LTCP which indicates that elimination of NYC CSO loads to the Kill Van Kull will not result in water quality attainment for pathogens. In addition, the time to recovery or duration of impacts of wet-weather events in Kill Van Kull is relatively short.

In addition, Section 9 presents affordability issues and impacts on disadvantaged communities that would come into play if the CSO program costs were to further significantly increase. This is of particular concern for alternatives that provide little or no improvements in water quality attainment. For these reasons, none of the CSO storage alternatives were recommended for Kill Van Kull.

Comment #22: DEP's proposed plan is also based on out-of-date science, allowing water quality to fall well short of meeting federal health standards mandated by the federal Environmental Protection Agency. (During the public comment period on the plan, DEP released modeling results that show widespread non-compliance with EPA's enterococcus standards, across all of the water bodies covered by the Citywide/Open Waters LTCP, under the "baseline" scenario. (https://www1.nyc.gov/assets/dep/downloads/pdf/water/nyc-waterways/citywide-east-river-open-water/ltcp-citywide-east-river-open-waters-mosaics-maps.pdf). **The miniscule CSO reductions in the proposed plan surely would not remedy these violations.) In fact, it would achieve zero reductions at over 300 discharge locations, including many along the shoreline of major parks and water access points like East River Park, Stuyvesant Cove, promenade on Two Bridges, Hudson River Park, Inwood Hill Park, Roberto Clemente State Park, Astoria Park, and Brooklyn Bridge Park, and Snug Harbor.** (Letters: Berger, BCEQ, BRA, LESEC, GCC, NRDC, Riverkeeper)

Response #22: In New York City, the Enterococci criteria only apply to Class SA and Class SB Coastal Primary Contact Recreational Waters. See Comment #8b for more detail.

The major parks and access points identified in the comment are located along the East River, Harlem River, Hudson River, and the Kill Van Kull. Each of these waterbodies is Class I with the exception of the Kill Van Kull which is Class SD. For Class SD and I waterbodies, the existing WQS for pathogens requires the monthly geomean for fecal coliform to be less than or equal to 200 cfu/100ml on an annual basis. The East River, Harlem River, and Hudson River Each are each in attainment with the existing WQS for fecal coliform under Baseline Conditions. As described above in the response to Comment #21, non-attainment of the WQ Criteria for fecal coliform in Kill Van Kull is due to sources other than NYC CSOs.

Comment #23: DEP's "recommended plan" consists of "system optimization measures" that target only a handful of outfalls in the East River, Hudson River, and New York Bay for a cumulative CSO reduction of 241 million gallons per year. (The plan also explains that DEP is also pursuing a stream daylighting project for Tibbett's Brook that would reduce CSO discharges to the Harlem River by 228 million gallons per year, of the 1.9 billion gallons that overflow to the river in a typical year. We fully support the Tibbetts Brook project for the CSO reduction it would yield and the many benefits it would bring to the surrounding community, and we urge DEP to make an enforceable commitment to implement it on a specific schedule. Unfortunately, the proposed plan offers no such commitment. The plan omits the Tibbetts Brook project from the LTCP "recommended plan." Instead, it considers the project to be part of DEP's "baseline" Green Infrastructure program, but nothing in that program obligates DEP to actually complete the project.) It does not address CSO pollution within the embayments and inlets where New Yorkers commonly access the water for recreation. Nor does it account for climate change projections for increased rainfall in our region. (Letters: Berger, BCEQ, BRA, LESEC, GCC)

Response #23: The open waters WQ model is used to assess water quality throughout the open waters. While the water quality monitoring stations used for validation and calibration of the model are located at various points throughout the open waters, the model computational grid spans from the shoreline to shoreline, including embayments. Under this LTCP, the density of the grid cells was increased near the CSO outfalls further enhancing the model resolution along the shoreline. The open waters model calculates water quality attainment for each grid cell.

PUBLIC PARTICIPATION

Comment #24: Seemed to me there was a major gap at the heart of last night's presentations, handouts, and Q&As: no attention to the relationship of the Citywide/Open Waters LTCP to other official policy processes with a geographic overlap. (Letters: Alpern)

Comment #24a: Relevant programs include: National Estuary Programs including the New York/New Jersey Harbor Estuary Program (HEP) and Long Island Sound Study (LISS); the Coastal Management Programs of New York State, New York City and New Jersey; the programs of the Mid-Atlantic Regional Council (MARCO) and Mid-Atlantic Regional Planning Body; the Corps of Engineers New York-New Jersey Harbor & Tributaries Focus Area Feasibility Study (NYNJHAT); and studies relating to the Constantanides proposal of a Rikers Island replacement for the Astoria, College Point and Hunts Point WWRFs.

Response #24a: Each of these programs were considered in identifying components that overlap with the CSO Program, however, many of their initiatives go well beyond CSO control, while others, like the Rikers Island proposal are early in the planning and evaluation stages. Since many New Jersey communities own and operate combined sewers which contribute CSO to the Hudson River, Kill Van Kull, Arthur Kill and their tributaries, DEP prioritized its efforts in coordinating with the Passaic Valley Sewerage Commission (PVSC) and the NJ CSO Group to share sampling data, model output and other related information. Periodic meetings were held to share project status, discuss modeling approaches, data sources and other information to facilitate coordination and consistency between the two CSO Programs. The coordination of the two CSO Programs and elements of the other relevant programs will continue to be considered in the future planning and design phases as the Recommended Plan is advanced towards implementation.

Comment #24b: Relevant issues include, among others: legal precedence; models and their data inputs; and assumptions about future demographics and land use, precipitation patterns, and water level and movement.

Response #24b: Each of these issues and model related patterns have been considered in the CSO LTCP modeling approach, which has been periodically reviewed with DEC and updated throughout the course of the CSO Program.

Comment #24c: Also relevant and worth discussing: the unexplained discontinuance of the Water Management Advisory Committee, the long-time advisor to DEC's Division of Water.

Response #24c: The Water Management Advisory Committee was convened as part of earlier water quality programs such as the Waterbody Watershed Facility Plan. As part of 2012 CSO Order and the Citywide (LTCP) program, DEP developed a proactive and robust public participation program to inform the development of watershed-specific and citywide LTCPs. The DEC-approved public participation plan describes the methods DEP utilized to inform and involve diverse stakeholders and the broader public throughout the LTCP process. The strategies and activities contained within the plan support DEP's agency goals of raising awareness about, encouraging input on, and fostering understanding of the LTCP program and associated benefits. The public participation activities and tools were focused on two main strategies:

1) *Use various existing forums to educate a broad array of stakeholder groups and encourage community input from within specific watersheds; and*
2) *Provide a forum for sustained regional participation in the development of the citywide LTCP program.*

Comment #25: <u>Continue the Status Reports and Meetings on the LTCP</u>s. Publishing status reports with proposed schedules, cost, expected approvals, should be continued. (Letters: BCEQ)

Response #25: While the formal public participation plan for the Citywide/Open Waters LTCP has concluded, DEP will work with stakeholders to continue public participation on approved LTCP projects.

Comment #26: <u>Create a Citizens Advisory Committee, Working Group, or Citywide Stakeholders group to provide</u> more GI locations and types, establishing sustainable goals, and handling new ideas provided by science which promotes new methods of low impact development like green infrastructure. Because of this, we recommend alternate analysis be reviewed over a set period of time, perhaps every 5 or 10 years. (Letters: BCEQ)

Response #26: DEP has ongoing dialogue with a variety of stakeholders around GI implementation. Topics include the Annual Report, GI Private Incentives, Maintenance Planning, and others. While the formal public participation plan for the Citywide/Open Waters LTCP has concluded, DEP will work with stakeholders to continue public participation on the NYC GI Program.

***Comment #27:* DEP has provided only summary documents and has not committed to provide the actual Long Term Control Plan, along with the data upon which it relies, for public review and**

comment. Throughout this process, DEP has provided only minimalist summary documents regarding the proposed Long Term Control Plan. Some of the misrepresentations and distortions in that summary plan have been addressed above. Yet we understand that DEP's intent is to stay with their past practice of not releasing the actual very detailed Long Term Control Plan that will ultimately be submitted. While the summaries can be a good complement to the LTCP itself, it is not a substitute. Given the concerns expressed above with representations about Water Quality Standards and how they are being calculated, along with failure to address key pollutants in the summary, it is also vitally important for DEP to release the underlying data and methodology to support their conclusions in both the LTCP and in the summary documents. (Letters: STS)

Response #27: Public participation for the Long Term Control Plans has evolved since the first kick-off meeting in 2012. Over the years DEP has worked to incorporate public feedback as it relates to venue locations, presentation content, educational materials, and meeting advertising. DEP has also worked to incorporate public feedback as it relates to public comments on the Recommended Plan. For the LTCPs submitted between 2013 and 2017, DEP conducted two public meetings per LTCP before the final LTCP was submitted to DEC: a kick-off meeting and an alternatives meeting. A third final meeting on the Recommended Plan would not occur until after it had already been submitted to DEC. The public submitted multiple comments asking for the opportunity to review and provide feedback on the final recommendations before the LTCP was submitted to DEC. In response, DEP worked with DEC to develop a compromise for the Jamaica Bay and Citywide/Open Waters LTCP that would give the public an opportunity to review the substance of the recommendation (proposed projects, costs, benefits) without further delaying LTCP submittal deadlines. In addition, DEP held additional public meetings and offered additional public comment response opportunities.

In response to requests from the stakeholders, DEP has placed sampling data and water quality mosaics on our website at www.nyc.gov/dep/ltcp.

WATERBODY/LOCATION SPECIFIC

Comment #28: It's a longstanding request of ours--and, we believe, a regulatory requirement--that the LTCP address impacts at all of the principal boating and swimming access points in the target area. In other words, the LTCP must assess locations with water-contact recreation as "sensitive areas" under federal and state CSO Policy, and describe in detail how the plan will (or will not) improve conditions at each of them. After securing what we felt was a promise to provide such site-by-site analysis, and sending a list of access sites to the agency last year (see this map), we were disappointed to receive this boilerplate non-response (#1d):

"The USEPA CSO Policy defines "sensitive areas" as "…designated Outstanding National Resource Waters, National Marine Sanctuaries, waters with threatened and endangered species and their habitat, waters with primary contact recreation, public drinking water intakes or their designated protection areas, and shellfish beds." The Citywide/Open Waters CSO LTCP included the consideration of "sensitive areas" as defined under the CSO Policy and also considers boat launches, marinas, and other secondary contact recreational uses along the waterbodies as part of the evaluation conducted for this LTCP. The Retained Alternatives Summary includes figures that identify the location of waterfront access points. Collection system optimization evaluations prioritized alternatives that reduced CSO discharges in the vicinity of CSO Policy defined sensitive areas and areas of secondary contact uses. The retained alternatives include cost-

effective alternatives that provided CSO reductions without adversely impacting hydraulics of the collections system such as increasing the risk of basement backups or upstream flooding."

In fact, no 'consideration' or 'optimization evaluations' of any launch sites are offered in the summary LTCP, and even the 'figures' the response mentions (maps on pages 4 and 49 of the document) show only a handful of access points in the target area. Yet by our count there are dozens (see map). (Letters: NYCWTA)

Response #28: The optimization evaluations were performed system-wide and prioritized those regulators and outfalls in close proximity to waterfront access points. While over 65,000 alternatives were evaluated for each system, the majority of these alternatives resulted in the transfer of CSO to other outfalls or increased the risk of flooding. These evaluations confirmed that each collection system was performing as designed by maximizing flow to the WRRFs while providing hydraulic relief when wet-weather flows exceed collection system capacity. The retained alternatives presented in the Citywide/Open Waters CSO LTCP Summary Document consist of those optimization alternatives that cost-effectively improved CSO capture without transferring large amounts of CSO to neighboring outfalls or tributaries and did not increase the risk of basement backups or flooding.

The maps and figures have been updated to reflect additional publicly identified waterfront access points in response to feedback provided throughout the public participation process. The updated figures are provided in the Executive Summary and Sections 2, 6 and 8 of the LTCP.

Comment #29: The LTCP plan for Citywide/Open Waters is very inadequate in curbing sewage from entering into City waterways, but nowhere is it more deficient than it's lack of plans for the environmental justice communities on the North Shore of Staten Island which border the Kill Van Kull. These communities will be victimized again by an LTCP that leaves their waterways without any new projects for improvements. Here are communities where many consume the fish they catch. Here are communities that would love to swim in their waters again. Here are community activists who have been begging for years to see an upgrade to our old outdated Port Richmond Treatment plant. Here are communities which will be victimized again by the omission of the Kill Van Kull in the LTCP.

"The agency didn't recommend any projects for Kill Van Kull or the Arthur Kill, two of the dirtiest waterways in New York. In fact, when asked about the agency's decision not to advance any plans for these waterways, the DEP seemed unclear about why it had even bothered to consider them in the first place." (https://ny.curbed.com/2020/2/20/21144943/new-york-water-combined-sewer-overflow-dep-plan) (Letters: Cohen)

Response #29: As shown in the gap analysis presented in Section 6 of the LTCP, under Baseline Conditions, the reach of Kill Van Kull between New York Bay and Newark Bay meets the Class SD WQ Criteria for fecal coliform on both an annual and recreational season (May 1st to October 31st) basis. The reach along Newark Bay meets the Class SD WQ Criteria for fecal coliform on a recreational season basis, but not on an annual basis. The level of attainment with the Class SD WQ Criteria for fecal coliform in this reach would not change with 100 percent control of the CSOs discharging to Kill Van Kull from the Port Richmond WRRF system, demonstrating that the non-attainment is due to sources other than NYC CSOs. The Class SD WQ Criteria for DO are met throughout Kill Van Kull on an annual average basis under Baseline Conditions.

The LTCP considered alternatives for controlling CSOs to Kill Van Kull from the Port Richmond WRRF system, in particular focusing on Outfall PR-029, which discharges approximately 85 percent of the total annual CSO volume to Kill Van Kull. As described in Section 8, a real-time control alternative for Outfall PR-029 was determined to be hydraulically infeasible, due to the rapid increase in hydraulic grade line that occurs in the West Interceptor during large storm events. Storage alternatives identified for Outfall PR-029 would not result in a change in the level of attainment of the Class SD WQ Criteria for fecal coliform in Kill Van Kull and were extremely expensive with significant implementation challenges. For these reasons, these alternatives were not recommended.

Comment #30: There are several huge CSOs near the Port Richmond sewage plant. Our new Heritage Park is a few blocks east of the sewage plant, but probably more important is Faber Park, which is a very popular park a few blocks west from the sewage plant. There is a huge CSO nearby to Faber Park, which I believe is PR-029. Here are communities that use Faber Park, very popular, in the area, though it was not even mentioned in the LTCP. Why is that? According to the sewershed map brochure from SWIM (with DEP collaborating), it accounts for 50% of our CSO and has 152 million gallons of discharge a year. It has a very large drainage area. (Letters: Cohen)

Response #30: See response to Comment No. 29, above.

Comment #31: Additionally, PR 031 which is in line with Broad Street, is equally as large at PR-029. It accounts for approximately 191 million gallons of sewage overflow a year. It is a few blocks from the new large URBY development (which has fishing stations on their pier area) It is in the Stapleton renaissance area. It also is the area of the mayor's recent Bay Street corridor rezoning. So we should expect thousands of more residents with the many new high risers that are planned, and lots more sewage. (Letters: Cohen)

Response #31: Outfall PR-031 discharges to New York Bay. As shown in the gap analysis presented in Section 6 of the LTCP, under Baseline Conditions, the area of New York Bay along the Staten Island Shoreline where CSOs from the Port Richmond WRRF system discharge meets the Class SB WQ Criteria for fecal coliform on both an annual and recreational season (May 1st to October 31st) basis, and meets the Class SB Coastal Primary Recreational Enterococci geometric mean criteria for the recreational season (May 1st to October 31st). Attainment with the Class SB Coastal Primary Recreational Enterococci STV criteria for the recreational season (May 1st to October 31st) along the shoreline of Staten Island in that area falls in the 90 to 95 percent range. The Class SB WQ Criteria for DO are met in this part of New York Bay under Baseline Conditions.

As described in Section 8 of the LTCP, the Recommended Plan includes the Hannah Street Pumping Station Bypass project (Alternative NYB-2), which will reduce CSO volumes from the Port Richmond WRRF system to New York Bay by about 40 MG/year. Most of this reduction will occur at Outfall PR-013. However, as a result of this project, the volume at Outfall PR-031 is also predicted to be reduced by about 8 MG/year. No other hydraulically feasible optimization alternatives were identified for Outfall PR-031. Storage alternatives for CSO outfalls to New York Bay were extremely expensive, carried significant implementation challenges, and would not result in a change in the level of attainment of the Class SB WQ Criteria for fecal coliform or DO, or the Class SB Coastal Primary Recreational Enterococci geometric mean criteria in New York Bay. For these reasons, storage alternatives were not recommended.

