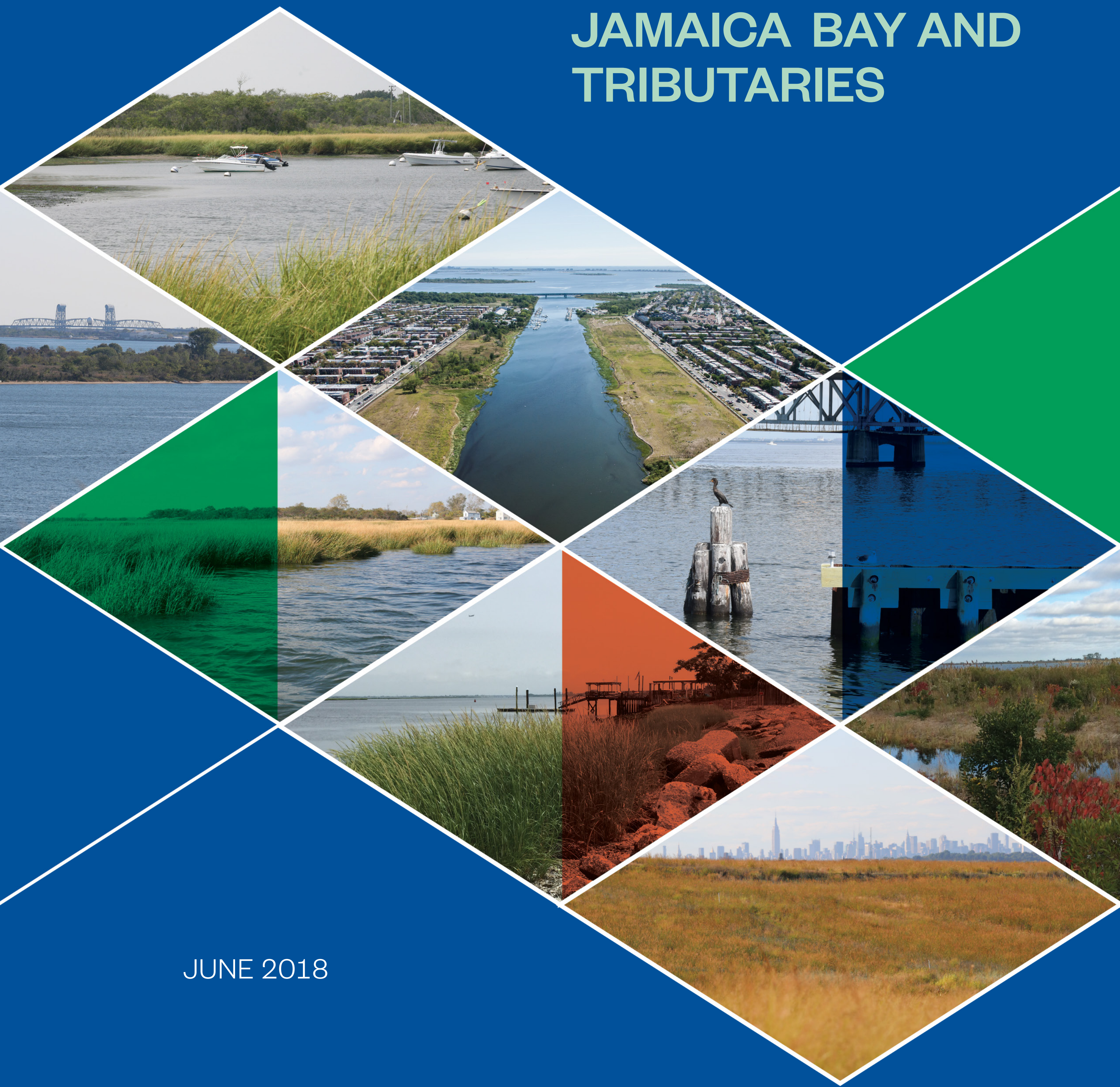
NYC Environmental Protection

New York City Department of Environmental Protection

Capital Project No. WP-169
Long Term Control Plan II

Combined Sewer Overflow Long Term Control Plan For JAMAICA BAY AND TRIBUTARIES



JUNE 2018

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Combined Sewer Overflow Long Term Control Plan for Jamaica Bay and Tributaries

June 2018

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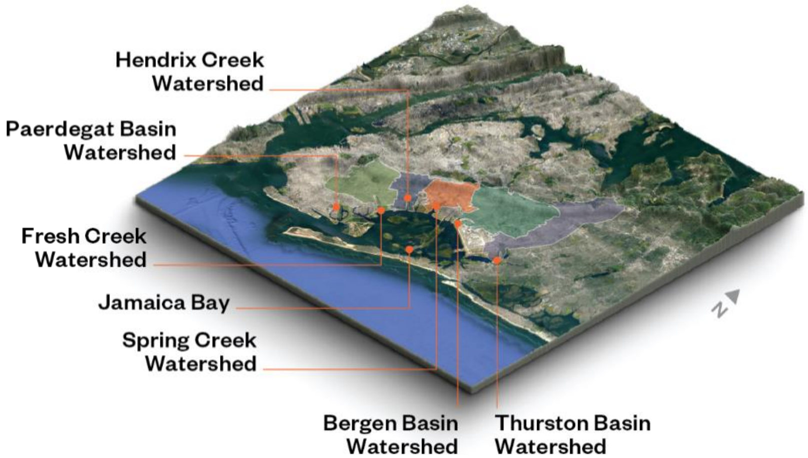
EXECUTIVE SUMMARY

This Executive Summary is organized as follows:

- Synopsis – a high-level summary of this Long Term Control Plan (LTCP);
- Recommended Plan – a summary of the Recommended Plan, water quality (WQ) modeling results, triple-bottom line benefits;
- Background – an overview of the regulations, approach, and characterization of Jamaica Bay and its tributaries; and
- Findings – a summary of the key results of the WQ data analyses, WQ modeling simulations, and alternatives analysis.

1. SYNOPSIS

Historically, Jamaica Bay has served as an important ecological resource for many flora and fauna. The Bay is a critical ecosystem that supports multiple, diverse habitats, more than 325 bird species, 100 species of fish and 54 species of moths and butterflies. It also contains one of the largest and most important tidal wetland complexes in New York State, is located along the Atlantic Coastal Flyway bird migration route, and is a component of the National Park Service's Gateway National Recreation Area encompassing 26,000 acres. Approximately 17,000 acres of this area consists of aquatic ecosystems that include estuarine open water, intertidal zones, salt marsh islands, fringing salt marshes, tidal mud and sand flats, and freshwater wetlands, ponds, and tributaries. The Bay is home to many wildlife preserves, parks, marinas, and boat launches; supporting native habitat and recreational boating and fishing. Because of its geographic size and diverse functioning natural habitats, Jamaica Bay is a nationally and internationally renowned New York City location.



Rapid urbanization and development resulted in many water quality challenges in Jamaica Bay and the six urban tributaries evaluated in this Combined Sewer Overflow (CSO) LTCP. Those tributaries include Thurston Basin, Bergen Basin, Spring Creek, Hendrix Creek, Fresh Creek, and Paerdegat Basin. Efforts to address water quality in Jamaica Bay and its tributaries date back to the 1900s, when New York City was constructing wastewater treatment plants (WWTPs) to treat sewage flow during dry-weather and to capture a portion of the combined storm and sanitary sewage flow generated during wet-weather. Since then, significant water quality improvements have been achieved through several strategic initiatives. These strategic investments, in excess of $3.6B, have led to significant water quality improvements in Jamaica Bay. Water quality attainment is achieved in most tributaries and open waters; however, impairments for fecal coliform remain at the head ends of Fresh Creek, Bergen Basin, and Thurston Basin. The Recommended Plan in this LTCP will build upon these past investments and provide further water quality improvements across Jamaica Bay.

WATER QUALITY IMPROVEMENTS Achieved through Strategic Investments

$600 Million
Biological Nutrient Reduction (BNR) Upgrades across four wastewater treatment plants (JA, 26W, RK, and CI) that discharge to Jamaica Bay

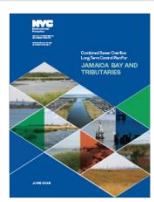
$1 Billion
Past and Existing Grey Infrastructure investments to reduce combined sewer overflows

$300 Million
Existing and Planned Green Infrastructure commitment over the next decade under the OneNYC Plan

Jamaica Bay

$32 Million
Ecosystem Restoration and Research Efforts to support pathogen reduction and DO improvement under the Jamaica Bay Watershed Protection Plan

$1.7 Billion
Southeast Queens Sewer Buildout commitment over the next decade under the OneNYC Plan



LTCP Recommended Plan will build upon these past investments and provide further water quality improvements.

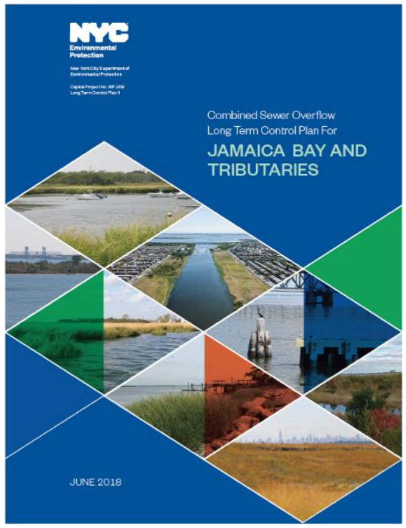
This LTCP has been developed in an effort to better understand and identify cost-effective and implementable projects to reduce CSO impacts to meet water quality standards (WQS) within Jamaica Bay and its tributaries. Throughout the process for developing this LTCP, New York City Department of Environmental Protection (DEP) collected water quality data, performed extensive collection system and water quality modeling, held multiple public meetings and analyzed potential CSO control alternatives based on costs, implementability and model predicted water quality improvement. The selection of the Recommended Plan was based on multiple considerations including public input, environmental and water quality benefits, community and societal impacts, issues related to implementation and operation and maintenance (O&M), as well as cost-performance and cost-attainment evaluations.

The Recommended Plan includes construction of green infrastructure (GI) within separately sewered portions of the Jamaica WWTP collection system in Bergen and Thurston Basins, environmental dredging, ribbed mussel colony creation and tidal wetlands restoration.

In addition to closing the gap in attainment of Existing WQ Criteria for Jamaica Bay and its tributaries, the Recommended Plan provides economic, social, and environmental benefits that build upon the significant ecological improvements provided by prior grey infrastructure projects. Furthermore, the Recommend Plan can be implemented in 14 years as opposed to the grey retained alternatives, which are projected to take over 25 years to design, construct and activate.

In addition to the co-benefits of the Recommended Plan, which go beyond the requirements of the Clean Water Act, the plan furthers many of the ecosystem goals outlined in Plan OneNYC, including expansion of GI, reduction of pollution from stormwater runoff, expansion in tree planting, urban heat island reduction, resiliency, and habitat improvements for pollinators, wildlife aquatic species.

ELEMENTS OF THE RECOMMENDED PLAN



Additional 379 greened acres in Bergen and Thurston Basin tributary areas

7 acres of ribbed mussel colony creation

50,000 CY of environmental dredging in Bergen Basin

50 acres of wetland restoration

TRIPLE BOTTOM LINE BENEFITS

Reduce CSO discharges to Bergen and Thurston Basins by 15 MGY

Reduce Stormwater discharges by 234 MGY

Provide air quality improvement

Carbon footprint reduction

Habitat creation

Heat island construction reduction

Property value improvement

Water quality improvement through the filtering of the ribbed mussels

The implementation of the Recommended Plan has an estimated Net Present Worth of $401M, reflecting $91M of annual O&M costs over the course of 100 years and a Probable Bid Cost (PBC) of $310M (design and construction management costs would be additional). Figure ES-1 provides a comparison of the Triple-Bottom-Line benefits that will be realized through the implementation of the Recommended Plan, versus the grey infrastructure alternatives. Full details associated with the alternative evaluations and detailed elements of the Recommended Plan are presented in Section 8 of this LTCP.

Triple Bottom Line Benefits of the Recommended Plan

includes economic, social and environmental co-benefits beyond what can be achieved through a traditional Grey Infrastructure approach of underground CSO Storage Tunnels.

The Recommended plan meets many of the ecosystem goals outlined in Plan #ONENYC

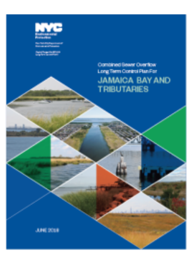
#ONENYC INITIATIVES	RECOMMENDED PLAN	GREY ALTERNATIVE
Expand Green Infrastructure	✓	×
Reduce Pollution from Stormwater Runoff	✓	✓
Increase Trees Planted	✓	×
Increase Terrestrial Species	✓	×
Improve Habitat for Aquatic Species	✓	×

In addition to water quality benefits, the Recommended Plan provides co-benefits such **as carbon sequestration, air quality improvements, heat island reduction, habitat creation, and property value appreciation.**

TRIPLE BOTTOM LINE BENEFITS*		RECOMMENDED PLAN	GREY
ECONOMIC	Probable Bid Cost ($ Millions)	310	1,560
	Lifetime O&M and Replacement Costs ($ Millions)	91	124
WATER QUALITY BENEFITS	Reduction in Annual CSO Volume (MG)	15	493
	Reduction in Annual Stormwater Volume (MG)	234	0
	Volume of Water Filtered by Ribbed Mussels (MGD)	8,354	0
	Rec. Season Fecal Coliform Attainment (%)	57-100	67-100
ENVIRONMENTAL	Lifetime Carbon Footprint (Construction & Operation)(MT)	-12,806	31,894
	Air Quality (NO_2 Removal) (lbs/yr)	664	0
	Air Quality ($PM_{2.5}$ Removal) (lbs/yr)	46	0
	Ecosystem Habitat Creation (acres)	72	0
	Heat Island Area Reduction (acres)	10	0
	Valuation of Environmental Footprint ($ Millions)	-1.6	1.2
SOCIAL	Offset from Property Value Increase ($ Millions)	-83	0
TOTAL NET PRESENT COST*	Without Co-Benefits	$401M	$1,684M
	With Co-Benefits	$318M	$1,685M

The co-benefits provided by the Recommended Plan reduce its Net Present Cost from $401M to $318M, thereby offsetting its O&M and replacement costs. The Grey Approach provides fewer co-benefits and cost three times more than the Recommended Plan.

Recommended Plan



Triple Bottom Line Benefits

*Based upon a 100 year service life.

Figure ES-1. Triple-Bottom-Line Analysis of the Recommended Plan

2. RECOMMENDED PLAN

Summary of Recommended Plan

Water quality in Jamaica Bay and its tributaries will be improved through the implementation of the following: (1) currently planned improvements including those recommended in the November 2012 Jamaica Bay Waterbody/Watershed Facility Plan (Jamaica Bay WWFP); (2) current and future GI baseline projects (summarized in Section 5); and (3) the implementation of this Jamaica Bay and Tributaries LTCP Recommended Plan which calls for the design, construction, and maintenance of the projects summarized in Table ES-1:

Table ES-1. Recommended Plan Projects

Waterbody	Project
Thurston Basin	• 147 greened acres of Green Infrastructure Expansion • 3 acres of Ribbed Mussel Colony Creation
Bergen Basin	• 232 greened acres of Green Infrastructure Expansion • 50,000 CY Environmental Dredging • 4 acres of Ribbed Mussel Colony Creation
Spring Creek	• 13 acres of Tidal Wetland Restoration
Hendrix Creek	• 3 acres of Tidal Wetland Restoration
Fresh Creek	• 14 acres of Tidal Wetland Restoration
Paerdegat Basin	• 4 acres of Tidal Wetland Restoration
Jamaica Bay	• 16 acres of Tidal Wetland Restoration

The Recommended Plan for the Jamaica Bay and Tributaries LTCP is projected to reduce CSO discharges to Bergen and Thurston Basins by 15 MGY and stormwater discharges by 234 MGY. The implementation of these elements has an estimated Net Present Worth (NPW) of $401M, reflecting $91M of annual O&M costs over the course of 100 years and a PBC of $310M.

A preliminary constructability analysis has been conducted and DEP has deemed these improvements to be implementable based on information currently available. The Recommended Plan has been developed with input from the public and other stakeholders, and with an awareness of the cost to the citizens of New York City (NYC).

Water Quality Modeling Results

Section 8 of this report provides quantitative WQ attainment details for individual WQ monitoring stations under both annual and recreational season (May 1st through October 31st) conditions for the Recommended Plan. Figure ES-2 below summarizes the calculated recreational season attainment of the Existing WQ Criteria for fecal coliform (Monthly geometric mean (GM) <=200 cfu/100mL) and the Proposed *Enterococci* WQ Criteria* (rolling 90-day GM<=35 cfu/100mL with a not-to-exceed 90th percentile statistical threshold value (STV) of 130 cfu/100mL applied during the recreation season) based on a continuous 10-year model simulation.

As indicated in Figure ES-2, the Recommended Plan will achieve attainment of the Existing WQ Criteria for fecal coliform during the recreational season for most waterbodies, with the exception of the head ends of Thurston Basin (TBH1, TBH3), Bergen Basin (BB5, BB6), and Fresh Creek (FC1). However, public access to the impacted stations in Bergen Basin and Thurston Basin is prohibited near John F. Kennedy (JFK) International Airport. At Stations TBH3, BB6, and FC1, attainment during the recreational season is 92 percent or better, falling just short of the 95 percent metric.

In March 2018, New York State Department of Environmental Conservation (DEC) released Proposed *Enterococci* WQ Criteria* for coastal Class SB waters, which, if adopted would apply to Jamaica Bay (a coastal Class SB waterbody), but not the tributaries (all Class I waterbodies). As requested by DEC, DEP assessed compliance with those proposed criteria for all waters considered in this LTCP including the tributaries. The DEC Proposed *Enterococci* WQ Criteria* (rolling 90-day GM <35 cfu/100mL during the recreation season), if adopted as proposed, would be met for most Jamaica Bay waters, except for Thurston and Bergen Basins. Notably, the stations where attainment falls short of the 95 percent goal were at stations adjacent to JFK International Airport where the Port Authority of New York and New Jersey (PANYNJ) has prohibited public access for security reasons.

With respect to attainment of dissolved oxygen (DO) water quality standard, DO attainment is unchanged under the Recommended Plan for baseline conditions, as shown in Figure ES-3. The LTCP framework evaluates DO attainment based upon 2008 typical year rainfall conditions.

Table ES-2 presents an overview of the attainment status. Note that the Primary Contact WQ Criteria for fecal coliform are the same as the Existing WQ Criteria for fecal coliform for Class I and SB.

*Proposed *Enterococci* WQ Criteria, if adopted as proposed, would only apply to coastal Class SB and SA waters.

Table ES-2. Recommended Plan Compliance with Bacteria WQ Criteria

Waterbody	Location	Fecal Coliform Annual Attainment(1)	Fecal Coliform Recreational Attainment(2)	Proposed *Enterococci* 90-Day GM(3)	Proposed *Enterococci* 90-Day STV(4)	Dissolved Oxygen Annual Attainment(5)
Thurston Basin	Head End(9)	✗	✗	N/A	N/A	✗
	Mid-Point(9)	✗	✓	N/A	N/A	✗
	Mouth	✓	✓	N/A	N/A	✓
Bergen Basin	Head End(9)	✗	✗	N/A	N/A	✗
	Mid-Point(9)	✗	✓	N/A	N/A	✓
	Mouth	✓	✓	N/A	N/A	✓
Hendrix Creek	Head End	✓	✓	N/A	N/A	✗(6)
	Mid-Point	✓	✓	N/A	N/A	✓
	Mouth	✓	✓	N/A	N/A	✓
Fresh Creek	Head End	✗(7)	✗(7)	N/A	N/A	✓
	Mid-Point	✓	✓	N/A	N/A	✓
	Mouth	✓	✓	N/A	N/A	✓
Paerdegat Basin	Head End	✓	✓	N/A	N/A	✓
	Mid-Point	✓	✓	N/A	N/A	✓
	Mouth	✓	✓	N/A	N/A	✓
Jamaica Bay (Grassy Bay)	Northern	✓	✓	✓	✗(8)	✓
	Southern	✓	✓	✓	✓	✓
Jamaica Bay (North Channel)	Entire	✓	✓	✓	✓	✓
Jamaica Bay (Beach Channel)	Entire	✓	✓	✓	✓	✓
Jamaica Bay (Island Channel)	Entire	✓	✓	✓	✓	✓
Jamaica Bay (Rockaway Inlet)	Entire	✓	✓	✓	✓	✓

Notes:

✓ indicates that attainment is projected to occur ≥ 95% of the time
✗ indicates that attainment is projected to occur < 95% of the time

(1) Fecal coliform annual attainment is based on a monthly geometric mean (GM) of ≤200 CFU/100mL.
(2) Fecal coliform recreational attainment is based on a monthly GM of ≤200 CFU/100mL from May 1 thru Oct 31.
(3) The proposed 90-day *Enterococci* GM attainment is based on DEC proposed 90-day *Enterococci* standard of ≤35 CFU/100mL for coastal recreational waters during recreational season (May 1 thru Oct 31).
(4) The proposed 90-day *Enterococci* STV attainment is based on the DEC proposed 90-day *Enterococci* standard that required 90% of the values to be ≤ 130 CFU/100mL during the recreational season (May 1 thru Oct 31).
(5) The DO standard in the tributaries is never less than 4 mg/L and in Jamaica Bay is never less than 3 mg/L and a allows for duration-based excursions between 3 and 4.8 mg/L.
(6) The projected dissolved oxygen attainment in the head end of Hendrix Creek is 94%.
(7) The projected attainment at the very head end of Fresh Creek is about 86% and 93% for annual and recreational attainment, respectively.
(8) Only a small area of Grassy Bay just outside of Bergen Basin is projected not to attain the proposed 90-day *Enterococci* STV that required 90% of values to be less ≤ 130 CFU/100mL.
(9) Unauthorized access to these portions of Bergen and Thurston Basins is prohibited by JFK International Airport security.

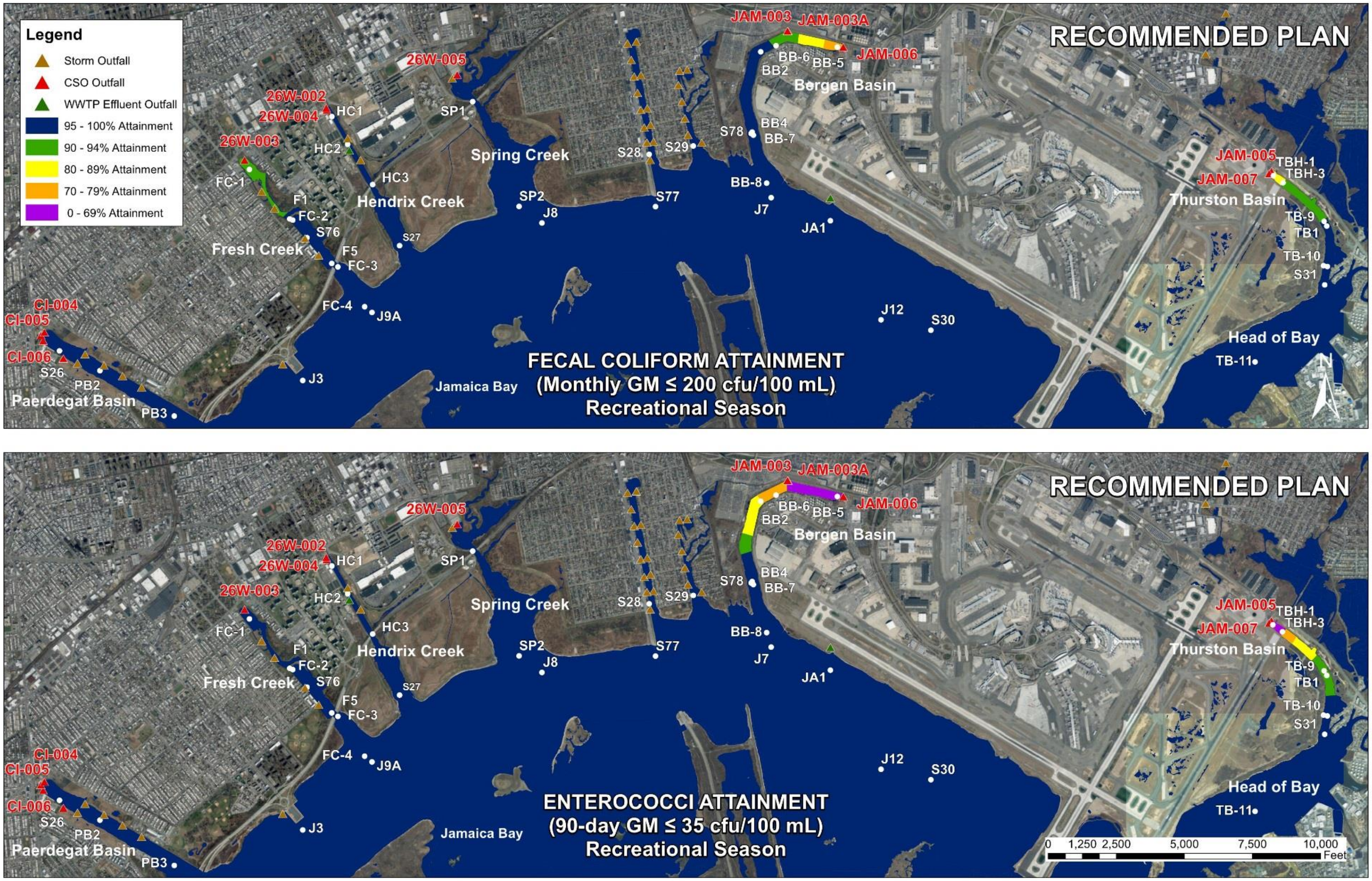


Figure ES-2. Recommended Plan Model Predicted Bacteria Results (Recreational Season)

AECOM with Hazen

Figure ES-3. Recommended Plan Model Predicted DO Attainment Results

Triple-Bottom-Line Benefits

In addition to closing the gap in attainment of Existing WQ Criteria for Jamaica Bay and its tributaries, the Recommended Plan provides economic, social, and environmental benefits that supplement prior grey infrastructure improvements. A Triple-Bottom-Line analysis was performed to estimate the monetary value of environmental and social benefits and aggregate them alongside the traditional financial bottom line estimates for the project. The Triple-Bottom-Line analysis is based on estimated magnitude of benefits and an equivalent monetary value per unit benefit, which may be derived by calculation obtained from a representative reference. Although the CSO Policy does not require a Triple-Bottom-Line analysis, or the attainment of such co-benefits, they are worth noting. Details of the analysis are provided in Section 8.

Table ES-3 summarizes and quantifies the Triple-Bottom-Line benefits that DEP anticipates will be realized through the implementation of GI, performance of environmental dredging, creation of ribbed mussel colonies, and restoration of tidal wetlands. Other Triple-Bottom-Line benefits that were not monetized include aesthetic improvements associated with installation of GI and tidal wetland restoration, as well as the reduction of odors associated with exposed organics during low tide. The benefits provided by the Recommended Plan achieve many of the ecosystem goals outlined in Plan OneNYC, including expansion of GI, reduction of pollution from stormwater runoff, expansion in tree planting, increase in terrestrial species, and habitat improvements for aquatic species.

In comparison, the 50 percent Control Tunnel for Bergen and Thurston Basins grey alternative provided none of the environmental or economic benefits of the Recommended Plan. Although the grey alternative had a higher reduction in annual CSO volume, it provided no co-benefits such as improvement in stormwater volume, and would not provide the 24/7 continuous filtering of the water in Bergen and Thurston Basins that would be provided with the ribbed mussel habitat.

Table ES-3. Triple-Bottom-Line Comparison

Triple-Bottom-Line Benefits	Recommended Plan	50% Control Tunnel for Bergen and Thurston Basins
Water Quality Benefits		
Reduction in CSO Volume (MG)	15	493
Reduction in Stormwater Volume (MG)	234	0
Volume of Water Filtered by Ribbed Mussels (MG)	8,354	0
Environmental Benefits		
Lifetime Carbon Footprint Reduction (MT)	12,806(1)	-31,894(1)
Air Quality (NO_2 Removal) (lbs/yr)	664	0
Air Quality PM_{25} Removal) (lbs/yr)	46	0
Ecosystem Habitat Creation (acres)	72	0
Heat Island Reduction (acres)	10	0
Economic Benefit ($ Millions)		
Probable Bid Cost	-$310	-$1,293
Lifetime O&M and Replacement Cost	-$91	-$124
Valuation of Environmental Benefit	+$2	-$1.2
Property Value Appreciation	+$83	0
Total Net Present Cost	-$317	-$1,418

Note:
(1) Positive value indicates reduction in carbon footprint versus baseline; negative value indicates increase in carbon footprint versus baseline.

*Proposed *Enterococci* WQ Criteria, if adopted as proposed, would only apply to coastal Class SB and SA waters.

3. BACKGROUND

DEP prepared this LTCP for Jamaica Bay and Tributaries pursuant to an Order on Consent for CSOs, Case No. CO2-20000107-8 (2005 CSO Order), modified by a 2012 CSO Order on Consent (Case No CO2-20110512-25) (2012 CSO Order) and subsequent modifications (collectively referred to herein as the "CSO Order") overseen by the DEC. 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 Jamaica Bay and Tributaries LTCP is the tenth of the waterbody-specific LTCPs.

As described in the LTCP Goal Statement in the CSO Order, the goal of each LTCP is to identify, with public input, appropriate CSO controls necessary to achieve waterbody-specific WQS consistent with the Federal CSO Control Policy and related guidance. In addition, the Goal Statement advises: *"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."* DEP conducted water quality assessments where the data is represented by percent attainment with pathogen targets and associated recovery times. Consistent with guidance from DEC, 95 percent attainment of applicable WQ criteria constitutes compliance with the existing WQS or the Section 101(a)(2) goals conditioned on verification through Post-Construction Compliance Monitoring (PCM).

Regulatory Requirements

The waters of NYC are subject to Federal and New York State (NYS) laws and regulations. Particularly relevant to this LTCP is the U.S. Environmental Protection Agency's (EPA) CSO Control Policy, which provides guidance on the development and implementation of LTCPs, and the promulgation of WQS. In NYS, Clean Water Act (CWA) regulatory and permitting authority has been delegated to DEC.

DEC has designated Jamaica Bay as a Class SB waterbody and the tributaries as Class I waterbodies. The best usages of Class SB waters are primary and secondary contact recreation and fishing, while the best usages of Class I waters are secondary contact recreation and fishing. These waters shall also be "suitable for fish, shellfish, and wildlife propagation and survival. In addition, the water quality shall be suitable for primary contact recreation, although other factors may limit the use for this purpose" (6 NYCRR 701.13). Figure ES-4 shows the Jamaica Bay and its tributaries watershed.

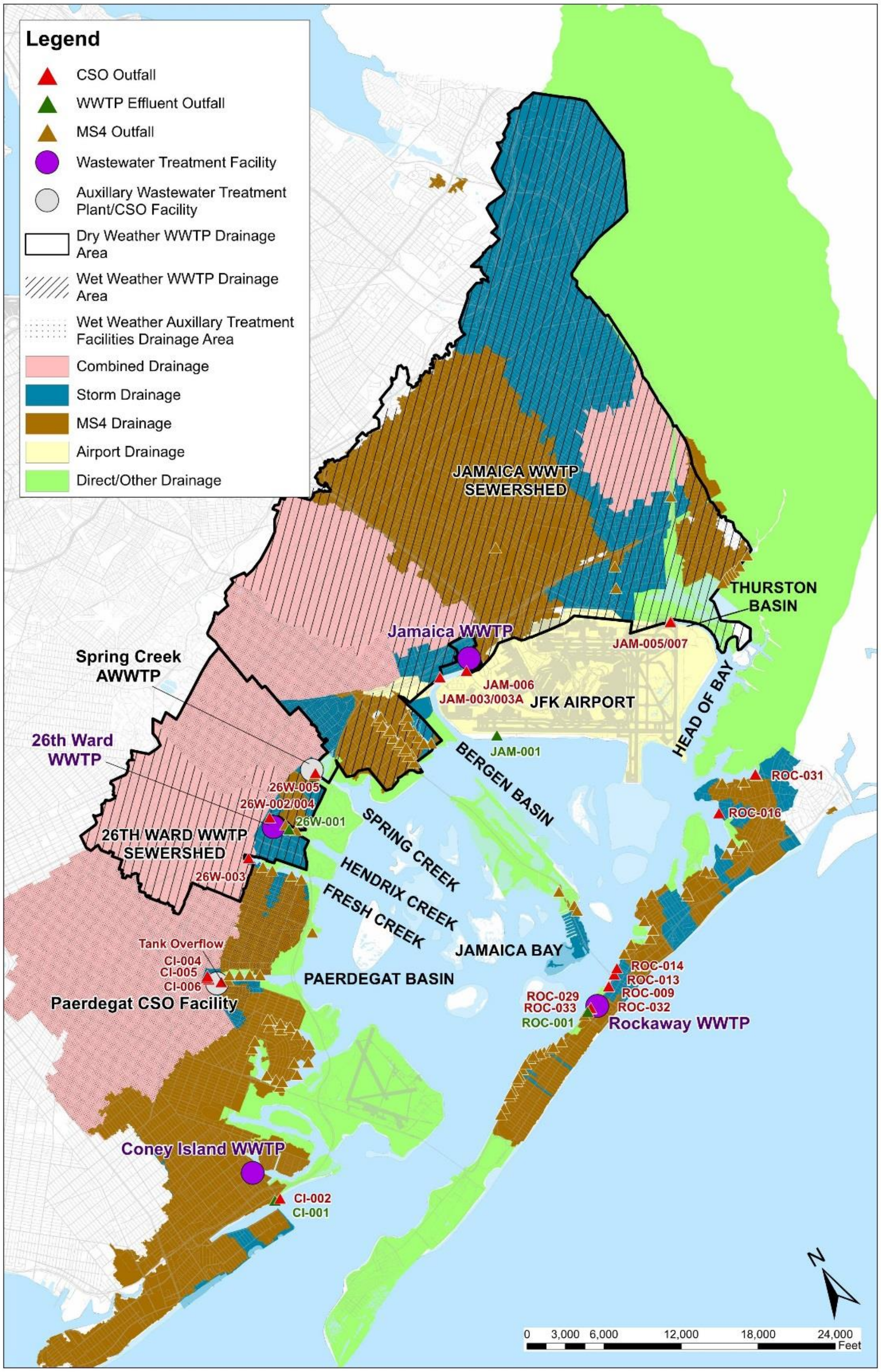


Figure ES-4. Jamaica Bay Watershed Characteristics and Associated WWTP Sewershed

The criteria assessed in this Jamaica Bay and Tributaries LTCP includes the Existing WQ Criteria for fecal coliform and DO (Class SB - Jamaica Bay and Class I - Tributaries). On March 21, 2018, DEC publicly noticed a revision to the WQS that included application of an *Enterococci* WQS to coastal SA & SB waters during the primary contact recreation season, a limitation on the applicability of water quality standards for total and fecal coliform in Class SB, I and SD waters to the primary contact recreation season and a reclassifications for the Upper and portion of the Lower New York Bay from Class I to Class SD. Although these proposed amendments have not been finally adopted, Sections 6 and 8 of this LTCP include assessments of attainment with both the Existing WQ Criteria for fecal coliform and DO and Proposed *Enterococci* WQ Criteria*. Based on DEC's March 21 proposed rulemaking and information provided by DEC, the Proposed *Enterococci* WQ Criteria* modeled for this LTCP will include a 90-day rolling GM for *Enterococci* of 35 cfu/100mL with a not-to-exceed 90th percentile statistical threshold value (STV) of 130 cfu/100mL applied during the recreation season. In accordance with the proposed rulemaking, these criteria would not apply to the tributaries of Jamaica Bay that are non-coastal Class I waters. However, for informational purposes, the LTCP also presents the level of attainment of those criteria for the tributaries in Sections 6 and 8.