Comment #32: On Lower New York Bay: People also know to stay away from South Beach after rain due to the terrible odors. Also, the problems of sewage very near to the sanitary only Oakwood treatment plant (feminine hygiene applicators), is still an issue and their source remains a mystery. This impacts Great Kills Beach (very popular for bathing, fishing, and also used for kayaking). It also impacts Cedar Grove Beach. We have been asking for decades that DEP funds be used to find the source. (Letters: Cohen)

Response #32: In accordance with the Untreated Discharge provision of the current SPDES, DEP performs Sentinel Monitoring at 80 ambient water quality monitoring stations. Water quality data is compared to the waterbody's baseline levels and any statistically significant exceedance of this baseline will trigger an investigation in the associated area by DEP. If any dry-weather discharge is identified, immediate action is taken to abate any found discharge. In addition, DEP has initiated investigations due to consumer complaints of dry-weather discharges. Once a dry-weather discharge is verified, DEP undertakes abatement proceedings immediately.

There are six Sentinel Monitoring Stations along the southeastern shore of Staten Island and two Harbor Survey Stations. Of these six Sentinel Stations, several are in the above described area: Great Kills Harbor (S42), Great Kills Beach (S73), Midland Beach (S41), and South Beach (S40). Fecal Coliform concentrations are generally below the baseline value of 200cfu/100mL during dry-weather at these stations. Since 2001, DEP has investigated, identified, and abated several illicit connections in the Oakwood Beach drainage area.

DEP continues to monitor and investigate dry-weather discharges, citywide. Responses to dry-weather discharges can be found in the Sentinel Monitoring Program's Annual Report, which can be found on DEP's website.

Comment #33: GCC provided comments on the inadequacy of the Gowanus Canal Long-Term Control Plan, which was approved by DEC in 2015 and utilized a faulty sampling protocol to determine baseline water quality measurements and did not strive to improve water quality beyond what has already been mandated by the EPA Superfund process. These comments remain unaddressed but the Citywide/Open Waters LTCP provides an opportunity for additional infrastructure investment to mitigate ongoing pollution to the Gowanus Canal, which is a tributary to the East River receiving more than 363 million gallons of CSO discharge per year. Furthermore, in anticipation of the proposed rezoning of the Gowanus neighborhood, which will bring an additional 20,000 residents to the area, there is an imminent need for infrastructure improvements that will address a 1 billion gallon annual increase in wastewater generation to the Owl's Head and Red Hook Sewersheds. (Letters: GCC)

Response #33: In parallel with the tank design, DEP evaluated the feasibility of constructing a CSO storage tunnel in lieu of a storage tank. Although the tunnel provided flexibility to address historical flooding issues, proposed growth and other issues in the sewershed, this alternative plan was rejected by EPA.

DEPARTMENT OF PARKS COMMENTS

Comment #34: Retained Alternatives Summary Page 19-20: These two pages on Tibbetts Brook & VC Lake seem randomly included. They are not the same format as the other pages, and it's unclear why they are in the 'Baseline Conditions' section. Shouldn't it be under the Harlem River retained alternatives? (Letters: City of New York Parks & Recreation)

Response #34: DEP is advancing efforts towards design and land acquisition for the Tibbetts Brook and Van Cortlandt Lake Improvements and considers this work to be part of its Green Infrastructure program. As such, these projects are considered part of the Baseline Conditions, along with other system-wide Green Infrastructure.

Comment #35: Retained Alternatives Summary Page 28-29: Different scales (feet vs. miles) on the two maps. (Letters: City of New York Parks & Recreation)

Response #35: The scale on Page 29 will be converted to feet for consistency with the other maps.

Comment #36: Retained Alternatives Summary Page 23: Green infrastructure implementation is described very generally. Each waterbody should include more detailed GI opportunities analysis in order to facilitate proactive alignment of DEP's outreach and incentive programs. (Letters: City of New York Parks & Recreation)

Response #36: Several planning and design contracts are currently evaluating green infrastructure opportunities throughout the Citywide/Open Waters drainage areas, in addition to the incentive programs for GI on private properties. DEP will continue to seek to maximize effective and feasible GI implementation throughout the Citywide/Open Waters drainage areas. Final implementation rates will be reassessed as part of the adaptive management approach.

Comment #37: Retained Alternatives Summary Page 31-32: So there are no proposed actions to be taken in the Bronx? Only changes shown are in Northern Manhattan. The only updates to the system shown are not related to any of the five largest CSOs. This seems strange, and warrants more explanation. As it stands now, it appears nothing will change with any of the CSOs on the Bronx side of the Harlem River... meaning more than 1 billion gallons of CSO will still be discharged from 4 CSOs alone! (Letters: City of New York Parks & Recreation)

Response #37: Optimization alternatives evaluations for the Wards Island collection system found that modifications to existing regulators caused increases in CSO at other regulators that cancelled out the CSO reductions at the modified regulator. As a result, the net reduction in CSO to the Harlem River was nominal. Alternatives HAR-3, HAR-4, HAR-5, and HAR-6 evaluate tunnels for capture of 25%, 50%, 75%, and 100% of the CSO discharged to the Harlem River under Baseline Conditions. These alternatives range in cost from $0.8 to $7.7 billion. Figures illustrating the tunnel alignments will be provided in Section 8 of the LTCP.

Comment #38: Retained Alternatives Summary Page 32: Where would these proposed tunnels go? HAR-6 is longer than the Harlem River. (Letters: City of New York Parks & Recreation)

Response #38: The tunnel alignments generally follow the shoreline of the waterbodies, picking up outfalls that the tunnels would pass under. The tunnel alignments are very conceptual, and detailed siting studies have not been conducted. The HAR-6 tunnel (100% CSO Control) is a dual-bore tunnel (two parallel tunnels). The length listed is the sum of the lengths of the two parallel tunnels. Figures illustrating the tunnel alignments will be provided in Section 8 of the LTCP.

Comment #39: Retained Alternatives Summary Page 32: Can any of the retained alternatives be done in concert? Or will only one be selected? More information is needed to help determine which option (or options) to pick & advocate for. (Letters: City of New York Parks & Recreation)

Response #39: Each of the Retained Alternatives identified on Page 32 is presented as a stand-alone alternative. Alternative HAR-1 includes the optimization measures proposed under HAR-2 in addition to optimization of regulators associated with CSOs NR-007, NR-009, and NR-017. Alternatives HAR-3, HAR-4, HAR-5, and HAR-6 utilize different size tunnels and routes to achieve capture rates of 25%, 50%, 75%, and 100% of the annual CSO volume during the 2008 typical year.

Comment #40: NYC Parks suggests including Tibbetts Wetland Restoration in VCP as part of Tibbetts Brook Daylighting for added ecological and CSO reduction benefit. See NYC Parks conceptual design at https://www.nycgovparks.org/pagefiles/138/2018-06-14-Tibbetts-Brook-Wetland-Restoration-Design-Report-NYC-Parks-FINAL__5cb8b6cc72b7c.pdf

Response #40: As indicated on Page 20 of the summary document, 0.85 acres of wetland plantings will be created in Van Cortlandt Lake to diversify the shoreline and improve water quality.

Appendix C: New York Bay/ Kill Van Kull/Arthur Kill Use Attainability Analysis

EXECUTIVE SUMMARY

The New York City Department of Environmental Protection (DEP) has performed a Use Attainability Analysis (UAA) for New York Bay, Kill Van Kull, and Arthur Kill in accordance with the 2012 CSO Order. Key findings of the UAA for these waterbodies are summarized below.

New York Bay

The New York Bay watershed encompasses portions of the Boroughs of Manhattan, Brooklyn, and Staten Island in New York and a portion of Hudson County in New Jersey (Figure 1). The Upper Bay is fed by the waters of the Hudson River and the East River. The boundary between the Upper and Lower Bay is approximately at the Verrazano Narrows Bridge. South of the bridge, the Lower Bay opens directly into the Atlantic Ocean between Rockaway, Queens, and Sandy Hook, New Jersey. Four wastewater resource recovery facilities (WRRFs) are located within the New York Bay sewershed: Red Hook, Owls Head, Port Richmond, and Oakwood Beach. These WRRFs are permitted pursuant to New York State Department of Environmental Conservation (DEC)-issued SPDES permits. The Oakwood Beach WRRF serves a separate sanitary sewer system, and no CSOs are associated with the Oakwood Beach WRRF.

The gap analyses performed as part of the Citywide/Open Waters LTCP concluded that under baseline conditions, the Class SB Coastal Primary Recreational 30-day statistical threshold value (STV) water quality (WQ) Criteria for *Enterococci* would not be attained in portions of New York Bay generally along the Brooklyn shoreline during the recreational season (May 1st through October 31st). Individual pockets of non-attainment were also identified along the southern shoreline of Staten Island, and at one location in Rockaway Inlet. The non-attainment in the individual locations along the southern shoreline of Staten Island and in Rockaway Inlet would remain even with a condition of No NYC CSO Loads. The load component analysis presented in Section 6 indicated that the non-attainment in those areas was driven by sources from outside of New York City (NYC). The gap analyses also indicated that the Class SB WQ Criteria for dissolved oxygen (DO) would not be attained in a portion of the Bay adjacent to the southwestern tip of Staten Island on an average annual basis even with No NYC CSO Loads. The non-attainment of the DO criteria in this area is similarly driven by sources from outside of NYC.

The Recommended Plan presented in the Citywide/Open Waters Long Term Control Plan (LTCP) includes system optimization Alternatives NYB-1 (optimization of regulators associated with Outfalls RH-005 and RH-014), NYB-2 (Hannah Street Pumping Station Bypass), and NYB-3 (real time controlled gate for Regulator 9C associated with Outfall OH-015). Collectively, these alternatives are predicted to result in a net reduction in annual CSO volume of 132 MG. The LTCP assessment shows that the Recommended Plan would achieve annual and recreational season (May 1st through October 31st) attainment of the WQ Criteria for fecal coliform bacteria at all WQ model cells in New York Bay for the 10-year simulation. The Class SB Coastal Primary Recreational 30-day geometric mean WQ Criteria for *Enterococci* would similarly be attained for the recreational season (May 1st through October 31st). However, attainment with the Class SB Coastal Primary Recreational 30-day STV WQ Criteria for *Enterococci* for the recreational season (May 1st through October 31st) would not substantially change from baseline conditions. Attainment levels would generally range from approximately 50 percent in the vicinity of Gravesend Bay, to greater than 95 percent in parts of the Bay away from the Brooklyn shoreline.

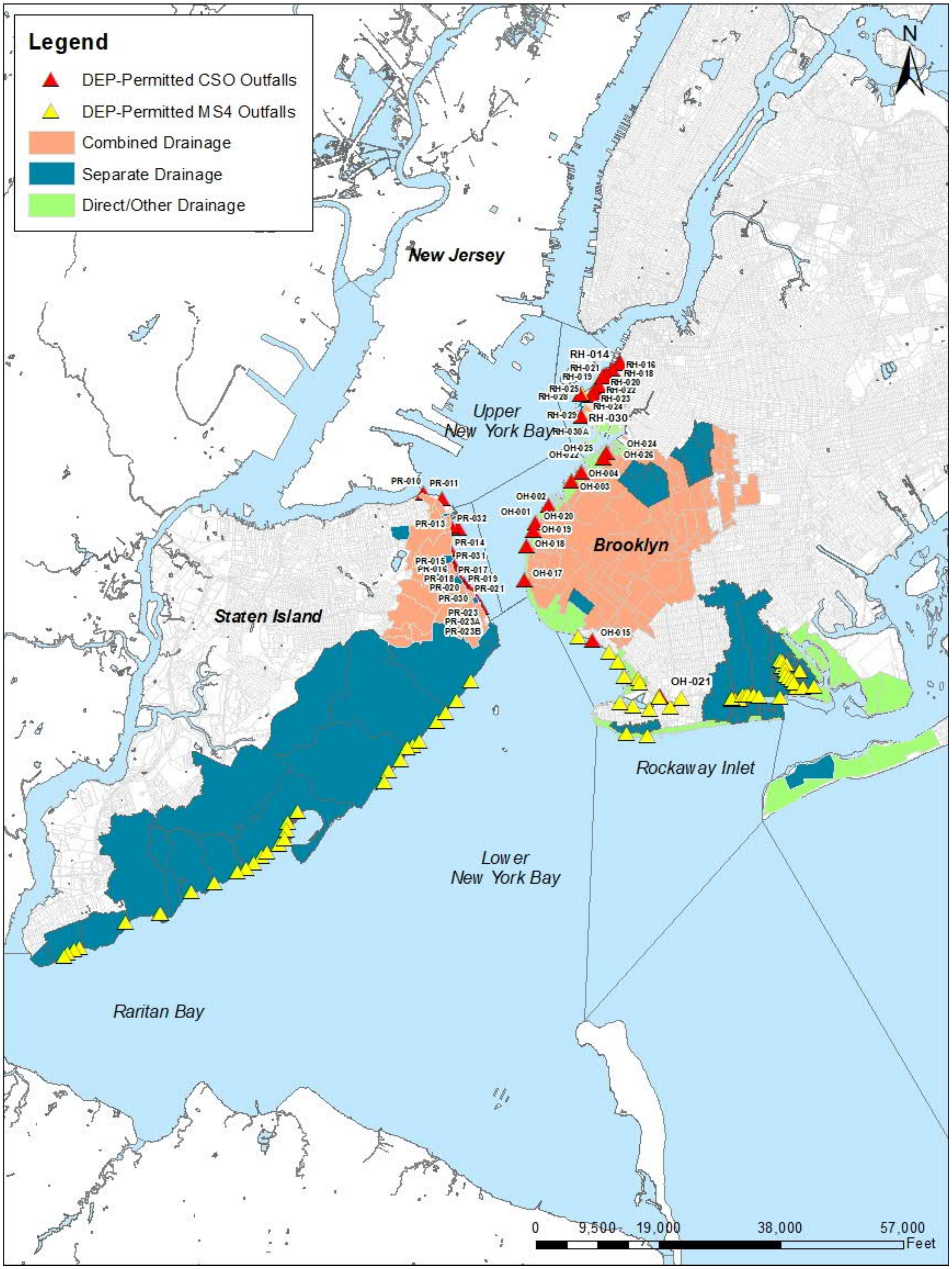


Figure 1. Components of the New York Bay Watershed

The Recommended Plan is not predicted to substantially change the level of attainment with the Class SB WQ Criteria for DO. As noted above, the DO criteria are attained throughout the Bay, except for an area of the southwestern tip of Staten Island, where the non-attainment is driven by sources from outside of NYC.

New York Bay is a large natural harbor that supports a mix of shipping, ferry, and recreational boating traffic. Active bathing beaches are located along the shoreline of Staten Island, Coney Island, and Rockaway Inlet (Figure 2). Along the Brooklyn shoreline from the East River to Gravesend Bay, direct public access to the water is limited. As indicated in Figure 2, locations of kayak launches or marinas along the Brooklyn shoreline include Governor's Island, Louis Valentino Park, and Marine Basin Marina. However, the shoreline in the vicinity of the projected non-attainment at the southwestern side of Brooklyn is heavily bulkheaded and rip-rapped, further limiting access onto or off of the water.

Based on the analyses summarized above, projected *Enterococci* levels do not meet the Class SB Coastal Primary Recreational 30-day STV WQ Criteria for the recreational season (May 1st through October 31st) along the Brooklyn shoreline, at localized areas along the southern shoreline of Staten Island, and at a localized area in Rockaway Inlet. The non-attainment in the individual locations along the southern shoreline of Staten Island and in Rockaway Inlet would remain even with No NYC CSO Loads. The load component analysis presented in Section 6 indicated that the non-attainment in those areas was driven by sources from outside of NYC.

Along the Brooklyn shoreline, non-attainment appears to be primarily related to CSO sources, as the gap analysis indicated that a condition of No NYC CSO Loads would achieve compliance with the STV criteria in that area. As indicated in Section 8 of the Citywide/Open Waters LTCP, a 50 percent level of CSO control would be needed to achieve attainment with the *Enterococci* STV criteria along the Brooklyn shoreline. A 50 percent control storage tunnel alternative for New York Bay would have an un-escalated estimated probable bid cost of $3B, and would have numerous constructability challenges.

Non-attainment of the Class SB DO criteria in the portion of the Bay adjacent to the southwestern tip of Staten Island is driven by sources from outside of NYC, and a condition of No NYC CSO Loads would not change the level of attainment.

It is recommended that the current designated uses of the waterbody and the Class SB Coastal Primary Recreational classification be maintained after implementation of the LTCP Recommended Plan. After implementation, future data collection efforts will provide data that could be used to re-assess the attainment of Class SB Coastal Primary Recreational 30-day STV WQ Criteria and the best use of the Bay could be evaluated accordingly.

Figure 2. Public Access Locations in New York Bay

Kill Van Kull

The Kill Van Kull watershed encompasses portions of the Boroughs of Staten Island in New York and Bayonne, New Jersey. Kill Van Kull is a four and a half-mile long, navigable tidal channel which separates New York and New Jersey, and connects Newark Bay with Upper New York Bay (Figure 3). The Port Richmond WRRF is located within the Kill Van Kull sewershed.