Table ES-4 summarizes the Existing WQ Criteria, Bacteria Primary Contact WQ Criteria and Proposed *Enterococci* WQ Criteria* applied in this LTCP.

Table ES-4. Classifications and Standards Applied

Analysis	Numerical Criteria Applied	
Existing WQ Criteria – Tributaries	Class I	Fecal Monthly GM ≤ 200; DO never <4.0 mg/L
Existing WQ Criteria – Jamaica Bay	Class SB	Fecal Monthly GM ≤ 200; DO between > 3.0 & ≤4.8 mg/L(3); DO never < 3.0 mg/L(1)
Bacteria Primary Contact WQ Criteria – Jamaica Bay and Tributaries(1)	Class SB	Fecal Monthly GM ≤ 200 DO between > 3.0 & ≤4.8 mg/L(1, 3); DO never < 3.0 mg/L(1)
Proposed *Enterococci* WQ Criteria(2)	Class SB Coastal	*Enterococci*: rolling 90-d GM – 35 cfu/100mL *Enterococci*: STV – 130 cfu/100mL

Notes:
(1) This water quality standard is not currently assigned to tributaries of Jamaica Bay.
(2) DEC has not yet adopted the Proposed *Enterococci* WQ Criteria*. These proposed criteria, if adopted as proposed, will not apply to the tributaries to Jamaica Bay.
(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 on Table 2-7 in Section 2.

*Proposed *Enterococci* WQ Criteria, if adopted as proposed, would only apply to coastal Class SB and SA waters.

Jamaica Bay Watershed

Watershed characteristics for Jamaica Bay and its tributaries, including the NYC CSO and municipal separate storm sewer system (MS4) stormwater outfalls, are shown in Figure ES-4. Jamaica Bay and its tributaries are saline waterbodies surrounding JFK International Airport to the south, east, and west in the Boroughs of Brooklyn and Queens. Jamaica Bay is tributary to Lower New York Bay. Water quality in Jamaica Bay and its tributaries is influenced by multiple sources including stormwater discharges, dry-weather sources, and CSOs. The Jamaica Bay watershed comprises approximately 66,269 acres (in NYC) and the majority of the land immediately surrounding the shoreline is utilized for recreational, transportation and commercial purposes. The urbanization of NYC and the Jamaica Bay watershed has led to the creation of a large combined sewer system as well as extensive areas served by separate sanitary and storm sewer systems, with stormwater outfalls that discharge directly to the Bay and tributaries. The Jamaica Bay watershed is served by the Jamaica WWTP, the 26th Ward WWTP, the Coney Island WWTP, and the Rockaway WWTP that are permitted pursuant to DEC issued State Pollution Discharge Elimination System (SPDES) permits. Dry-weather sanitary flow is conveyed to the WWTPs for treatment. During wet-weather, combined storm and sanitary flow is conveyed by the sewer system to the WWTPs. If the sewer system or WWTP is at full capacity, a diluted mixture of combined storm and sanitary flow may discharge through one or more of the 22 SPDES permitted CSO Outfalls to Jamaica Bay or its tributaries.

Table ES-5 summarizes the model projected average annual CSO overflow volume and frequency of overflow for each SPDES-permitted CSO Outfall under the CSO LTCP selected baseline conditions as described herein. A total of 109 DEP owned MS4 outfalls also discharge to Jamaica Bay and its tributaries. Figure ES-5 illustrates the location of the DEP MS4 outfalls as well as 74 New York City Department of Transportation (DOT) outfalls and 347 other stormwater discharge points to Jamaica Bay and its tributaries.

Table ES-5. CSO Discharges Tributary to Jamaica Bay and Tributaries (2008 Typical Year)

Receiving Waters	Combined Sewer Outfalls	Discharge Volume(1) (MGY)	No. of Discharges(1)	Percentage of Total CSO Discharge to Jamaica Bay
Thurston Basin	JAM-005/007	626 (213)	73 (25)	27.6%
Bergen Basin	JAM-003	108	17	4.8%
	JAM-003A	230	33	10.1%
	JAM-006	2	14	0.1%
	Subtotal	340	33	15.0 %
Spring Creek(2)	26W-005	310	7	13.6%
Hendrix Creek	26W-004	104	30	4.6%
Fresh Creek	26W-003	300	15	13.2%
Paerdegat Basin(3)	Tank Overflow	553	12	24.3%
	CI-004/005/006	38	5	1.7%
	Subtotal	591	12	26.0%
Jamaica Bay	Rockaway Outfalls(3)	0	0	0.0%
Jamaica Bay and Tributaries	Total CSO	2,271 (1,858)	73 (33) max.	100%

Notes:

(1) CSO volumes and activation frequency are based upon overflow at the respective weirs and do not account for stormwater contributions to the outfall downstream of the regulator with the exception of Thurston Basin, which is based upon the sum of the CSO and stormwater discharges just downstream of Regulators JA-06, JA-07 and JA-08. The values in parentheses are the specific CSO AAOV and frequency of flow that tips over the weirs and diversion structures within the Thurston Basin drainage area.

(2) The Spring Creek Auxiliary Wastewater Treatment Plant (AWWTP) and the Paerdegat Basin CSO Retention Facility provide floatables control and settling prior to overflow of storms exceeding the tank storage capacity.

(3) The Rockaway CSOs do not activate during the typical 2008 rainfall year.

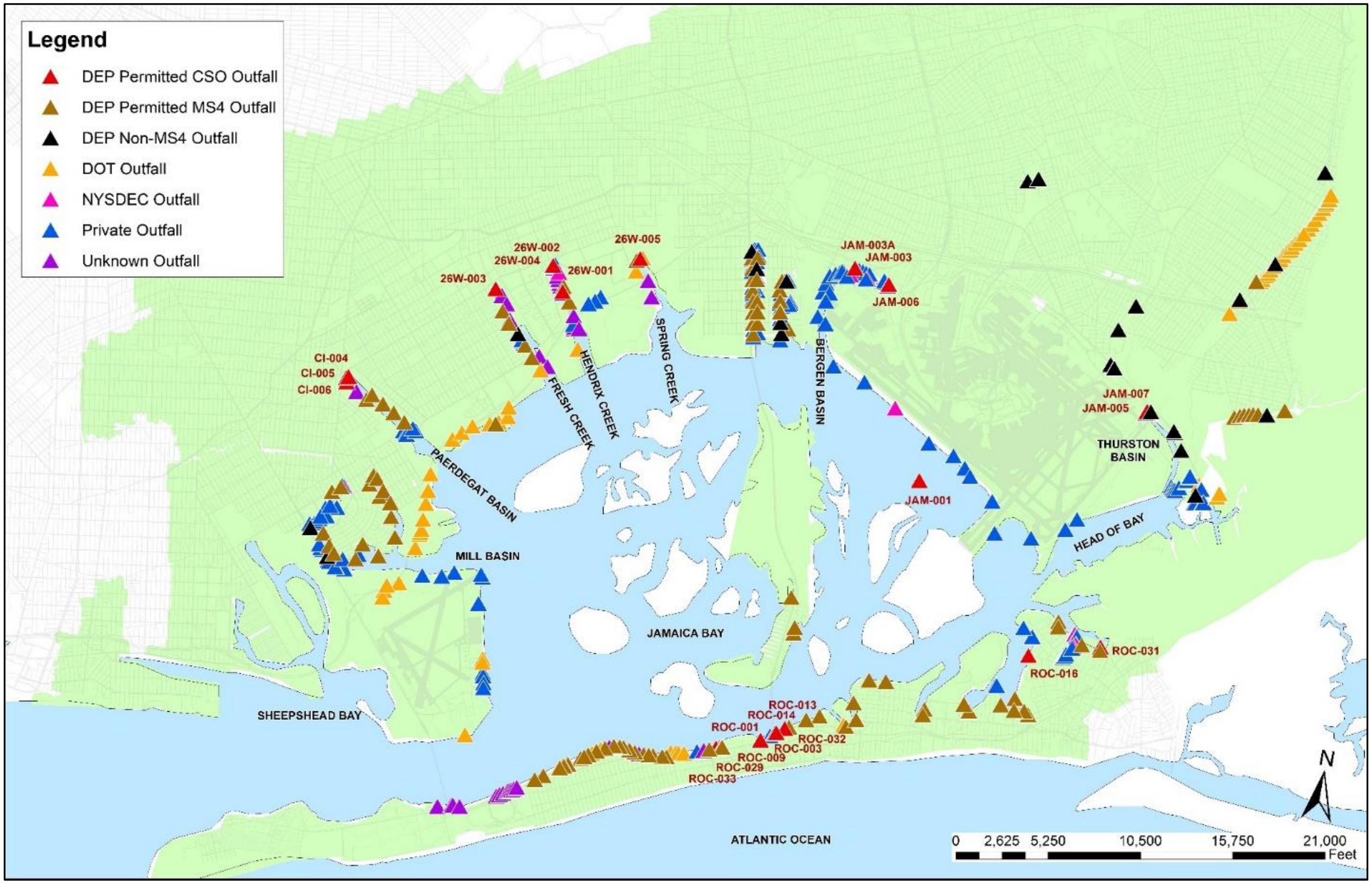


Figure ES-5. Jamaica Bay and Tributaries Outfalls

Southeast Queens Sewer Buildout

Under OneNYC, DEP has commenced an extensive sewer buildout in Southeast Queens that is intended to help alleviate upland flooding and improve the drainage and conveyance of stormwater from the roadways and neighborhoods into the receiving waters. Over the next 10 years, DEP's capital budget includes about $1.7B to continue this long term sewer buildout. Full buildout will go well beyond the 10 year plan and will include installation of about 450 miles of new storm sewers. In addition, there will be approximately an additional 260 miles of new sanitary sewers and an additional 30 miles of combined sewers. Upon completion, this project is expected to greatly alleviate flooding and also significantly reduce CSO discharges into Thurston Basin. Any potential water quality improvements from these future projects were not included in the baseline for this LTCP, and projected water quality improvements from the Recommended Plan do not include any potential improvements from the current planned sewer buildout in Southeast Queens.

Green Infrastructure

Jamaica Bay and its tributaries are priority CSO watersheds for DEP's GI Program, and DEP seeks to saturate priority watersheds with GI based on the specific opportunities each watershed presents. DEP has over 1,000 GI assets in construction, or constructed, including right-of-way (ROW) practices, public property retrofits, and GI implementation on private properties as of 2017 in the Jamaica Bay and Tributaries watershed. In addition, thousands of additional assets are currently planned or in design. Based on the 2008 baseline rainfall condition, all built and planned GI assets under baseline conditions, are projected to result in a CSO volume reduction of approximately 202 MGY.

For the Jamaica Bay and Tributaries LTCP, the baseline reduction is based on GI implementation constructed or planned in the watershed, primarily through retention practices including ROW rain gardens and public property retrofits, but also including an assumption that detention-based GI systems on private property will control runoff from three percent of the combined sewer impervious area tributary to Jamaica Bay and its tributaries. The GI Program will be implemented through 2030 and the final implementation rate will be reassessed as part of the adaptive management approach. Figure ES-6 shows the current contracts in progress in the combined sewer areas tributary to Jamaica Bay and its tributaries. As more information on field conditions, feasibility, and costs becomes known, and as GI projects progress, DEP will continue to report on the progress of the GI in the watershed of Jamaica Bay and its tributaries through 2030.

CSO GREEN INFRASTRUCTURE (GI) BASELINE (Current and Future)	
Greened Acres	877 ac.
CSO Reduction	201 MGY
Stormwater Reduction	Not applicable

RECOMMENDED PLAN		
Additional Benefits	**Thurston Basin**	**Bergen Basin**
Greened Acres	147 ac.	232 ac.
CSO Reduction	6 MGY	9 MGY
Stormwater Reduction	22 MGY	211 MGY

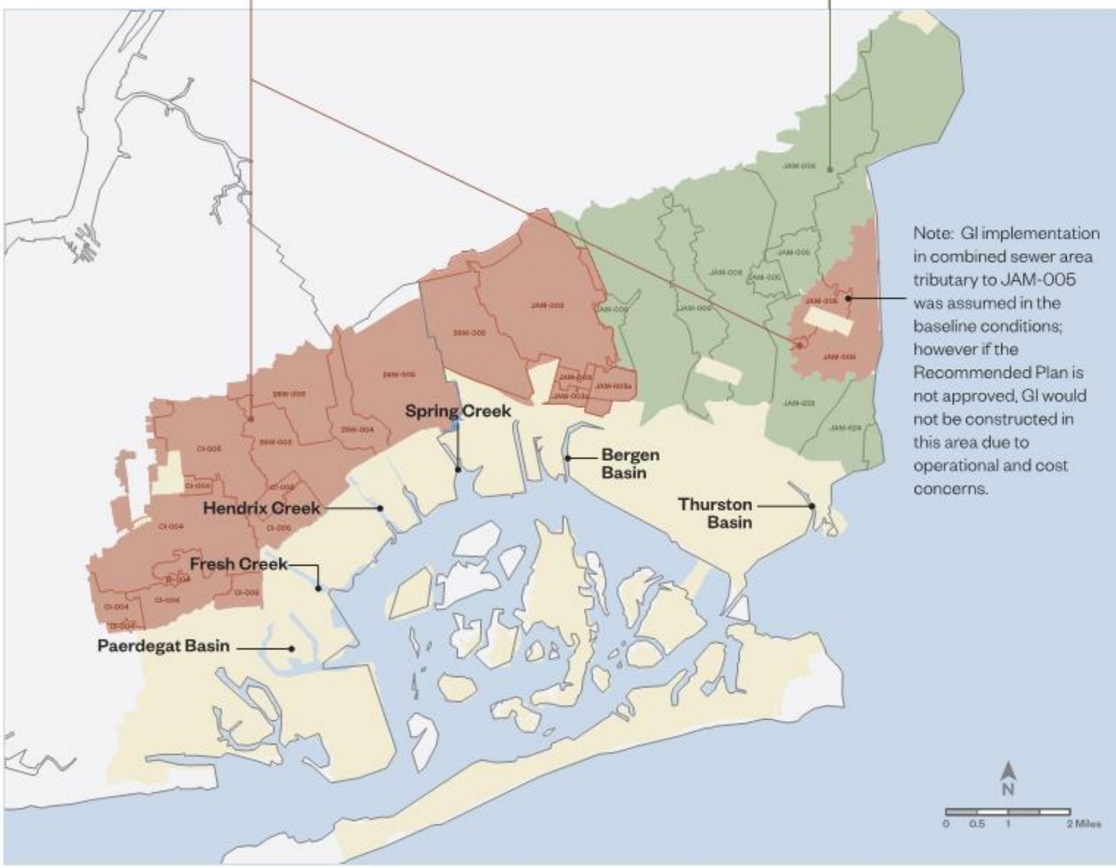


Figure ES-6. GI CSO Baseline and GI Expansion in Recommend Plan

4. FINDINGS

Current Water Quality Conditions

Data collected within Jamaica Bay and its tributaries by DEP's Harbor Survey Monitoring Program (HSM) are available from 2013 to 2016, and data are available from sampling conducted by the LTCP team from October 2015 through November 2015 to support the Jamaica Bay and Tributaries LTCP. The sampling locations for both programs are depicted in Figure ES-7.

Overall, water quality conditions generally fall within standards during dry-weather conditions with the exception of Bergen Basin. The sampling program indicated that pathogen impacts are observed primarily during wet-weather conditions in Bergen Basin, Thurston Basin, and Fresh Creek. DO averages generally achieve standards in all waterbodies with the exception of Bergen Basin, Thurston Basin, and Hendrix Creek during wet-weather conditions.

Full details regarding the sampling results are presented in Section 2 of this report. Figure ES-7 through Figure ES-13 provides a qualitative summary of the sampling results for fecal coliform, *Enterococci*, and dissolved oxygen under dry- and wet-weather conditions.

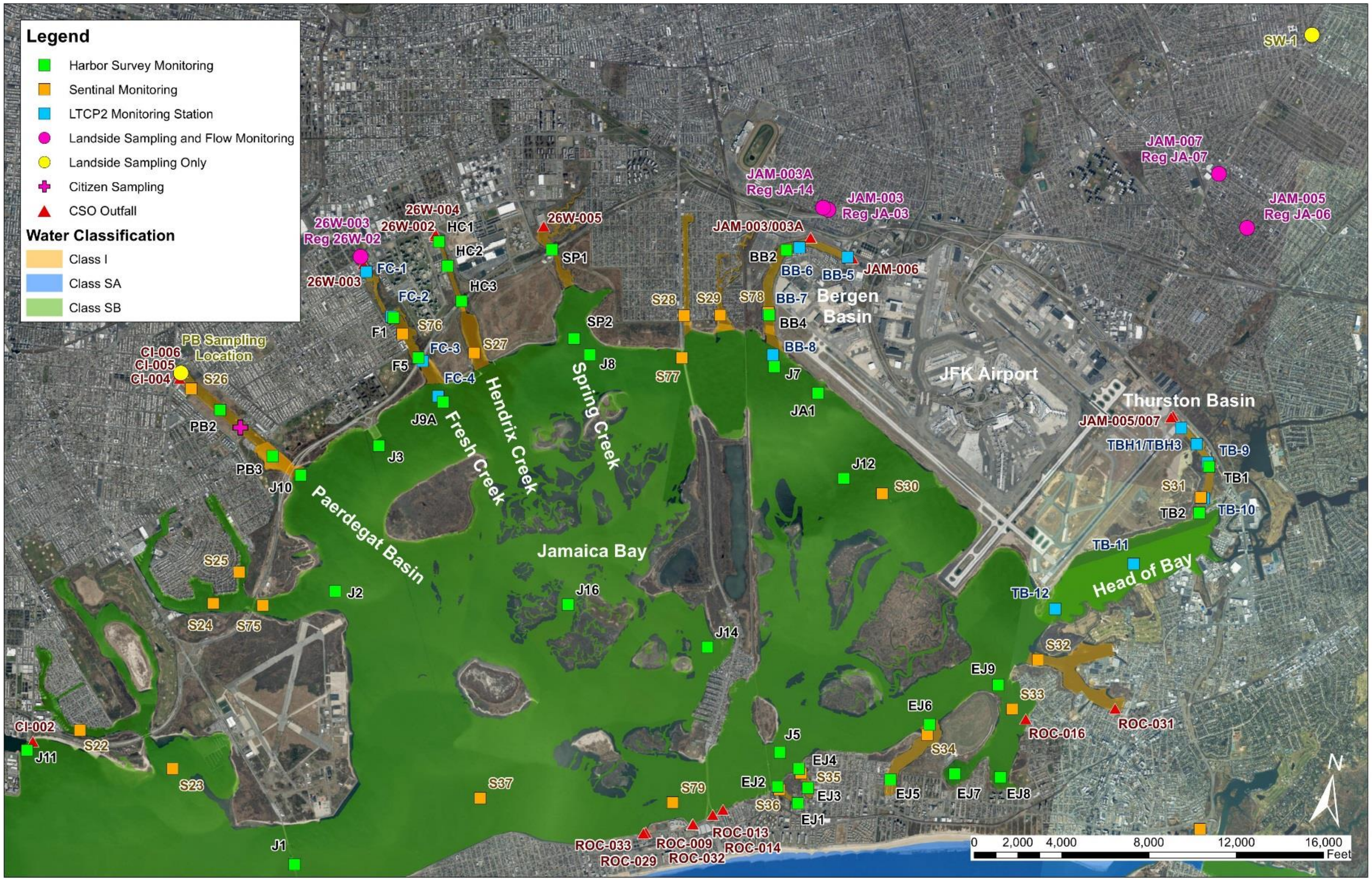


Figure ES-7. Jamaica Bay LTCP Field Sampling Analysis Program and Harbor Survey Monitoring Program and Third Party Sampling Locations

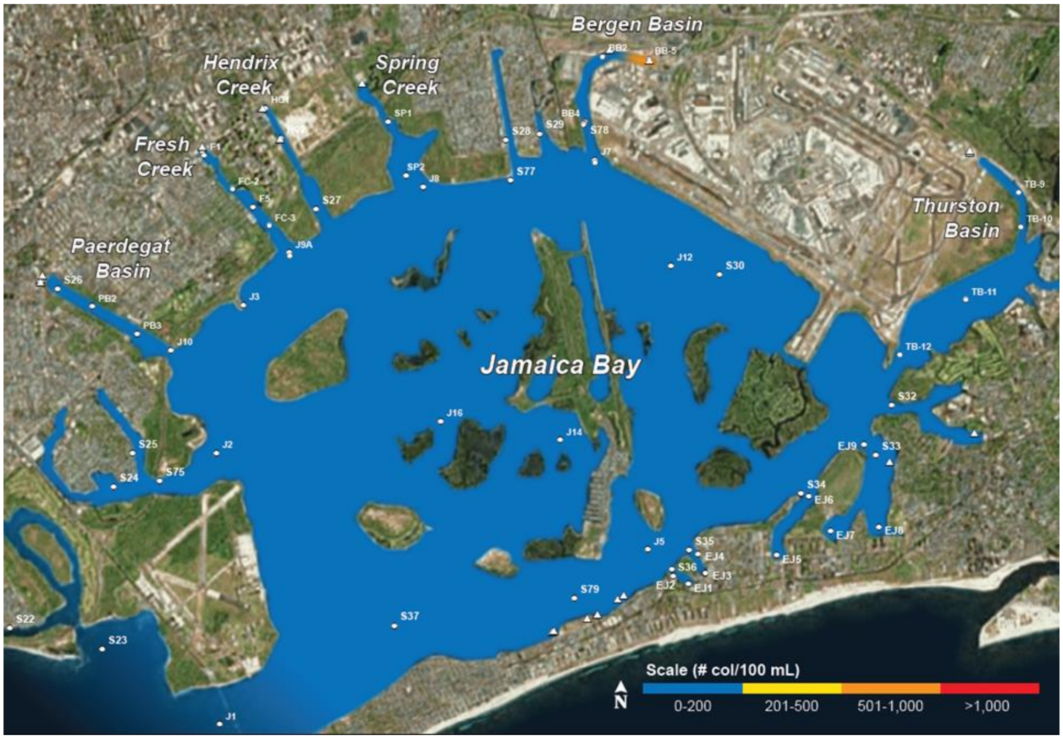


Figure ES-8. Fecal Coliform Sampling Results (1/1/15 – 3/30/16) – Dry-Weather

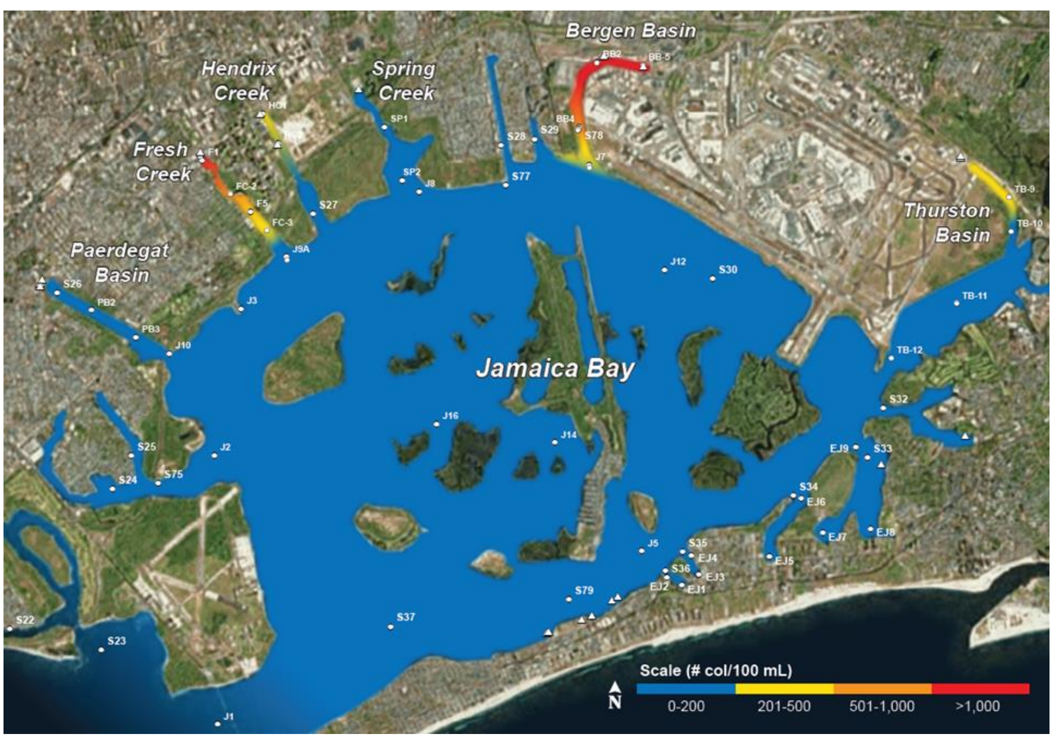


Figure ES-9. Fecal Coliform Sampling Results (1/1/15 – 3/30/16) – Wet-Weather

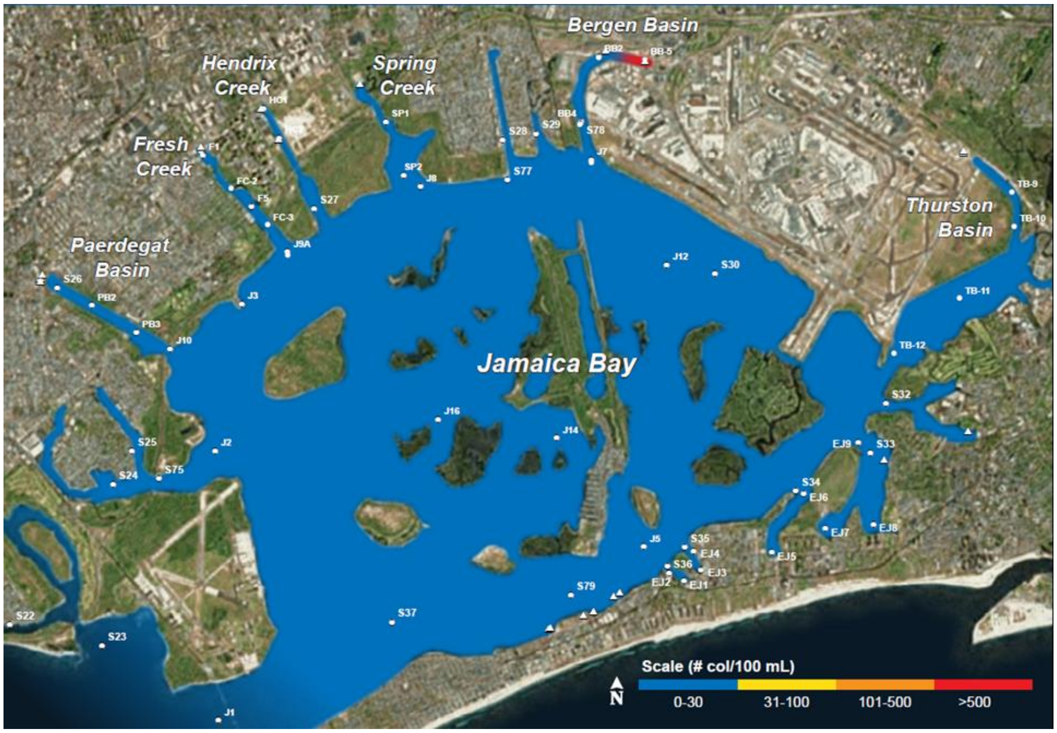


Figure ES-10. *Enterococci* Sampling Results (1/1/15 – 3/30/16) – Dry-Weather

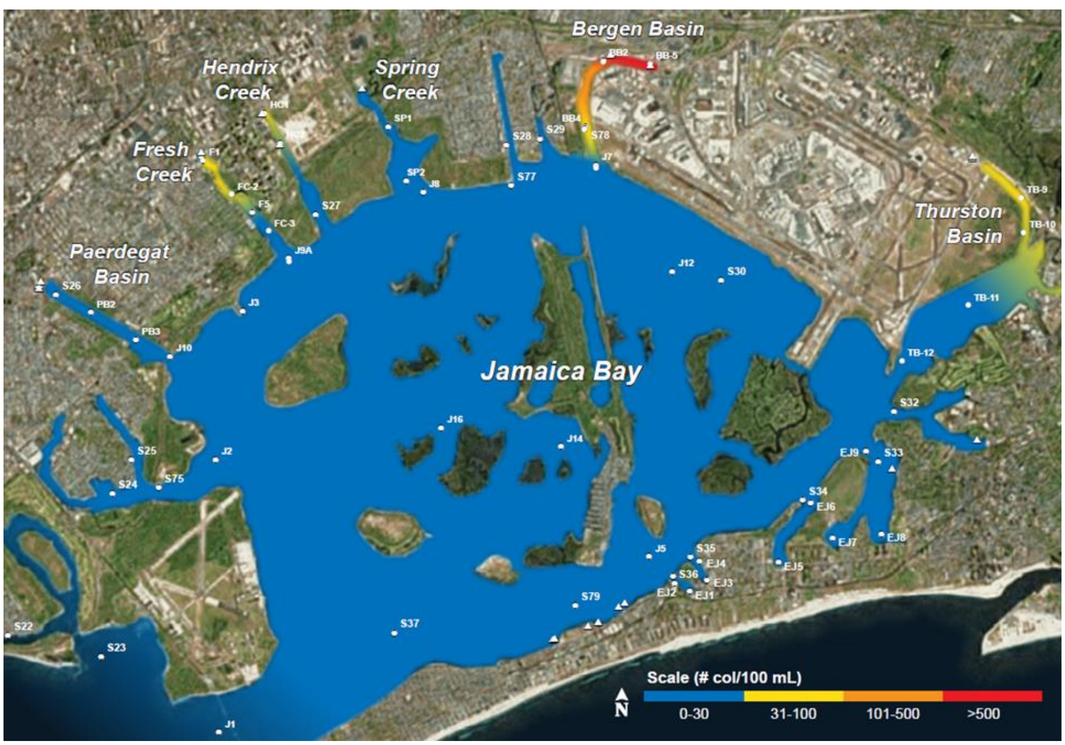


Figure ES-11. *Enterococci* Sampling Results (1/1/15 – 3/30/16) – Wet-Weather

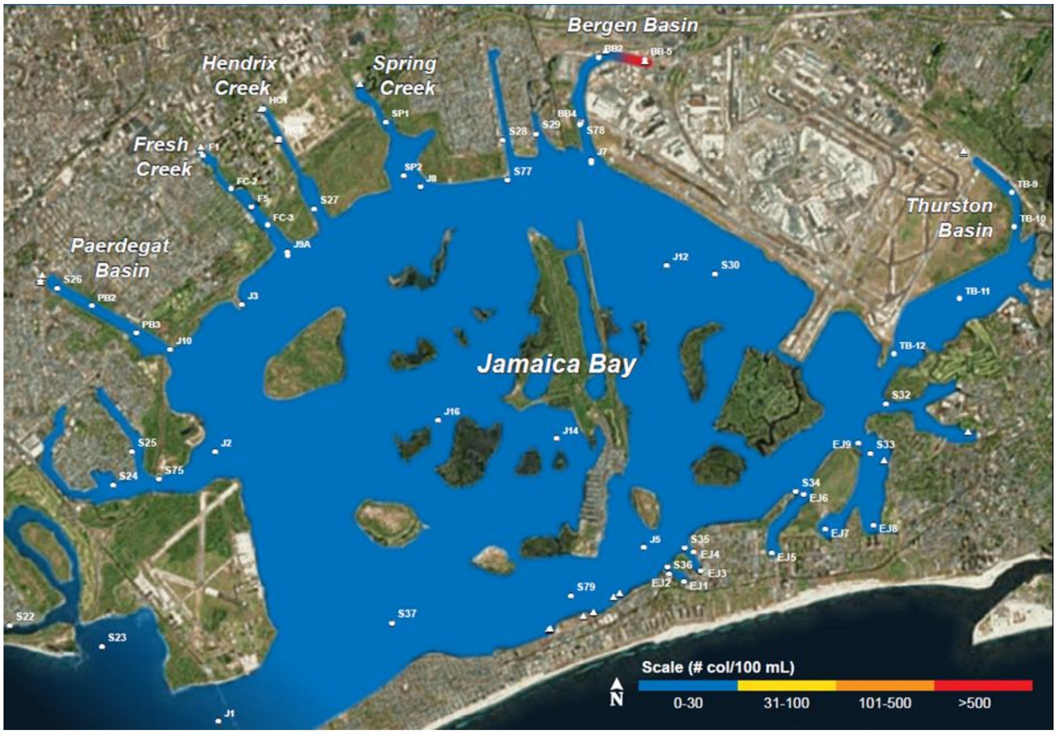


Figure ES-12. Dissolved Oxygen Sampling Results (1/1/15 – 3/30/16) – Dry-Weather

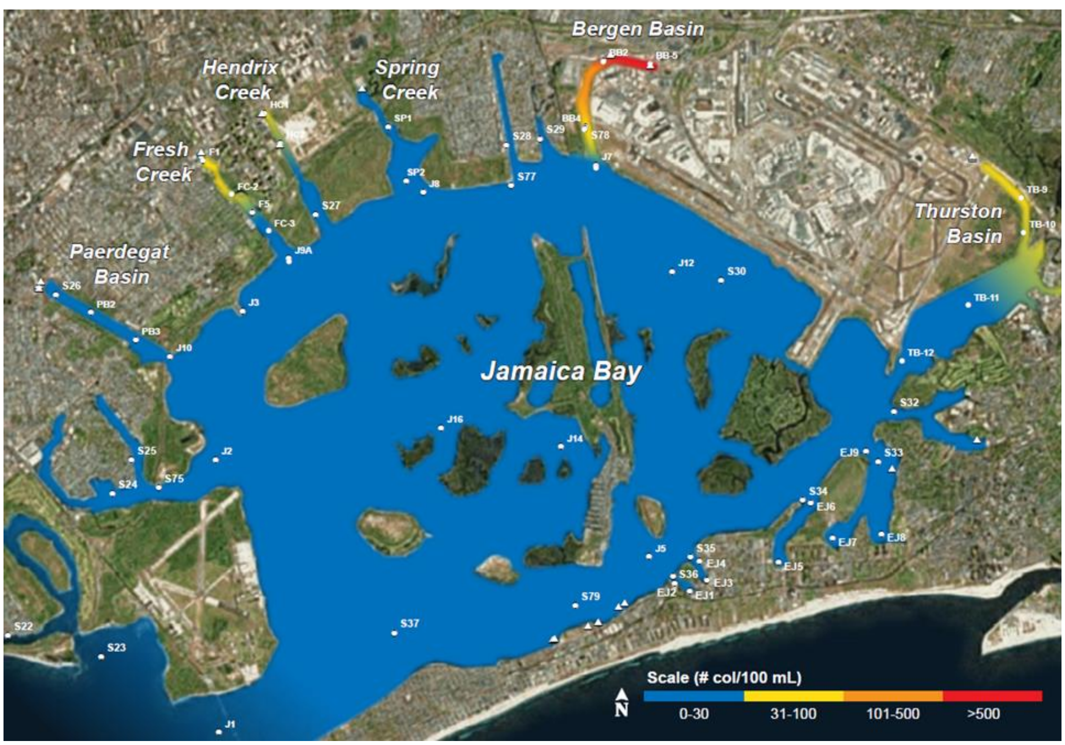


Figure ES-13. Dissolved Oxygen Sampling Results (1/1/15 – 3/30/16) – Wet-Weather

Baseline Conditions, 100% CSO Control and Performance Gap

Computer models were used to assess attainment with Existing WQ Criteria for fecal coliform and DO (Class SB – Jamaica Bay and Class I - Tributaries) and the Proposed *Enterococci* WQ Criteria* for Jamaica Bay and its tributaries. However, as proposed, these criteria do not apply to non-coastal waters, including the tributaries to Jamaica Bay. The analyses focused on two primary objectives:

1. Determine the levels of compliance with WQ criteria under future baseline conditions. This analysis is presented for Existing WQ Criteria for fecal coliform and DO (Class I and SB) and Proposed *Enterococci* WQ Criteria* (coastal Class SB).

2. Determine potential attainment levels without discharge of CSO to the waterbody (100% CSO control), keeping the remaining non-CSO sources. This analysis is based on the criteria shown in Table ES-4.

Details of the baseline conditions and performance gap analyses are covered in Section 6 of this report. Figure ES-14 through Figure ES-16 depicts the findings of the gap analysis which identifies the gap in attainment under baseline in comparison to 100% CSO control (No CSO) conditions. The gap analysis is performed to identify the impact of CSO controls on water quality conditions and provides an indication of whether there are other sources that preclude the attainment of WQ criteria.

As indicated in Figure ES-14, 100% CSO control of the bacteria loading results in some improvement in the tributaries. Under baseline conditions, 10-year continuous model simulations indicate the head ends of Fresh Creek, Bergen Basin, and Thurston Basin do not achieve 95 percent attainment of the Existing WQ Criteria for fecal coliform. This is also the case for 100% CSO control, with the exception of the head end of Fresh Creek which improves from 93 to 98 percent attainment. This analysis indicates that CSO controls cannot completely close the gap between attainment and non-attainment of the fecal coliform WQ criteria for Thurston and Bergen Basins. However, these monitoring stations are located within portions of these tributaries that are prohibited from public access by JFK International Airport security.

Under baseline conditions, 10-year continuous model simulations (Figure ES-15) indicate that greater than 95 percent attainment of the Proposed *Enterococci* WQ Criteria* (rolling 90-day GM *Enterococci* criterion of 35 cfu/100mL) is achieved during the recreational season (May 1st through October 31st) in Jamaica Bay and its tributaries, except for Thurston and Bergen Basins. With 100% CSO control, the improvement in attainment is less than 5 percent, with negligible improvement in Thurston and Bergen Basins. Similar to the gap analysis for fecal coliform, 100% CSO control cannot completely close the gap between attainment and non-attainment of the Proposed *Enterococci* WQ Criteria* in Thurston and Bergen Basins.

Figure ES-16 presents a comparison of the Class I DO criterion attainment for the tributaries and the Class SB DO criteria attainment for Jamaica Bay, for the 2008 typical year, under baseline conditions and 100% CSO control. The model generally projects improvements of at most only a few percentage points in attainment with the DO criteria. Thus, CSO loads are not the controlling factor for limiting DO concentrations and CSO controls will not substantially improve DO concentrations.

*Proposed *Enterococci* WQ Criteria, if adopted as proposed, would only apply to coastal Class SB and SA waters.

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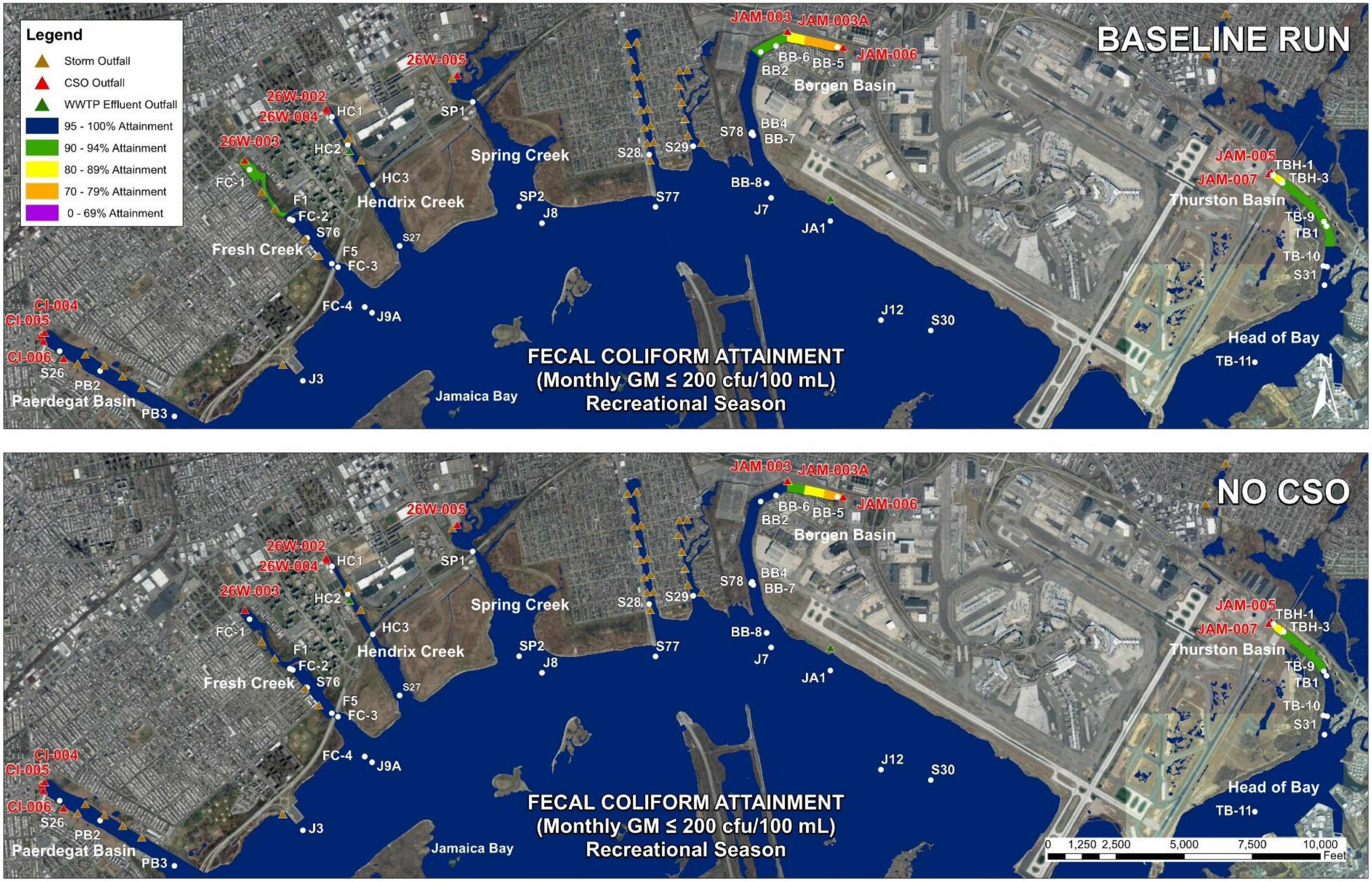

Figure ES-14. Fecal Coliform Attainment – Baseline vs 100% CSO Control

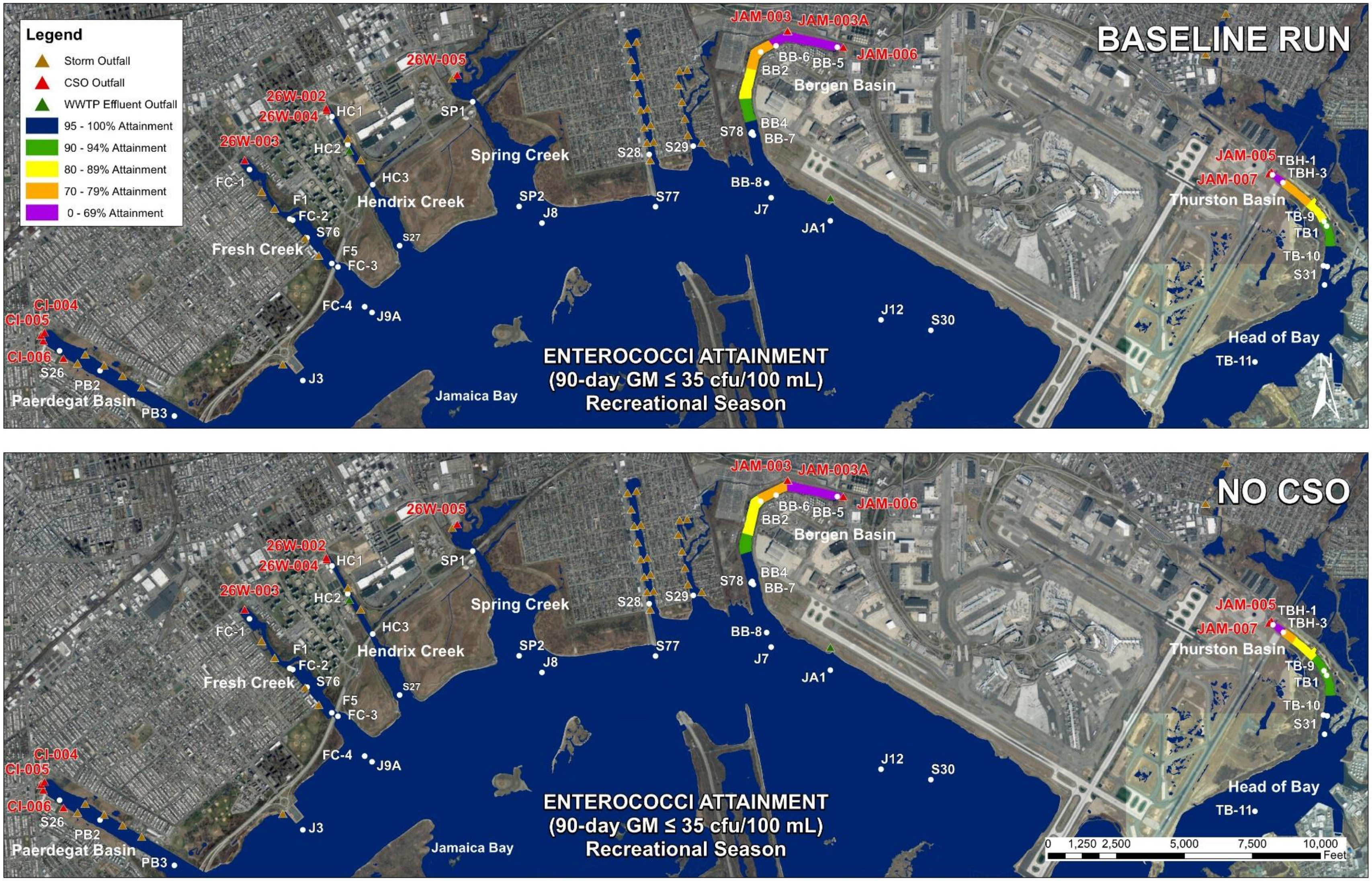

Figure ES-15. ***Enterococci*** **Attainment – Baseline vs 100% CSO Control**

Figure ES-16. Dissolved Oxygen – Baseline vs 100% CSO Control

Public Outreach

DEP's comprehensive public participation plan provides the opportunity for interested stakeholders to be involved in the LTCP process. Stakeholders include local residents and citywide and regional groups, a number of whom offered comments at three public meetings held for this LTCP.

On September 22, 2016, DEP hosted a Public Kickoff Meeting to initiate the water quality planning process for the Jamaica Bay and Tributaries LTCP. Approximately 15 stakeholders from different non-profit, community, planning, environmental, economic development, governmental organizations, and the broader public attended the event, as did representatives from DEP. The two-hour event, held at Jamaica Chamber of Commerce, Queens, provided stakeholders with information about DEP's LTCP Program, Jamaica Bay and surrounding tributaries watershed characteristics, GI implementation, and the status of waterbody improvement projects. The presentation is available on DEP's LTCP Program website: http://www.nyc.gov/dep/ltcp.

DEP hosted a Public Status Update Meeting on October 19, 2017 to present information regarding a one-year extension for Jamaica Bay and Tributaries LTCP. Approximately 15 stakeholders from different non-profit, community, planning, environmental, economic development, governmental organizations, and the broader public, attended the event, as did representatives from DEC. The two-hour event, held at the Jamaica Bay Wildlife Refuge Center in Broad Channel, Queens, provided information regarding the one-year time extension for the CSO LTCP for Jamaica Bay and Tributaries, details about planned projects in the Jamaica Bay watershed, an overview of the Southeast Queens Programs Green Infrastructure and Bluebelt Projects, and described additional opportunities for public input and outreach. The presentation is available on DEP's LTCP Program website: http://www.nyc.gov/ dep/ltcp.

On April 18, 2018, DEP hosted a third Public Meeting to continue discussion of the water quality planning process. Approximately 12 stakeholders from the general public attended the event. The purpose of the nearly two-hour event, held at the Jamaica Bay Wildlife Refuge Center in Broad Channel, was to describe the alternatives identification and selection processes, present the Recommended Plan, and solicit public comment and feedback. The presentation is available on DEP's LTCP Program website: http://www.nyc.gov/dep/ltcp.

DEP has received multiple stakeholder emails and comment letters. These documents and additional information on the public outreach activities are available on DEP's website and are also included in Appendix B, Public Participation Materials.

Evaluation of Alternatives

DEP used a multi-step process to evaluate CSO control measures and CSO control alternatives. Section 8 of this report includes DEP's analysis along with figures and descriptions of the conceptual layouts for the CSO control alternatives. These conceptual layouts were prepared for the purposes of developing costs and evaluating the feasibility of the various CSO control alternatives for improving water quality in Jamaica Bay and its tributaries. The final siting of the facilities and other associated details which make up the Recommended Plan presented herein will be further evaluated and finalized during subsequent planning and design stages. The evaluation process considered environmental benefits, community and societal impacts, and issues related to implementation and O&M. Following the comments generated by detailed technical workshops, the retained alternatives were subjected to a functional review and cost-performance and cost-attainment evaluations, where economic factors were introduced.

Table ES-6 presents the retained alternatives that resulted from the evaluation process. As water quality at the head ends of Thurston Basin and Bergen Basin do not attain the 95 percent criterion for fecal coliform, DEP initially focused on waterbody specific controls (parallel interceptors and tunnels) for Thurston and Bergen Basin (Alternatives 1 through 7). For the remaining Jamaica Bay waterbodies, DEP evaluated a range of regional tunnel configurations for control of CSO discharges throughout the Jamaica Bay watershed (Alternatives 7 through 10). Table ES-6 summarizes the remaining model predicted annual average untreated CSO volumes to Jamaica Bay and its tributaries and the percent reductions in CSO volume and bacteria loads for the retained alternatives.

As the gap analysis provided in Figure ES-14 indicates that attainment of fecal coliform WQ criteria in Thurston and Bergen Basins cannot be achieved under a 100% CSO control scenario, an alternative featuring Additional GI and Environmental Improvements (Alternative 11) was also developed. This alternative includes construction of GI within separately sewered portions of the Jamaica WWTP collection system, environmental dredging, ribbed mussel colony habitat creation, and tidal wetlands restoration. Alternative 11 provides economic, social and environmental benefits beyond what can be achieved using traditional grey infrastructure approaches for CSO control and further enhances the water quality benefits achieved through the projects previously implemented pursuant to the WWFP. The Additional GI and Environmental Improvements alternative can be implemented in 14 years as opposed to the grey retained alternatives that were evaluated, which are projected to take approximately 25 years to design, construct and activate.

Table ES-6. Retained Alternatives

Alternative	Description
Thurston Basin Alternatives	
1. CSO Tunnel from JAM-005/007 to Jamaica WWTP (50% Control)	15,200 linear foot (LF), 101-foot diameter CSO tunnel (9 MG) from JAM-005/007 to Jamaica WWTP
2. CSO Tunnel from JAM-005/007 to Jamaica WWTP (75% Control)	15,200 LF, 18-foot diameter CSO tunnel (29 MG) from JAM-005/007 to Jamaica WWTP
3. CSO Tunnel from JAM-005/007 to Jamaica WWTP (100% Control)	15,200 LF, 28-foot diameter CSO tunnel (91 MG) from JAM-005/007 to Jamaica WWTP
Bergen Basin Alternatives	
4. CSO Conveyance from JAM-003/003A to Jamaica WWTP	3,200 LF, 8-foot diameter sewer from Outfalls JAM-003/003A to a 50 MGD pumping station at the Jamaica WWTP

Table ES-6. Retained Alternatives

Alternative	Description
5. CSO Tunnel from JAM--03/003A to Jamaica WWTP (50% Control)	3,200 LF, 21-foot diameter CSO tunnel (8 MG) from JAM-003/003A to Jamaica WWTP
6. CSO Tunnel from JAM-003/003A to Jamaica WWTP (75% Control)	3,200 LF, 32-foot diameter CSO tunnel (19 MG) from JAM-003/003A to Jamaica WWTP
7. CSO Tunnel from JAM-003/003A to Jamaica WWTP (100% Control)	5,400 LF, 49-foot diameter CSO tunnel (45 MG) from JAM-003/003A to Jamaica WWTP
Regional Alternatives	
8. Jamaica WWTP CSO Tunnel (30% Regional Control)	18,500 LF, 35-foot diameter CSO tunnel (133 MG) from JAM-003/003A to JAM-005/007 with Dewatering Pumping Station at Jamaica WWTP
9. Jamaica/26W WWTP CSO Tunnel (70% Regional Control)	40,100 LF, 35-foot diameter CSO tunnel (288 MG) from JAM-005/007 (Thurston Basin) to 26W-003 (Fresh Creek) with Dewatering Pumping Stations at Jamaica WWTP and 26th Ward WWTP
10. North Shore CSO Storage Tunnel (100% Regional Control)	67,000 LF, 35-foot diameter CSO tunnel (482 MG) from JAM-005/007 (Thurston Basin) to the Coney Island WWTP with Dewatering Pumping Stations at Jamaica, 26th Ward and Coney Island WWTPs
11. Additional GI and Environmental Improvements	*Thurston Basin* • Green Infrastructure – 147 greened acres • Ribbed Mussels – 3 Acres *Bergen Basin* • Environmental Dredging – 50,000 cubic yards • Green Infrastructure – 232 greened acres • Ribbed Mussels – 4 acres *Spring Creek* • Tidal Wetlands Restoration – 13 acres *Hendrix Creek* • Tidal Wetlands Restoration – 3 acres *Fresh Creek* • Tidal Wetlands Restoration – 14 acres Paerdegat Basin • Tidal Wetlands Restoration – 4 acres Jamaica Bay • Tidal Wetlands Restoration – 16 acres

Table ES-7. Jamaica Bay Retained Alternatives Summary (2008 Rainfall)

Alternative[1]	Untreated CSO Volume (MGY)[2,6]	Frequency of Overflow[3,6]	Untreated CSO Volume Reduction (%)	Fecal Coliform Reduction (%)[4]	*Enterococci* Reduction (%)[4]
Thurston Basin					
Baseline Conditions	626 (213)	73 (25)	-	-	-
1. CSO Tunnel from JAM-005/007 to Jamaica WWTP (50% Control)	313 (146)	41 (6)	50 (32)	32	32
2. CSO Tunnel from JAM-005/007 to Jamaica WWTP (75% Control)	155 (85)	40 (2)	75 (60)	60	60
3. CSO Tunnel from JAM-005/007 to Jamaica WWTP (100% Control)	0	0	100	100	100
Bergen Basin					
Baseline Conditions	338	33	-	-	-
4. CSO Conveyance from JAM-003/003A to Jamaica WWTP	230	16	32	32	32
5. CSO Tunnel from JAM-003/003A to Jamaica WWTP (50% Control)	169	11	50	50	50
6. CSO Tunnel from JAM-003/003A to Jamaica WWTP (75% Control)	85	7	75	75	75
7. CSO Tunnel from JAM-003/003A to Jamaica WWTP (100% Control)	0	0	75	75	75
Regional Alternatives					
Baseline Conditions	2,271 (1,858)	73 (33)	-	-	-
8. Jamaica WWTP CSO Tunnel (30% Regional Control)	1,590	30	30	30	30
9. Jamaica/26W WWTP CSO Tunnel (70% Regional Control)	681	12	68	68	68
10. North Shore CSO Storage Tunnel (100% Regional Control)	0	0	100	100	100

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Table ES-7. Jamaica Bay Retained Alternatives Summary (2008 Rainfall)

Alternative[1]	Untreated CSO Volume (MGY)[2,6]	Frequency of Overflow[3,6]	Untreated CSO Volume Reduction (%)	Fecal Coliform Reduction (%)[4]	*Enterococci* Reduction (%)[4]
11. Additional GI and Environmental Improvements	2,256 (1,843)	73 (33)	1	10[5]	10[5]

Notes:

(1) Retained alternatives include waterbody-specific control where water quality attainment is not currently achieved under baseline conditions.
(2) Based upon 2008 typical year rainfall conditions. Rockaway CSOs do not overflow.
(3) Frequency of overflow includes remaining CSO discharges to Jamaica Bay Tributaries that are not captured or receive primary treatment.
(4) Bacteria reduction is computed on an annual basis.
(5) Fecal coliform and *Enterococci* load reductions shown are based on CSO and SW volume reductions associated with Alternative 11. An additional 10 percent reduction in the in-receiving water concentrations within Thurston and Bergen Basins has been assumed to account for the ribbed mussels installed within those basins.
(6) Stormwater connections contribute flow to JAM-005/007 downstream of the regulator weirs in Thurston Basin. As a result, the diversion chambers would direct CSO and stormwater to the tunnel during wet-weather events. The statistics represent the CSO volume and stormwater volume at the point the flow is diverted to the tunnel. Flows in parentheses identify the model predicted CSO volumes overtopping the regulator weirs.

Estimated Costs of Retained Alternatives and Selection of the Recommended Plan

The retained alternatives were reviewed for cost effectiveness, ability to meet WQ criteria, public comments and operations. 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 4 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 June 2018 dollars and are considered Level 5 cost estimates by the Association for the Advancement of Cost Engineering (AACE) International with an accuracy of -50% to +100%. The estimated PBC, annual O&M costs, and total present worth for the retained alternatives are shown below in Table ES-8. The total NPW for the alternatives ranges from $401M to $9,851M.

Table ES-8. Cost of Retained Alternatives

Alternative	PBC(1) ($ Million)	Annual O&M Cost ($/Yr Million)	Total Net Present Worth ($ Million)(2)
Thurston Basin Alternatives			
1. **CSO Tunnel from JAM-005/007 to Jamaica WWTP (50% Control)**	665	1	722
2. **CSO Tunnel from JAM-005/007 to Jamaica WWTP (75% Control)**	939	2	1,020
3. **CSO Tunnel from JAM-005/007 to Jamaica WWTP (100% Control)**	1,509	3	1,637
Bergen Basin Alternatives			
4. **CSO Conveyance from JAM-003/003A to Jamaica WWTP**	633	1	690
5. **CSO Tunnel from JAM-003/003A to Jamaica WWTP (50% Control)**	676	2	736
6. **CSO Tunnel from JAM-003/003A to Jamaica WWTP (75% Control)**	818	2	896
7. **CSO Tunnel from JAM-003/003A to Jamaica WWTP (100% Control)**	1,635	3	1,755
Regional Alternatives			
8. **Jamaica WWTP CSO Tunnel (44% Regional Control)**	2,740	4	2,901
9. **Jamaica/26W WWTP CSO Tunnel (72% Regional Control)**	5,831	11	6,219
10. **North Shore CSO Storage Tunnel (100% Regional Control)**	9,102	23	9,851
11. **Additional GI and Environmental Improvements**	310	2	401

Notes:

(1) The Probable Bid Cost (PBC) for the construction contract based on June 2018 dollars.

(2) The Net Present Worth is based upon a 100-year service life, and is calculated by multiplying the annual O&M cost by a present worth factor of 24.505 and adding this value to the PBC.

As shown in Figure ES-14, most of the areas of Jamaica Bay and the tributaries that are accessible to the public for recreational use would achieve full compliance with the Existing Contact WQ Criteria under baseline conditions. The one exception was the upstream end of Fresh Creek, where the baseline conditions attainment would be 93 percent. In light of this information, and the costs and potential benefits of the retained alternatives, these alternatives are quite costly as compared to the relatively small improvement of attainment of bacterial and DO WQ criteria for Existing Contact WQ Criteria (Class SB).

Selection of the Recommended Plan is based on multiple considerations including public input, environmental and water quality benefits, and costs. A traditional knee-of-the-curve (KOTC) analysis is presented in Section 8.5 of the LTCP. Based on that analysis, the Alternative 11 - Additional GI and Environmental Improvements alternative was identified as the most cost-effective alternative for reducing the frequency and volume of CSOs to Jamaica Bay and its tributaries, and was therefore selected as the Recommended Plan. A more detailed description of the projects included in the Recommended Plan is provided in Section 8 of this LTCP.

The Recommended Plan is projected to result in attainment of the Existing WQ Criteria for fecal coliform in the areas of Jamaica Bay and its tributaries that are accessible to the public. The only area that would not achieve attainment of the Existing WQ Criteria for fecal coliform would be the upstream ends of Thurston and Bergen Basins, and access to those areas is prohibited by JFK International Airport security.

While grey infrastructure alternatives were identified for Bergen and Thurston Basins that would provide greater reduction in annual CSO volume than the Recommended Plan, those alternatives were not selected because they carried significantly higher costs, would not significantly improve the attainment of WQ criteria, and would not provide the range of ancillary benefits that would be provided by the Recommended Plan. As described in Section 8, DEP conducted a Triple-Bottom-Line evaluation of the grey alternative versus the Recommended Plan, where the ancillary benefits of the Recommended Plan were monetized. That assessment demonstrated the cost effectiveness of the Recommended Plan more clearly than the traditional cost/performance curves. The benefits that would accrue from the Recommended Plan, beyond reduction in CSO and stormwater discharge volumes, include air quality improvement, carbon footprint reduction, habitat creation, heat island construction reduction, anticipated property value improvement, and water quality improvement through the filtering of the ribbed mussels. For Bergen Basin in particular, the future buildout of the Southeast Queens drainage plan will eventually reduce the volume of CSO discharged to Bergen Basin, and increase the volume of stormwater. Therefore, in the future, the benefits of a grey infrastructure project targeted at CSO control would be reduced, while the benefits of the additional GI would be expected to increase.

In addition, the Recommended Plan would further many of the ecosystem goals outlined in the City's OneNYC Plan, including expansion of GI, reduction of pollution from stormwater runoff, expansion in trees planting, urban heat island reduction, resiliency, and habitat improvements for pollinators, wildlife and aquatic species. Thus, the Recommended Plan is both more cost-effective than the feasible grey infrastructure alternatives with the added benefit of these additional quality of life and ecological improvements. For these multiple reasons, the Recommended Plan consisting of Additional GI and Environmental Improvements was selected over the more traditional grey infrastructure alternatives.

UAA, WQ Compliance and Time to Recovery

The CSO Order Goal Statement stipulates that, in situations where the proposed alternatives presented in the LTCP will not achieve existing WQS or the Clean Water Act (CWA) Section 101(a)(2) goals, the LTCP will include a Use Attainability Analysis (UAA). Because the analyses developed indicate that Bergen Basin, Thurston Basin and Fresh Creek are not projected to fully meet Existing WQ Criteria for fecal coliform and Bergen Basin, Thurston Basin and Hendrix Creek are not projected to fully attain the Existing DO Criteria, a UAA is included in this LTCP.

DEP has performed an analysis to determine the amount of time following the end of rainfall periods required for Jamaica Bay and its tributaries to recover and return to fecal coliform concentrations of less than 1,000 cfu/100mL. This concentration represents the maximum that the New York City Department of Health and Mental Hygiene (DOHMH) considers safe for primary contact.

Details of this analysis are described in Section 8. The median duration of time within which pathogen concentrations are expected to be higher than 1,000 cfu/100mL varies by location within Jamaica Bay and each of its tributaries. For the Recommended Plan, the median times to recovery are below 24 hours at all of the water quality stations for the storm sizes up to 1.5 inches except for Stations TBH1, TBH2, and TB9 in Thurston Basin, BB5 and BB6 in Bergen Basin and FC1 in Fresh Creek. The median times to recovery at those stations ranged from 32 to 43 hours. For storms greater than 1.5 inches, the median times to recovery are well above 24 hours at all stations located near the head end of each tributary, except for Hendrix Creek (22 hours). All stations within Jamaica Bay have median times to recovery well below 24 hours.

1.0 INTRODUCTION

The New York City Department of Environmental Protection (DEP) prepared this Long Term Control Plan (LTCP) for Jamaica Bay and Tributaries 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 Jamaica Bay and Tributaries LTCP is the tenth of these LTCPs.

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 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 the Jamaica Bay and Tributaries 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 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. Section 303(d) of the CWA and 40 CFR §130.7 (2001) require states to identify waterbodies that do not meet 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.

In the proposed Final 2016 Section 303(d) list of impaired waters, DEC has also identified Jamaica Bay and some of the tributaries as waterbodies for which TMDLs were deferred as Category 4b impaired waters for certain sources of impairment pending development, implementation, evaluation of other restoration measures, in this case, the submittal, and approval of the LTCP. Table 1-1 summarizes DEC's November 2016 Section 303(d) and Category 4b listing status that is currently in effect for Jamaica Bay and its tributaries.