The gap analyses performed as part of the Citywide/Open Waters LTCP concluded that under baseline conditions, the Class SD WQ Criteria for fecal coliform would not be attained in the western portions of Kill Van Kull adjacent to Newark Bay on an annual basis. However, the non-attainment in that area would remain even with No NYC CSO Loads. The load component analysis presented in Section 6 indicated that the non-attainment was driven by sources from outside of NYC.

The Recommended Plan presented in the Citywide/Open Waters LTCP includes no specific grey infrastructure projects for the Port Richmond CSO outfalls to Kill Van Kull. No feasible system optimization alternatives were identified, and storage alternatives for Outfall PR-029, the largest CSO to Kill Van Kull, would cost in the hundreds of millions of dollars, would not change the level of attainment with the Class SD WQ Criteria for fecal coliform in Kill Van Kull and would have significant implementation challenges. The LTCP assessment showed that with no additional projects for Kill Van Kull, the WQ Criteria for fecal coliform bacteria would be met in the recreational season (May 1st through October 31st). On an annual basis, attainment would range from approximately 80 to 100 percent.

The Class SD DO criteria are projected to be attained in Kill Van Kull under baseline conditions and with the Recommended Plan (no project).

Kill Van Kull supports a mix of shipping, ferry, and recreational boating traffic, and the northern shoreline along Kill Van Kull is the most urbanized part of Staten Island. With the marine industrial uses along the shoreline, direct public access to the water is limited. No Department of Health and Mental Hygiene (DOHMH) certified bathing beaches or formal kayak launch sites are located along Kill Van Kull. Greenspace along Kill Van Kull includes Mariners Marsh Park, the Snug Harbor area, the North Shore Esplanade, and some smaller green spaces (Figure 4).

Based on the analyses summarized above, projected fecal coliform levels do not meet the Class SD WQ Criteria on an annual basis in the area of Kill Van Kull adjacent to Newark Bay. The non-attainment is driven by sources from outside of NYC, and a condition of No NYC CSO Loads would not change the level of attainment. It is recommended that the current designated uses of the waterbody and the Class SD classification be maintained after implementation of the LTCP Recommended Plan. After implementation, future data collection efforts will provide data that could be used to re-assess the attainment of Class SD WQ Criteria and the best use of Kill Van Kull could be evaluated accordingly.

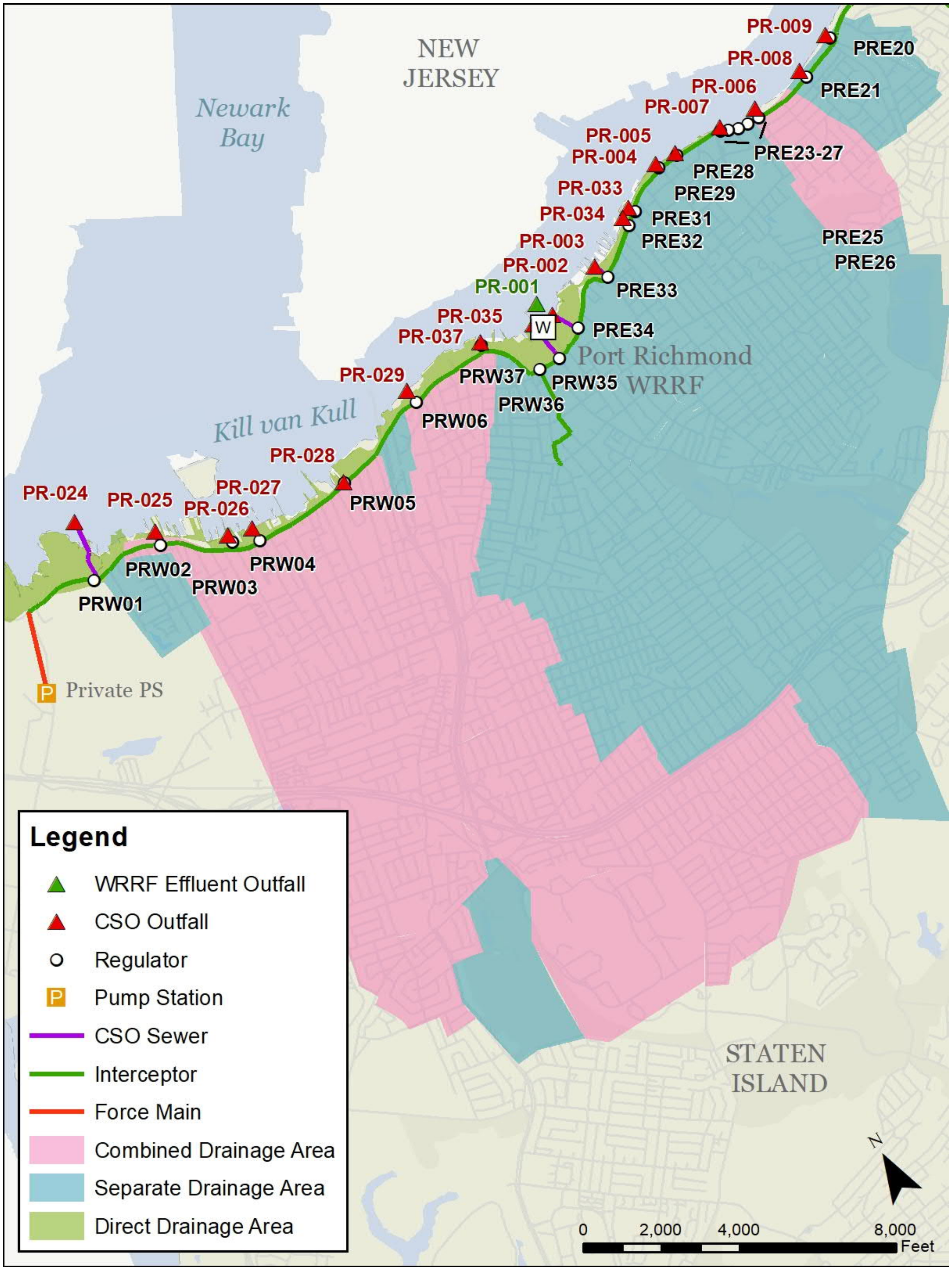


Figure 3. Components of the Kill Van Kull Watershed

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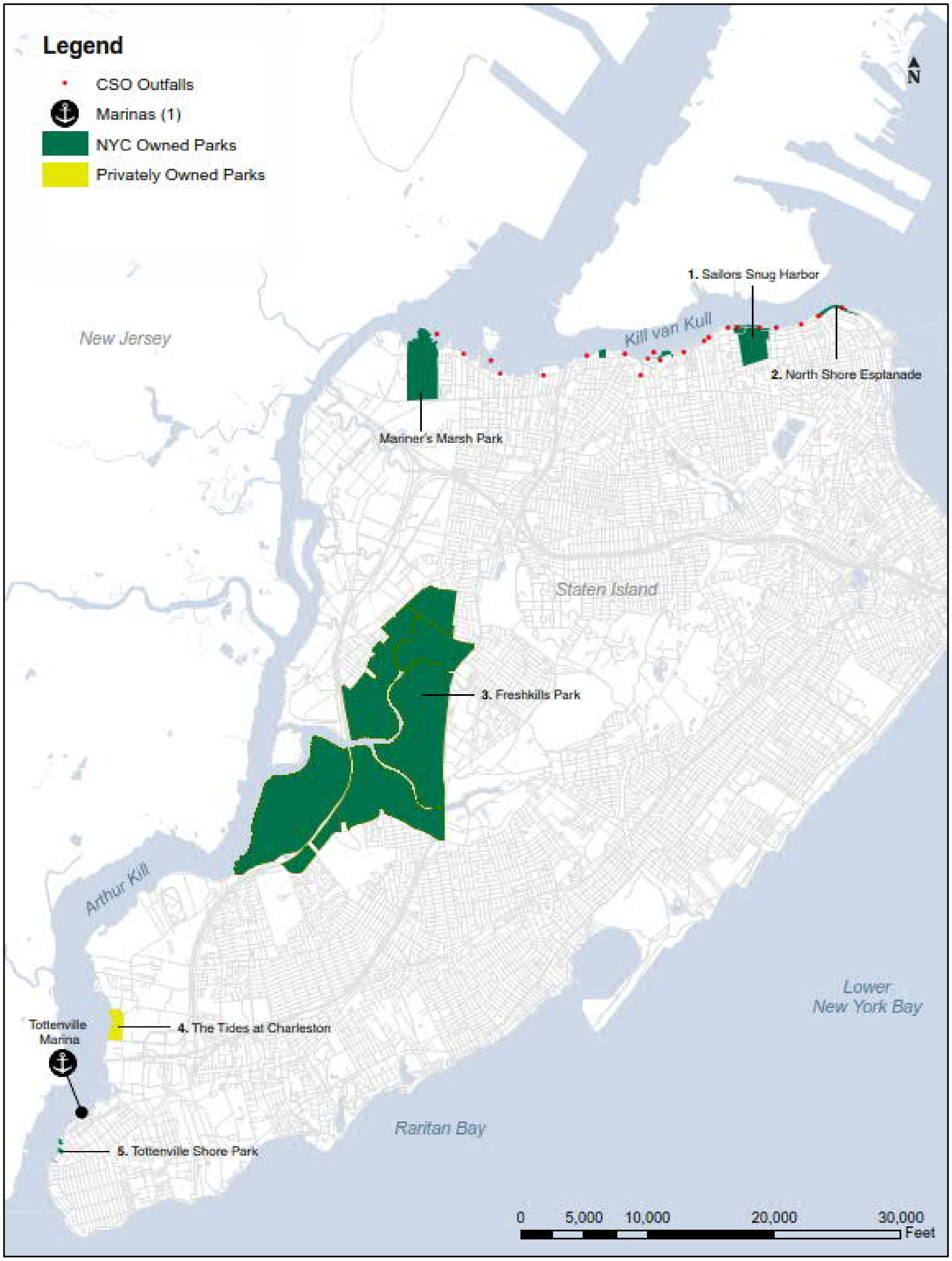

Figure 4. Public Access Locations along Kill Van Kull and Arthur Kill

Arthur Kill

The Arthur Kill watershed encompasses portions of the Boroughs of Staten Island in New York and Union and Middlesex counties in northern New Jersey. Arthur Kill is a ten-mile long, navigable tidal channel which separates New York and New Jersey, and connects Newark Bay with Raritan Bay (Figure 5). Sanitary sewage from the areas along Arthur Kill is treated at the Oakwood Beach WRRF. The collection system for the Oakwood Beach WRRF is a separate sanitary system, and no CSOs exist along the Staten Island shoreline of Arthur Kill.

The gap analyses performed as part of the Citywide/Open Waters LTCP concluded that under baseline conditions, the Class SD WQ Criteria for fecal coliform would not be attained in the entire reach of Arthur Kill north of the Outerbridge Crossing Bridge on an annual basis, and would not be attained in the reach north of Pralls Island in the recreational season (May 1st through October 31st). In addition, the Class I WQ Criteria for fecal coliform and DO would not be attained in the portion of Arthur Kill south of the Outerbridge Crossing Bridge on an annual basis. However, the gap analyses indicated that the levels of attainment with these fecal coliform and DO criteria would not change with a condition of No NYC CSO Loads. The load component analysis presented in Section 6 demonstrated that the non-attainment in this area is driven by sources from outside of NYC .

Since no CSOs discharge directly to Arthur Kill, no CSO control alternatives were identified for this waterbody. The LTCP assessment showed that with the Recommended Plan (i.e., no additional projects for Arthur Kill), the levels of attainment with WQ Criteria would not change from baseline conditions. Attainment with the Class SD WQ Criteria for fecal coliform north of the Outerbridge Crossing Bridge would range from approximately 90 to 100 percent in the recreational season (May 1st through October 31st), and from about 60 to less than 95 percent on an annual basis. Attainment with the Class I WQ Criteria for fecal coliform south of the Outerbridge Crossing Bridge would range from approximately 80 to greater than 95 percent on an annual basis, while recreational season (May 1st through October 31st) attainment is projected to be greater than 95 percent.

The Class SD DO criteria are projected to be attained in Arthur Kill north of the Outerbridge Crossing Bridge under baseline conditions and with the Recommended Plan (no project). Attainment with the Class I WQ Criteria for DO in Arthur Kill south of the Outerbridge Crossing Bridge is projected to be in the 90 to 95 percent range on an annual average basis.

Arthur Kill supports a mix of shipping and recreational boating traffic. Arthur Kill is a major navigational channel of the Port of New York and New Jersey, receiving heavy shipping traffic. Periodic dredging has been required to deepen and widen both channels to depths of 35 to 50 feet in order to accommodate large commercial ship traffic.

The shoreline along Arthur Kill is mostly natural with some areas of piers, bulkhead, and riprap. Locations for direct public access to the water are limited. No DOHMH certified bathing beaches or formal kayak launch sites are located along Arthur Kill. Boating access is provided at Tottenville Marina. Greenspace along Arthur Kill includes Fresh Kills Park, Tottenville Park, and some smaller green spaces (see Figure 4 above).

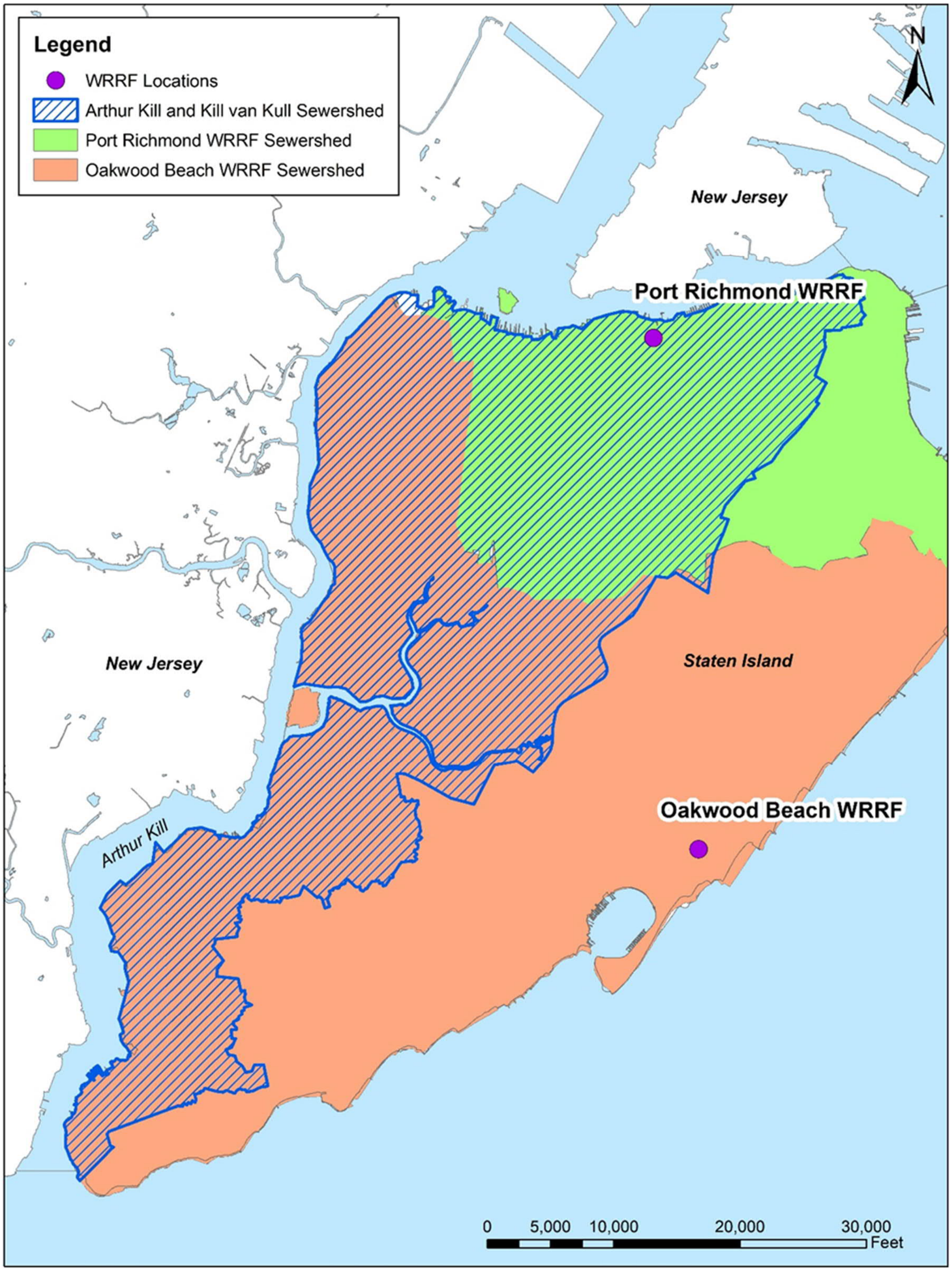

Figure 5. Components of the Kill Van Kull Watershed

Based on the analyses summarized above, projected fecal coliform levels do not meet the Class SD WQ Criteria on an annual basis or recreational season (May 1st through October 31st) basis in Arthur Kill north of the Outerbridge Crossing Bridge, and the Class I WQ Criteria for fecal coliform and DO are not projected to be met on an annual basis in Arthur Kill south of the Outerbridge Crossing Bridge. The non-attainment of these criteria is driven by sources from outside of NYC, as no NYC CSOs directly discharge to Arthur Kill and thus a condition of No NYC CSO Loads would not change the level of attainment. It is recommended that the current designated uses of the waterbody and the Class SD and Class I classifications be maintained after implementation of the LTCP Recommended Plan. After implementation, future data collection efforts will provide data that could be used to re-assess the attainment of Class SD and Class I WQ Criteria and the best use of Arthur Kill could be evaluated accordingly. The following sections present the UAA for New York Bay, Kill Van Kull, and Arthur Kill.