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

Waterbody	Pathogens	DO/Oxygen Demand	Nitrogen	Floatables
Jamaica Bay Eastern, and tribs, Queens	Listed Part 3c (Urban/Storm/CSO)	Identified as Category 4b (Urban/CSO, Municipal)	Identified as Category 4b (Urban/CSO, Municipal)	Identified as Category 4b (CSOs, Urban/Storm)
Thurston Basin	Listed Part 3c (Urban/Storm/CSO)	Listed Part 3c (Urban/CSO, Municipal)	Not identified in Part 3C or as Category 4b	Identified as Category 4b (CSOs, Urban/Storm)
Bergen Basin	Listed Part 3c (Urban/Storm/CSO)	Identified as Category 4b (Urban/CSO, Municipal)	Identified as Category 4b (Urban/CSO, Municipal)	Identified as Category 4b (CSOs, Urban/Storm)
Spring Creek	Listed Part 3c (Urban/Storm/CSO)	Listed Part 3c (Urban/CSO, Municipal)	Not identified in Part 3C or as Category 4b	Identified as Category 4b (CSOs, Urban/Storm)
Hendrix Creek	Listed Part 3c (Urban/Storm/CSO)	Identified as Category 4b (Urban/CSO, Municipal)	Identified as Category 4b (Urban/CSO, Municipal)	Identified as Category 4b (CSOs, Urban/Storm)
Paerdegat Basin	Not identified in Part 3C or as Category 4b	Listed Part 3c (Urban/CSO, Municipal)	Not identified in Part 3C or as Category 4b	Identified as Category 4b (CSOs, Urban/Storm)

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. Jamaica Bay is classified as a Class SB waterbody. The best usages of Class SB waters are primary and secondary contact recreation and fishing. These waters "shall be suitable for fish, shellfish, and wildlife propagation and survival" and the water quality "shall be suitable for primary and secondary contact recreation." Each of the Jamaica Bay CSO tributaries are classified as Class I waterbodies. The best usages of Class I waters are secondary contact recreation and fishing. These waters "shall be suitable for fish, shellfish, and wildlife propagation and survival" and the water quality "shall be suitable for primary contact recreation, although other factors may limit the use for this purpose." The corresponding total and fecal coliform standards for primary contact recreation are set forth in 6 NYCRR Part 703. This LTCP reflects the water quality criteria for fecal coliform protective of primary contact recreation, i.e., Primary Contact Water Quality Criteria.

In March 2018, DEC released Proposed *Enterococci* WQ Criteria* for coastal Class SB waters, which, if adopted would apply to Jamaica Bay (a coastal Class SB waterbody), but not the tributaries (all Class I waterbodies). As requested by DEC, DEP assessed compliance with those proposed criteria for all waters considered in this LTCP including the tributaries.

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 Jamaica Bay and Tributaries. 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. Jamaica Bay is classified as Type A under the IEC system. Details of the IEC Classifications are presented in Section 2.2.

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.

*Proposed *Enterococci* WQ Criteria, if adopted as proposed, would only apply to coastal Class SB and SA waters.

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 is gathering 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 November 2012, DEP issued the Jamaica Bay WWFP, which was prepared pursuant to the CSO Order that includes an analysis and presentation of operational and structural modifications targeting the reduction of CSOs and improvement of the overall performance of the collection and treatment systems within the watershed. The projects approved in the WWFP were incorporated into the CSO Order as modified and are in various stages of construction or are complete.

In June of 2006, DEP issued a watershed-specific LTCP for control of CSO discharges to Paerdegat Basin in accordance with the terms of the CSO Order. The LTCP report was developed from the Paerdegat Basin WWFP and other water quality planning studies. The LTCP recommended the construction of a 20 MG off-line storage tank with an additional 30 MG of storage provided within the influent channels and collections system. The Paerdegat Basin CSO Facility was certified complete in May 2011. Post-construction compliance monitoring is performed in accordance with the facility's SPDES Permit.

The Spring Creek Auxiliary Wastewater Treatment Plant (AWWTP) was constructed in the early 1970s and upgrades, pursuant to the CSO Order, were certified complete in July 2009. The facility consists of a 13.8 MG storage tank with an additional 6.2 MG of inline storage provided in the collection system. The facility operates as a flow-through retention facility. Post-construction compliance monitoring is performed in accordance with the facility's SPDES Permit.

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 Jamaica Bay and Tributaries LTCP.

DEP shared the Jamaica Bay and its tributaries alternatives and held discussions with DEC on the formulation of various control measures, and coordinated public meetings and other stakeholder presentations with DEC. On a quarterly basis, DEC, DEP, and outside technical consultants also convene 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.

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. As discussed in Section 5.0, 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.

1.3.d Public Participation Efforts

DEP made a concerted effort during the Jamaica Bay and Tributaries LTCP planning process to involve relevant and interested stakeholders, and to keep interested parties informed about the project. A public outreach participation plan was developed and implemented throughout the process; the plan is posted and regularly updated on DEP's LTCP program website, www.nyc.gov/dep/ltcp. 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 Jamaica Bay and Tributaries LTCP are summarized in Section 7.0.

2.0 WATERSHED/WATERBODY CHARACTERISTICS

This section summarizes the major characteristics of the Jamaica Bay watershed and waterbody, building upon earlier documents that characterize the area including, most recently, the Jamaic Bay WWFP (DEP, 2012). Section 2.1 addresses watershed characteristics and Section 2.2 addresses waterbody characteristics.

2.1 Watershed Characteristics

The Jamaica Bay 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 Brooklyn and Queens, NY. The most notable outdoor recreation areas within this watershed include the federally owned Gateway National Recreation Area and City–owned parks such as Marine Park, Idlewild/Hook Creek Parks, and Dubos Point Wildlife Sanctuary.

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.

2.1.a Description of Watershed

The Jamaica Bay watershed is situated at the southwestern tip of Long Island and encompasses portions of the Boroughs of Brooklyn and Queens in New York, and portions of the Towns of Hempstead and North Hempstead in Nassau County. The Jamaica Bay estuary connects to Lower New York Bay to the west through the Rockaway Inlet (Figure 2-1). The estuary encompasses approximately 20,000 acres and is approximately 10 miles wide at its widest point east to west and 4 miles wide at its widest point north to south. Jamaica Bay and its surroundings have evolved from a landscape mosaic dominated by salt marsh wetlands, freshwater streams, grasslands, and woodlands with a diverse array of plant and animal life to one of the most densely urbanized areas in the United States (DEP, 2007).

Typically, the watershed of a body of water is delineated by the topography of the surrounding area. Overland flow from rainfall or snow melt flows from topographic high points down to the receiving waterbody. Based on topography alone, the watershed of Jamaica Bay is approximately 91,000 acres. Elevations within the watershed range from sea level to a maximum of approximately 250 feet above sea level. However, the sewer system that has been installed in conjunction with the urbanization of the Jamaica Bay watershed has altered the natural flow path within the watershed by intercepting and diverting flow that would normally drain to the Bay. The land area that is actually tributary to Jamaica Bay (approximately 66,269 acres in NYC) is the area served by combined and separate storm sewer systems (e.g., the sewershed) that collect and convey sanitary wastewater and stormwater that is eventually discharged to Jamaica Bay as CSO, stormwater, and treated wastewater. The focus of this Long Term Control Plan will be on the NYC portion of the sewershed of Jamaica Bay.

Jamaica Bay 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

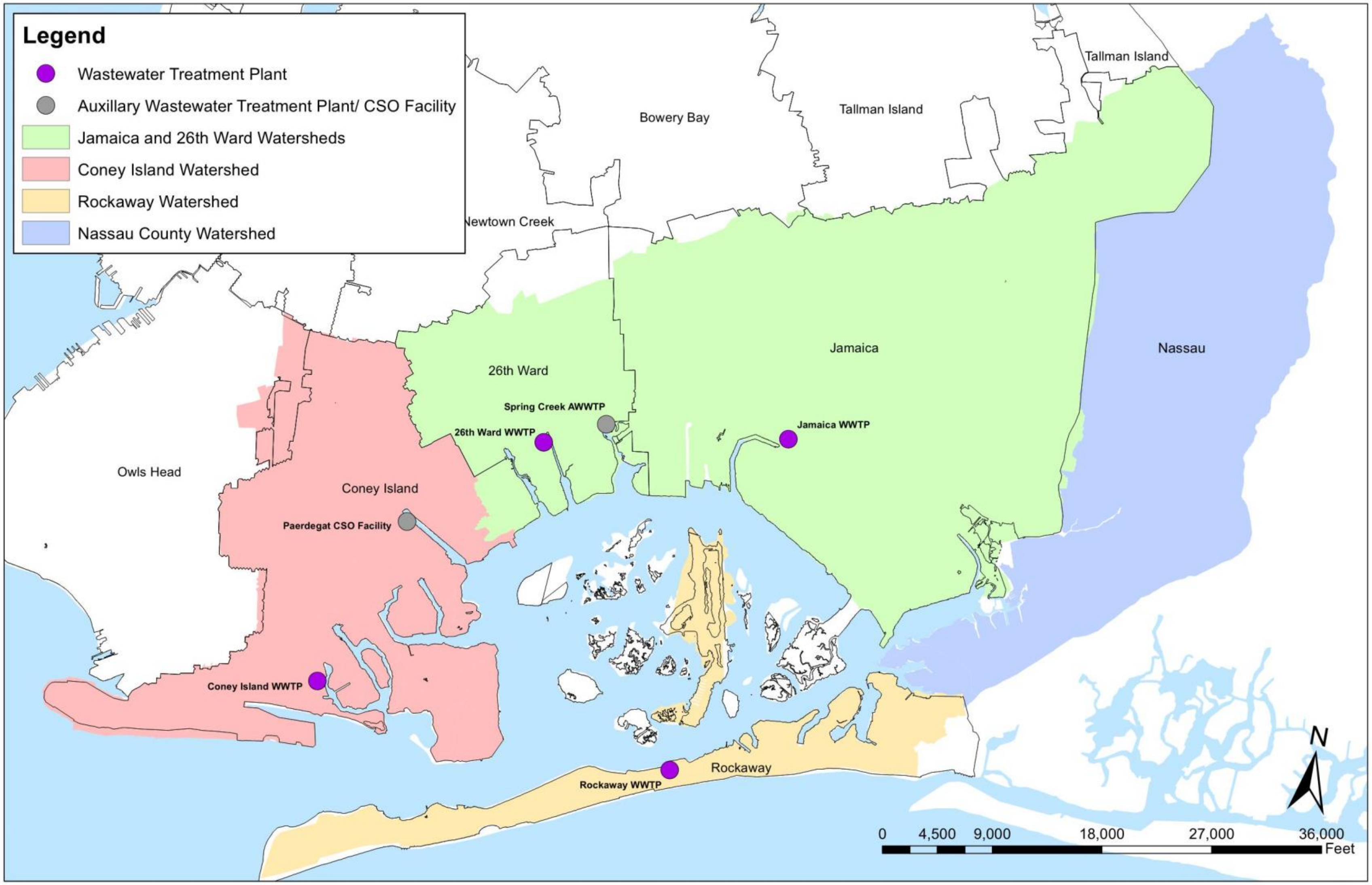

Figure 2-1. Jamaica Bay Watershed

activities have eradicated natural habitats, negatively impacted water quality, and modified the rich ecosystem that characterized the Bay up until the mid-nineteenth century. A comparison of nautical charts from 1899 and 2002 illustrates the extensive alterations that have occurred within Jamaica Bay **(**Figure 2-2). The tributaries to the Bay, in particular, have undergone extensive physical changes over the years (DEP, 2007). They have been altered through dredging and bulkheading to the extent that they bear little resemblance to the original watercourses that fed the Bay. The tributary system within Jamaica Bay has been altered to a point where freshwater input is derived almost exclusively from CSOs, storm sewers, and WWTP effluent. Eight tributaries to the Bay that receive CSOs and/or WWTP effluent (in addition to stormwater discharges) include Sheepshead Bay, Paerdegat Basin, Fresh Creek, Hendrix Creek, Spring Creek, Bergen Basin, and Thurston Basin.

As the watershed was developed, the condition of the tributary waterbodies and their shorelines was influenced by engineered sewer systems, filled-in wetlands and waterways, and an overall “hardening” of the shorelines with bulkheads. The urbanization of NYC and the Jamaica Bay watershed has led to the creation of large combined sewer systems (CSS), separately sewered areas, as well as areas of direct drainage primarily in areas adjacent to the Bay. Four WWTPs are located within the Jamaica Bay sewershed: Coney Island (DDWF=110 MGD), 26th Ward (85 MGD), Jamaica (100 MGD), and Rockaway (45 MGD). These WWTPs are permitted pursuant to DEC issued SPDES permits. During dry-weather, the combined and sanitary sewer systems convey sewage to the WWTPs for treatment. During wet-weather, combined storm and sanitary flow is conveyed by the sewer system to the WWTPs. If the sewer system or WWTP is at full capacity, a diluted mixture of combined storm and sanitary flow may discharge through one or more of the 22 SPDES permitted CSO Outfalls to Jamaica Bay or its tributaries. The Paerdegat Basin and Spring Creek CSO facilities capture CSO during rain events and transmit it to WWTPs for treatment once the rain has subsided and treatment capacity returns to normal. A total of 110 SPDES-permitted MS4) outfalls also discharge to Jamaica Bay and its tributaries. These features are shown in Figure 2-3.

The Jamaica Bay sewershed has several large and notable transportation corridors that cross the watershed to provide access between industrial, commercial, and residential areas, as well as JFK International Airport. The major east/west transportation corridors include the Belt Parkway, Linden Boulevard (Route 27), Jackie Robinson Parkway, Grand Central Parkway, Jamaica Avenue, Atlantic Avenue, Rockaway Boulevard, and Conduit Avenue. The major north/south transportation corridors include Flatbush Avenue, Pennsylvania Avenue, Fountain Avenue, Woodhaven Boulevard/Cross Bay Boulevard, the Van Wyck Expressway, Guy R. Brewer Boulevard, Merrick Boulevard, Farmers Boulevard Springfield Boulevard, and Laurelton Parkway/Cross Island Parkway. Jamaica Station of the Long Island Rail Road (LIRR) and the A, B, C, D, E, F, J, N, Q, Z, 2, 3, 4, and 5 subway lines also traverse the sewershed. The Airtrain also serves JFK International Airport with connections to the A subway line at the Howard Beach subway station and the LIRR and E, J and Z subway lines at the Sutphin Boulevard/Archer Avenue Station. 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.

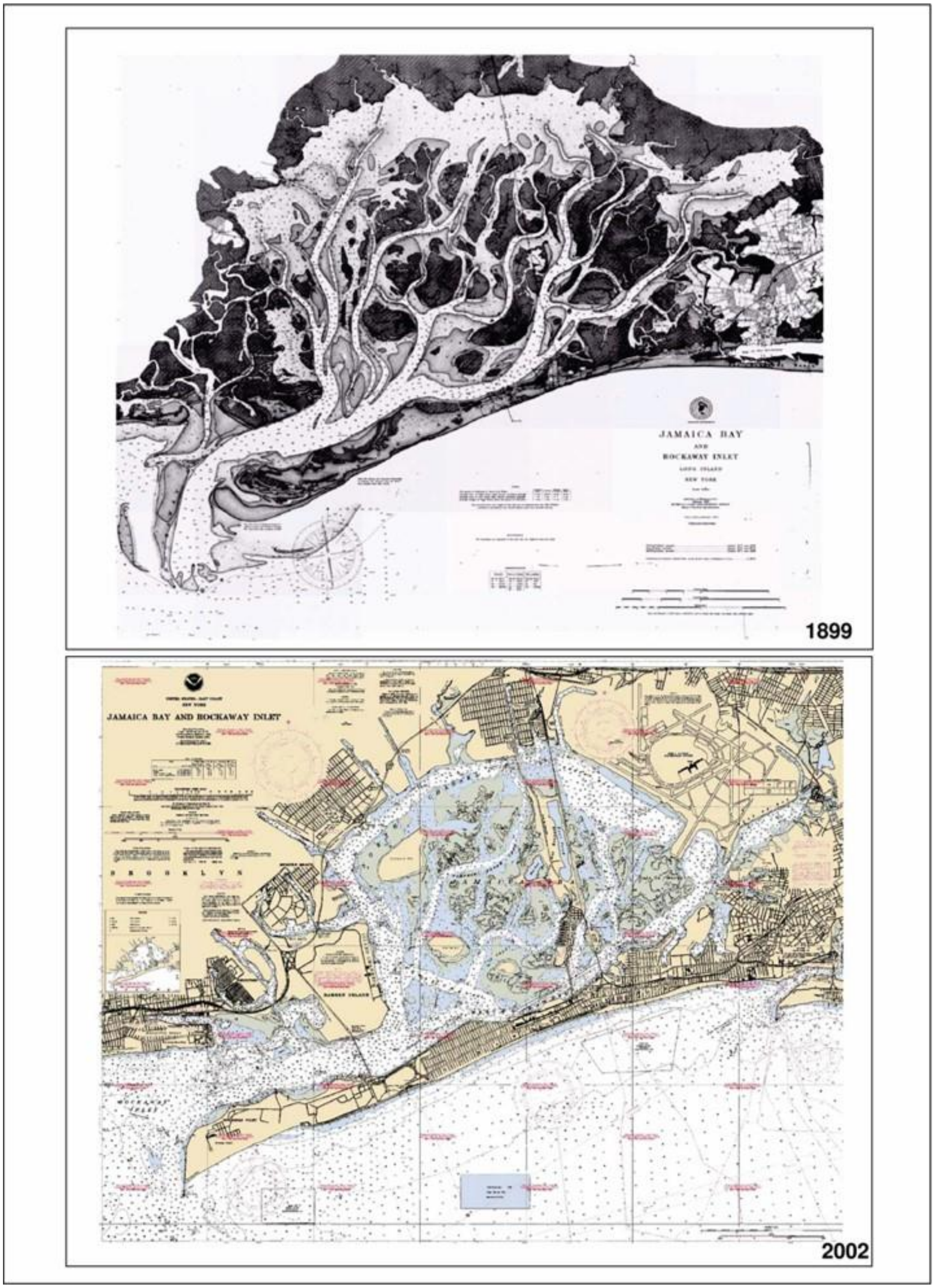

Figure 2-2. Nautical Charts of Jamaica Bay 1899 and 2002

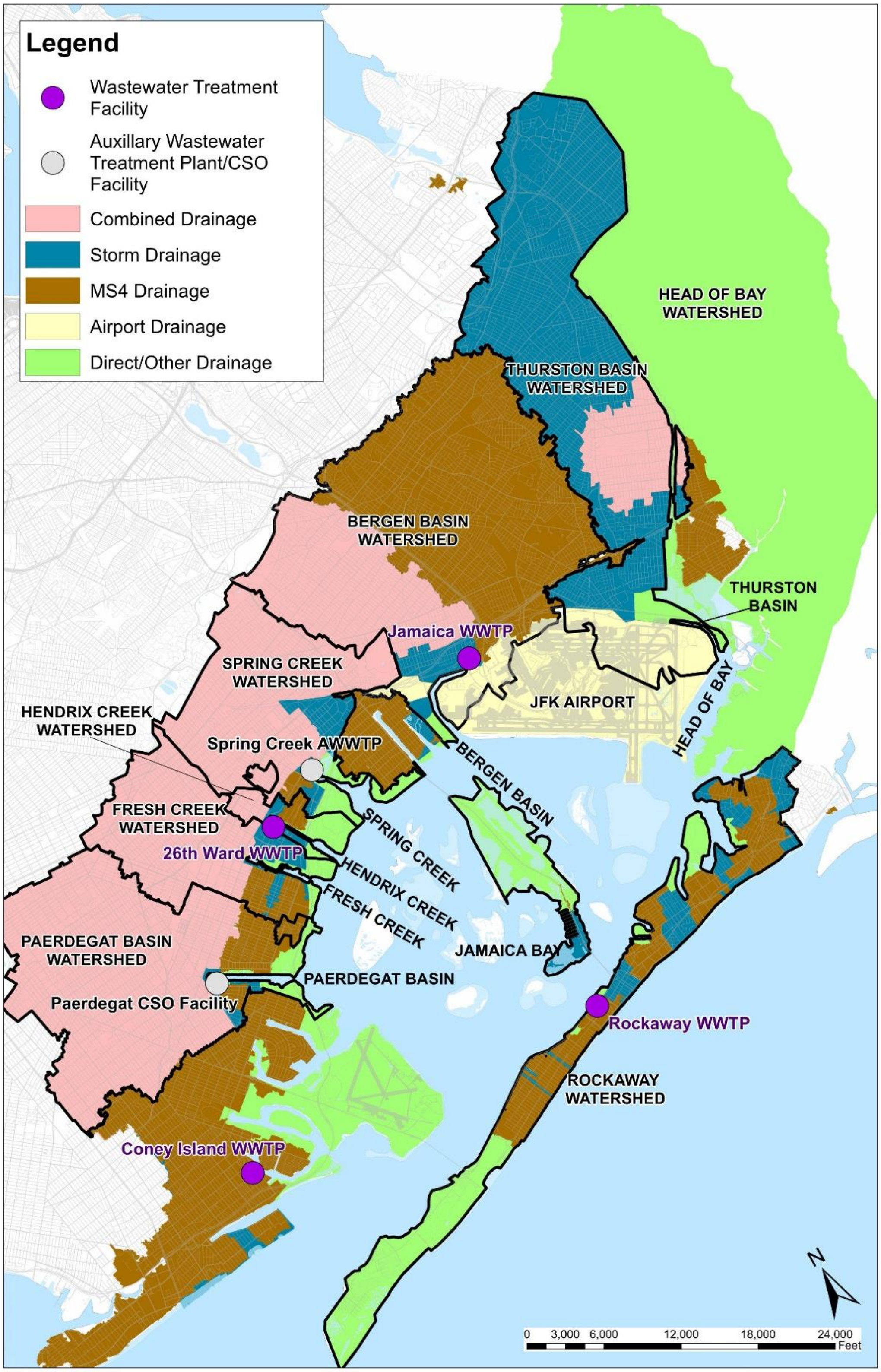

Figure 2-3. Components of the Jamaica Bay Watershed

AECOM with Hazen

Figure 2-4. Major Transportation Features of the Jamaica Bay Sewershed

2.1.a.1 Existing and Future Land Use and Zoning

The current land use in the Jamaica Bay 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. Existing land use within the Jamaica Bay sewershed is shown graphically in Figure 2-5. Figure 2-5 shows the distribution of land uses in the overall Jamaica Bay sewershed, and Figure 2-7 shows the distribution of land uses within 0.25 miles of the shoreline. Table 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.

Table 2-1. Existing Land Use within the Jamaica Bay Sewershed Area

Land Use Category	Percent of Area	
	Within Sewershed	Within 1/4-mile of Shoreline
Residential	49.5	25.5
Mixed Residential and Commercial	1.8	0.7
Commercial and Office	3.0	2
Industrial and Manufacturing	2.0	0.5
Transportation and Utility	14.3	15.9
Public Facilities and Institutions	5.5	3.9
Open Space and Outdoor Recreation	18.6	44.0
Parking Facilities	1.4	1.0
Vacant Land	3.4	6.0
Unknown	0.5	0.5

The Jamaica Bay sewershed covers approximately 40,146 acres in land area. The sewershed is extensively developed, with the predominant land use being residential that is comprised mainly of one- and two-family homes (39%). Two high density areas within the sewershed, downtown Jamaica Queens located in the northeastern portion of the sewershed and Broadway Junction-East New York which straddles the Brooklyn-Queens border in the northern portion of the sewershed, contain a mixture of residential, commercial, and industrial land districts. Commercial land uses within the sewershed represent a wide variety of uses that are representative of any large metropolitan area and are generally geared towards servicing the residential population. Industrial land use properties make up a relatively small portion of the overall sewershed and consist of industries such as automotive parts, plastics packaging, fuel storage facilities, metal parts fabrication, and printing/newspaper publication. The relatively large percentage of land use under the Transportation/Utility category is primarily due to JFK International Airport which is almost 4,000 acres in size.

Open space also makes up a significant percentage of the sewershed (19%) due to the presence of National Park Service properties and facilities. The Jamaica Bay Unit of the Gateway National Recreation Area (GNRA) consists of approximately 12,000 acres including the waters surrounding the Jamaica Bay Wildlife Refuge but also significant land areas that surround the Bay including Floyd Bennett Field,

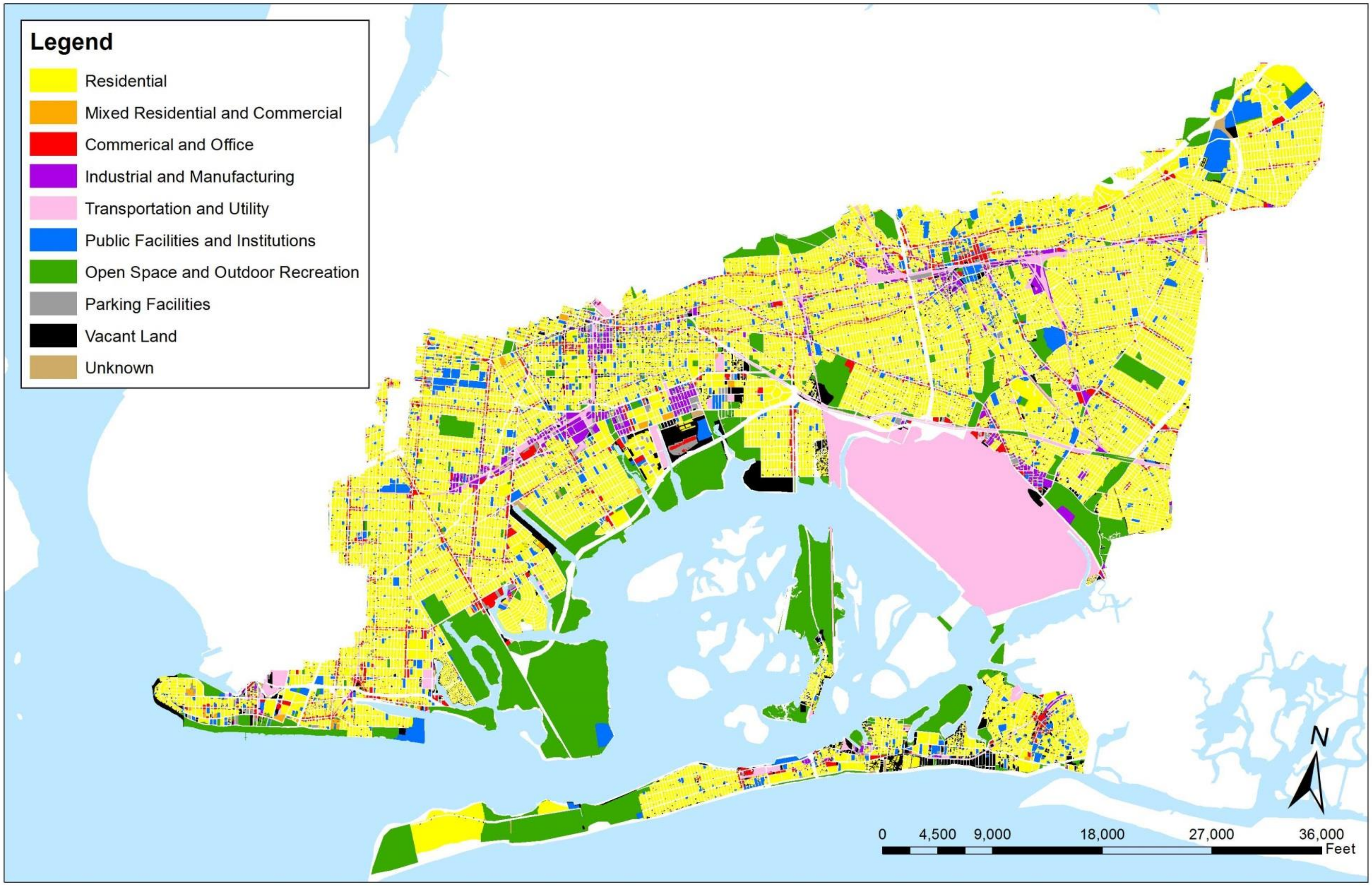

Figure 2-5. Land Use in the Jamaica Bay Sewershed

Canarsie Pier, Dead Horse Bay, Plumb Beach, Bergen Beach, and a portion of the Rockaway Peninsula. The sewershed contains two State parks: Bayswater State Park and Rockaway Beach State Park. The sewershed also contains numerous City parks including Marine Park, Broad Channel Park, Dubos Point Park, Idlewild Park, and many smaller neighborhood parks and playgrounds.

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.

As indicated in Table 2-1, approximately 50 percent of the sewershed is zoned residential with the largest share (74 percent) being low density housing consisting of R1, R2, R3, and R4 districts. Medium density residential districts including R5, R6, and R7 districts account for approximately 26 percent of the residential zoning and high density residential districts, R8 or higher make up less than one percent of residential zoning within the watershed. Manufacturing zones cover approximately two percent of the sewershed while commercial zones cover less than five percent. About 19 percent of the watershed consists of parks or other open space.

In an effort to identify siting opportunities for potential CSO facilities in the future, Figure 2-6 identifies the zoning classifications within a quarter mile of the shoreline of Jamaica Bay and its tributaries. As indicated in Table 2-1, park properties are the predominant zoning classification making up to 44 percent of the quarter mile buffer, largely due to the aforementioned GNRA sites surrounding the Bay and its shorelines. JFK International Airport contributes a large percentage to transportation and utility zones (16 percent) within a quarter mile of the shoreline. Residential zoning comprise approximately 26 percent of the quarter mile buffer with 72 percent of this residential zoning being low density housing consisting of R1, R2, R3, and R4 districts. Commercial zones cover two percent of the area within a quarter mile of the shoreline.

In addition to the standard zoning classifications, three "Special Use Districts" are located within the Jamaica 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 Sheepshead Bay Special Use District was identified to protect and strengthen that neighborhood's waterfront recreation and commercial character. New commercial projects and residential development must meet conditions that will support the tourist-related activities along the waterfront. Provision for widened sidewalks, landscaping, useable open space, height limitations, and additional parking areas have been established. The Ocean Parkway Specials Use District encompasses a band of streets east and west of the parkway extending from Prospect Park to Brighton Beach. The purpose of this special use district is to enhance the character and quality of this broad, landscaped parkway which is a designated Scenic Landmark. The Special Downtown Jamaica District initiated a comprehensive planning and rezoning strategy to replace outdated zoning that did not adequately address Jamaica's current and future housing and economic needs. The Jamaica rezoning plan would preserve lower

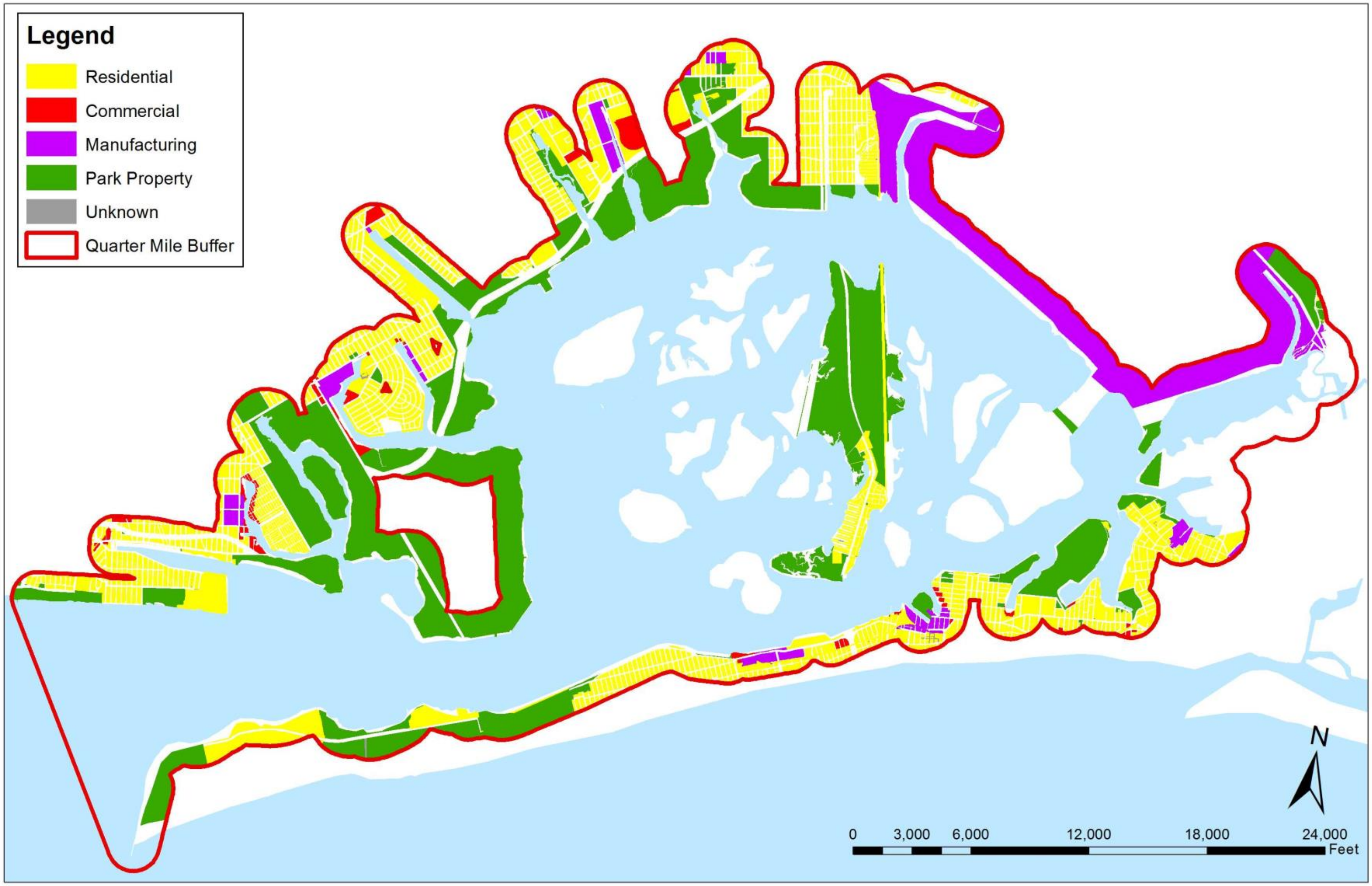

Figure 2-6. Zoning within 1/4 Mile of Shoreline

density one- and two-family neighborhoods surrounding downtown while providing a mix of business, community, and residential growth in the downtown area.

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

- The Jamaica Now Action Plan builds on Jamaica's historic legacy to sustain and enhance the neighborhood as a unique central business district that evolves as a livable, cultural, and attractive destination for residents and visitors. Uniting new initiatives with ongoing projects, the Action Plan seeks to address the challenges that have faced the Jamaica area in recent years by providing workforce training and small business support, initiating new mixed-use development anchored by affordable housing, and improving the livability of the neighborhood through investment in safety measures and green spaces.

- The Jamaica Infrastructure Improvements consist of three key projects that will create attractive new gateways to downtown Jamaica. The Sutphin Underpass, completed in 2012, created a more attractive street-level pedestrian experience directly across the street from the Air Train Terminal by illuminating the underpass and creating new retail space. The Atlantic Avenue Extension will ease traffic into and out of the Jamaica Station area and create new neighborhood open space. The Station Plaza Redevelopment will decrease traffic congestion, create a safer pedestrian environment, and create new public plazas.

- The Downtown Far Rockaway Urban Design and Reconstruction Project is aimed at enhancing the public realm in Downtown Far Rockaway by implementing a comprehensive urban design plan and streetscape improvements that would encourage safer, more hospitable pedestrian circulation while employing sustainable, energy efficient, and cost-effective materials, as well as image defining street design elements. This project will help accomplish the larger goals of inviting increased activity in the central business district and strengthen the districts environmental sustainability and resiliency in the wake of weather events.

- The Build It Back program is rebuilding and elevating almost 1,400 homes to current regulations for flood compliance. Another 6,500 homeowners with moderate damage from Hurricane Sandy are being assisted with repair and reimbursement. Build It Back has served 99 percent of all active homeowners by starting construction, reimbursement of repairs, or acquisition of their homes. Neighborhoods receiving repair assistance include Howard Beach, Belle Harbor, Rockaway Park, Far Rockaway-Bayswater, and Canarsie.

- Under the PlaNYC program, the DEP initiated several Watershed Restoration Pilot Studies in an effort to improve and restore Jamaica Bay habitat and water quality. Oyster, eel grass, and ribbed mussel pilot studies were conducted to establish cost, benefits, and success ratios associated with restoration of these important habitat types. The program also identified and inventoried salt marsh and beach habitats for future preservation and restoration. Algae and sea lettuce harvesting pilot studies were conducted to determine feasible, cost-effective methods to remove these plants and improve dissolved oxygen (DO) levels in the Bay.

- Plans for the expansion and upgrade of JFK International Airport (depicted in Figure 2-7**)** include redeveloping older terminals and enlarging newer terminals, expanding taxiways to reduce

Figure 2-7. JFK International Airport Redevelopment Graphic

ground delays and add new flight slots, redesigning airport roadways to develop a “ring road” configuration to improve access, and providing world class amenities including fine dining and best-in-class retail, hotel, and conference facilities.

- 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. Jamaica Bay is identified as Reach 17 within the Vision 2020 plan and consists of 10 site-specific waterfront revitalization strategies (Figure 2-8).

- The DEP has initiated the Southeast Queens Drainage Plan to better manage stormwater through a comprehensive upgrade of the sewer system that will include storm sewer infrastructure improvements (e.g., installation of catch basins, storm sewers, and high level storm sewers [HLSS]) to improve stormwater drainage and reduce flooding in Community Board Districts 12 and 13 and installation of grey/green infrastructure (e.g., bioswales and other greenspaces) to capture and infiltrate stormwater runoff.

2.1.a.2 Permitted Discharges

The Jamaica Bay sewershed contains 22 SPDES-permitted CSO outfalls, 109 SPDES-permitted DEP-owned MS4 outfalls, 4 wastewater treatment plants, and 2 CSO facilities. These discharge locations are shown on Figure 2-9 and discussed in more detail in Section 2.1.c. In addition, JFK International Airport contains 31 SPDES-permitted stormwater outfalls (SPDES No. NY-000 8109) into Jamaica Bay and Bergen and Thurston Basins.

2.1.a.3 Impervious Cover Analysis

Impervious surfaces within a watershed are those characterized by an artificial 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 WWTPs that serve combined watersheds to support the several 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

Neighborhood Strategies

Reachwide

- Improve coordination between city, state, and federal agencies to create a comprehensive public access strategy for the bay, including coordinating with the National Park Service on the General Management Plan process for all sites that are part of Gateway National Recreation Area (GNRA).
- Implement marshland restoration projects, including local sponsorship of the U. S. Army Corps restoration project at Yellow Bar Hassock.
- Complete installation of nitrogen control technologies at Waste Water Treatment Plants.

From Spring Creek to Fresh Creek 1

- Preserve and promote public awareness of salt marshes and support restoration plans for Spring Creek.
- For portion of Belt parkway between Fresh Creek and Knapp Street, support bridge and roadway improvements to enhance pedestrian and bike connectivity, and with improvements to natural landscape.
- Explore opportunities for boat launch and fishing based on the criteria described in the Citywide Strategy.
- Improve pedestrian access to existing waterfront parks.
- Continue monitoring of capped Pennsylvania and Fountain Ave. landfills and explore future opportunities for public access (GNRA).
- Improve maintenance and explore options for public access in Fresh Creek.

From Fresh Creek to Paerdegat Basin 2

- Conduct a ribbed mussel pilot, evaluating filtration of pollutants.
- Explore options for rehabilitation and further active, cultural use of historic Canarsie pier (GNRA).
- Complete restoration of Canarsie Park including a nature trail.
- Complete CSO storage facility and Ecology Park including tidal wetland and adjacent upland habitat.

Mill Basin (Fort Sparrow Marsh) 3

- Support development of city-owned land along Flatbush Ave with public access where appropriate and protection of ecologically-sensitive areas.

Floyd Bennett Field & Jacob Riis Park 4

- Support plans to maximize public use and activation (GNRA).
- Explore options for boat access to Jamaica Bay in Jacob Riis Park.
- Collaborate on work of the Floyd Bennett Field Blue Ribbon Panel.

Former Schmitt's Marina Site 5

- Explore options for creating a nature preserve and publicly accessible open space with walkways and seating.

Beach Channel West/Beach Channel Park 6.a

- Secure funding for seawall repair from the Cross Bay Bridge to Beach 156th St. and improve public access along the bay by enhancing walkway connections between Tribute Park at Beach 116th St. and Beach 130th St.

Beach 108th St. 6.b

- Examine options for the reuse of the LIPA site once remediation is complete, as well as the vacant City-owned waterfront lots on the bay for waterfront recreation and transportation opportunities.

Beach Channel 7

- Improve Beach 88th St. for waterfront public access with walkways and seating.
- Support proposed commercial and marina development at Beach 80th St. which will restore the wetlands located on the site, provide public access on designated walkways, and provide a human-powered boat launch.

Arverne Urban Renewal Area 8

- Complete construction of the Arverne by the Sea project, including the Dunes, and a new YMCA recreation center, and ensure implementation of all five oceanfront public access paths, including Beach 67th St. which would lead to the elevated transit station.
- Improve wayfinding along Beach 59th St. to connect waterfront resources on the ocean and bay as well as the elevated transit station and planned Rockaway Institute for Sustainable Environment.
- Support planned educational center and nature preserve and maintain habitat between Beach 44th St. and Beach 56th St.

Edgemere 9

- Continue construction of Edgemere Urban Renewal Area with housing, parks, and additional open spaces.
- Examine possible future uses for remediated landfill in conjunction with a master plan for Rockaway Community Park that improves pedestrian access and includes opportunities for boat launch based on the criteria in the Citywide Strategy.
- Address mosquito issue and restore shoreline and habitats.

Idlewild Park 10

- Advance park master plan to enhance public access including an environmental education center.
- Explore opportunities for an additional human-powered boat launch based on the criteria described in the Citywide Strategy.

Rockaway Peninsula

- Conduct an eel-grass pilot study at Breezy Point Tip.
- Explore providing human powered boat access to the Atlantic Ocean.
- Coordinate any additional community suggestions for improving waterfront access with current set of recommendations.
- Support the implementation of the National Park Service's Jamaica Bay Greenway Missing Links Study and the Department of City Planning's Bike Lanes Under Elevated Rail Lines report.
- Complete improvements to Rockaway Beach Park, including recreational areas and amenities.

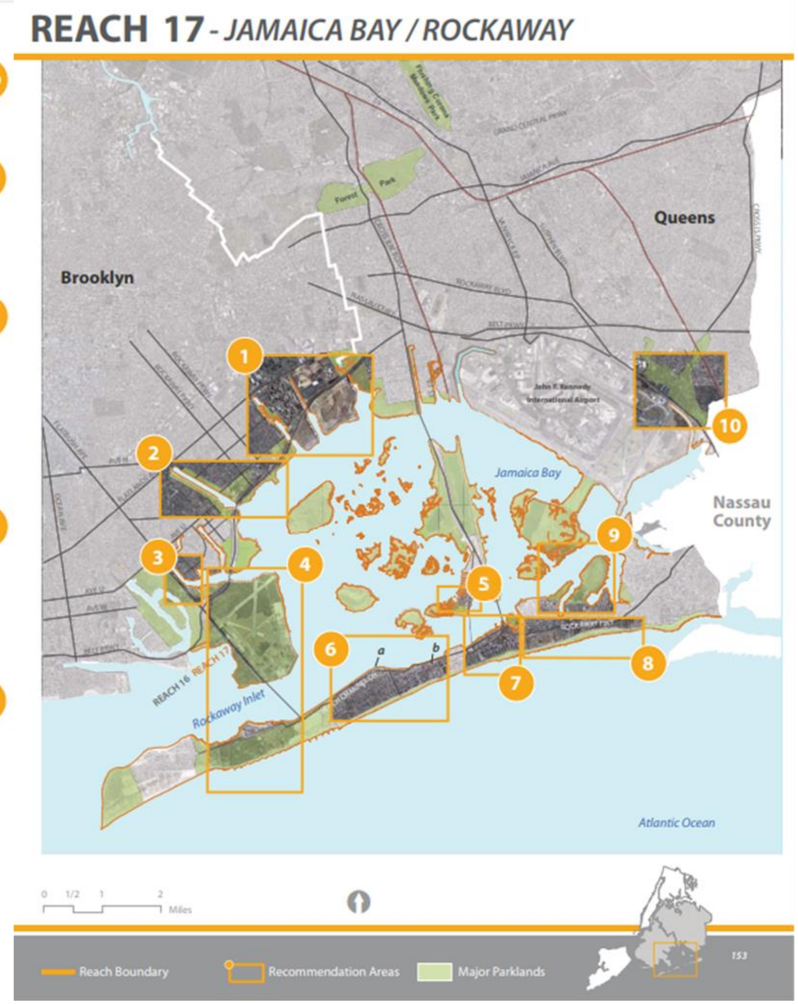

Figure 2-8. NYCDCP Vision 2020 Comprehensive Waterfront Plan – Reach 17

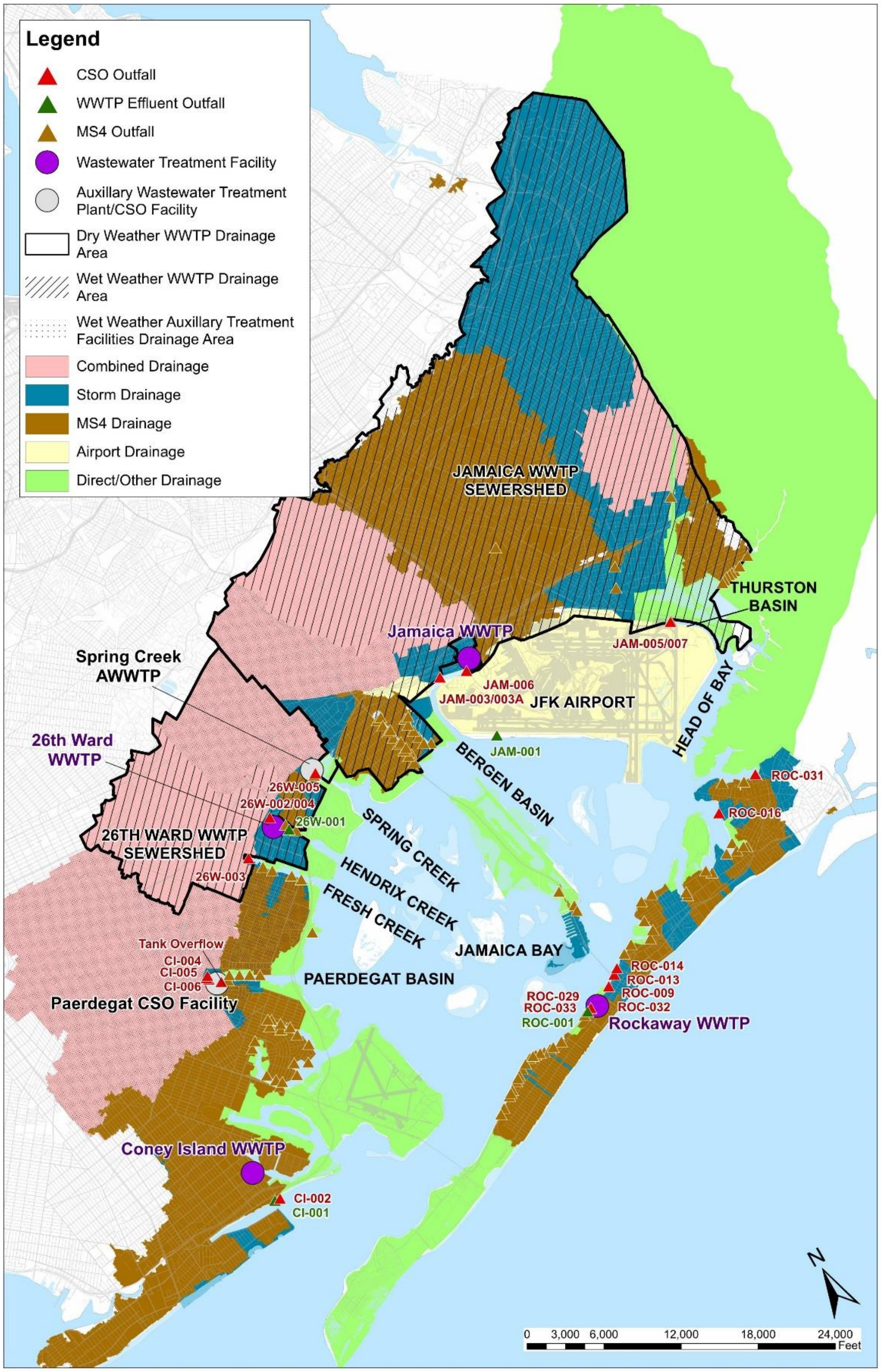

Figure 2-9. Jamaica Bay WWTP Sewershed and Outfalls

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™ (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 better deployment of GI projects to reduce runoff from impervious surfaces that contribute flow to the CSS.

2.1.a.4 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 New York City Department of Planning (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 Coney Island WWTP, 26th Ward WWTP, Jamaica WWTP, and Rockaway WWTP sewersheds. This was accomplished by using Geographical Information System (GIS) tools to proportion the 2040 populations locally from the 2010 census information for each landside subcatchment tributary to each CSO. Per capita dry-weather sanitary sewage flows for these landside model subcatchments were established as the ratio of two factors: the per capita dry-weather sanitary sewage flow for each year; and 2040 estimated population for the landside model subcatchment within the Coney Island WWTP, 26th Ward WWTP, Jamaica WWTP, and Rockaway WWTP sewersheds.

2.1.a.5 Updated Landside Modeling

The majority of the Jamaica Bay sewershed is included within the overall 26th Ward and Jamaica WWTP collection systems IW models. A smaller portion of the sewershed, at the western and southern ends, is represented by the Coney Island and Rockaway WWTPs collection systems IW models. Several modifications to the collection systems have occurred since the models were calibrated in 2007. Given that these models have been used for analyses associated with the annual reporting requirements of the SPDES permit, Best Management Practices (BMPs) and Post-Construction Compliance Monitoring (PCM) program for the Paerdegat CSO Retention Facility and Spring Creek Auxiliary Wastewater Treatment Plant (AWWTP), many of these changes already have been incorporated into the models. Other updates to the modeled representation of the collection systems that have been made since the 2007 update include:

<u>Coney Island/Owl's Head IW Model</u>

- The Owls Head and Coney Island WWTP areas have been integrated into a single IW model network due to certain hydraulic interconnections.

- The Paerdegat Basin CSO Retention Facility was added to the model, including dewatering operations.
- Infiltration and inflow (I&I) from the storm and combined sewers tributary to the Paerdegat CSO Retention Facility was included based on existing conditions.
- The DEP desktop MS4 delineation mapping information was incorporated.
- Green Infrastructure was incorporated based on 2030 projections, including both retention and detention in combined and separate areas.

Jamaica/26th Ward IW Model

- The 26th Ward and Jamaica areas were integrated into a combined 26th Ward/Jamaica IW model.
- The Spring Creek AWWTP was added to the model, including dewatering operations.
- I&I from the storm and combined sewers tributary to the Spring Creek AWWTP was included based on existing conditions.
- The DEP desktop MS4 delineation mapping information (as of October 2017) was incorporated.
- The latest information on the Bergen Basin sewer project (additional sewer crossing Belt Parkway) was incorporated.
- Bending weirs were added at Regulators JA-03, JA-06 and JA-14, including increasing the Regulator JA-03 orifice opening size.
- Actuated control was added for the gate at Regulator JA-02, which diverts wet-weather flow to the Spring Creek AWWTP.
- The latest build out information for HLSS in the Fresh Creek area was added.
- The model network was expanded to include sanitary sewers serving downtown Jamaica, and the future gravity trunk sewer to support redevelopment of downtown Jamaica was included in the baseline conditions model.
- The model was recalibrated based on 10 additional meters installed within the expanded model network serving downtown Jamaica.
- Green Infrastructure was incorporated based on 2030 projections, including both retention and detention in combined and separate areas.

Rockaway IW Model

- Designations of a number of direct drainage areas were updated to storm and sanitary subcatchments based on GIS review.

In addition to changes made to the modeled representations of the collection system configuration, other changes included:

- ***Runoff Generation Methodology***. The identification of pervious and impervious surfaces was updated. In addition, as described in Section 2.1.a.3 above, the impervious surfaces were also categorized into DCIA and impervious runoff surfaces that do not contribute runoff to the collection system.

- ***GIS Aligned Model Networks.*** Historical IW models were constructed using record drawings, maps, plans, and studies. Over the last decade, DEP has been developing a GIS system that provides the most up-to-date information available on the existing sewers, regulators, outfalls, and pump stations. Part of the update and model recalibration utilized data from the GIS repository for interceptor sewers.

- ***Interceptor Sediment Cleaning Data.*** Between April 2009 and May 2011, DEP undertook a citywide interceptor sediment inspection and cleaning program, where over approximately 136 miles of NYC's interceptor sewers were inspected. Data on the average and maximum sediment depth in the inspected interceptors were available for use in the model as part of the update and recalibration process. Multiple sediment depths available from sonar inspections were spatially averaged to represent depths for individual interceptor segments included in the model that had not yet been cleaned.

- ***Evapotranspiration Data.*** Evapotranspiration (ET) is a meteorological input to the hydrology module of the IW model that represents the rate at which depression storage (surface ponding) is depleted and available for use for additional surface ponding during subsequent rainfall events. In previous versions of the model, an average rate of 0.1 inches/hour (in/hr) was used for the model calibration, while no evaporation rate was used as a conservative measure during alternatives analyses. During the update of the model, hourly ET estimates obtained from four National Oceanic and Atmospheric Administration (NOAA) climate stations (John F. Kennedy [JFK], Newark [EWR], Central Park [CPK], and LaGuardia [LGA]) for an 11-year period were reviewed. These data were used to calculate monthly average ETs, which were then used in the updated model. The monthly variations enabled the model simulation to account for seasonal variations in ET rates, which are typically higher in the summer months.

- ***Tidal Boundary Conditions at CSO Outfalls.*** Tidal stage can affect CSO discharges when tidal backwater in a CSO outfall reduces the ability of that outfall to relieve excess flow. Model updates took into account this variable boundary condition at CSO outfalls that were influenced by tides. Water elevation, based on the tides, was developed using a customized interpolation tool that assisted in the computation of meteorologically-adjusted astronomical tides at each CSO outfall in the New York Harbor complex.

- ***Dry-Weather Sanitary Sewage Flows.*** Dry-weather sewage flows were developed as discussed in Section 2.1.a.4 above. Hourly dry-weather flow (DWF) data for 2011 were used to develop the hourly diurnal variation patterns at each plant. For the calibration period, the DWF generation rates were developed by dividing 2011 plant flows by the population from the 2010 census. The DWF generation rate was then applied to each catchment in the model based on population. The resulting DWF was then adjusted, if necessary, to match the calibration meters. The projected 2040 DWF were used in the LTCP Baseline Conditions model that was the basis for evaluating alternatives.

- ***Precipitation.*** The annual rainfall series that was to be used to represent a typical year of rainfall for annual model simulations was re-evaluated as part of this exercise. This re-evaluation is discussed in Section 2.1.b below.

In addition to the updates and enhancements listed above, 13 of DEP's IW landside models underwent recalibration in 2012. 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 WWTPs. 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. These updated models were used for the alternatives analysis as part of the Jamaica Bay LTCP. A comprehensive discussion of the recalibration efforts can be found in the previously noted IW Citywide Recalibration Report (DEP, 2012a) and the Hydraulic Analysis Report (DEP, 2012b). Additional model updates were made in support of this LTCP and were described above.

2.1.b 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. 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 EPA CSO Control Policy 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 selection of 1988 as the average condition was re-considered. A comprehensive range of historical rainfall data were evaluated from 1969 to 2010 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 2-10 shows the annual rainfall at JFK for 1969 through 2014. As indicated in Figure 2-10, the JFK 2008 rainfall currently used for the LTCP typical year includes almost six inches more rainfall than JFK 1988 rainfall that was used for the WWFP evaluations, and is more consistent with recent rainfall trends. As a result, recent landside modeling analyses as part of the LTCP process have used the 2008 precipitation as the typical rainfall year in NYC, together with the 2008 tide observations. The 10-year period of 2002 to 2011 is also used to assess long term performance of the LTCP recommended plans (see Section 6).

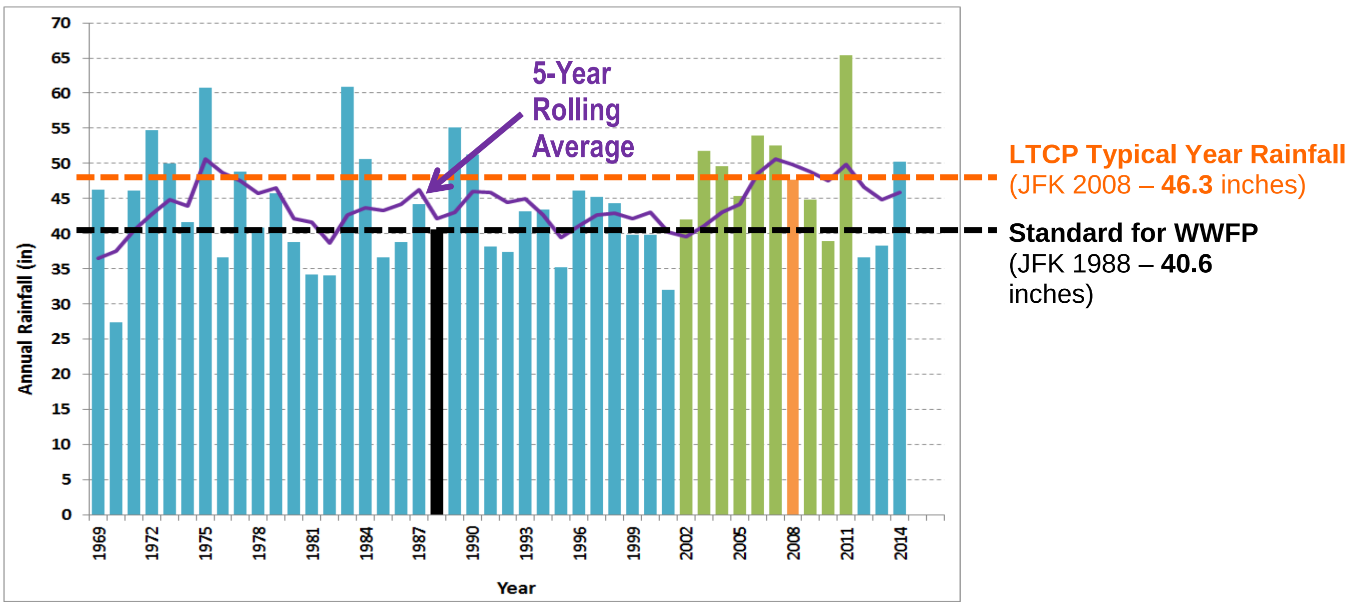

Figure 2-10. Annual Rainfall Data and Selection of the Typical Year

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2.1.c Description of Sewer System

The Jamaica Bay watershed/sewershed is located within the Boroughs of Queens (Queens County, within NYC) and Brooklyn (Kings County, within NYC) and is served by four WWTPs and two CSO facilities. The western shore of the watershed and one tributary with CSO outfalls, Paerdegat Basin, is served by the Coney Island WWTP and its collection system and the Paerdegat Basin CSO Facility. The northern shore of the watershed is served by two WWTPs – 26th Ward on the western side (which includes Fresh Creek, Hendrix Creek, and Spring Creek) and Jamaica on the eastern side (which includes Bergen Basin and Thurston Basin). Both the 26th Ward and Jamaica WWTP tributary areas are major contributors of CSO to the waterbodies. The southern shore is served by the Rockaway WWTP, which contributes no CSO to the waterbody in the typical year. Figure 2-5 and Table 2-1 show the different land uses within the sewersheds of the Coney Island, 26th Ward, Jamaica, and Rockaway WWTPs that are tributary to Jamaica Bay. The locations of these wastewater treatment facilities and the respective sewershed boundaries are shown in Figure 2-9. The CSO and stormwater outfalls associated with Jamaica Bay are shown in Figure 2-11. As the figure shows, numerous discharge points are located around the perimeter of Jamaica Bay and Tributaries. In total, 554 discharge points have been documented to exist along the shoreline of Jamaica Bay and Tributaries by the Shoreline Survey Unit of the DEP, as shown in Table 2-2.

Table 2-2. Outfalls Discharging to Jamaica Bay

Identified Ownership of Outfalls	Number of Outfalls
DEP	DEP MS4 Permitted = 109
	DEP Non-MS4 Permitted = 26
	DEP CSO Permitted = 22
DEC	15
NYS Department of Transportation	74
Private	250
Unknown	56
Total	554

2.1.d Southeast Queens Sewer Buildout

Under OneNYC, DEP has taken on an extensive sewer buildout in Southeast Queens that is intended to help alleviate upland flooding and improve the drainage and conveyance of stormwater from the roadways and neighborhoods into the receiving waters. Over the next 10 years, DEP's capital budget includes about $1.7B to continue this long term sewer buildout. Full buildout will go well beyond the 10 year plan and will include installation of about 450 miles of new storm sewers. In addition, approximately 260 miles of new sanitary sewers and an additional 30 miles of combined sewers will be constructed. Upon completion, this project is expected to greatly alleviate flooding and also significantly reduce CSO discharges into Thurston Basin. Given the timeframe for the Southeast Queens improvements, the water quality improvements projected from these future projects were not included in the baseline for this LTCP, and projected water quality improvements from the Recommended Plan do not include the projected improvements from the current planned sewer buildout in Southeast Queens.

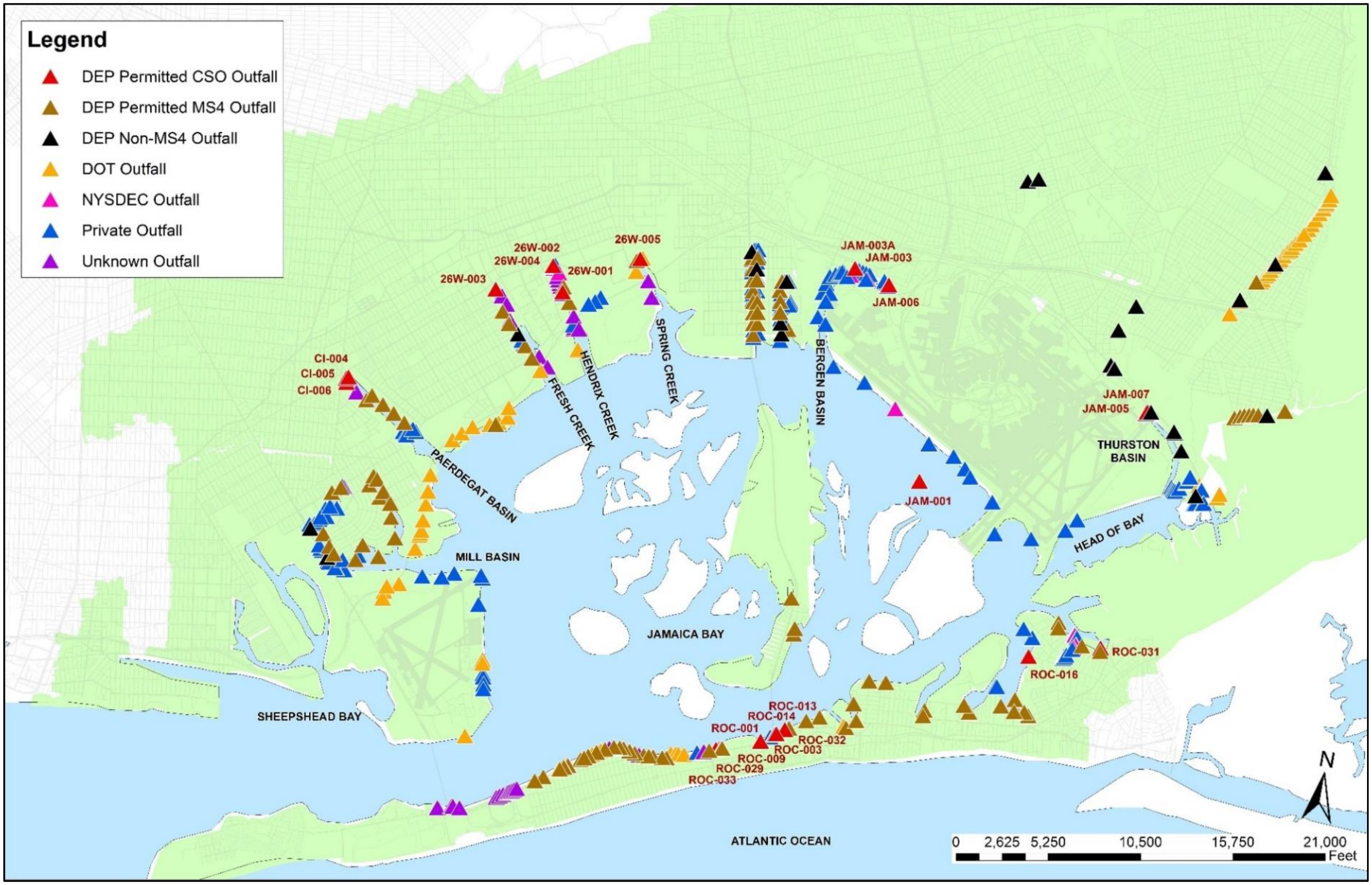

Figure 2-11. All Outfalls Discharging to Jamaica Bay

The following sections describe the major features of the Coney Island, 26th Ward, Jamaica, and Rockaway WWTP sewersheds within the Jamaica Bay watershed. For each sewershed, Table 2-3 identifies the waterbodies that continue to receive permitted CSO discharges after implementation of the WWFPs and Table 2-4 provides the drainage areas served by the various sewer system categories within each tributary waterbody.