NEW YORK BAY

Introduction – New York Bay

Regulatory Considerations

The DEC has designated New York Bay as a Class SB Coastal Primary Recreational waterbody. "*The best usages of Class SB waters are primary and secondary contact recreation and fishing." In addition, "These waters shall be suitable for fish, shellfish and wildlife propagation and survival*" (6 NYCRR 701.11).

Federal policy recognizes that the uses designated for a waterbody may not be attainable, and the UAA has been established as the mechanism to modify the water quality standards (WQS) in such a case. As described in more detail below, portions of New York Bay would not meet the Class SB Coastal Primary Recreational *Enterococci* 30-day STV criteria during the recreational season (May1st through October 31st), based on the 10-year rainfall simulation with the implementation of the LTCP Recommended Plan. The Class SB WQ Criteria for fecal coliform would be met both on an annual and recreational season (May1st through October 31st) basis, and the Class SB Coastal Primary Recreational *Enterococci* 30-day geometric mean criteria would be met during the recreational season (May1st through October 31st).

With the Recommended Plan, the Class SB DO criteria would be met throughout New York Bay on an average annual basis, except for a localized area adjacent to the southwestern tip of Staten Island.

This UAA identifies the attainable and existing uses of New York Bay and compares them to those designated by DEC in order to provide data to establish appropriate WQ goals for this waterway. Under Federal regulations (40 CFR 131.10), six factors may be considered in conducting a UAA:

1. Naturally occurring pollutant concentrations prevent the attainment of the use; or
2. Natural, ephemeral, intermittent or low flow conditions or water levels prevent the attainment of the use, unless these conditions may be compensated for by the discharge of sufficient volume of effluent discharges without violating State water conservation requirements to enable uses to be met; or
3. Human caused conditions or sources of pollution prevent the attainment of the use and cannot be remedied or would cause more environmental damage to correct than to leave in place; or

4. Dams, diversions, or other types of hydrologic modifications preclude the attainment of the use, and it is not feasible to restore the waterbody to its original conditions or to operate such modification in a way that would result in the attainment of the use; or
5. Physical conditions related to the natural features of the waterbody, such as the lack of proper substrate, cover, flow, depth, pools, riffles, and the like, unrelated to water quality, preclude attainment of aquatic life protection uses; or
6. Controls more stringent than those required by Sections 301(b) and 306 of the Clean Water Act would result in substantial and widespread economic and social impact.

The UAA shall "examine whether applicable waterbody classifications, criteria, or standards should be adjusted by the State." The UAA process specifies that States can remove a designated use which is not an existing use if the scientific assessment can demonstrate that attaining the designated use is not feasible for at least one of six factors listed above.

Identification of Existing Uses

New York Bay is a large natural harbor that supports a mix of shipping, ferry, and recreational boating traffic. Active DOHMH certified bathing beaches are located along the shoreline of Staten Island, Coney Island, and Rockaway Inlet (see Figure 2 above), and fishing is a common activity along the non-industrial portions of the shoreline. Along the Brooklyn shoreline from the East River to Gravesend Bay, direct public access to the water is limited. As indicated in Figure 2, locations of kayak launches or marinas along the Brooklyn shoreline include Governor's Island, Louis Valentino Park, and Marine Basin Marina. The shoreline in this area is highly bulkheaded and rip-rapped, further limiting access onto or off of the water. Figure 6 and Figure 7 show examples of the New York Bay shoreline.

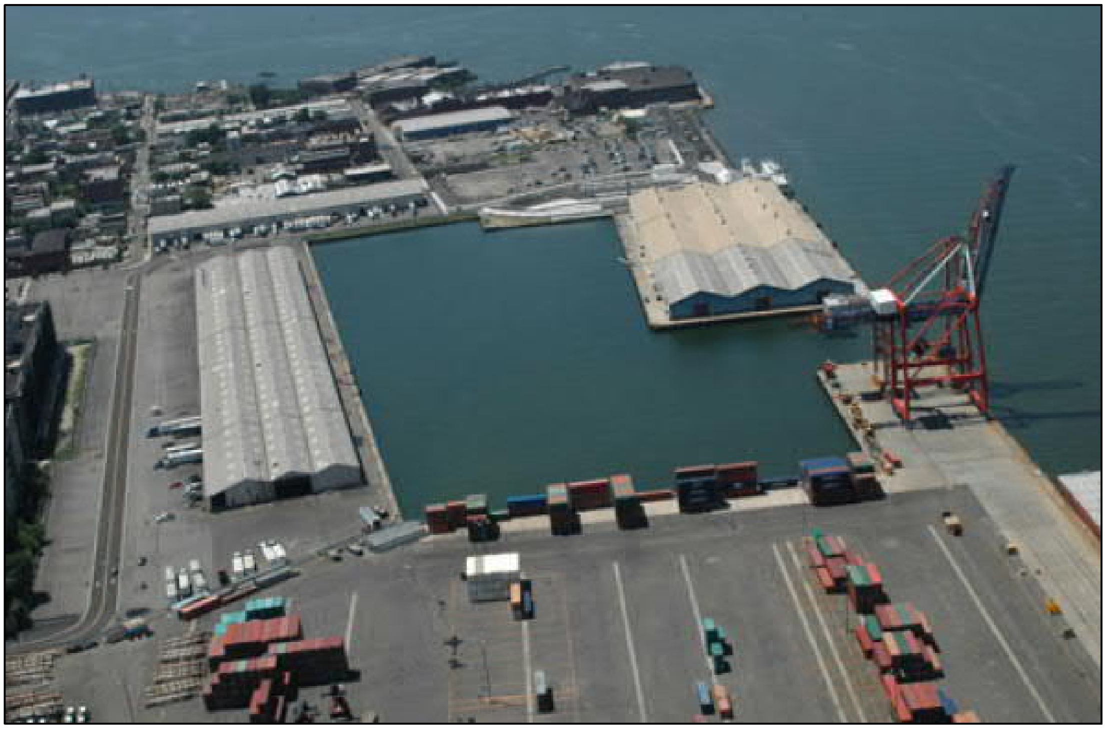

Figure 6. Example of Piers on Brooklyn Shoreline of Upper New York Bay

Figure 7. Example of Natural Shoreline and Groin at Midland Beach on Staten Island Shoreline in the Lower New York Bay

Attainment of Designated Uses – New York Bay

New York Bay is a Class SB Coastal Primary Recreational waterbody, with best usages defined as primary and secondary contact recreation and fishing, and the waters shall be suitable for fish, shellfish, and wildlife propagation and survival. Active DOHMH certified bathing beaches are located along the shoreline of Staten Island, Coney Island, and Rockaway Inlet. Figure 8 to Figure 11 present mosaics of the percent attainment with the Class SB WQ Criteria for fecal coliform (annual and recreational season [May 1st through October 31st]), and the Class SB Coastal Primary Recreational WQ Criteria for *Enterococci* (geometric mean and STV), with the Citywide/Open Waters LTCP Recommended Plan. These figures present results for the surface layer of the WQ model, for the 10-year simulation. As indicated in Figure 8 to Figure 10, Class SB WQ Criteria for fecal coliform (annual and recreational season [May 1st through October 31st]), and the Class SB Coastal Primary Recreational WQ Criteria for *Enterococci* geometric mean are projected to be met throughout New York Bay. Figure 11 shows the areas of projected non-attainment with the Class SB Coastal Primary Recreational WQ Criteria for *Enterococci* STV. The pockets of non-attainment along the southern Staten Island shoreline, and at the one model cell in Rockaway Inlet would remain even with a condition of No NYC CSO Loads, indicating that the non-attainment in those areas is due to sources other than NYC CSOs. Attainment levels would generally range from approximately 50 percent in the vicinity of Gravesend Bay, to greater than 95 percent in parts of the Bay away from the Brooklyn shoreline. In the model cells adjacent to Seagate 42nd Street Beach and Seagate Beach Club, the attainment with the Class SB Coastal Primary Recreational WQ Criteria for *Enterococci* STV ranges from 92 to 94 percent. Otherwise, no DOHMH certified bathing beaches are located along the shoreline of Brooklyn in the areas not meeting the *Enterococci* STV criteria.

With the Recommended Plan, attainment with the Class SB Coastal Primary Recreational 30-day STV WQ Criteria for *Enterococci* for the recreational season (May 1st through October 31st) would not substantially change from baseline conditions. A 50-percent level of CSO control for New York Bay would be required to achieve attainment with the Class SB Coastal Primary Recreational *Enterococci* 30-day STV criteria in the area along the Brooklyn shoreline. As described in Section 8 of the Citywide/Open Waters LTCP, this alternative would have an un-escalated probable bid cost of approximately $3B, and would have a number of significant constructability challenges, as well as affordability concerns.

Figure 12 presents a mosaic of the percent attainment with the Class SB WQ Acute Criteria for DO under the Recommended Plan, for the 2008 typical year, and Figure 13 presents attainment with the Class SB WQ Chronic Criteria for DO. As indicated in Figure 12, all of New York Bay is projected to be in attainment with the Acute Criteria for DO. As indicated in Figure 13, all of New York Bay is projected to be in attainment with the Chronic Criteria for DO with the exception of an area off the southwestern tip of Staten Island. This area of non-attainment would remain even with a condition of No NYC CSO Loads. The load component analysis presented in Section 6 demonstrated that the cause of non-attainment is sources from outside of NYC.

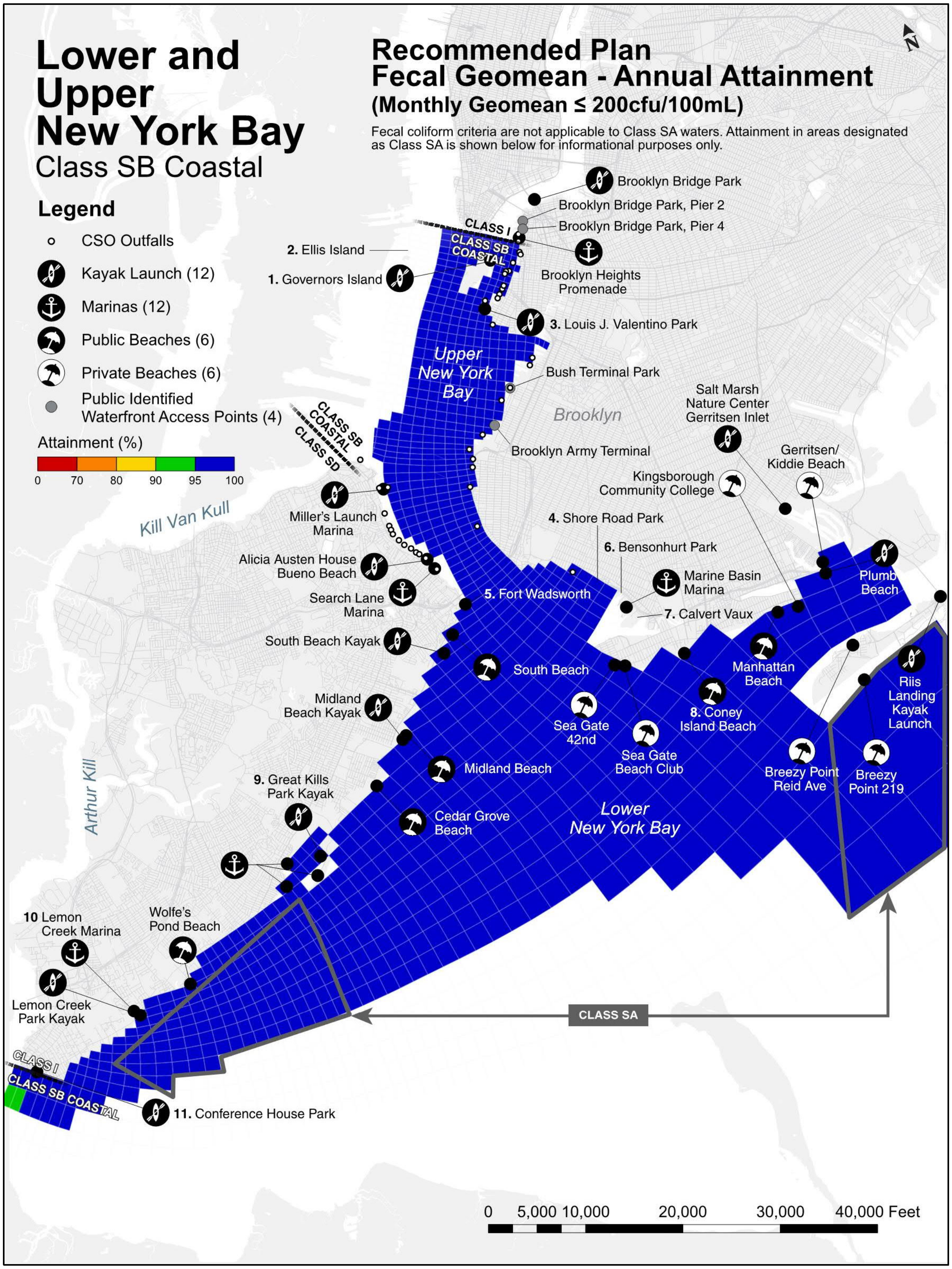

Figure 8. Fecal Coliform Class SB - Annual Attainment (10-year Runs), New York Bay, Recommended Plan

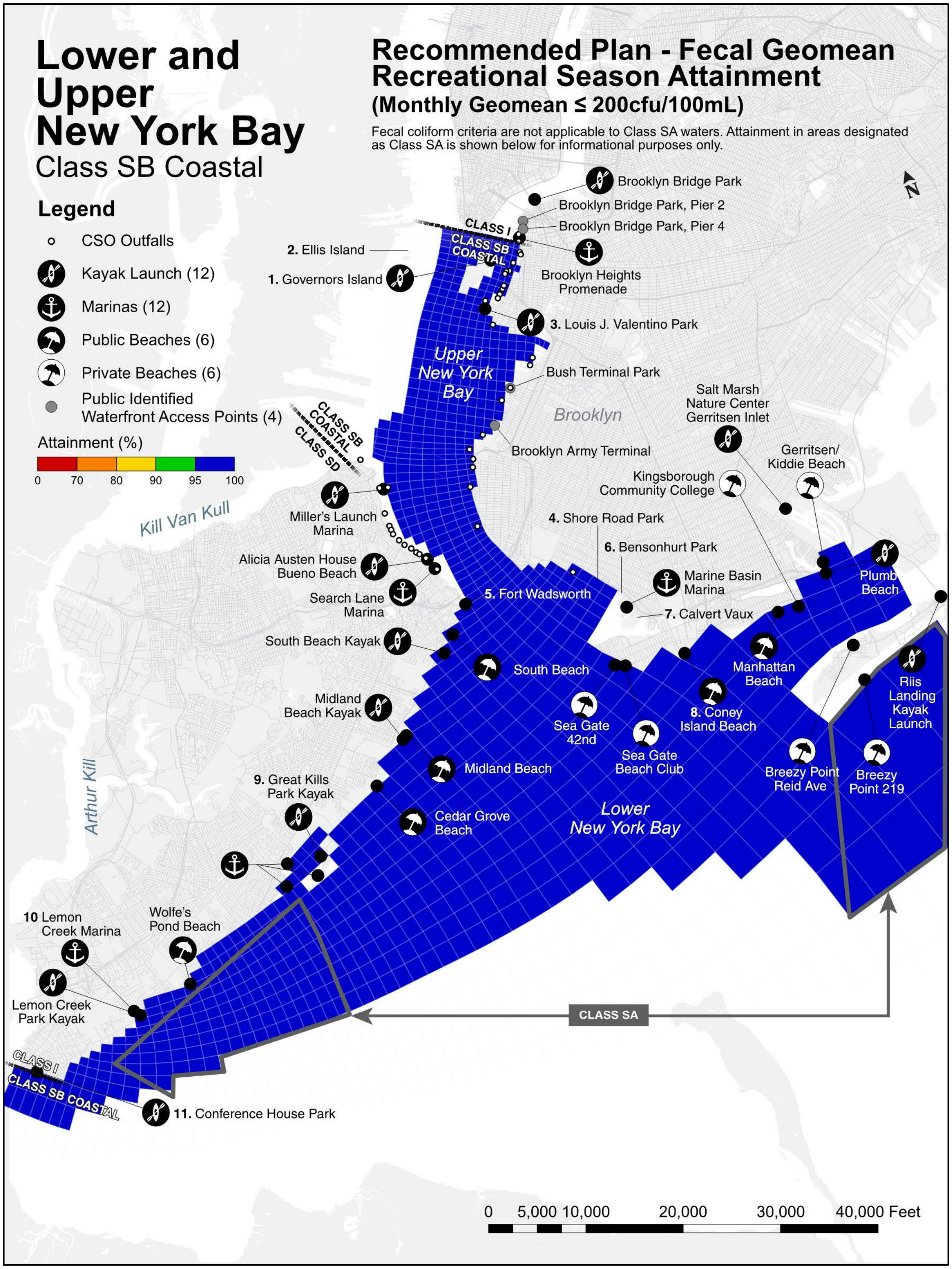

Figure 9. Fecal Coliform Class SB – Recreational Season Attainment (10-year Runs), Recommended Plan

AECOM with Hazen

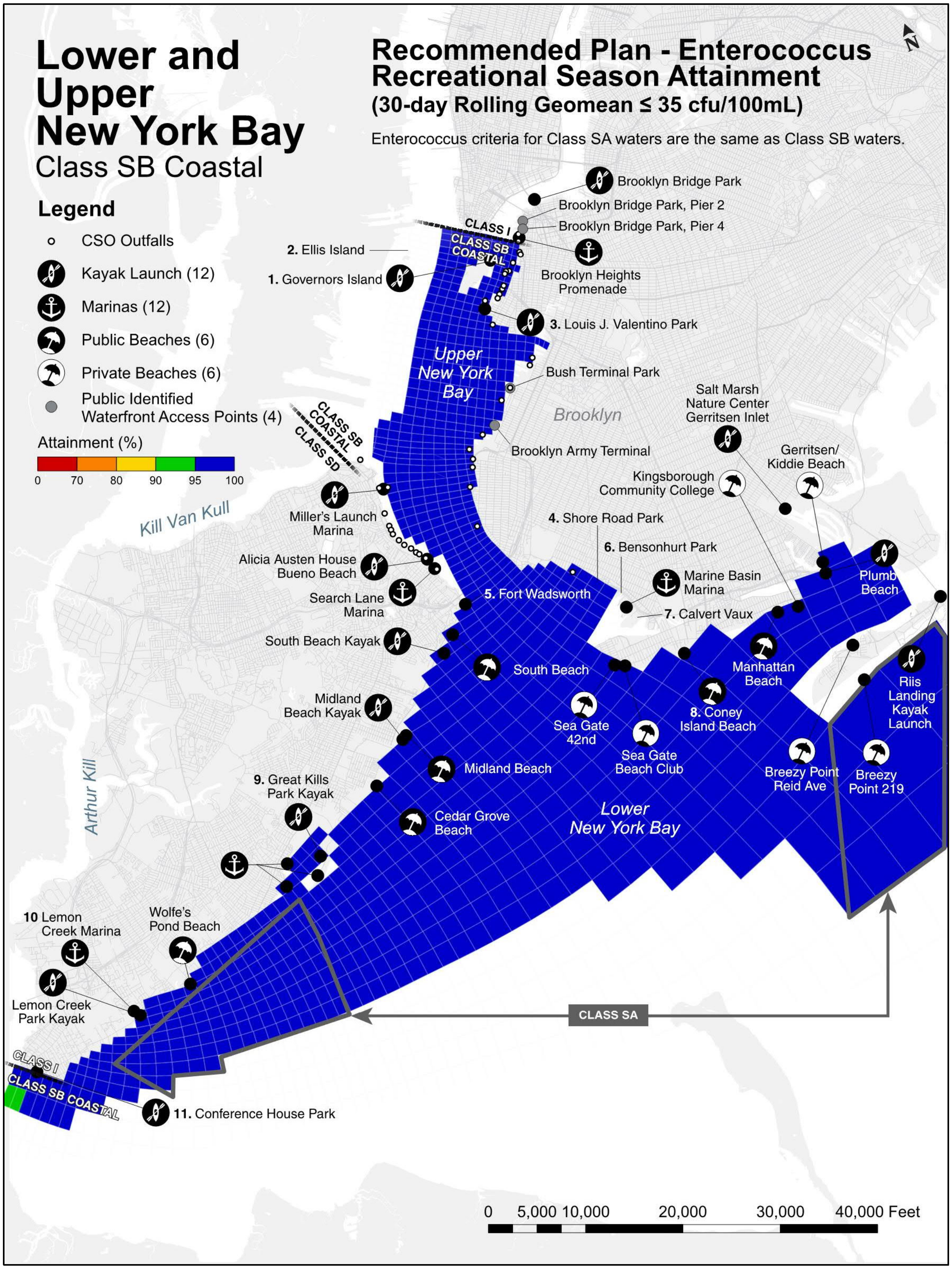

Figure 10. *Enterococci* Class SB Coastal Primary Recreational GM Attainment (10-year Runs), New York Bay, Recommended Plan

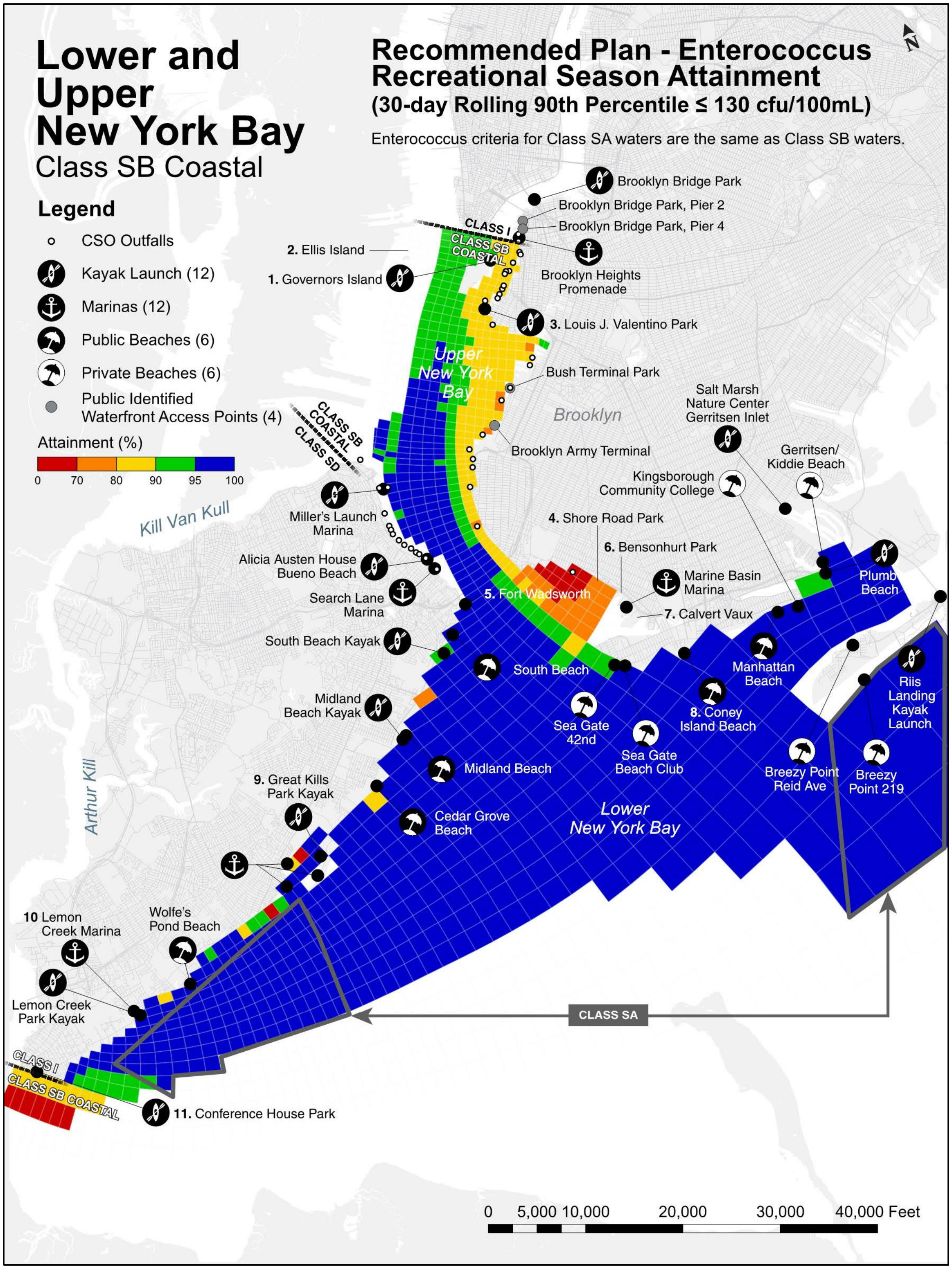

Figure 11. *Enterococci* Class SB Coastal Primary Recreational STV Attainment (10-year Runs), New York Bay, Recommended Plan

AECOM with Hazen

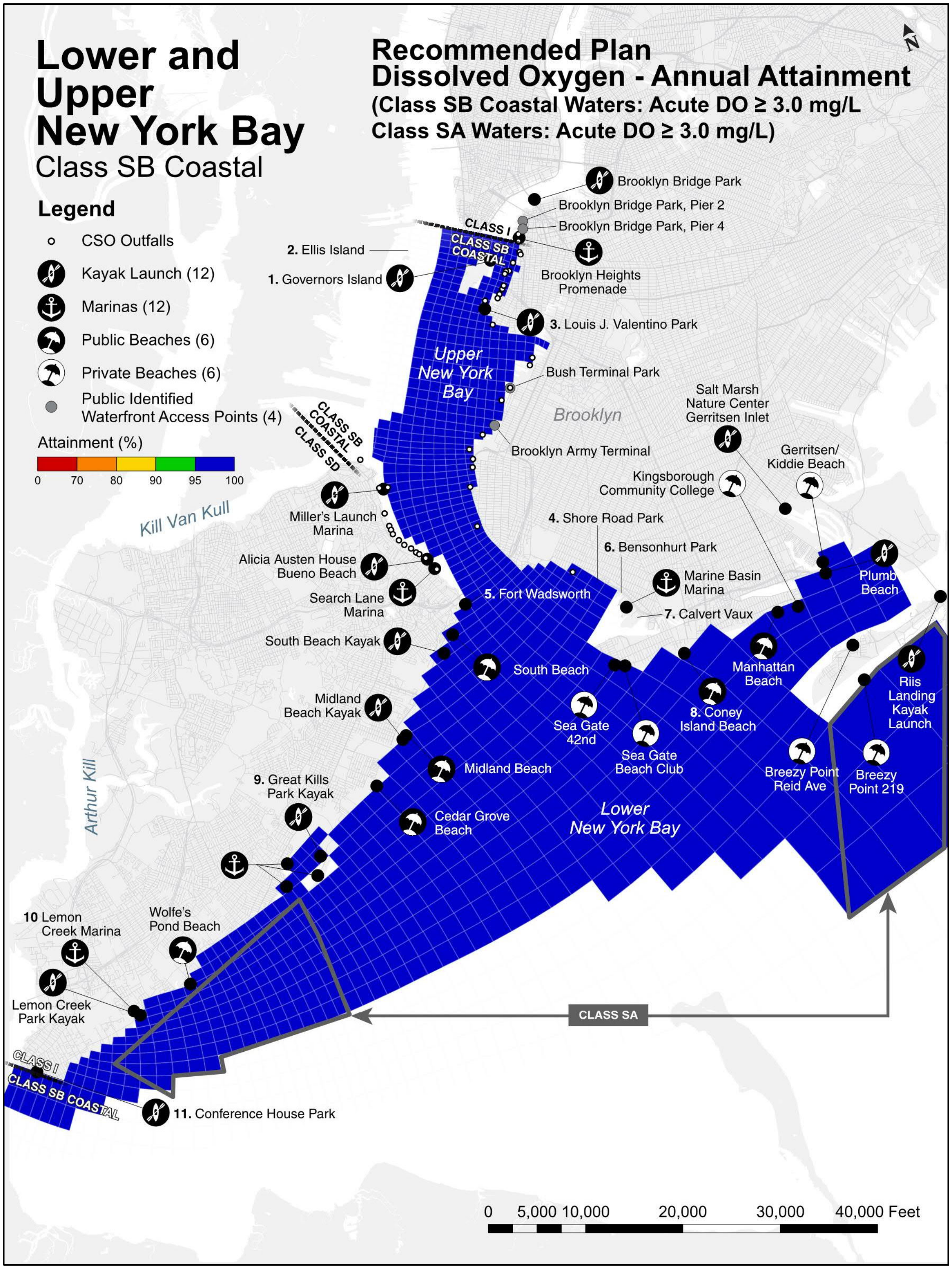

Figure 12. DO Class SB Acute Criteria - Annual Attainment (2008 Typical Year), New York Bay, Recommended Plan

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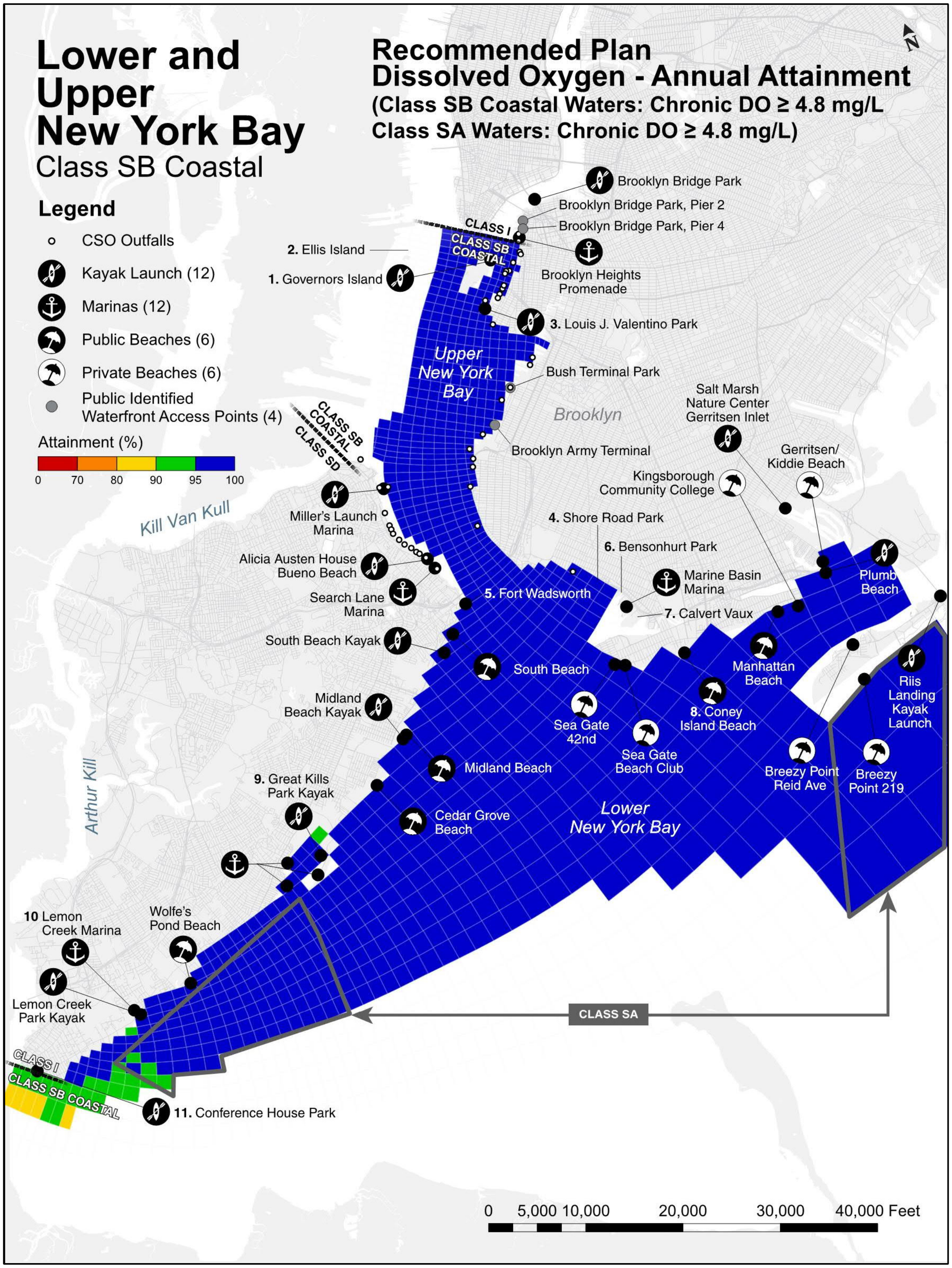

Figure 13. DO Class SB Chronic Criteria - Annual Attainment (2008 Typical Year)

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An analysis was also conducted to predict the recovery time in New York Bay following a rain event. DEP used the primary contact fecal coliform recreation warning level of 1,000 cfu/100mL from the DOHMH guidelines in this analysis, and also assessed recovery to an *Enterococci* concentration of 130 cfu/100mL, corresponding to the STV criterion for Class SB coastal primary contact recreational waters. The analyses consisted of examining the WQ model calculated bacteria concentrations in New York Bay for the recreational season (May 1st through October 31st) extracted from 10 years of model simulations. For New York Bay, the JFK Airport rainfall data was compared against water quality model bacteria results for the 10 recreational seasons to determine how long it took for the water column concentration to return to target threshold concentrations from the end of the rain event. The various rainfall events were then placed into rain event size “bins” ranging from less than 0.1 inch to greater than 1.5 inches. Only rain events that reached the target threshold concentrations before the beginning of the next storm were included. The median time to recovery for each bin at each water quality station was calculated. Table 1 presents the median time to recovery to a fecal coliform level of 1,000 cfu/100mL for the Recommended Plan for New York Bay. Results are presented for the greater than 1.0 to 1.5 inch rainfall bin, which includes the 90th percentile event.