Table 2-3. WWTP and Receiving Waterbody Classifications

WWTP	CSO Receiving Water(s)	Waterbody Classification
Coney Island	Paerdegat Basin	**I**
26th Ward	Hendrix Creek, Fresh Creek, Spring Creek	**I**
Jamaica	Bergen Basin, Thurston Basin	I
Rockaway	Open water areas of Jamaica Bay, Norton Basin, Bannister Creek, Mott Basin	**SB**

Table 2-4. Drainage Area by Tributary Waterbody and Sewer Category

Waterbody	Area (Acres)					
	Combined	DEP MS4	Stormwater	Airport	Direct Overland and Other	Total
Thurston Basin	1,167	0	6,873	973	207	**9,220**
Bergen Basin	2,873	5,594	1,159	606	56	**10,288**
Hawtree Creek	0	99	68	0	0	**167**
Shellbank Basin	0	676	13	0	0	**689**
Spring Creek	3,289	67	579	0	323	**4,258**
Hendrix Creek	245	95	103	0	0	**443**
Fresh Creek	2,521	323	198	0	132	**3,174**
Paerdegat Basin	5,192	281	205	0	245	**5,923**
Jamaica Bay - Coney Island (Excl. Paerdegat Basin)	0	4,789	162	0	2,224	**7,175**
Jamaica Bay - Rockaway	0	1,472	1,283	0	2,570	**5,325**
Jamaica Bay - JFK Airport (Excl. Thurston and Bergen Basins)	0	0	0	2,430	0	**2,430**
Head of Bay (Nassau County)	0	0	0	0	17,177	**17,177**
Total	**15,287**	**13,396**	**10,643**	**4,009**	**22,934**	**66,269**

2.1.d.1 Overview of Drainage Area and Sewer System

Coney Island WWTP Drainage Area and Sewer System

The Coney Island WWTP is located at 2591 Knapp Street in the Sheepshead Bay section of Brooklyn, on a 30-acre site adjacent to the Rockaway Inlet/Shell Bank Creek. The Coney Island WWTP serves approximately 15,087 acres in the southern/central section of Brooklyn, including the communities of Sea Gate, Coney Island, Brighton Beach, Homecrest, Manhattan Beach, Sheepshead Bay, Manhattan Terrace, Midwood, Gerritsen Beach, Plum Beach, Flatlands, Canarsie, Paerdegat Basin, Georgetown, Mill Basin, Marine Park, Bergen Beach, Mill Island, Rugby, Remsen Village, East Flatbush, Ditmas Park, and Wingate.

Full secondary treatment has been provided at the Coney Island WWTP since 1994, including 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 Coney Island WWTP has a design dry-weather flow (DDWF) capacity of 110 million gallons per day (MGD), and is designed to receive a maximum flow of 220 MGD (2xDDWF) with 165 MGD (1.5x DDWF) receiving secondary treatment. Flows over 165 MGD receive primary treatment and disinfection. The Coney Island WWTP is required to be upgraded for Biological Nitrogen Removal in accordance with the First Amended Nitrogen Consent Judgment (FANCJ) and construction is projected to be completed in 2022.

Figure 2-12 shows the Coney Island Creek WWTP collection system. Wastewater flows are conveyed to the Coney Island WWTP by the 120-inch diameter Paerdegat Interceptor, which primarily serves a combined drainage area, and the Coney Island Interceptor, which serves a separate drainage area. The Coney Island WWTP sewershed includes the Paerdegat Basin Pumping Station (as shown in Figure 2-12), five combined sewer regulator structures which discharge to Paerdegat Basin through three SPDES-permitted CSO outfalls, and five SPDES-permitted MS4 outfalls. The sewershed tributary to the Paerdegat Basin CSO regulators is approximately 5,678 acres, of which 5,192 acres (91 percent) is served by combined sewers and 486 acres (9 percent) by separate sanitary and storm sewers. An additional 245 acres drain directly to Paerdegat Basin from parks and other undeveloped lands adjacent to Paerdegat Basin.

The Coney Island WWTP sewershed also includes the Paerdegat Basin CSO Facility, as shown in Figure 2-12, which was completed in May 2011 and has the capacity to store up to 50 MG of CSO (30 MG of off-line tank storage and 20 MG of in-line storage in the upstream connecting sewers). When the retention tank reaches capacity, overflows are discharged to Paerdegat Basin from the tank (after screening for floatables capture), as well as through three CSO outfalls (CI-004, CI-005, CI-006). Post-event, retained flow is pumped to the Paerdegat Interceptor sewer and conveyed to the Coney Island WWTP for treatment.

26th Ward WWTP Drainage Area and Sewer System

The 26th Ward WWTP is located at 122-66 Flatlands Avenue in the East New York section of Brooklyn, on a 45.5 acre site adjacent to Hendrix Creek. The 26th Ward WWTP serves an area in the eastern section of Brooklyn, including the communities of Brighton Beach, Manhattan Beach, Gravesend, Sheepshead Bay, Marine Park, Mill Basin, Bergen Basin, Midwood, Flatwoods, Flatbush-Ditmas Park, East Flatbush, Crown Heights, and Canarsie.

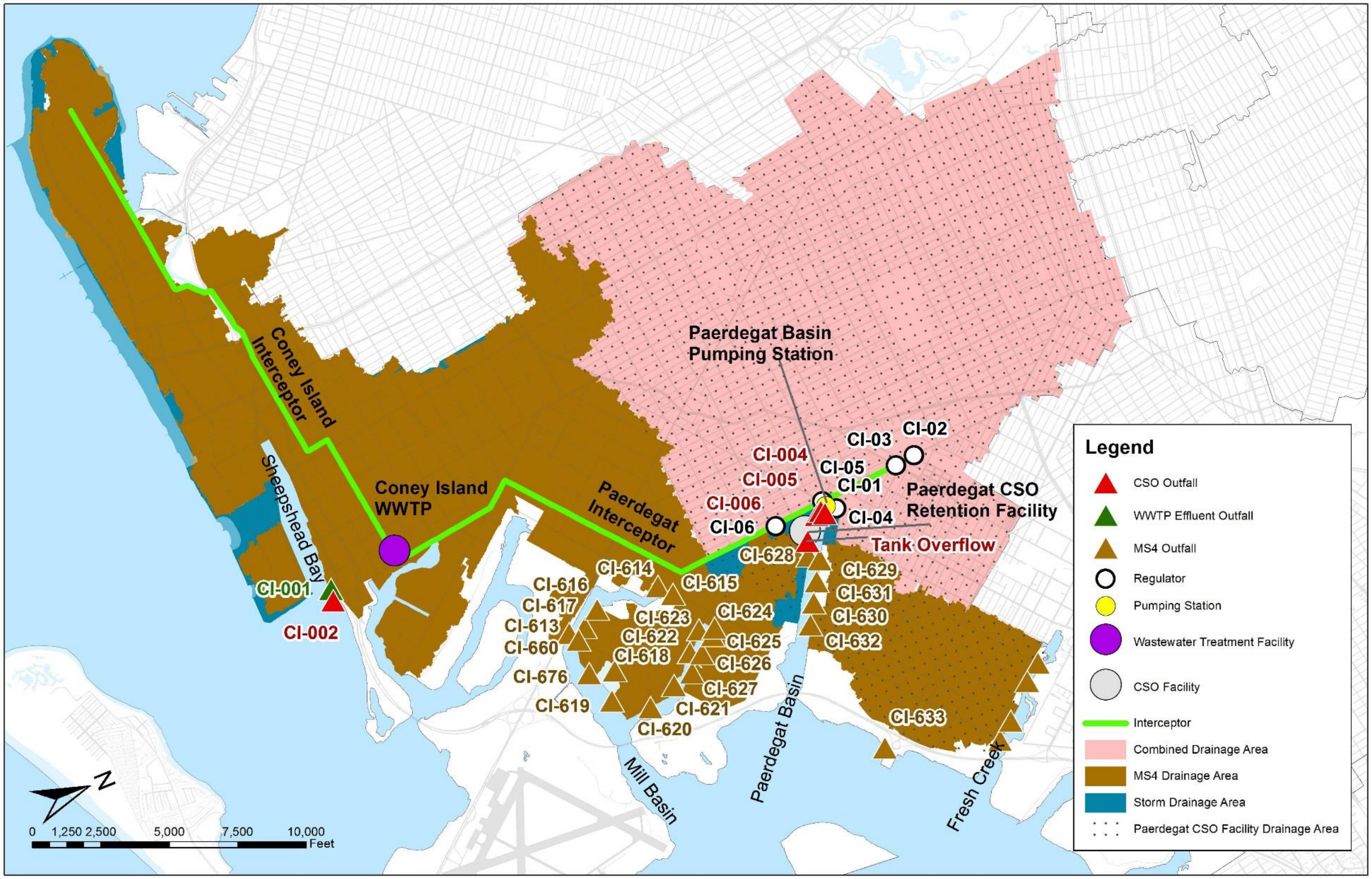

Figure 2-12. Coney Island WWTP Collection System

The 26th Ward WWTP has a DDWF capacity of 85 MGD, and is designed to receive a maximum flow of 170 MGD (2xDDWF) with 127.5 MGD (1.5xDDWF) receiving secondary treatment. Flows over 127.5 MGD receive primary treatment and disinfection. Under the FANCJ, 26th Ward WWTP has been upgraded for Biological Nitrogen Removal, which has resulted in significant decreases in nitrogen loadings into Jamaica Bay.

The 26th Ward WWTP drainage area consists of 7,420 acres (combined sewer = 6,055 acres, separate sanitary/storm = 1,365 acres, direct runoff = 455 acres). Starrett City, located west of the WWTP, and the Gateway Center, located on the east side of the WWTP, are the only separately sewered areas in the 26th Ward system. The sewershed and collection system for the 26th Ward WWTP is depicted in Figure 2-13. Wastewater is conveyed to the 26th Ward WWTP via the Hendrix Street Canal Interceptor, Flatlands Avenue Interceptor, and Vandalia Avenue Interceptor.

The 26th Ward WWTP sewershed also includes the Spring Creek AWWTP retention facility which was placed into service in the early 1970s and has undergone recent upgrades. The primary function of the Spring Creek AWWTP is to capture CSO from the tributary drainage areas in Brooklyn and Queens and convey them to the 26th Ward WWTP for treatment. Flow is conveyed to the AWWTP by four overflow barrels from the Autumn Avenue Regulator (26W-03) located in the Borough of Brooklyn, and by two overflow barrels from the 157th Avenue Regulator (JA-02) located in the Borough of Queens. Spring Creek AWWTP can provide up to 38 MG of CSO storage. The total tributary area is comprised of 3,486 acres (1,801 acres in Brooklyn and 1,685 acres in Queens). Post-event, captured CSO is pumped back into the sewer system to be conveyed to the 26th Ward WWTP. Figure 2-14 shows the Spring Creek AWWTP.

<u>Jamaica WWTP Drainage Area and Sewer System</u>

The Jamaica WWTP (Figure 2-15) is located at 150-20 134th Street in the Jamaica section of Queens, on a 34.6 acre site adjacent to the Bergen Basin. The Jamaica WWTP serves an area in the southeastern section of Queens, including the communities of Howard Beach, Ozone Park, Woodhaven, Richmond Hill, South Ozone Park, South Jamaica, Jamaica, Street Albans, Queens Village, Laurelton, Rochdale, Springfield Gardens, Rosedale, and Valley Stream.

The Jamaica WWTP has a DDWF capacity of 100 MGD, and is designed to receive a maximum flow of 200 MGD (2xDDWF) with 150 MGD (1.5xDDWF) receiving secondary treatment. Flows over 150 MGD receive primary treatment and disinfection. Under the FANCJ, Jamaica WWTP has been upgraded for Biological Nitrogen Removal, which has resulted in significant decreases in nitrogen loadings into Jamaica Bay.

Figure 2-16 shows the collection system tributary to the Jamaica WWTP. The Jamaica WWTP services approximately 37 percent of the Borough of Queens and has a drainage area of approximately 23,352 acres. Approximately 15,303 acres of the collection system is served by separate sewers and 4,040 acres by combined sewers, with 552 acres providing direct runoff to Jamaica Bay. JFK Airport, owned and operated by the Port Authority of NY & NJ, makes up the remaining 4,009 acres of land served by the Jamaica WWTP collections system. The sanitary system tends to be influenced by inflow sources in areas where stormwater systems have not yet been constructed. Due to the lack of storm sewers, stormwater has been historically drained to the sanitary sewer system to relieve flooding in low lying areas throughout the upstream collection system drainage areas tributary to Bergen and Thurston Basins. These areas have been modeled to reflect the sewer response to wet-weather. In total, the area is

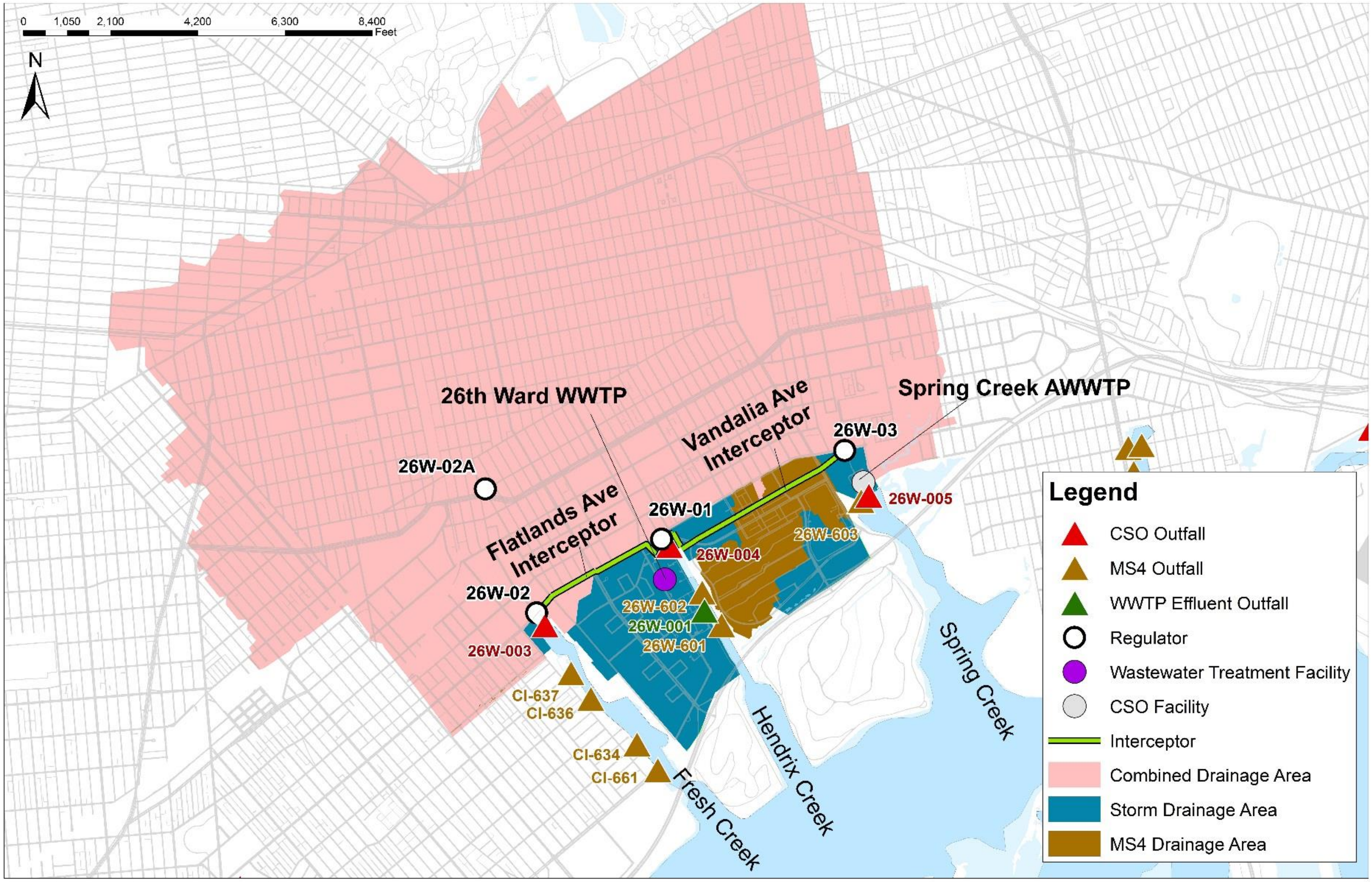

Figure 2-13. 26th Ward WWTP Collection System

AECOM with Hazen

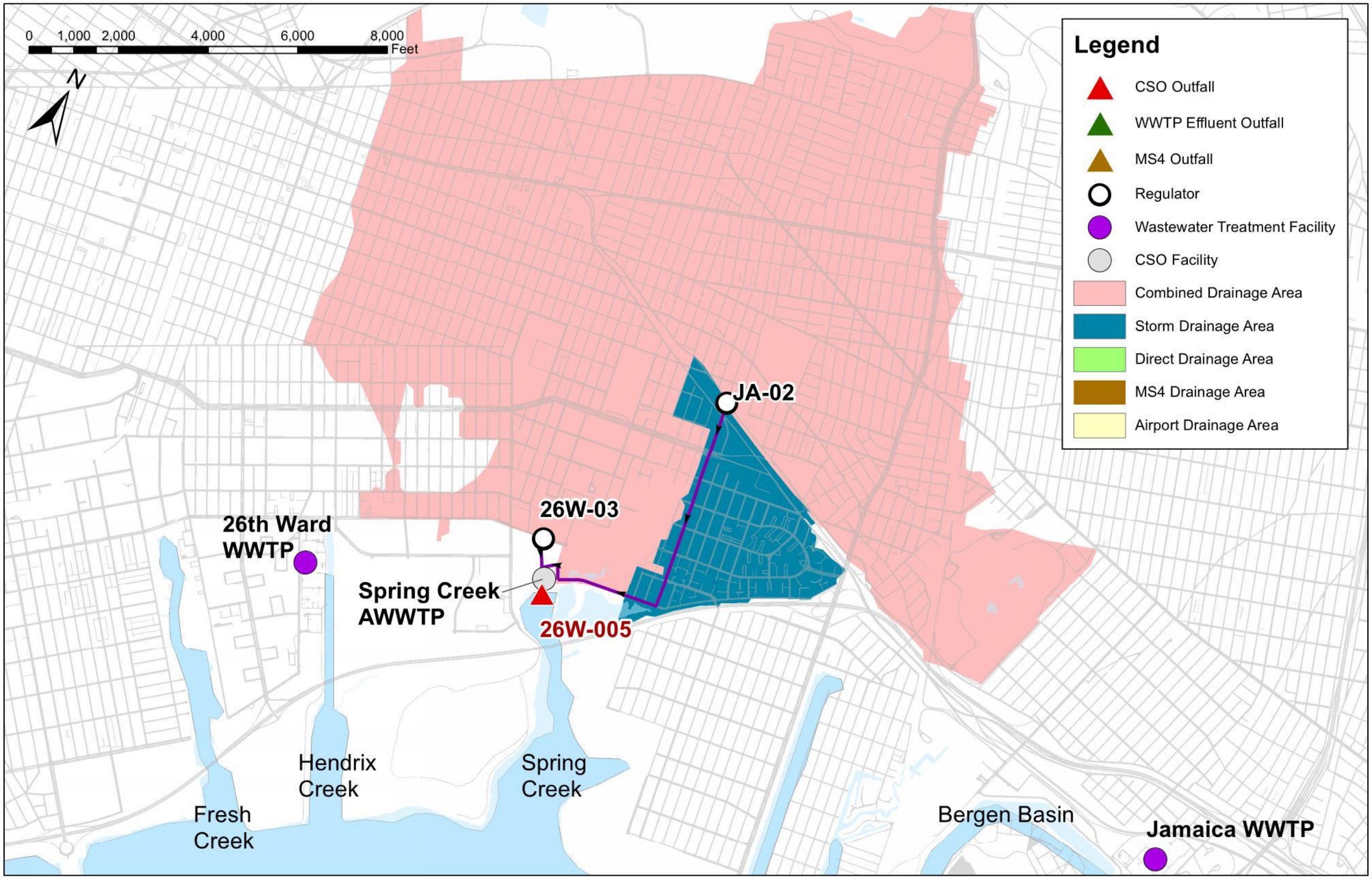

Figure 2-14. Spring Creek AWWTP Collection System

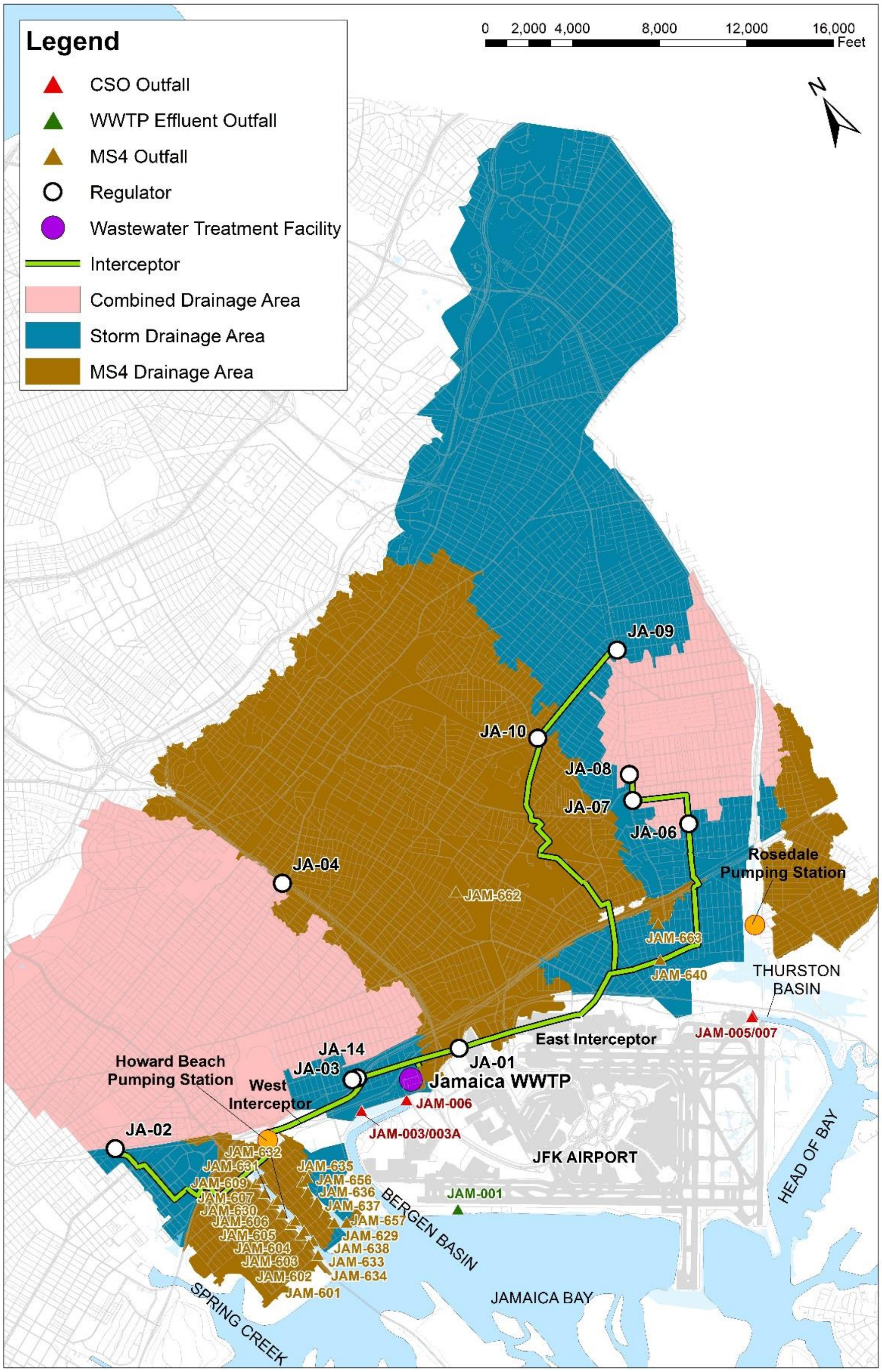

Figure 2-15. Jamaica WWTP Collection System

serviced by 200 miles of combined sewers, 552 miles of sanitary sewers, and 390 miles of storm sewers. In addition, Jamaica Bay Regulator J-2, which has a drainage area of approximately 1,255 acres, directs wet-weather flow to the Spring Creek AWWTP.

The Jamaica WWTP sewershed also includes two pumping stations. The Howard Beach Pumping Station is fed by combined sewers which serve the Ozone Park, Lindenwood, and Howard Beach areas within the southwestern portion of the Borough of Queens. This pumping station also receives DWF from Regulator JA-02 that was designed to divert CSO to the Spring Creek AWWTP during wet-weather conditions. The Rosedale Pumping Station is fed by a separately sewered area and pumps to a gravity branch sewer of the East Interceptor. The pumping station is located on 147th Avenue west of Brookville Boulevard and is equipped with three pumps rated at 4,150 gpm (6 MGD) each.

Rockaway WWTP Drainage Area and Sewer System

The Rockaway WWTP is located at 106-21 Beach Channel Drive in the Rockaway section of Queens, on a 10.82-acre site adjacent to the southern shore of Jamaica Bay. The Rockaway WWTP serves the sewered area in the southernmost section of Queens, including the communities of Far Rockaway, Broad Channel, Rockaway Park, Seaside, and Averne. The corresponding Rockaway WWTP sewershed is shown in Figure 2-16. A total of 2,755 acres of the Jamaica Bay watershed area are served by the Rockaway WWTP, with an additional 2,570 acres providing direct runoff to Jamaica Bay.

The Rockaway WWTP has a DDWF capacity of 45 MGD, and is designed to receive a maximum flow of 90 MGD (2xDDWF) with 67.5 MGD (1.5xDDWF) receiving secondary treatment. Flows over 67.5 MGD receive primary treatment and disinfection. Under the FANCJ, Rockaway WWTP is being upgraded for Biological Nitrogen Removal and construction is projected to be completed in 2020.

The Rockaway WWTP serves the Rockaway Peninsula and the community of Broad Channel in the middle of Jamaica Bay. The sewer system was designed as a completely separate system. However, when the sewer system was originally constructed only sanitary sewers were installed. The storm sewers have not yet been fully built out. The WWTP is located towards the center of the peninsula and receives flow from two interceptors: a 48-inch interceptor that conveys flows from the western portion of the drainage area and a 66-inch interceptor that services the eastern part of the drainage area. These interceptors merge on Beach Channel Drive and convey wastewater to the WWTP through a single conduit. The western interceptor and all of its tributary sewers flow by gravity while the flow from the eastern side of the peninsula is conveyed by a combination of gravity and pumping.

Non-Sewered Areas

Some areas within the Jamaica Bay sewershed are considered direct drainage areas, where stormwater drains directly to receiving waters without entering the combined sewer system or a separate drainage pipe network. As shown in Figure 2-3, these areas are generally located along the shoreline. Some areas, also shown in Figure 2-3, are not served by sanitary sewers, relying on on-site septic systems for sanitary sewage disposal. In some of these areas, including Southeast Queens, redevelopment will include build out of sanitary sewers tributary to the 26th Ward WWTP and Jamaica WWTP CSS and storm sewers discharging through outfalls to Jamaica Bay. This redevelopment is part of Reach 17 – Jamaica Bay/ Rockaway of the Vision 2020 New York City Comprehensive Waterfront Plan. The planned redevelopment areas are shown in Figure 2-8. The Plan also proposes the completion of nitrogen control

Figure 2-16. Rockaway WWTP Collection System

technologies at the four WWTPs, implementing marshland restoration projects, and improving the coordination between City, State, and federal agencies to create and enhance public access to the Bay.

MS4 Outfalls

A total of 109 SPDES-permitted MS4 outfalls are located within the Jamaica Bay sewershed. Of those, 26 are associated with the Coney Island WWTP sewershed, four are associated with the 26th Ward WWTP sewershed, 33 are associated with the Jamaica WWTP sewershed, and 47 are associated with the Rockaway WWTP sewershed. These MS4 outfalls are shown in Figure 2-11. These outfalls drain stormwater runoff from the separate sanitary sewer areas throughout the planning area. While runoff from these areas does not enter the combined system, the stormwater discharges can also impact the water quality of Jamaica Bay and its tributaries.

CSO Outfalls

A total of 22 SPDES-permitted CSO outfalls are located within the Jamaica Bay sewershed. Three are associated with the collection system tributary to the Coney Island WWTP, one is associated with the Paerdegat Tank CSO Facility, four are associated with the 26th Ward WWTP, and five are associated with the Jamaica WWTP. Nine SPDES-permitted CSO outfalls are associated with the collection system tributary to the Rockaway WWTP. Those outfalls, however, do not contribute CSO to Jamaica Bay during the typical year. The CSO outfalls to Jamaica Bay are shown in Figure 2-9.

2.1.d.2 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 bacteria and *Enterococci* bacteria to use in calculating loadings from various sources.

Table 2-5 shows both the sanitary and stormwater concentrations assigned to the sewersheds of the collection systems that discharge to Jamaica Bay. Influent dry-weather samples at the WWTPs were used to model sanitary concentrations (HydroQual, 2005b). Previously-collected citywide sampling data from Inner Harbor Facility Planning Study (DEP, 1994) was combined with data from the EPA Harbor Estuary Program (HydroQual, 2005a) to develop the stormwater concentrations. The stormwater concentrations shown below are based on the most recent data available. The IW sewer system model (Section 2.1.a.5) was used to generate the flows from NYC CSO and storm sewer outfalls.

A flow monitoring and sampling program targeting CSOs tributary to Jamaica Bay was implemented as part of this LTCP. Data were collected to supplement existing information on the flows/volumes and concentrations of various sources to the waterbody.

CSO concentrations can vary widely and are a function of many factors. Generally, CSO concentrations are a function of the amounts of local sanitary sewage and stormwater runoff entering the combined sewers.

Table 2-5. Jamaica Bay Source Loadings Characteristics

Source	Fecal Coliform (cfu/100mL)	*Enterococci* (cfu/100mL)	BOD_5 (mg/L)
Urban Stormwater (Bergen Basin)(1)	45,000	55,000	15
Urban Stormwater (Rockaway)(2)	35,000	15,000	15
Urban Stormwater (All Others)(2)	120,000	50,000	15
Sanitary for Mass Balance CSOs(3)	4,000,000	1,000,000	110
CSOs 26W-003, JAM-003, JAM-003A, PB-CSO, CI-004, CI-005 and CI-006(4)	Monte Carlo	Monte Carlo	Mass Balance
All other CSOs	Mass Balance	Mass Balance	Mass Balance
Highway/Airport Runoff (5)	20,000	8,000	15
Direct Drainage(6)	4,000	6,000	15
WWTP Effluent(7)	Monte Carlo	Monte Carlo	Quarterly

Notes:

(1) Stormwater bacteria concentrations based on 2015-2017 Jamaica Bay and Tributaries LTCP measurements. Stormwater BOD_5 based on Jamaica Bay Waterbody/Watershed Report (2011).
(2) Stormwater bacteria concentrations based on HydroQual Memo to DEP, 2005a.. Stormwater BOD_5 based on Jamaica Bay Waterbody/Watershed Report (2011).
(3) Sanitary bacteria concentrations from the HydroQual Memo to DEP, 2005a.
(4) MonteCarlo based on 2015 LTCP CSO data.
(5) Highway/Airport runoff concentrations based on airport drainage data used in the Flushing Bay LTCP model estimated from NYS Stormwater Manual, Charles River LTCP, and National Stormwater Data Base.
(6) Direct drainage bacteria concentrations based on NYS Stormwater Manual, Charles River LTCP, and National Stormwater Data Base for commercial and industrial land uses. Direct drainage BOD_5 concentrations specified as stormwater.
(7) WWTP effluent bacteria concentrations based on 2016 DMR measurements: Monte Carlo selection of daily averages for fecal coliform and median of several months for *Enterococci*. BOD concentrations based on quarterly Biowin model results from the FANCJ analysis.

CSO concentrations were measured in 2015 to provide site-specific information for Outfalls 26W-003, JAM-003, JAM-003A, JAM-005, and JAM-007, and at the Paerdegat Basin CSO Facility effluent. The CSO bacteria concentrations were characterized by direct measurements of at least four CSO events during various storms occurring during the months of August 2015 through December 2015. These concentrations are shown in the form of a cumulative frequency distribution in Figure 2-17 through Figure 2-22. 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 are log-normally distributed. Table 2-6 below provides the ranges of the measured CSO fecal coliform and *Enterococci* concentrations for each outfall.

Table 2-6. Jamaica Bay and Tributaries Measured CSO Bacteria Concentrations

Outfall	Fecal Coliform (cfu/100mL)	*Enterococci* (cfu/100mL)
26W-003	54,000 – 790,000	30,000 – 1,300,000
JAM-003	320,000 – 10,700,000	220,000 – 2,400,000
JAM-003A	60,000 – 14,700,000	30,000 – 3,000,000
JAM-005	41,000 – 2,300,000	33,000 – 560,000
JAM-007	2,700 – 250,000	1,000 – 570,000
PB-CSO	320,000 – 3,400,000	150,000 – 1,350,000

Flow monitoring data were collected for CSO Outfalls 26W-003, JAM-003, JAM-003A, JAM-005, and JAM-007 to support the development of the Jamaica Bay and Tributaries LTCP. Descriptions of the 26th Ward WWTP and Jamaica WWTP IW model updates and calibration processes based on the flow monitoring data gathered for Outfalls 26W-003, JAM-003, JAM-003A, JAM-005, and JAM-007 was provided earlier in Section 2.1.a.5.

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.