DEC has advised that it seeks to have a time to recovery of less than 24 hours, and this target has been consistent in the previously approved LTCPs. As indicated in Table 1, for the Recommended Plan, all of the stations assessed except for NB-7, NB-9, and J11 had time to recovery of zero hours, indicating that the fecal coliform concentration never reached the level of 1,000 cfu/100mL for more than half of the storms within the 1-to-1.5 inch rainfall bin assessed. Times to recovery for Stations NB-7, NB-9 and J11 were eight hours or less.

Table 1. New York Bay Time to Recovery, Fecal Coliform, Recommended Plan

Location	Median Time to Recovery (hours) Fecal Coliform Threshold (1,000 cfu/100mL)(1)
New York Bay (Class SB Coastal Primary Contact Recreational)	
NB-1	0(2)
NB-2	0
NB-3	0
NB-4	0
NB-5	0
NB-6	0
NB-7	4
NB-8	0
NB-9	8
NB-10	0
NB-11	0
NB-12	0
K5A	0
J11	2

Table 1. New York Bay Time to Recovery, Fecal Coliform, Recommended Plan

Location	Median Time to Recovery (hours) Fecal Coliform Threshold (1,000 cfu/100mL)(1)
N9A	0
Governors Island	0
Louis Valentino Park	0
Search Lane Marina	0
Marine Basin Marina	0
Sea Gate Beach Club/42nd	0
Coney Island Beach	0
Manhattan Beach/	0
Gerritson/Plumb Beach	0
Riis Landing Kayak Launch	0
Breezy Point Reid Ave. Beach	0
Breezy Point 219	0
Millers Launch Marina	0
Alice Austen House Buono Beach	0
South Beach Kayak/Midland	0
Cedar Grove Beach	0
Great Kills Park Kayak	0
Wolf's Pond Beach	0
Lemon Creek Marina/Kayak	0

Notes:

(1) Median time to recovery values presented for storms from the 10-year simulation, recreational seasons, in the size range of >1.0 to 1.5-inches of rainfall, which includes the 90th percentile rain event.

(2) Median time to recovery of "0" means that the average concentration across the water column never reached the 1,000 cfu/100mL threshold at the referenced station for more than half of the storms within the 1-to-1.5 inch rainfall bin assessed.

The results of the analysis for time to recovery to an *Enterococci* concentration of 130 cfu/100mL for the Recommended Plan are presented in Table 2. As indicated in Table 2, for the Recommended Plan, the highest median time to recovery for the stations assessed was 12 hours, and most of the stations assessed had median time to recovery of zero hours, indicating that the concentration of *Enterococci* at those locations was less than 130 cfu/100mL for more than half of the storms within the 1-to-1.5 inch rainfall bin assessed.

Table 2. New York Bay Time to Recovery, *Enterococci*, Recommended Plan

Location	Median Time to Recovery (hours) *Enterococci* Threshold (130 cfu/100mL)(1)
New York Bay (Class SB Coastal Primary Contact Recreational)	
NB-1	7
NB-2	6
NB-3	4
NB-4	5
NB-5	0(2)
NB-6	0
NB-7	11
NB-8	0
NB-9	12
NB-10	0
NB-11	0
NB-12	0
K5A	0
J11	0
N9A	0
Governors Island	0
Louis Valentino Park	7
Search Lane Marina	0
Marine Basin Marina	0
Sea Gate Beach Club/42nd	0
Coney Island Beach	0
Manhattan Beach/ Kingsborough Community College Beach	0
Gerritson/Plumb Beach	0
Riis Landing Kayak Launch	0
Breezy Point Reid Ave. Beach	0
Breezy Point 219	0
Millers Launch Marina	0
Alice Austen House Buono Beach	0
South Beach Kayak/Midland	0
Cedar Grove Beach	0
Great Kills Park Kayak	0
Wolf's Pond Beach	0
Lemon Creek Marina/Kayak	0

AECOM with Hazen

Table 2. New York Bay Time to Recovery, *Enterococci*, Recommended Plan

Location	Median Time to Recovery (hours) *Enterococci* Threshold (130 cfu/100mL)(1)

Notes:
(1) Median time to recovery values presented for storms from the 10-year simulation, recreational seasons, in the size range of >1.0 to 1.5-inches of rainfall, which includes the 90th percentile rain event.
(2) Median time to recovery of "0" means that the average concentration across the water column never reached the 130 cfu/100mL threshold at the referenced station for more than half of the storms within the 1-to-1.5 inch rainfall bin assessed

Conclusions – New York Bay

With the LTCP Recommended Plan, *Enterococci* levels are not projected to meet the Class SB Coastal Primary Recreational 30-day STV WQ Criteria for the recreational season (May 1st through October 31st) along the Brooklyn shoreline, at localized areas along the southern shoreline of Staten Island, and at a localized area in Rockaway Inlet. The non-attainment in the individual locations along the southern shoreline of Staten Island and in Rockaway Inlet would remain even with a condition of No NYC CSO Loads, indicating that the non-attainment in those areas was driven by sources other than NYC CSOs.

Along the Brooklyn shoreline, non-attainment with the *Enterococci* STV WQ criteria appears to be primarily related to NYC CSO sources. As described above, a 50-percent level of CSO control to New York Bay would be required to achieve compliance with the STV criteria in that area.

The time to recovery analysis indicated that for storms in the 1 to 1.5-inch range, the median time to recovery to an *Enterococci* concentration of 130 cfu/100mL was in the range of 4 to 12 hours for Stations NB-3, NB-4, NB-7, and NB-9 along the Brooklyn shoreline. All beach locations, including Seagate 42nd Street Beach and Seagate Beach Club, had time to recovery of zero hours, indicating that the *Enterococci* concentration did not reach 130 cfu/100mL for more than half of the storms in the 1 to 1.5-inch range. The non-attainment of the Class SB Coastal Primary Recreational WQ Criteria for *Enterococci* STV at Seagate 42nd Street Beach and Seagate Beach Club is therefore most often due to storms with rainfall greater than 1.5 inches. This analysis indicates that the duration of wet-weather impacts in New York Bay is relatively short.

As indicated in Section 8 of the Citywide/Open Waters LTCP, the 50-percent control storage tunnel alternative for New York Bay that would be needed to achieve attainment with the *Enterococci* STV WQ criteria along the Brooklyn shoreline would have an un-escalated estimated probable bid cost of $3B, and would have numerous constructability challenges. Section 9 of the Citywide/Open Waters LTCP identifies the financial burdens currently facing the disadvantaged communities within New York City, and demonstrates that significant further investment in the CSO program beyond the current $6.3B commitment would create conditions of substantial and widespread economic and social impact.

Under baseline conditions, the Class SB WQ Criteria for dissolved oxygen (DO) are not attained in a portion of the Bay adjacent to the southwestern tip of Staten Island on an average annual basis. The non-attainment in that location would remain even with a condition of No NYC CSO Loads. The load component analysis presented in Section 6 indicated that the non-attainment in that area is driven by sources from outside of NYC.

Based on the above analysis, DEP concludes that non-attainment of the Class SB Coastal Primary Recreational 30-day STV WQ Criteria for *Enterococci* is attributable to the following UAA factors:

- For areas other than along the Brooklyn shoreline, human caused conditions (pollutant loadings from outside of NYC, direct drainage and urban runoff), create high bacteria levels that prevent the attainment of the use and cannot be fully remedied (UAA Factor #3).

- For areas along the Brooklyn shoreline, Controls more stringent than those required by Sections 301(b) and 306 of the Clean Water Act would result in substantial and widespread economic and social impact (UAA Factor #6).

In addition, DEP has determined that non-attainment of the Class SB Criteria for DO is attributable to the following UAA factors:

- Human caused conditions or sources of pollution (pollutant loadings from sources outside of NYC) prevent the attainment of the use and cannot be remedied by DEP (UAA Factor #3).

It should be emphasized that the New York Bay watershed provides many shoreline access points for on-shore recreation, which allow the public to take advantage of the recreational uses of the waterway. These uses should generally be protected in recreational periods, with the exception of during rain events when WQ advisories will likely be in place.

Recommendations – New York Bay

With implementation of the Citywide/Open Waters LTCP Recommended Plan, parts of New York Bay are not projected to attain the current Class SB Coastal Primary Recreational 30-day STV WQ Criteria for *Enterococci*, and parts of New York Bay are not projected to attain the current Class SB WQ Criteria for DO. The Class SB Coastal Primary Recreational 30-day geometric mean WQ Criteria for *Enterococci,* and the Class SB WQ Criteria for fecal coliform are projected to be attained throughout New York Bay. The areas of non-attainment with the Class SB WQ Criteria for DO, and the areas of non-attainment with the Class SB Coastal Primary Recreational 30-day STV WQ Criteria for *Enterococci* other than Brooklyn shoreline would remain even with a condition of No NYC CSO Loads, indicating that the causes of non-attainment in those areas are sources other than NYC CSOs.

Best usages for New York Bay are defined as primary and secondary contact recreation and fishing, and the waters shall be suitable for fish, shellfish, and wildlife propagation and survival. Additional CSO control would not affect primary contact recreation at the DOHMH sanctioned beaches other than potentially Seagate 42nd Street Beach and Seagate Beach Club, where the attainment with the Class SB Coastal Primary Recreational WQ Criteria for *Enterococci* STV is projected to range from 92 to 94 percent with the Recommended Plan. The time to recovery analysis indicated that the non-attainment at those beach locations is mostly driven by storms with greater than 1.5 inches of rainfall. In the area of non-attainment with the Class SB Coastal Primary Recreational WQ Criteria for *Enterococci* STV along the Brooklyn shoreline, the physical features of the shoreline limit the extent of direct access for secondary contact recreation. The current uses are primarily associated with on-shore activities at specific access locations, as well as boating/kayaking facilitated by kayak launches at Governor's Island and Louis Valentino Park, and boating access at the Marine Basin Marina. The LTCP assessments demonstrated that the LTCP Recommended Plan will cost-effectively reduce CSO volume discharged to New York Bay from CSOs along the Brooklyn shoreline. However, to achieve the level of CSO control needed to bring the area along the Brooklyn shoreline into attainment with the Class SB Coastal Primary Recreational WQ Criteria for *Enterococci* STV would require an alternative (50 percent CSO control tunnel) that would have an un-escalated probable bid cost estimated at $3B and would carry a number of significant constructability challenges. The above conclusions support that New York Bay should remain a designated Class SB Coastal Primary Recreational waterbody after the implementation of the LTCP Recommended Plan. Future Post-Construction Compliance Monitoring data collection efforts may later support a re-evaluation of the best uses and designated WQ classification for New York Bay.

KILL VAN KULL

Introduction – Kill Van Kull

Regulatory Considerations

The DEC has designated Kill Van Kull as a Class SD waterbody. The best usage of Class SD waters is fishing. In addition, "*These waters shall be suitable for fish, shellfish and wildlife survival. This classification may be given to those waters that, because of natural or man-made conditions, cannot meet the requirements for fish propagation"* (6 NYCRR 701.14).

Federal policy recognizes that the uses designated for a waterbody may not be attainable, and the UAA has been established as the mechanism to modify the WQS in such a case. Portions of Kill Van Kull adjacent to Newark Bay would not meet the Class SD WQ Criteria for fecal coliform on an annual basis, based on the 10-year rainfall simulation with the implementation of the LTCP Recommended Plan. The Class SD WQ Criteria for fecal coliform would be met for the recreational season (May1st through October 31st) basis, and the Class SD DO criteria would be met on an annual average basis.

This UAA identifies the attainable and existing uses of Kill Van Kull and compares them to those designated by DEC in order to provide data to establish appropriate WQ goals for this waterway. Under Federal regulations (40 CFR 131.10), six factors may be considered in conducting a UAA:

1. Naturally occurring pollutant concentrations prevent the attainment of the use; or
2. Natural, ephemeral, intermittent or low flow conditions or water levels prevent the attainment of the use, unless these conditions may be compensated for by the discharge of sufficient volume of

effluent discharges without violating State water conservation requirements to enable uses to be met; or

3. Human caused conditions or sources of pollution prevent the attainment of the use and cannot be remedied or would cause more environmental damage to correct than to leave in place; or
4. Dams, diversions, or other types of hydrologic modifications preclude the attainment of the use, and it is not feasible to restore the waterbody to its original conditions or to operate such modification in a way that would result in the attainment of the use; or
5. Physical conditions related to the natural features of the waterbody, such as the lack of proper substrate, cover, flow, depth, pools, riffles, and the like, unrelated to water quality, preclude attainment of aquatic life protection uses; or
6. Controls more stringent than those required by Sections 301(b) and 306 of the Clean Water Act would result in substantial and widespread economic and social impact.

The UAA shall "examine whether applicable waterbody classifications, criteria, or standards should be adjusted by the State." The UAA process specifies that States can remove a designated use, which is not an existing use, if the scientific assessment can demonstrate that attaining the designated use is not feasible for at least one of six factors listed above.

Identification of Existing Uses

Kill Van Kull supports a mix of shipping, ferry, and recreational boating traffic, and the northern shoreline along Kill Van Kull is the most urbanized part of Staten Island. With the marine industrial uses along the shoreline, locations of direct public access to the water are limited. No DOHMH certified bathing beaches or formal kayak launch sites are located along the Kill Van Kull shoreline. Greenspace along Kill Van Kull includes Mariners Marsh Park, the Snug Harbor area, and some smaller green spaces (see Figure 4 above).

Figure 14 and Figure 15 show examples of the Kill Van Kull shoreline.

Figure 14. Example of Kill Van Kull Shoreline at the North Shore Esplanade

Figure 15. Example of Kill Van Kull Shoreline Near Sailors Snug Harbor

Attainment of Designated Uses – Kill Van Kull

As described above, Kill Van Kull is a Class SD waterbody, with best usage of defined as "*fishing. The waters shall be suitable for fish, shellfish, and wildlife survival. This classification may be given to those waters that, because of natural or man-made conditions, cannot meet the requirements for fish propagation*" (6 NYCRR 701.14). No active DOHMH certified bathing beaches are located along the Staten Island shoreline of Kill Van Kull. Figure 16 and Figure 17 present mosaics of the percent attainment with the Class SB WQ Criteria for fecal coliform on an annual and recreational season (May 1st through October 31st) basis, respectively, with the Citywide/Open Waters LTCP Recommended Plan. These figures present results for the surface layer of the WQ model, for the 10-year simulation. As indicated in these figures, the Class SD WQ Criteria for fecal coliform is not projected to be fully attained in the western reach of Kill Van Kull adjacent to Newark