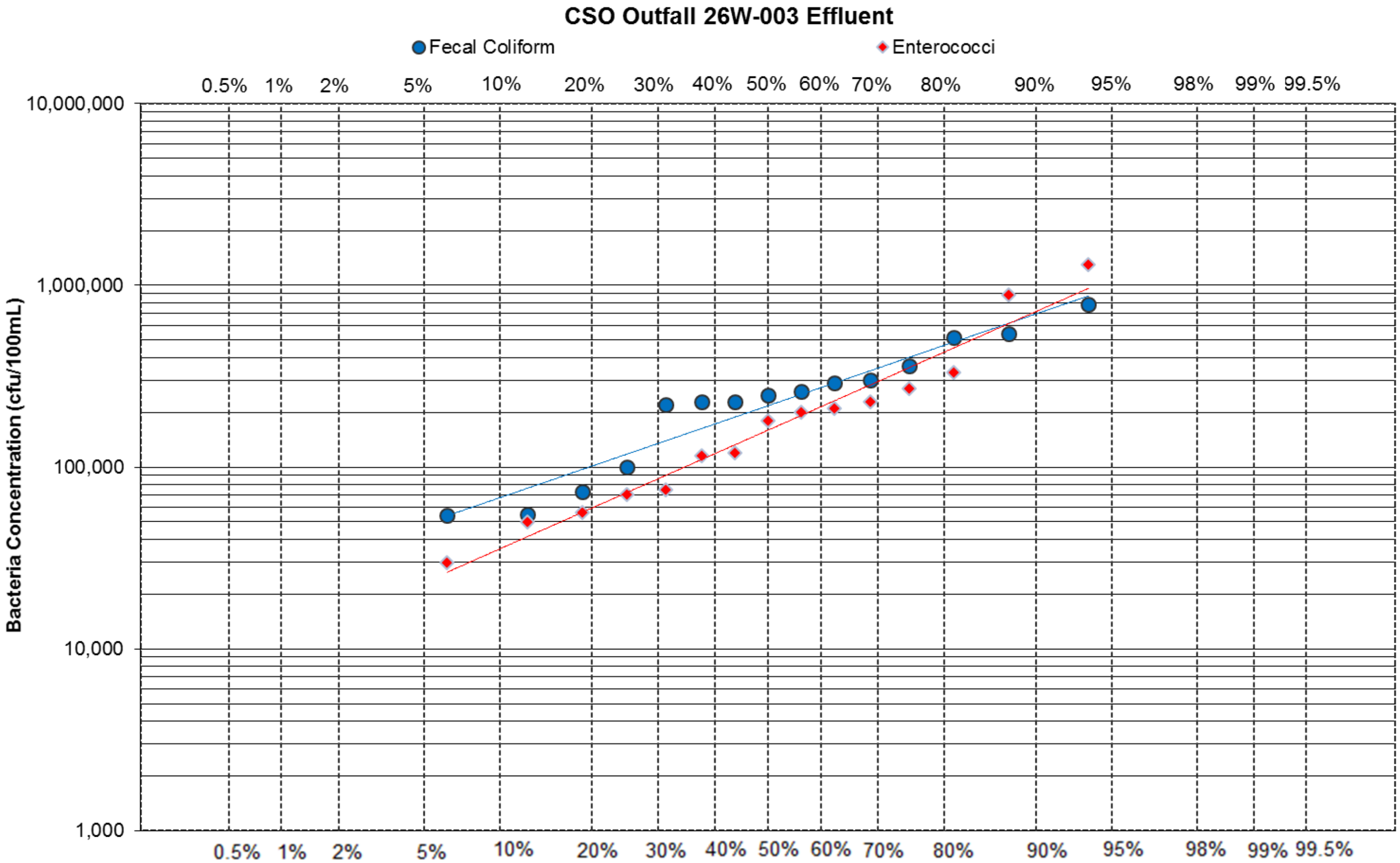

Figure 2-17. Outfall 26W-003 Measured CSO Bacteria Concentrations

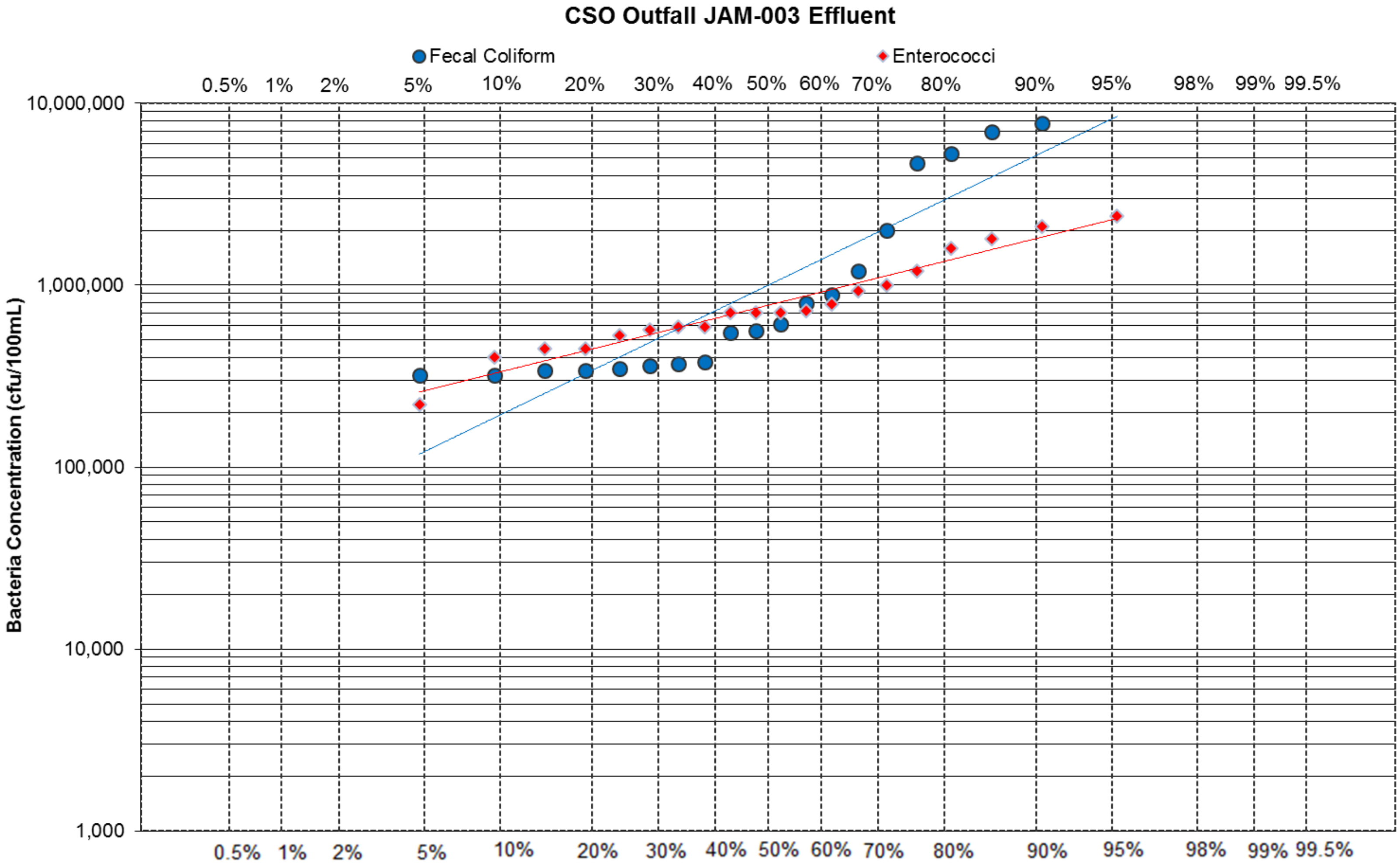

Figure 2-18. Outfall JAM-003 Measured CSO Bacteria Concentrations

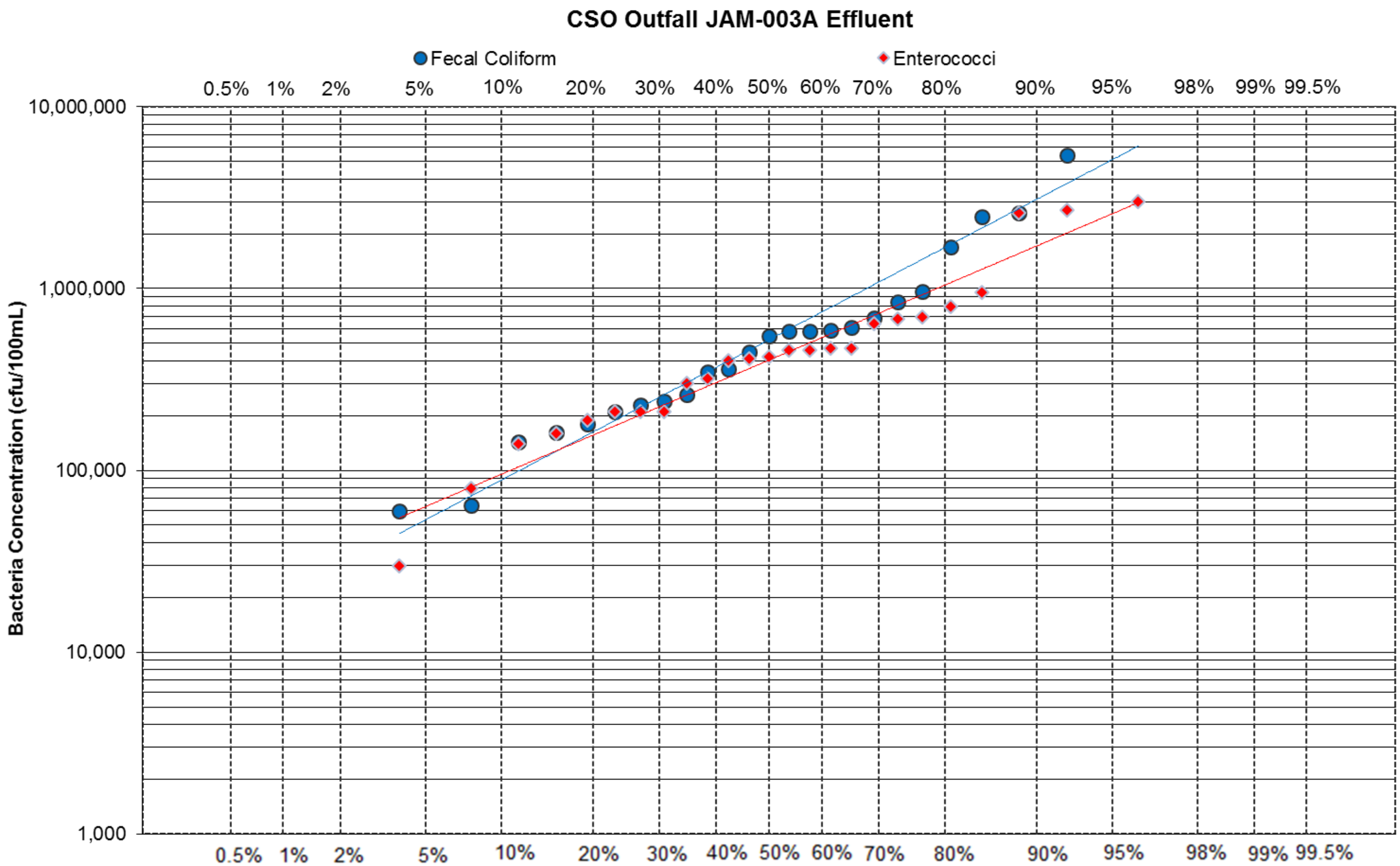

Figure 2-19. Outfall JAM-003A Measured CSO Bacteria Concentrations

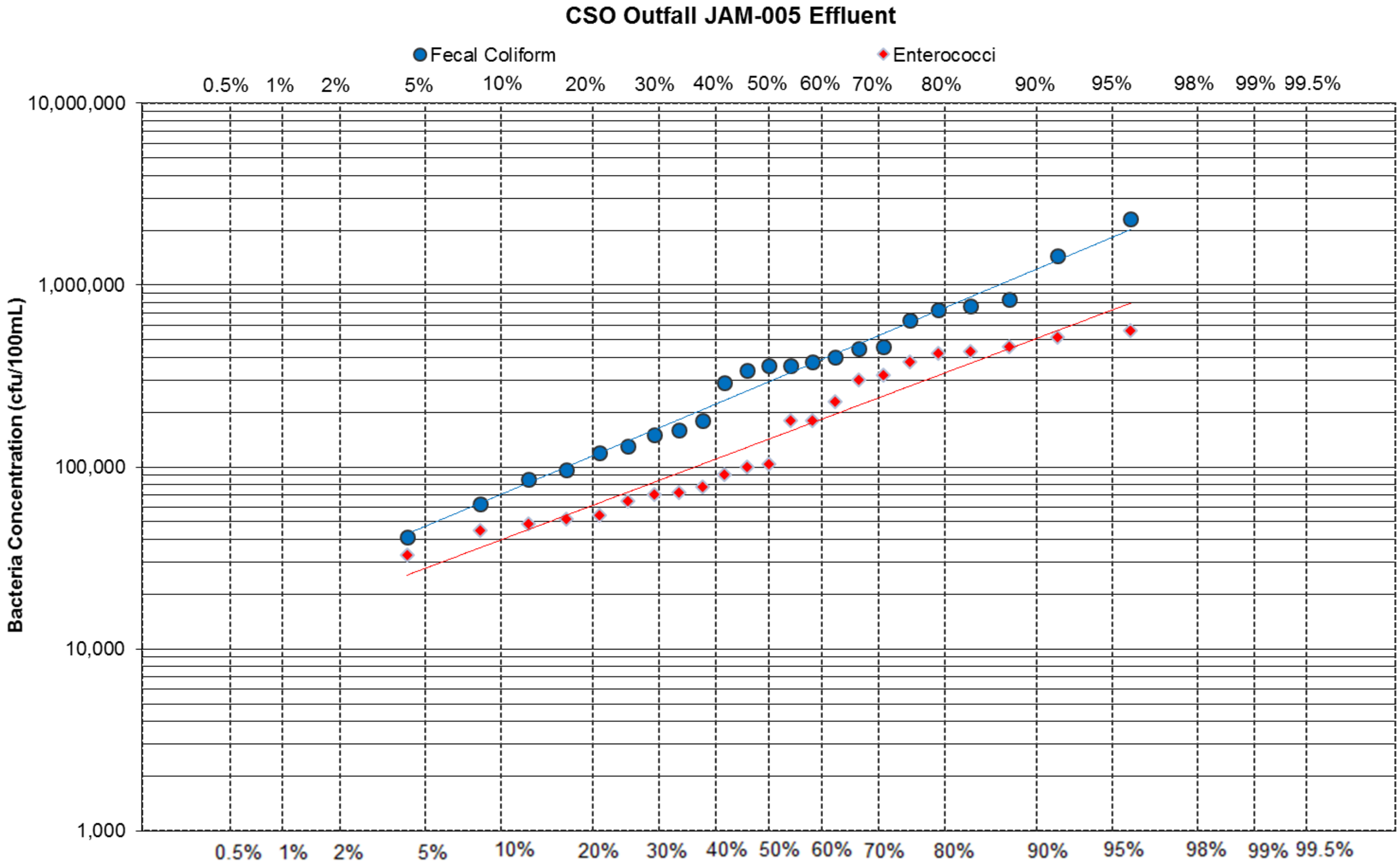

Figure 2-20. Outfall JAM-005 Measured CSO Bacteria Concentrations

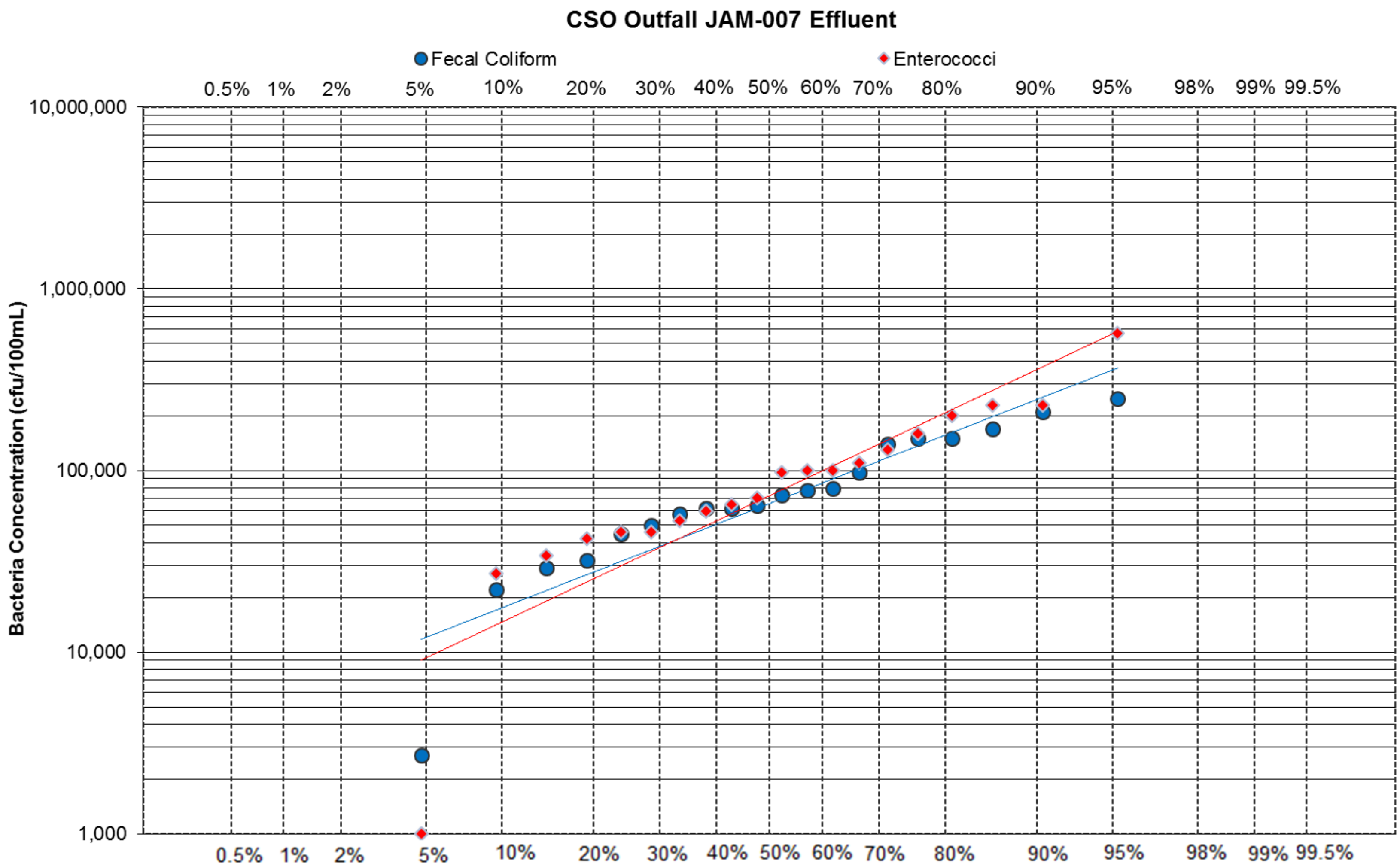

Figure 2-21. Outfall JAM-007 Measured CSO Bacteria Concentrations

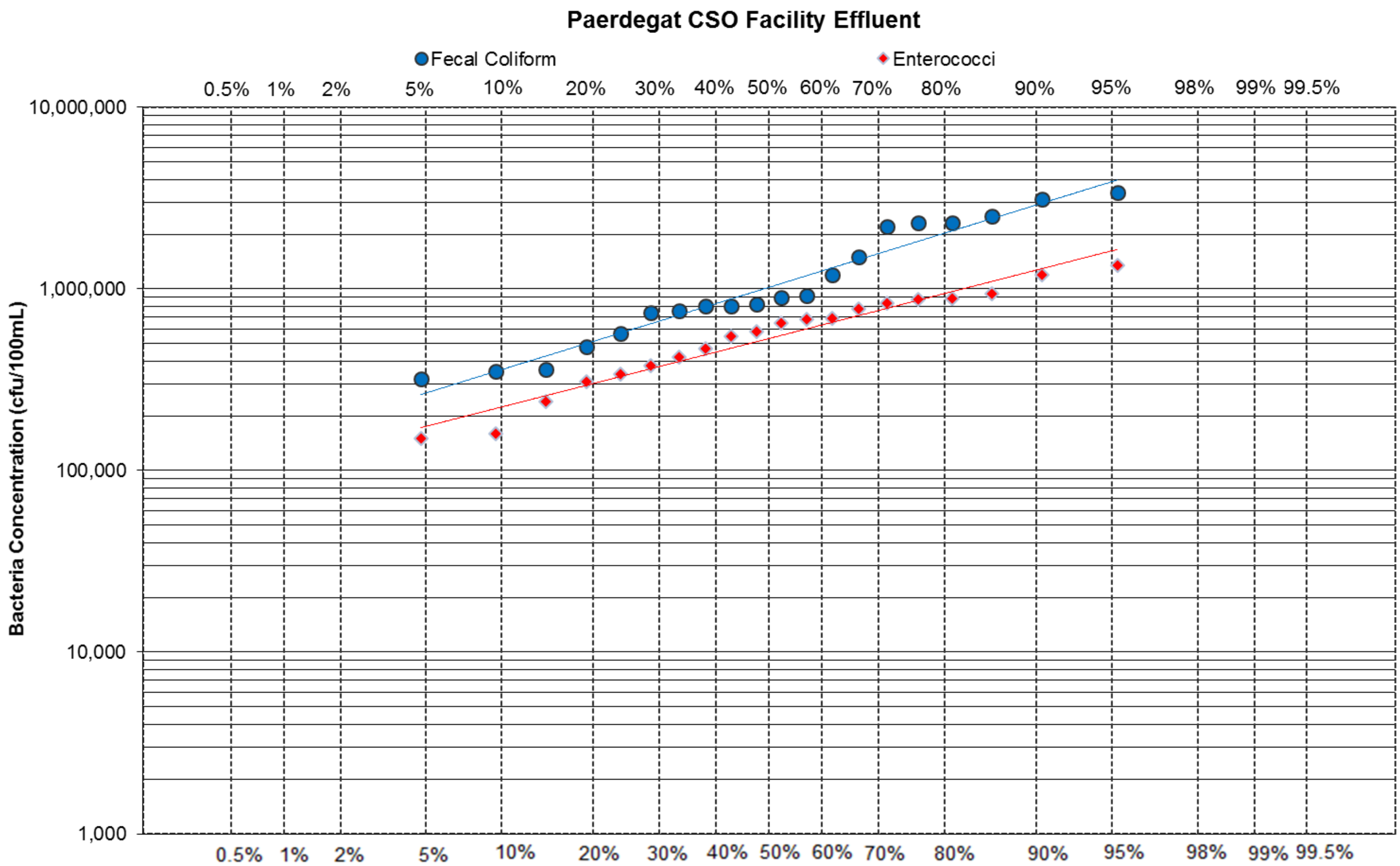

Figure 2-22. Paerdegat Basin CSO Facility Measured CSO Bacteria Concentrations

2.1.d.3 Hydraulic Analysis of Sewer System

A citywide hydraulic analysis was completed in December 2012 (an excerpt of which is included in this subsection), 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 WWTPs 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.

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 in the following paragraphs. Because the CSO contributions from the Rockaway WWTP collection system to Jamaica Bay are minimal in comparison to the CSO contribution from the other collections systems, the following summary of the 2012 recalibration effort is presented for the Coney Island, 26th Ward, and Jamaica WWTPs exclusively.

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

Model simulations were conducted to estimate the annual number of hours that the Coney Island WWTP 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. For the Coney Island WWTP sewershed, the only CEG condition applicable was the Paerdegat CSO Facility. For these simulations, the primary input conditions applied were as follows:

- Projected 2040 DWF conditions.
- 2008 tides and precipitation data.
- Coney Island WWTP at 2xDDWF capacity of 220 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 Coney Island WWTP would operate at its 2xDDWF capacity for 99 hours under the no-CEG condition. When the CEG conditions were applied in the model, the annual number of hours at 2xDDWF would increase to 161 hours.

- The total volume (dry- and wet-weather combined) treated annually at the Coney Island WWTP for the 2008 non-CEG condition was predicted to be about 34,196 MG, while the 2008 with-CEG condition resulted in a predicted 38,081 MG treated at the plant – an increase of 3,885 MG.

- The total annual CSO volume predicted for the outfalls in the Coney Island sewershed tributary to Jamaica Bay were as follows:

  - 2008 non-CEG: 1,723 MG
  - 2008 with CEG: 732 MG

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

26th Ward - Annual Hours at 2xDDWF for 2008 with Projected 2040 DWF

Model simulations were conducted to estimate the annual number of hours that the 26th Ward WWTP 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 CSO Order. The CEG conditions applicable to the 26th Ward sewershed included HLSS installed within approximately 443 acres of the Fresh Creek watershed. For these simulations, the primary input conditions applied were as follows:

- Projected 2040 DWF conditions.
- 2008 tides and precipitation data.
- 26th Ward WWTP at 2xDDWF capacity of 170 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 26th Ward WWTP would operate at its 2xDDWF capacity for 133 hours under the no-CEG condition. When the CEG conditions were applied in the model, the annual number of hours at 2xDDWF remained about the same (132 hours).

- The total volume (dry- and wet-weather combined) treated annually at the 26th Ward WWTP for the 2008 non-CEG condition was predicted to be about 20,056 MG, while the 2008 with-CEG condition resulted in a predicted 20,163 MG treated at the plant – an increase of 107 MG.

- The total annual CSO volume predicted for the outfalls in the 26th Ward sewershed were as follows:
  - 2008 non-CEG: 380 MG
  - 2008 with CEG: 453 MG

While the above results indicate a relatively constant number of hours at the 2xDDWF operating capacity for 26th Ward WWTP, the annual volume being delivered to the WWTP increased, and the annual CSO volume from the outfalls in the sewershed also increased. This seemingly odd system response may be largely due to the diversion of CSO from Regulator JA-02 to the Spring Creek AWWTP. While the diversion increased the annual CSO volume from the 26th Ward Sewershed, it contributed to a net volumetric CSO reduction to Jamaica Bay of 987 MG.

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

Model simulations were conducted to estimate the annual number of hours that the Jamaica WWTP 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 June 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 Jamaica WWTP sewershed included bending weirs at three CSO regulators, a relief sewer across the Belt Parkway, and automation of Regulator 2 which allows flow to be conveyed to the Spring Creek AWWTP (26th Ward area) for partial treatment, versus discharging as CSO from the Jamaica system. For these simulations, the primary input conditions applied were as follows:

- Projected 2040 DWF conditions.
- 2008 or 2011 tides and precipitation data.
- Jamaica WWTP at 2xDDWF capacity of 200 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 Jamaica WWTP would operate at its 2xDDWF capacity for 12 hours under the no-CEG condition. When the CEG conditions were applied in the model, the annual number of hours at 2xDDWF would increase to 68 hours.

- The total volume (dry- and wet-weather combined) treated annually at the Jamaica WWTP for the 2008 non-CEG condition was predicted to be about 32,354 MG, while the 2008 with-CEG condition resulted in a predicted 33,077 MG treated at the plant – an increase of 723 MG.

- The total annual CSO volume predicted for the outfalls in the Jamaica WWTP sewershed were as follows:
  - 2008 non-CEG: 2,574 MG
  - 2008 with CEG: 1,587 MG

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

Estimation of Peak Conduit/Pipe Flow Rates

Model output tables containing information on several pipe characteristics were prepared, coupled with calculation of the theoretical, non-surcharged, full-pipe flow capacity of each sewer included in the models. To test the conveyance system response under what would be considered a large storm event condition, a single-event storm that was estimated to approximate a five-year return period (in terms of peak hourly intensity as well as total depth) was selected from the historical record.

The selected single-event was simulated for two conditions, the first being prior to implementation of CEG conditions, and the second with the CEG conditions implemented. The maximum flow rates and maximum depths predicted by the model for each modeled sewer segment were retrieved and aligned with the other pipe characteristics. Columns in the tabulations were added to indicate whether the maximum flow predicted for each conduit exceeded the non-surcharged, full-pipe flow, along with a calculation of the maximum depth in the sewer as a percentage of the pipe full height. It was suspected that potentially, several of the sewer segments could be flowing full, even though the maximum flow may not have reached the theoretical maximum full-pipe flow rate for reasons such as: downstream tidal backwater, interceptor surcharge, or other capacity-limiting reasons. The resulting data were then scanned to identify the likelihood of such capacity-limiting conditions, and also to provide insight into potential areas of available capacity, even under large storm event conditions.

For both the 26th Ward and Jamaica WWTP tributary areas, capacity exceedances for each sewer segment were evaluated in two ways for both interceptors and combined sewers:

- Full flow exceedances, where the maximum predicted flow rate exceeded the full-pipe non-surcharged flow rate. This could be indicative of a conveyance limitation.
- Full depth exceedances, where the maximum depth was greater than the height of the sewer segment. This could be indicative of either a conveyance limitation or a backwater condition.

Key observations/findings of this analysis are described below.

26th Ward WWTP

- For the single storm event simulated, the model predicted that 98.3 percent (by length) of the interceptor sewer segments would exceed full-pipe capacity flow, while approximately 22 percent (by length) of the upstream combined sewers would exceed their full-pipe flow.

- 100 percent (by length) of the interceptors were predicted to flow at full depth or higher. Between 62.6 and 64.1 percent (by length) of the combined sewers were also predicted to flow at full depth, indicating that many of these sewers experienced backwater conditions from the downstream sewer (and interceptor) system as a result of either pipe or plant capacity limits.

- The flow rate comparison (with only 22 percent of the combined sewers reaching their full-pipe capacity) suggests that available conveyance or in-line storage capacity might exist in the combined sewers, even under the large storm events. However, the comparison of maximum depths shows that up to 64 percent of the combined sewers (by length) flow full even though their full capacity had not been reached during this large event.

- The results for the system condition without CEG improvements were nearly the same as the system condition with-CEG improvements in the 26th Ward sewershed. Again the hydraulic interactions between the 26th Ward and Jamaica sewersheds during wet-weather must be considered.

Based on the review of various metrics, the 26th Ward WWTP collection system generally exhibits full or near full-pipe flows during wet-weather, allowing little potential for in-line storage capability.

Jamaica WWTP

- For the single storm event simulated, the model predicted that between 93.1 and 95.5 percent (by length) of the interceptor sewer segments would exceed full-pipe capacity flow, while approximately 24 percent (by length) of the upstream combined sewers would exceed their full-pipe flow.

- About 93.1 to 95.5 percent (by length) of the interceptors were predicted to flow at full depth or higher. Approximately 75 percent (by length) of the combined sewers were also predicted to flow at full depth, indicating that many of these sewers experienced backwater conditions from the downstream sewer (and interceptor) system as a result of either pipe or plant capacity limits.

- The flow rate comparison (with only 24 percent of the combined sewers reaching their full-pipe capacity) suggests that available conveyance, or in-line storage capacity, might exist in the combined sewers, even under the large storm events. However, the comparison of maximum depths shows that up to 75 percent of the combined sewers (by length) flow full even though their full capacity had not been reached during this large event.

- The results for the system condition without CEG improvements were nearly the same as the system condition with-CEG improvements in the Jamaica sewershed.

- About 85 percent of the combined sewers (by length) reached a depth of at least 75 percent under the CEG simulations.

Based on the review of various metrics, the Jamaica WWTP collection system generally exhibits full or near full-pipe flows during wet-weather, allowing little potential for in-line storage capability.

2.1.d.4 Identification of Sewer System Bottlenecks, Areas Prone to Flooding and History of 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 "Call 311" system routes complaints of sewer issues to DEP for response and resolution. Although not every call reporting 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.

2.1.d.5 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 2-23 and Figure 2-24 illustrate the intercepting sewers that were inspected in the Boroughs of Brooklyn and Queens, respectively, encompassing the entire Jamaica Bay watershed. Throughout 2017, 15 cubic yards of sediment was removed from Jamaica WWTP intercepting sewers; 2,925 cubic yards of sediment was removed from Coney Island WWTP intercepting sewers and 17 cubic yards of sediment was removed from Rockaway WWTP intercepting sewers. No sediment was removed from 26th Ward WWTP intercepting sewers. Citywide, the inspection of 89,459 feet of intercepting sewers resulted in the removal of 6,969 cubic yards of sediment.

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.d.6 Status of Receiving Wastewater Treatment Plants

The majority of the Jamaica Bay basin is served by the 26th Ward and Jamaica WWTP sewersheds and the CSO outfalls associated with these collection systems are the major contributors of CSO to Jamaica Bay. Both WWTPs underwent improvements that enable the collection system and treatment facility to deliver, accept, and treat influent at twice the plants' DDWF during storm events. Both WWTPs also underwent upgrades for Biological Nutrient Removal (BNR).