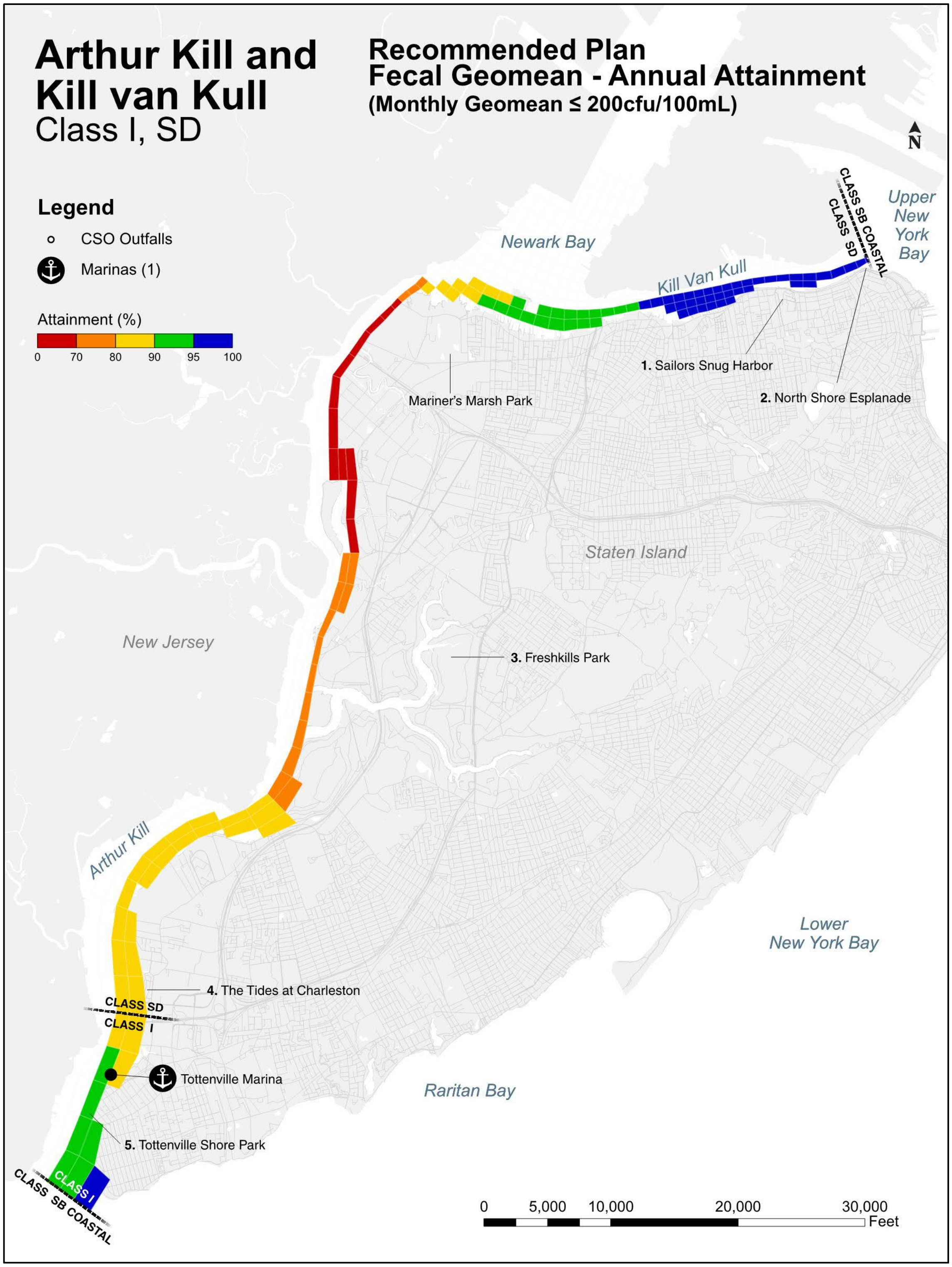

Figure 16. Fecal Coliform Class SD - Annual Attainment (10-year Runs), Kill Van Kull, Recommended Plan

Figure 17. Fecal Coliform Class SD – Recreational Season Attainment (10-year Runs), Kill Van Kull, Recommended Plan

Bay on an annual basis, but the criteria are projected to be fully attained for the recreational season (May 1st through October 31st). Projected levels of attainment would range from 100 percent in the eastern part of Kill Van Kull, to the 80 to 95 percent range in the western part. However, the non-attainment would remain even with a condition of No NYC CSO Loads. The load component analysis presented in Section 6 indicated that the non-attainment in the western part was driven by sources from outside of NYC.

Figure 18 presents a mosaic of the percent attainment with the Class SD WQ Criteria for DO under the Recommended Plan, for the 2008 typical year. As indicated in Figure 18, all of Kill Van Kull is projected to be in attainment with the criteria.

An analysis was also conducted to predict the recovery time in Kill Van Kull following a rain event. DEP used the primary contact fecal coliform recreation warning level of 1,000 cfu/100mL from the DOHMH guidelines in this analysis. The analyses consisted of examining the WQ model calculated bacteria concentrations in Kill Van Kull for the recreational season (May 1st through October 31st) extracted from 10 years of model simulations. For Kill Van Kull, the JFK Airport rainfall data was compared against water quality model bacteria results for the 10 recreational seasons to determine how long it took for the water column concentration to return to target threshold concentrations from the end of the rain event. The various rainfall events were then placed into rain event size "bins" ranging from less than 0.1 inch to greater than 1.5 inches. Only rain events that reached the target threshold concentrations before the beginning of the next storm were included. The median time to recovery for each bin at each water quality station was calculated. Table 3 presents the median time to recovery to a fecal coliform level of 1,000 cfu/100mL for the Recommended Plan for Kill Van Kull. Results are presented for the greater than 1.0 to 1.5 inch rainfall bin, which includes the 90th percentile event.

DEC has advised that it seeks to have a time to recovery of less than 24 hours, and this target has been consistent in the previously approved LTCPs. As indicated in Table 3, for the Recommended Plan, all of the stations assessed had median times to recovery of zero hours, indicating that the fecal coliform concentration never reached the level of 1,000 cfu/100mL for more than half of the storms assessed.

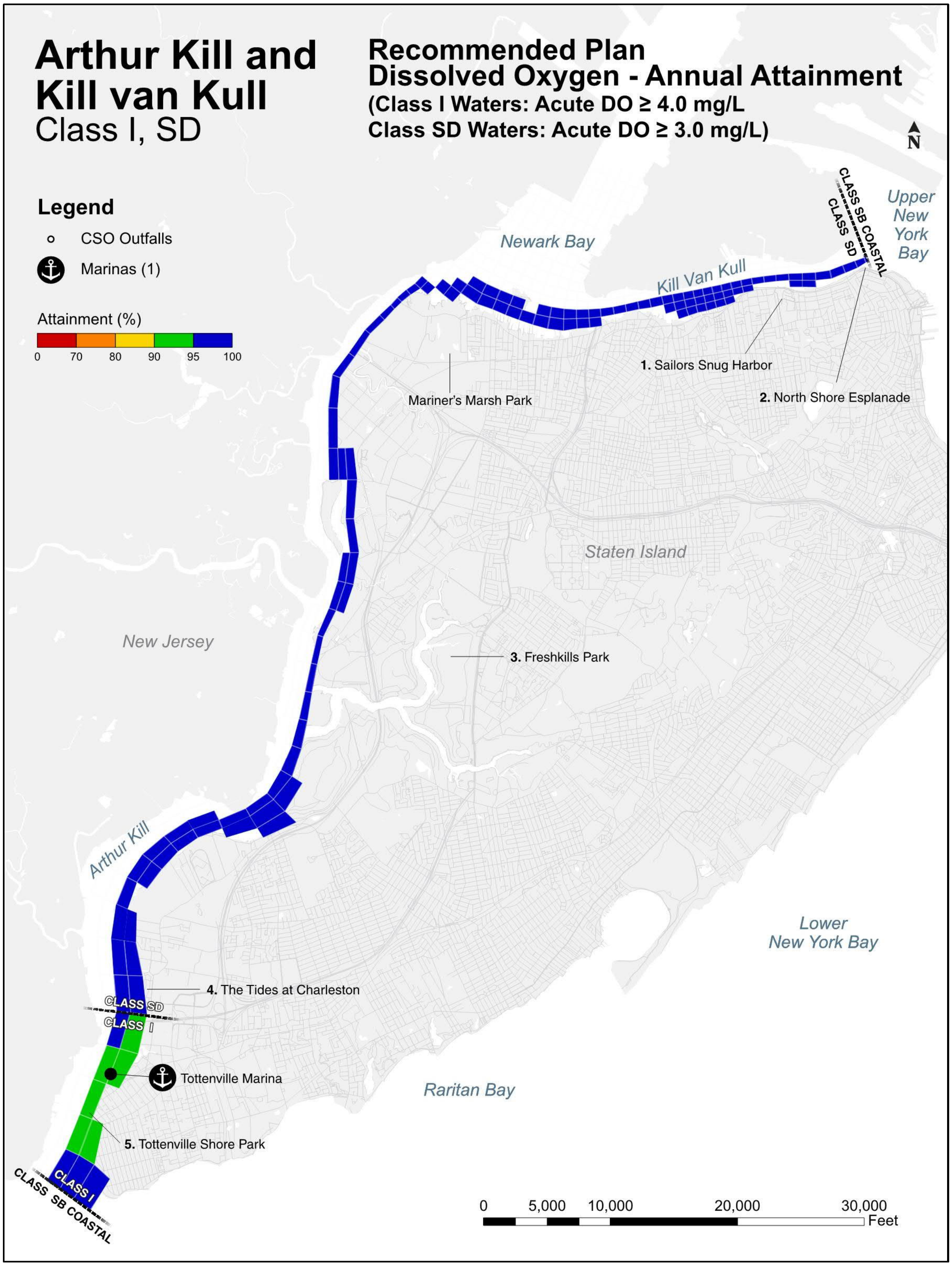

Figure 18. DO Class SD - Annual Attainment (2008 Typical Year), Kill Van Kull, Recommended Plan

Table 3. Kill Van Kull Time to Recovery, Fecal Coliform, Recommended Plan

Location	Median Time to Recovery (hours) Fecal Coliform Threshold (1,000 cfu/100mL)[1]
Kill Van Kull (Class SD)	
KK-1	0[2]
KK-2	0
KK-3	0
Mariners Marsh Park	0
Sailors Snug Harbor	0

Notes:
(1) Median time to recovery values presented for storms from the 10-year simulation, recreational seasons, in the size range of >1.0 to 1.5-inches of rainfall, which includes the 90th percentile rain event.
(2) Median time to recovery of "0" means that the average concentration across the water column never reached the 1,000 cfu/100mL threshold at the referenced station for more than half of the storms within the 1-to-1.5 inch rainfall bin assessed

Conclusions – Kill Van Kull

With the Citywide/Open Waters LTCP Recommended Plan, fecal coliform levels are not projected to meet the Class SD WQ Criteria for bacteria on an annual basis in the western portion of Kill Van Kull adjacent to Newark Bay. However, the non-attainment would remain even with a condition of No NYC CSO Loads, and the load component analysis presented in Section 6 indicated that the non-attainment in that area was driven by sources from outside of NYC.

For storms in the 1 to 1.5-inch range, the median time to recovery to fecal coliform concentration of 1,000 cfu/100mL was zero in all stations assessed, indicating that the concentration did not reach 1,000 cfu/100mL for more than half of those storms. This analysis indicates that the magnitude and duration of wet-weather impacts in Kill Van Kull is relatively short.

With the Recommended Plan, the Class SD WQ Criteria for DO are projected to be attained in Kill Van Kulll on an average annual basis.

As a result of these evaluations, it is concluded that non-attainment of the Class SD WQ Criteria for bacteria on an annual basis is attributable to the following UAA factor:

- Human caused conditions (pollutant loadings from outside of NYC) create high bacteria levels that prevent the attainment of the use and cannot be fully remedied by DEP (UAA factor #3).

It should be emphasized that the Kill Van Kull shoreline, although surrounded by commercial and industrial uses in most areas, does provide a few limited shoreline access points for on-shore recreation, which allow the public to take advantage of the recreational uses of the waterway.

Recommendations – Kill Van Kull

Since the areas of non-attainment with the Class SD WQ Criteria for fecal coliform in Kill Van Kull would remain unchanged even with a condition of No NYC CSO Loads, the causes of non-attainment are sources other than NYC CSOs. Therefore, additional CSO controls for Kill Van Kull would not result in attainment of the WQ Criteria.

The best usage for Kill Van Kull is *fishing. These waters shall be suitable for fish, shellfish and wildlife survival. This classification may be given to those waters that, because of natural or man-made conditions, cannot meet the requirements for fish propagation*. (6 NYCRR 701.14) No DOHMH sanctioned beaches are located along Kill Van Kull, and secondary contact and fishing uses would be protected in the recreational season (May 1st through October 31st). The above conclusions support that Kill Van Kull should remain a designated Class SD waterbody after the implementation of the LTCP Recommended Plan. Future Post-Construction Compliance Monitoring data collection efforts may later support a re-evaluation of the best uses and designated WQ classification for Kill Van Kull.

ARTHUR KILL

Introduction – Arthur Kill

Regulatory Considerations

The DEC has designated Arthur Kill as a Class SD waterbody north of the Outerbridge Crossing Bridge, and a Class I waterbody south of the Outerbridge Crossing Bridge. The best usage of Class SD waters is fishing. "*These waters shall be suitable for fish, shellfish and wildlife survival. This classification may be given to those waters that, because of natural or man-made conditions, cannot meet the requirements for fish propagation"* (6 NYCRR 701.14). The best usage of Class I waters are secondary contact recreation and fishing. *"These waters shall be suitable for fish, shellfish, and wildlife propagation and survival."* (6 NYCRR 701.13).

Federal policy recognizes that the uses designated for a waterbody may not be attainable, and the UAA has been established as the mechanism to modify the WQS in such a case. All of Arthur Kill north of the Outerbridge Crossing Bridge would not meet the Class SD WQ Criteria for fecal coliform on an annual basis, and a portion would not meet for the recreational season (May1st through October 31st), based on the 10-year rainfall simulation with the implementation of the LTCP Recommended Plan. The Class SD DO criteria would be met on an annual average basis. South of the Outerbridge Crossing Bridge, the Class I WQ Criteria for fecal coliform would not be met for portions of the waterbody on an annual basis, but the criteria would be met in the recreational season (May1st through October 31st). The Class I WQ Criteria for DO would not be met in portions of Arthur Kill south of the Outerbridge Crossing Bridge on an annual average basis.

As described further below, no NYC CSOs discharge to Arthur Kill. The loading component analysis presented in Section 6 demonstrated that the non-attainment of the Class SD and Class I WQ Criteria for fecal coliform, and the Class I WQ Criteria for DO, is due to sources from outside of NYC.

This UAA identifies the attainable and existing uses of Arthur Kill and compares them to those designated by DEC in order to provide data to establish appropriate WQ goals for this waterway. Under Federal regulations (40 CFR 131.10), six factors may be considered in conducting a UAA:

1. Naturally occurring pollutant concentrations prevent the attainment of the use; or
2. Natural, ephemeral, intermittent, or low flow conditions or water levels prevent the attainment of the use, unless these conditions may be compensated for by the discharge of sufficient volume of effluent discharges without violating State water conservation requirements to enable uses to be met; or
3. Human caused conditions or sources of pollution prevent the attainment of the use and cannot be remedied or would cause more environmental damage to correct than to leave in place; or
4. Dams, diversions, or other types of hydrologic modifications preclude the attainment of the use, and it is not feasible to restore the waterbody to its original conditions or to operate such modification in a way that would result in the attainment of the use; or
5. Physical conditions related to the natural features of the waterbody, such as the lack of proper substrate, cover, flow, depth, pools, riffles, and the like, unrelated to water quality, preclude attainment of aquatic life protection uses; or
6. Controls more stringent than those required by Sections 301(b) and 306 of the Clean Water Act would result in substantial and widespread economic and social impact.

The UAA shall "examine whether applicable waterbody classifications, criteria, or standards should be adjusted by the State." The UAA process specifies that States can remove a designated use, which is not an existing use, if the scientific assessment can demonstrate that attaining the designated use is not feasible for at least one of six factors listed above.

Identification of Existing Uses

Arthur Kill supports a mix of shipping and recreational boating traffic. Arthur Kill is a major navigational channel of the Port of New York and New Jersey, receiving heavy shipping traffic. Periodic dredging has been required to deepen and widen both channels to depths of 35 to 50 feet in order to accommodate large commercial ship traffic. Most of the shoreline in Arthur Kill is natural with some piers, bulkhead, and riprap.

Direct public access to the water is limited. No DOHMH certified bathing beaches or formal kayak launch sites are located along Arthur Kill. Boating access is provided at Tottenville Marina. Greenspace along Arthur Kill includes Fresh Kills Park, Tottenville Park, and some smaller green spaces (see Figure 4 above).

Figure 19 and Figure 20 show examples of the Arthur Kill shoreline.

Figure 19. Example of Arthur Kill Shoreline near The Tides at Charleston

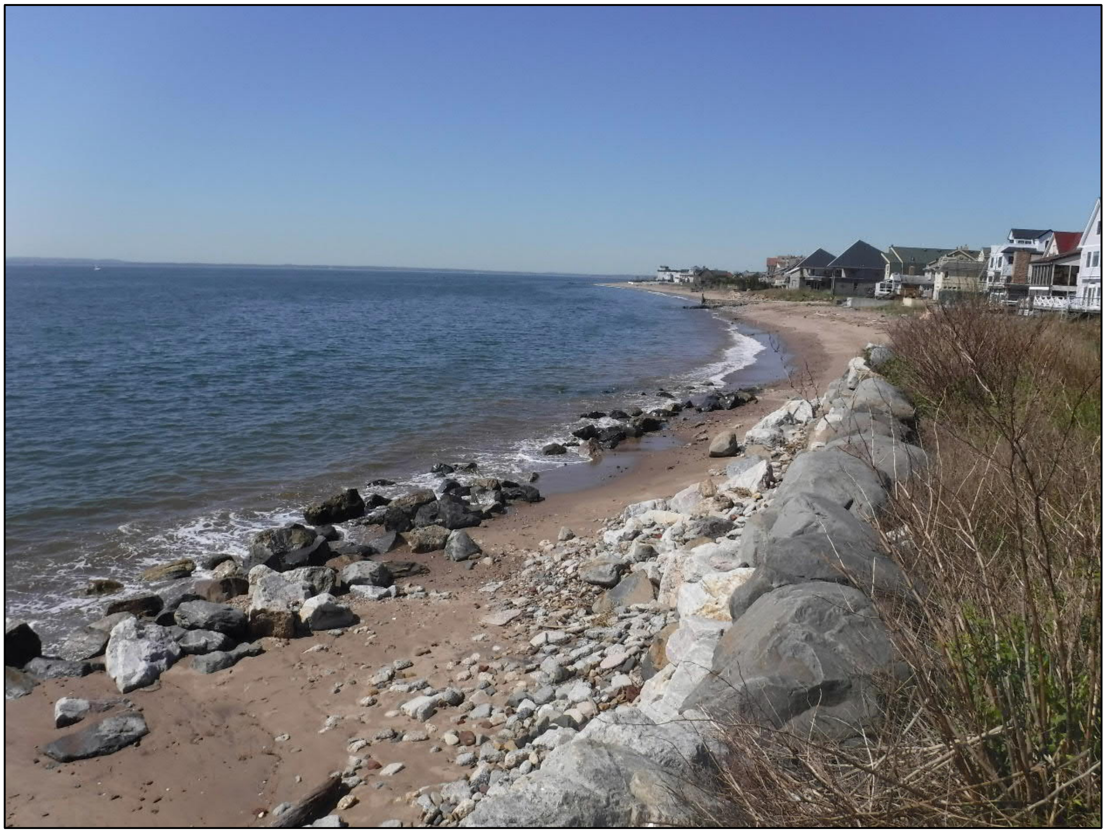

Figure 20. Example of Arthur Kill Shoreline Near Tottenville Shore Park

Attainment of Designated Uses – Arthur Kill

As described above, Arthur Kill north of the Outerbridge Crossing Bridge is a Class SD waterbody with best usage of defined as fishing, and Arthur Kill south of the Outerbridge Crossing Bridge is a Class I waterbody, with best usages defined as secondary contact recreation and fishing. No NYC CSOs discharge directly to Arthur Kill, and no active DOHMH certified bathing beaches are located along the Staten Island shoreline of Arthur Kill. Figure 21 and Figure 22 present mosaics of the percent attainment with the Class SD and Class I WQ Criteria for fecal coliform on an annual and recreational season (May 1st through October 31st) basis, respectively, with the Citywide/Open Waters LTCP Recommended Plan. These figures present results for the surface layer of the WQ model, for the 10-year simulation.

As indicated in these figures, all of Arthur Kill north of the Outerbridge Crossing Bridge would not meet the Class SD WQ Criteria for fecal coliform on an annual basis, and a portion would not meet the criteria for the recreational season (May1st through October 31st). Projected levels of attainment would range from approximately 60 to less than 95 percent on an annual basis, and between approximately 90 and 98 percent during the recreational season (May 1st through October 31st).

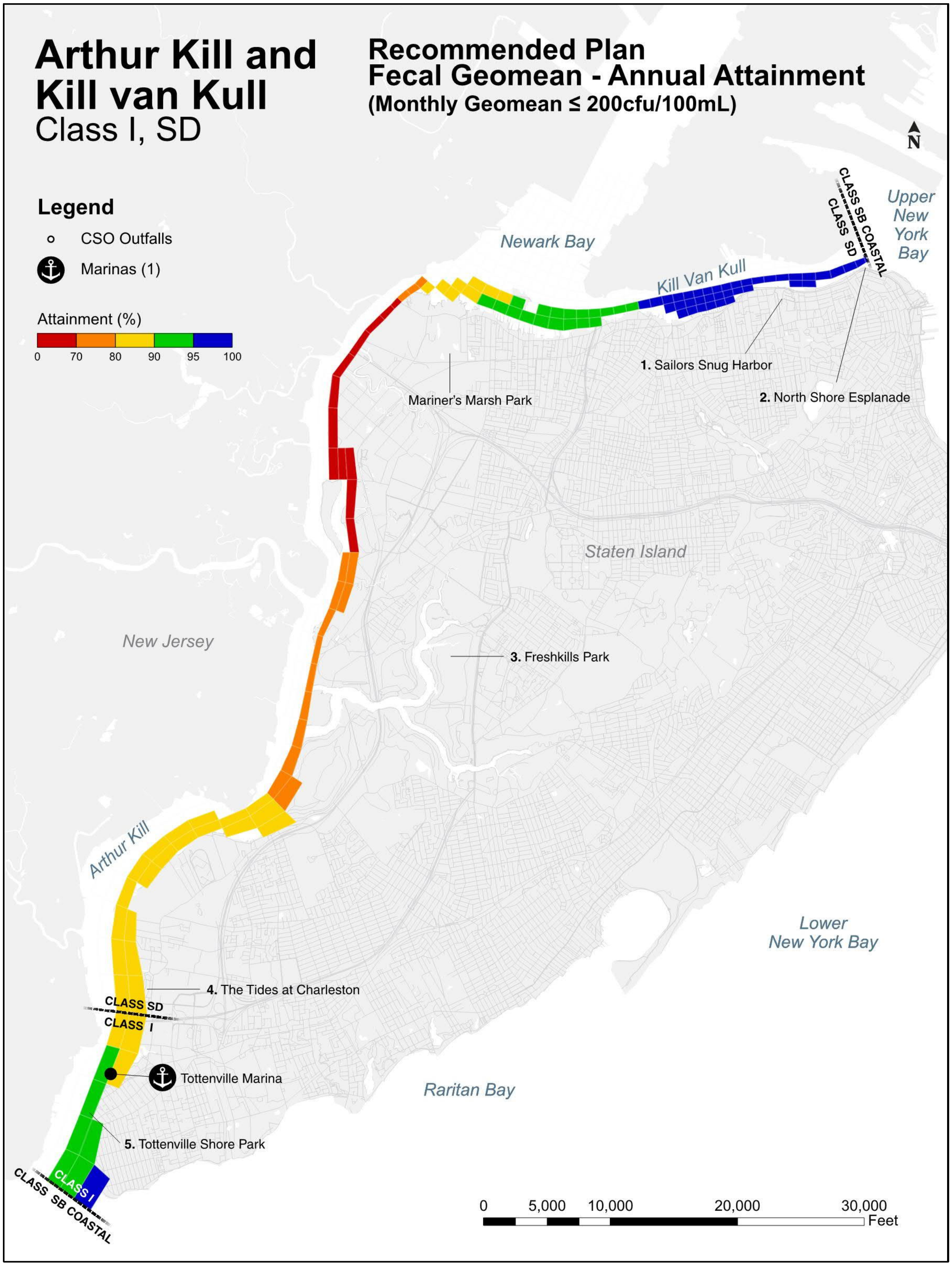

Figure 21. Fecal Coliform Class SD and Class I - Annual Attainment (10-year Runs), Arthur Kill, Recommended Plan

Figure 22. Fecal Coliform Class SD and Class I – Recreational Season Attainment (10-year Runs), Arthur Kill, Recommended Plan

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South of the Outerbridge Crossing Bridge, the Class I WQ Criteria for fecal coliform would not be met for portions of the waterbody on an annual basis, but the criteria would be met in the recreational season (May1st through October 31st). Projected levels of annual attainment would range from approximately 89 to greater than 95 percent.

Figure 23 presents a mosaic of the percent attainment with the Class SD WQ Criteria for DO under the Recommended Plan, for the 2008 typical year. As indicated in Figure 23, north of the Outerbridge Crossing Bridge, the Class SD DO criteria would be met on an annual average basis. South of the Outerbridge Crossing Bridge, the Class I WQ Criteria for DO would not be met in portions of Arthur Kill on an annual average basis. Projected levels of attainment with the Class I WQ Criteria for DO would range from approximately 85 to 100 percent.

No NYC CSOs discharge directly to Arthur Kill, and the areas of non-attainment of the Class SD and Class I WQ Criteria for fecal coliform, and the area of non-attainment of the Class I WQ Criteria for DO would all remain even with a condition of No NYC CSO Loads in the adjacent reaches of Kill Van Kull. The load component analysis presented in Section 6 demonstrated that the non-attainment in Arthur Kill is due to sources from outside of NYC.

An analysis was also conducted to predict the recovery time in Arthur Kill following a rain event. DEP used the primary contact fecal coliform recreation warning level of 1,000 cfu/100mL from the DOHMH guidelines in this analysis. The analyses consisted of examining the WQ model calculated bacteria concentrations in Arthur Kill for the recreational season (May 1st through October 31st) extracted from 10 years of model simulations. For Arthur Kill, the JFK Airport rainfall data was compared against water quality model bacteria results for the 10 recreational seasons to determine how long it took for the water column concentration to return to target threshold concentrations from the end of the rain event. The various rainfall events were then placed into rain event size “bins” ranging from less than 0.1 inch to greater than 1.5 inches. Only rain events that reached the target threshold concentrations before the beginning of the next storm were included. The median time to recovery for each bin at each water quality station was calculated. Table 4 presents the median time to recovery to a fecal coliform level of 1,000 cfu/100mL for the Recommended Plan for Arthur Kill. Results are presented for the greater than 1.0 to 1.5 inch rainfall bin, which includes the 90th percentile event.

DEC has advised that it seeks to have a time to recovery of less than 24 hours, and this target has been consistent in the previously approved LTCPs. As indicated in Table 4, for the Recommended Plan, all of the stations assessed had median time to recovery of two hours or less.

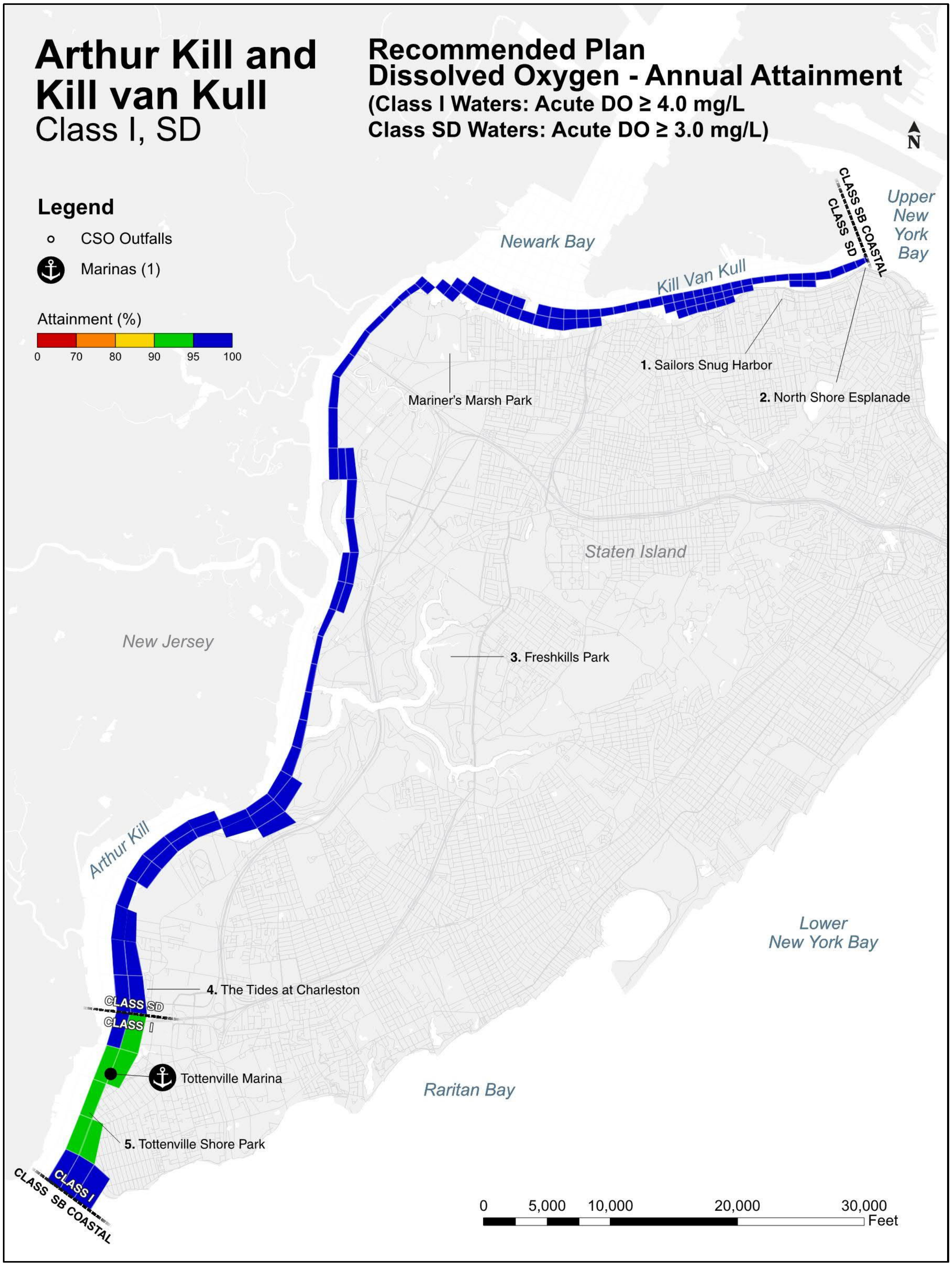

Figure 23. DO Class SD and Class I - Annual Attainment (2008 Typical Year), Arthur Kill, Recommended Plan

Table 4. Arthur Kill Time to Recovery, Fecal Coliform, Recommended Plan

Location	Median Time to Recovery (hours) Fecal Coliform Threshold (1,000 cfu/100mL)[1]
Arthur Kill (Class SD)	
K-3	2
K-4	0
Arthur Kill (Class I)	
K-5	0
Tottenville Marina	0

Notes:

(1) Median time to recovery values presented for storms from the 10-year simulation, recreational seasons, in the size range of >1.0 to 1.5-inches of rainfall, which includes the 90th percentile rain event.

(2) Median time to recovery of "0" means that the average concentration across the water column never reached the 1,000 cfu/100mL threshold at the referenced station for more than half of the storms within the 1-to-1.5 inch rainfall bin assessed

Conclusions – Arthur Kill

No NYC CSOs discharge directly to Arthur Kill. The evaluation for the Recommended Plan determined that fecal coliform levels are not projected to meet the Class SD WQ Criteria for bacteria on an annual basis or during the recreational season (May 1st through October 31st) in Arthur Kill north of the Outerbridge Crossing Bridge. Fecal coliform levels are not projected to meet the Class I WQ Criteria for bacteria on an annual basis in Arthur Kill south of the Outerbridge Crossing Bridge. The Class I WQ Criteria for DO are also not projected to be met in Arthur Kill south of the Outerbridge Crossing Bridge. However, in all cases, the non-attainment would remain even with a condition of No NYC CSO Loads. The load component analysis presented in Section 6 indicated that the non-attainment was driven by sources from outside of NYC .

For storms in the 1 to 1.5-inch range, the median time to recovery to fecal coliform concentration of 1,000 cfu/100mL was two hours or less at all stations assessed. This analysis indicates that the duration of wet-weather impacts in Arthur Kill from all sources is relatively short.

Based on the evaluations summarized above, non-attainment of the Class SD WQ Criteria for bacteria north of the Outerbridge Crossing Bridge, and non-attainment of the Class I WQ Criteria for bacteria and DO south of the Outerbridge Crossing Bridge, are all attributable to the following UAA factor:

- Human caused conditions (pollutant loadings from outside NYC) create high bacteria levels and oxygen demand that prevent the attainment of the use and cannot be fully remedied by DEP (UAA Factor #3).

The Arthur Kill shoreline does provide a few limited shoreline access points for on-shore recreation, which allow the public to take advantage of the recreational uses of the waterway.

Recommendations – Arthur Kill

No NYC CSOs discharge directly to Arthur Kill, and the areas of non-attainment with the Class SD and Class I WQ Criteria for fecal coliform, and the Class I WQ Criteria for DO, in the respective portions of Arthur Kill would remain unchanged even with a condition of No NYC CSO Loads from CSOs to the adjacent Kill Van Kull. The load component analysis presented in Section 6 demonstrated that the causes of non-attainment in Arthur Kill are sources from outside of NYC. Therefore, additional CSO controls for Kill Van Kull would not result in attainment of the applicable WQ Criteria in Arthur Kill.

Best usage for Arthur Kill north of the Outerbridge Crossing Bridge is *fishing. These waters shall be suitable for fish, shellfish and wildlife survival. This classification may be given to those waters that, because of natural or man-made conditions, cannot meet the requirements for fish propagation*. (6 NYCRR 701.14). Best usages for Arthur Kill south of Outerbridge Crossing Bridge are *secondary contact recreation and fishing. These waters shall be suitable for fish, shellfish and wildlife survival.* (6 NYCRR 701.13). No DOHMH sanctioned beaches are located along Arthur Kill, and secondary contact and fishing uses would be protected in the recreational season (May 1st through October 31st). The above conclusions support that Arthur Kill should remain a designated Class SD waterbody north of the Outerbridge Crossing Bridge, and a Class I waterbody south of the Outerbridge Crossing Bridge, after the implementation of the LTCP Recommended Plan. Future Post-Construction Compliance Monitoring data collection efforts may later support a re-evaluation of the best uses and designated WQ classifications for Arthur Kill.