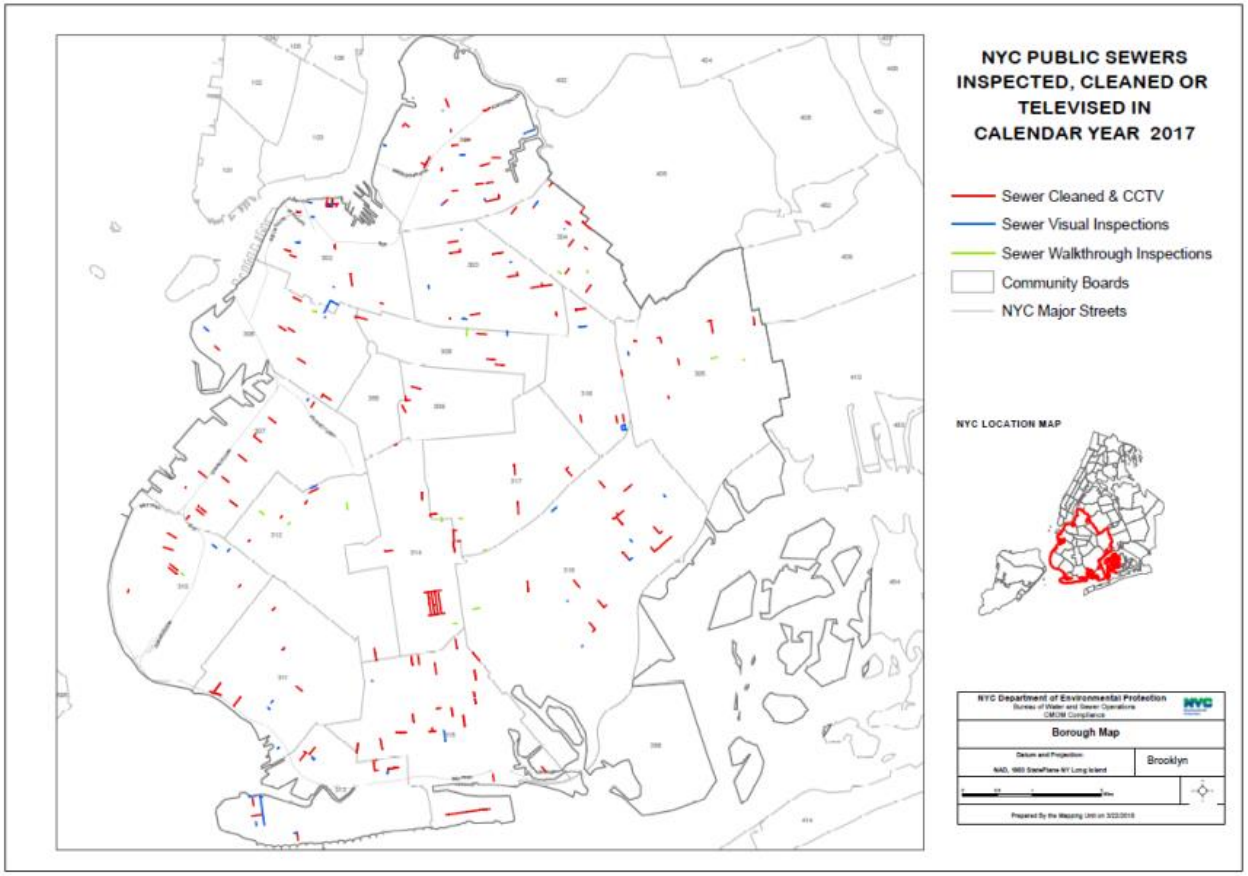

Figure 2-23. Sewers Inspected and Cleaned in Brooklyn Throughout 2017

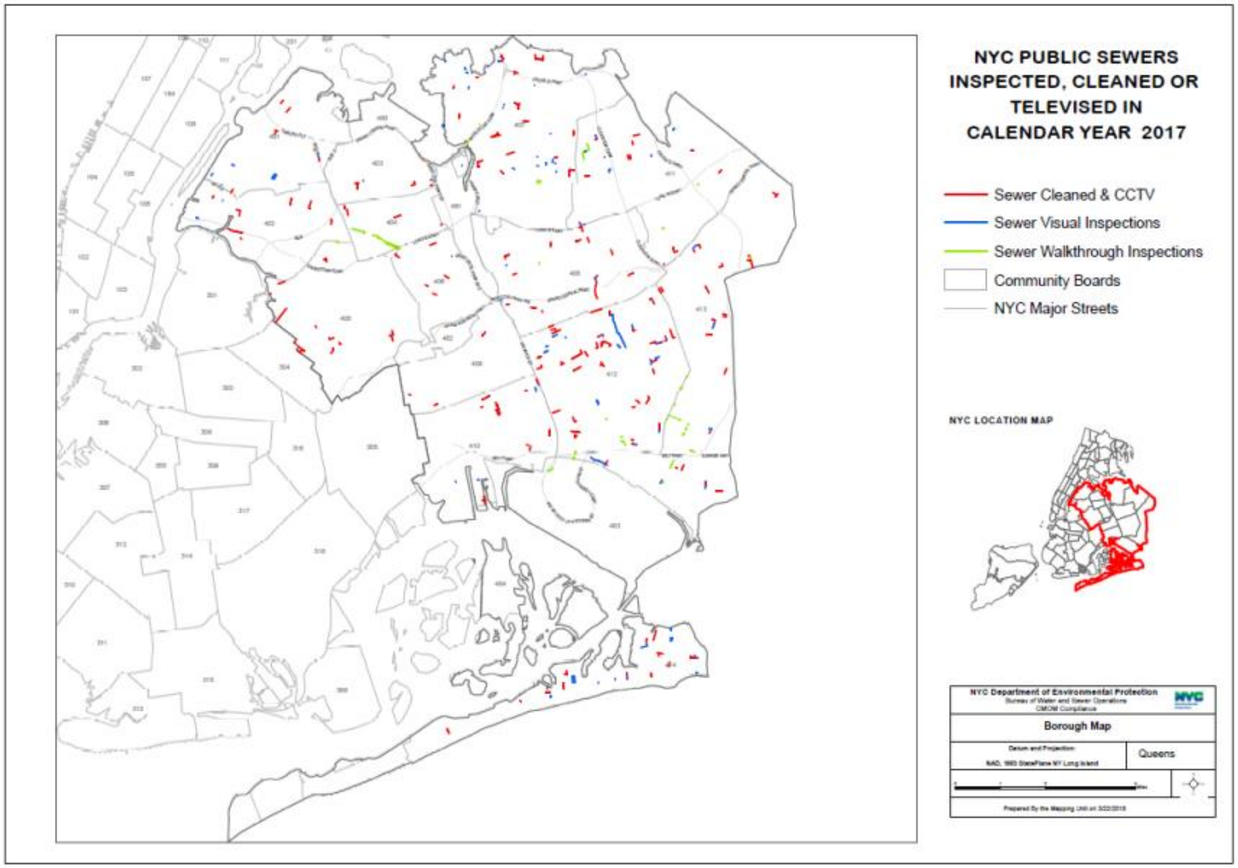

Figure 2-24. Sewers Inspected and Cleaned in Queens Throughout 2017

2.2 Waterbody Characteristics

This section of the report describes the features and attributes of Jamaica Bay. 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.a Description of Waterbody

Jamaica Bay is located on the south shore of western Long Island, New York. Roughly semi-circular in shape, Jamaica Bay is approximately four miles wide, north to south, and eight miles long, east to west. Much of the area in the central portion of the Bay consists of shallow channels and tidal marsh islands that are exposed during low tide. Navigation channels, approximately 30 feet deep, are located along the landward edge of the Bay and numerous navigable channels feed into the Bay from the southern shore of Brooklyn and Queens. Tidal exchange within the Bay occurs through the Rockaway Inlet. Water quality in Jamaica Bay is influenced by CSO, stormwater discharges, and tidal exchange with the Atlantic Ocean. The following section describes the present-day physical and water quality characteristics of Jamaica Bay, along with its existing uses.

2.2.a.1 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, but the primary and secondary recreational uses of the waterbody are limited due to other factors. Class I best uses are aquatic life protection, as well as secondary contact recreation. SD waters best uses are fish, shellfish and wildlife survival. DEC has classified Jamaica Bay as a Class SB waterbody. The CSO tributaries on the north shore of the Bay (Paerdegat Basin, Fresh Creek, Hendrix Creek, Spring Creek, Bergen Basin, and Thurston Basin) along with Head of Bay, Mott Basin, Sommerville Basin, Vernam Basin, and Barbades Basin on the south shore of the Bay are classified as Class I waterbodies (Figure 2-25).

Numerical standards corresponding to these waterbody classifications are shown in Table 2-7. DO is the numerical standard that DEC uses to establish whether a waterbody supports aquatic life uses. Total and fecal coliform bacteria concentrations are the numerical criteria that DEC uses to establish whether a waterbody supports recreational uses. In addition to numerical standards, NYS has narrative criteria to protect aesthetics in all waters within its jurisdiction, regardless of classification (see Section 1.2.c.). As indicated in Table 2-8, these narrative criteria apply to all five classes of saline waters. Narrative WQS criteria are presented in Figure 2-25.

Note that the *Enterococci* criterion of 35 cfu/100mL listed in Table 2-7, although not promulgated by DEC, is the applicable WQS in NYS for coastal recreational waters, because EPA established January 1, 2005 as the date upon which the criteria must be adopted for all coastal recreational waters. In New York State the *Enterococci* criterion applies on a 30-day moving GM basis during the recreational season (May 1st through October 31st). The *Enterococci* criterion applies to all Class SB waters within Jamaica Bay but not the Class I waterbodies that are tributaries to the Bay.

Table 2-7. New York State Numerical Surface WQS (Saline)

Class	Usage	Dissolved Oxygen (mg/L)	Total Coliform (cfu/100mL)	Fecal Coliform (cfu/100mL)	*Enterococci* (cfu/100mL)(7)
SA	Shellfishing for market purposes, primary and secondary contact recreation, fishing. Suitable for fish, shellfish and wildlife propagation and survival.	≥ 4.8(1) ≥3.0(2)	≤ 70(3)	N/A	N/A
SB	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(8)
SC	Limited primary and secondary contact recreation, fishing. Suitable for fish, shellfish and wildlife propagation and survival.	≥4.8(1) ≥3.0(2)	≤ 2,400(4) ≤ 5,000(5)	≤ 200(6)	N/A
I	Secondary contact recreation and fishing. Suitable for fish, shellfish and wildlife propagation and survival.	≥ 4.0	≤ 2,400(4) ≤ 5,000(5)	≤ 200(6)	N/A
SD	Fishing. Suitable for fish, shellfish and wildlife survival. Waters with natural or man-made conditions limiting attainment of higher standards.	≥ 3.0(2)	≤ 2,400(4) ≤ 5,000(5)	≤ 200(6)	N/A

Notes:

(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 3.0 mg/L).
(3) Colony forming unit per 100mLvalue in any series of representative samples.
(4) Monthly median value of five or more samples.
(5) Monthly 80th percentile of five or more samples.
(6) Monthly GM of five or more samples.
(7) This standard, although not promulgated by DEC, is now an enforceable standard in NYS since the EPA established January 1, 2005 as the date upon which the criteria must be adopted for all coastal recreational waters
(8) 30-day moving GM promulgated by the EPA BEACH Act of 2000 that is only applicable to coastal waters.

Table 2-8. 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.

On March 21, 2018, DEC publicly noticed a revision to the WQS that, if adopted as proposed, would include application of the Proposed *Enterococci* WQ Criteria* to coastal SB waters during the primary contact recreation season, a limitation on the applicability of WQS for total and fecal coliform in Class SB, I and SD waters to the primary contact recreation season, and a reclassifications for the Upper and portion of the Lower New York Bay from Class I to Class SD. DEP anticipates that any formal revision to the WQS will be promulgated after the submittal date of the Jamaica Bay and Tributaries LTCP. However, this LTCP includes assessment of attainment with both the Existing WQ Criteria and the Proposed *Enterococci* WQ Criteria*. Based on DEC's March 21 proposed rulemaking and information provided by DEC, the Proposed *Enterococci* WQ Criteria* modeled for this LTCP will include a 90-day rolling GM for *Enterococci* of 35 cfu/100mL with a not-to-exceed 90th percentile STV of 130 cfu/100mL. In accordance with the proposed rulemaking, these criteria would not apply to the tributaries of Jamaica Bay that are non-coastal Class I waters. However, as requested by DEC, DEP assessed compliance with those proposed criteria for all waters considered in this LTCP including the tributaries.

*Proposed *Enterococci* WQ Criteria, if adopted as proposed, would only apply to coastal Class SB and SA waters.

Figure 2-25. Waterbody Classifications for Jamaica Bay and Tributaries

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. Jamaica Bay is an interstate water and is regulated by IEC as Class A waters. Numerical standards for IEC-regulated waterbodies are shown in Table 2-9, while narrative standards are shown in Table 2-10.

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 CSOs 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 2-9. 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 2-10. 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

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). Only one such permitted bathing beach is located in Jamaica Bay. Gerritsen/Kiddie Beach is a private bathing beach located in Plumb Beach Channel in the western portion of Jamaica Bay. 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* 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.

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.

The CSO tributaries on the north shore of the Bay (Paerdegat Basin, Fresh Creek, Hendrix Creek, Spring Creek, Bergen Basin, and Thurston Basin) along with Head of Bay, Mott Basin, Sommerville Basin, Vernam Basin, and Barbades Basin on the south shore of the Bay are classified as Class I waterbodies (secondary contact recreation best use).

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 2-11, and includes limits for both the GM (30-day) and a STV based on exceeding a 90th 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 2-11. 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

As described above, on March 21, 2018, DEC publicly noticed a revision to the WQS that if adopted as proposed, included application of the Proposed *Enterococci* WQ Criteria* to coastal SB waters during the primary contact recreation season and the reclassifications of certain waterbodies. This LTCP includes assessment of attainment with both the Existing WQ Criteria and the Proposed *Enterococci* WQ Criteria*. Based on DEC's March 21 proposed rulemaking and information provided by DEC, the Proposed *Enterococci* WQ Criteria* modeled for this LTCP will include a 90-day rolling GM for *Enterococci* of 35 cfu/100mL with a not-to-exceed 90th percentile STV of 130 cfu/100mL. In accordance with the proposed rulemaking, these criteria would not apply to the tributaries of Jamaica Bay that are non-coastal Class I waters. However, as requested by DEC, DEP assessed compliance with those proposed criteria for all waters considered in this LTCP including the tributaries.

2.2.a.2 Physical Waterbody Characteristics

The Jamaica Bay watershed is situated at the southwestern tip of Long Island and encompasses portions of the Boroughs of Brooklyn and Queens, in New York, and portions of the Towns of Hempstead and North Hempstead in Nassau County. The Jamaica Bay estuary connects to Lower New York Bay to the west through the Rockaway Inlet (Figure 2-1). The estuary encompasses approximately 18,700 acres and is approximately 10 miles wide at its widest point east to west and 4 miles wide at its widest point north to south. Jamaica Bay and its surroundings have evolved from a landscape mosaic dominated by salt marsh wetlands, freshwater streams, grasslands, and woodlands with a diverse array of plant and animal life to one of the most densely urbanized areas in the United States (DEP, 2007).

Seven tributaries empty into Jamaica Bay: Paerdegat Basin, Fresh Creek, Hendrix Creek, Spring Creek, Shellbank Basin, Bergen Basin, and Thurston Basin. All of the Jamaica Bay tributaries have been highly altered over the years through channelization and tend to have little or no continuous freshwater flow. With the exception of Shellbank Basin, they all receive CSOs from the Jamaica Bay sewershed and two receive treated effluent from wastewater treatment plants (Hendrix Creek and Bergen Basin), and two receive overflow from CSO facilities (Spring Creek and Paerdegat Basin).

Much of the area in the central portion of the Bay consists of shallow channels and tidal marsh islands that are exposed during low tide. Navigation channels, approximately 30 feet deep, are located along the landward edge of the Bay and numerous navigable channels feed into the Bay from the southern shore of Brooklyn and Queens. Tidal exchange within the Bay occurs through the Rockaway Inlet. Water quality in Jamaica Bay is influenced by CSO, stormwater discharges, and tidal exchange with the Atlantic Ocean. The following section describes the present-day physical and water quality characteristics of Jamaica Bay, along with its existing uses.

* Proposed *Enterococci* WQ Criteria, if adopted as proposed, would only apply to coastal Class SB and SA waters.

Jamaica Bay is located within the Coastal Zone Boundary as designated by DCP. DCP has also designated the majority of Jamaica Bay as a Special Natural Waterfront Area (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 significance of the Jamaica Bay estuary as a valuable habitat area is reflected by the protected status it receives. The New York State Department of Sate (NYSDOS) has designated the Bay as a Significant Coastal Fish and Wildlife Habitat. The DEC has designated Jamaica Bay as a Critical Environmental Habitat, the only such designation in NYC. The National Parks Service created the Jamaica Bay Wildlife Refuge and the Bay area, as a whole, is recognized by the U.S. Fish and Wildlife as a regionally valuable habitat for migrating birds along the Atlantic Flyway. The Bay is also designated as Essential Fish Habitat for numerous species of fish by NOAA's National Marine Fisheries Service.

Shoreline Physical Characterization

The shorelines of Jamaica Bay are composed of a mix of natural areas, rip-rap, marina, and bulkhead, as illustrated in Figure 2-26. The majority of the shoreline of Jamaica Bay is composed mainly of natural shoreline except for JFK International Airport, which contains large portions of rip-rap shoreline with small pockets of bulkhead and piers. The Bay side of Rockaway Peninsula also contains a large portion of bulkheaded and rip-rap shoreline. The Jamaica Bay tributaries are composed predominantly of natural shoreline except for Shellbank and Hawtree Basins, which contain a mix of marinas, piers, and bulkheading. Bulkheading for existing CSO and wastewater treatment plant facilities exists in Paerdegat Basin, Hendrix Creek, Spring Creek, and Bergen Basin. Figure 2-27 shows examples of the predominant shoreline characteristics along the Bay.

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. In general, the three classification parameters describe the shoreline slope well for LTCP purposes. Gentle and intermediate slopes characterize the natural or vegetated shorelines of Jamaica Bay and its tributaries.

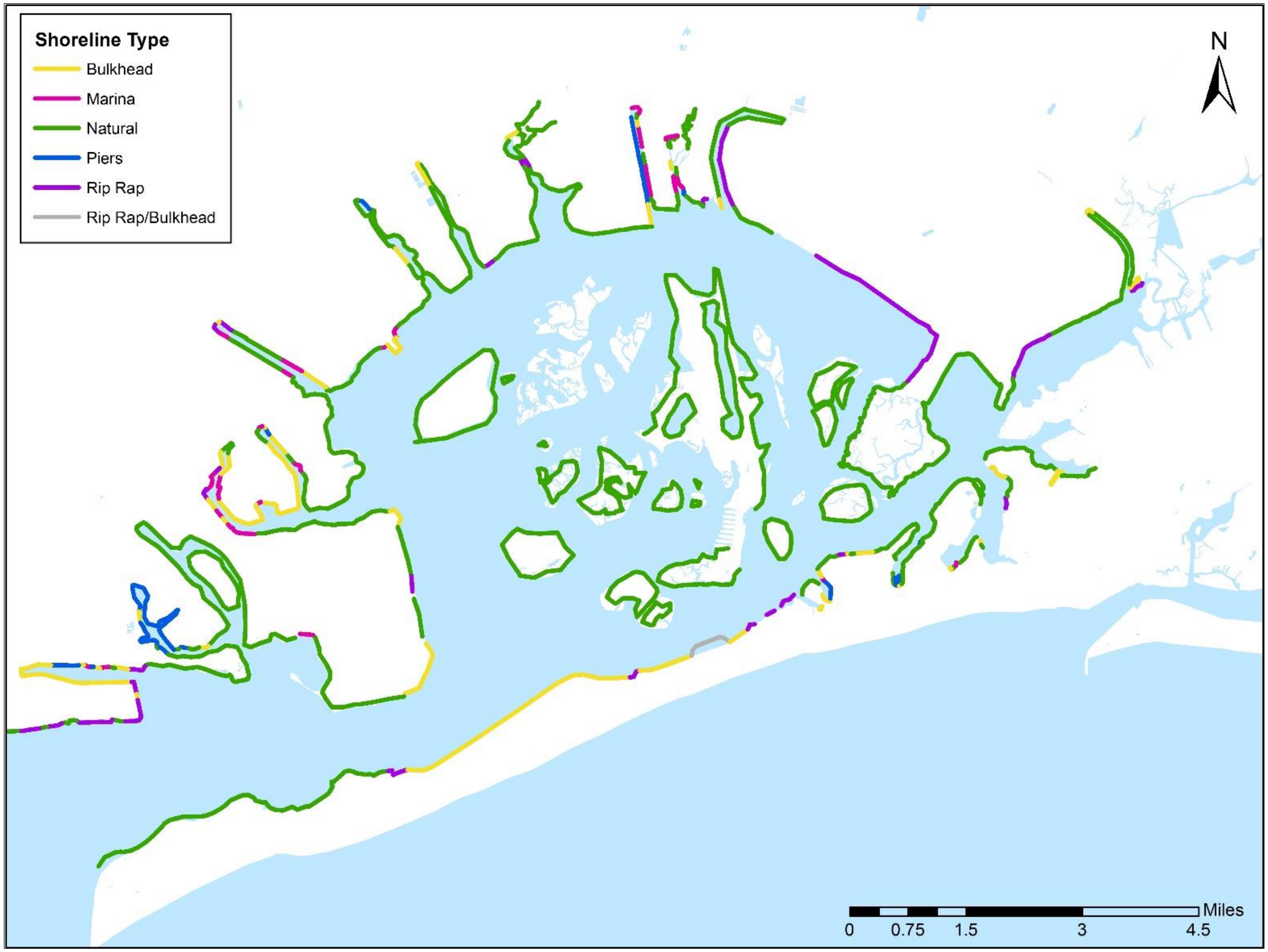

Figure 2-26. Jamaica Bay Shoreline Characteristics

Figure 2-27. Photographs of Predominant Shoreline Characteristics of Jamaica Bay

Waterbody Sediment Surficial Geology/Substrata

The metamorphic bedrock formations underlying Long Island are more than 400 million years old, and are overlain by glacial deposits that are about 70 million old. The surface features of Long Island that form the general topography are the result of glacial advances and retreats. Moraines are elongated ridges that are formed at the edge of a glacier. Outwash plains occur at the leading edges of moraines where glacial melt water deposits sand, gravel, and mud. In the Jamaica Bay watershed, the Harbor Hill moraine and its associated outwash plain had the most influence in shaping the surface geology of the watershed. The Harbor Hill moraine is a continuous ridge that extends from Brooklyn in the west to Port Jefferson to the east. The outwash plain from the Harbor Hill moraine extends southward sloping from the ridgeline of the moraine to the Atlantic Ocean.

Anthropogenic forces have influenced the surface soils that are now found in the Jamaica Bay watershed. Many of the soils found along the shoreline of Jamaica Bay 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). Shoreline slopes are often characterized by a gentle slope (less than five percent) along natural shorelines that have not been channelized or otherwise altered with piers, boat slips, or bulkheads to stabilize the shoreline. Inland areas within the watershed are generally characterized as “urban” soils or those areas where the soil has been covered by pavement, buildings, or other impervious surfaces.

The nature of bottom sediments at locations around the Bay is important. Different sediment types provide different habitats and support different interactive ecological communities. Generally, sediments in high energy environments are composed of coarse grained sands, while lower energy, depositional environments are dominated by finer silts and clays. A study in 1976 found that sediments in the western portion of Jamaica Bay from Cross Bay Boulevard to the Rockaway Inlet were generally composed of greater than 80 percent sands, 10 percent silts and 10 percent clay (DEP, 2007). The eastern portion of the Bay contained higher percentages of silt and clay (ranging from 30 to 50 percent) while the sand component was generally less than 40 percent. Franz and Harris (1985) observed that eastern portions of Jamaica Bay were covered with black sticky jelly-like muds and that the mud fraction of sediments was higher in the northern portion of the Bay. The Regional Environmental Monitoring and Assessment Program (REMAP) conducted by the EPA found that the mean fraction of silt-clay content of Jamaica Bay sediments increased from 30.3 percent in 1993 to 37.5 percent in 1998 (Adams, 1998).

Waterbody Type

Jamaica Bay is the largest estuarine waterbody in the New York metropolitan area and covers approximately 20,000 acres, 86 percent of which is open water and the remaining 24 percent is upland islands and salt marshes (DEP, 2007). The Bay is connected to the Atlantic Ocean through the Rockaway Inlet and has a tidal range of approximately five to six feet. The Bay measures approximately 10 miles at its widest point east to west and four miles at its widest point north to south. The mean depth of the Bay is approximately 13 feet with maximum depths of up to 30 to 50 feet in navigation channels and borrow pit areas, respectively.

Tidal/Estuarine Systems Biological Systems

Tidal Wetlands

Salt marsh wetlands occur along the Atlantic shoreline in estuaries which are protected from the full energy of the ocean. They occupy the zone between low and high tide and contain three general zones: mudflat, low marsh, and high marsh. Mudflats are typically unvegetated and represent a transition zone between subtidal waters and vegetated marsh habitat. Low marsh occurs in the portion of the tidal zone where plants are inundated twice daily by the tide. High marsh occurs just above the mean high tide elevation and is flooded only occasionally during storm events and higher than normal high tides (e.g., spring tides). From a habitat standpoint, as well as an economic perspective, the Jamaica Bay salt marshes are critical to three groups of animals: shellfish, finfish, and waterfowl. They also provide habitat for benthic invertebrates which serve as a food source for fish and shorebirds. Salt marshes also dissipate wave energy from severe storms and floodwaters.

Prior to European settlement, Jamaica Bay contained approximately 16,000 acres of salt marsh (DEP, 2007). Originally used as pastureland for farm animals, the Jamaica Bay salt marshes were extensively filled to create developable land, landfills, and other commercial and private uses. As of 1971, only about 4,000 acres of salt marsh remained in the Bay (National Academy of Sciences and National Board of Engineering, 1971). Prior to 1974, salt marsh disappearance occurred primarily along the periphery of the Bay due to dredging and filling activities. Since 1974, the vast majority of salt marsh loss in the Bay is due to erosion of the marsh islands as a result of numerous interrelated processes including changes in sediment deposition rates, increased wave action, and sea level rise. Figure 2-28 shows the changes in distribution of salt marsh islands in Jamaica Bay between 1924 and 1999. In August 2007, the Jamaica Bay Watershed Protection Plan Advisory Committee and the National Park Service released a report concluding that the rate of salt marsh loss in Jamaica Bay is accelerating. Their findings indicated that the rate of loss was approximately 33 acres per year between 1989 and 2003 but that rate has accelerated to 54 acres per year for certain marsh islands within the Bay.

Habitat restoration continues to play a significant role in meeting DEP’s and other stakeholders’ goals of creating and restoring productive ecological areas and improved habitat within Jamaica Bay. DEP and many other government agencies such as DEC, U.S. Army Corps of Engineers, National Park Service, NYC Department of Parks and Recreation, and the Port Authority of New York & New Jersey are active participants in the science-based restoration and ecological improvements of Jamaica Bay. Recent large scale restoration projects within Jamaica Bay have helped restore over 150 acres of saltmarsh islands (DEP, 2014). Local communities are also playing a strong role in restoration efforts. With funding from the DEC and DEP, local non-profit organizations completed a salt marsh planting effort to vegetate 30 new acres of salt marsh at Black Wall and Rulers Bar.

Freshwater Wetlands

Historically, several types of freshwater wetlands occurred throughout the watershed including deep marsh, shallow marsh, shrub swamps, lowland swamp forest, upland swamp forest, and wet meadow (Mockler, 1991). Today, freshwater wetlands are very limited in extent within the Jamaica Bay watershed, comprising less than one percent of their historic coverage (DEP, 2007). Their disappearance is directly attributable to urban development over the last century. Freshwater wetlands were filled for the construction of roads, buildings and infrastructure prior to the enactment of State and federal wetland regulations, which now protect the remaining freshwater wetlands from further encroachment.

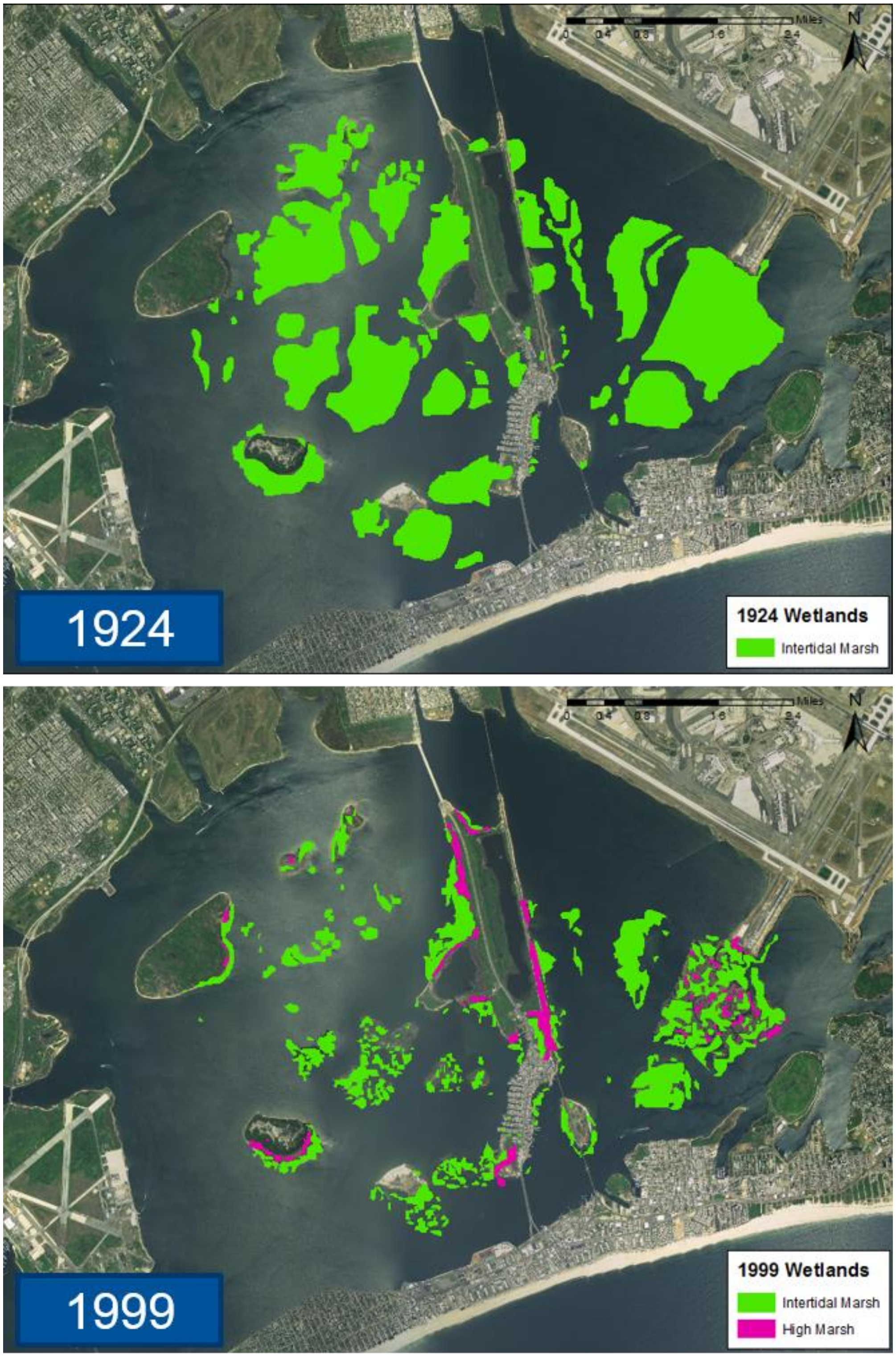

Figure 2-28. Salt Marsh Loss in Jamaica Bay from 1924 to 1999

Biological Communities

Jamaica Bay exhibits very high levels of primary productivity that is typical of estuarine systems. The pulsed tidal mixing of saline and freshwater and the diversity of habitat types that occur within the watershed ensure that an abundance of basic food sources and living conditions are available to support important fish, bird, and other wildlife populations. The Jamaica Bay watershed supports 91 species of fish, 325 bird species (62 of which are confirmed to breed locally), and is an important habitat for many species of reptiles, amphibians, and mammals. The Bay is a critical stopover area along the Atlantic Flyway migration route and is one of the best bird watching locations in the western hemisphere (DEP, 2014). The approximately 20,000 acres of open water, islands, marshes, and shorelines support seasonal or year round populations of 214 species of special concern including State and federally endangered and threatened species.

2.2.a.3 Jamaica Bay Watershed Protection Plan

The first Jamaica Bay Watershed Protection Plan (JBWPP) was first issued in 2007, and updated in 2008 and then every two years thereafter. The JBWPP included 127 strategies that focused on water quality, restoration ecology, stormwater management through sound land use, public education and outreach, public use and enjoyment, and coordination and implementation. Over 26 individual projects were implemented over the last 10-years, including $32M allocated for Jamaica Bay restoration efforts. DEP petitioned EPA to make Jamaica Bay a "No Discharge Zone", and DEP currently maintains boat pump-out facilities at the Rockaway and Coney Island WWTPs and at the Hudson River Yacht Club in Paerdegat Basin. The JBWPP also includes a robust upland/aquatic watershed approach, similar to the Chesapeake Bay programs, that is focusing on using natural systems for not only ecological improvements but to help meet regulatory WQS.

2.2.a.4 Current Public Access and Uses

Jamaica Bay, excluding the tributaries, is classified as suitable for primary and secondary contact recreation and fishing. Numerous public access points that facilitate primary and secondary contact activities within Jamaica Bay exist at federal, State, and City parklands (Figure 2-29). Approximately 66 percent of the publically accessible parkland is within the GNRA. The bulk of the remaining waterfront access is provided by the New York City Department of Parks and Recreation (DPR) operated parks and open space areas and includes four kayak/canoe launch sites. Only one public boat launch ramp is located within Jamaica Bay, adjacent to the Rockaway WWTP. Figure 2-30 shows several waterfront parks with access to Jamaica Bay or its tributaries.

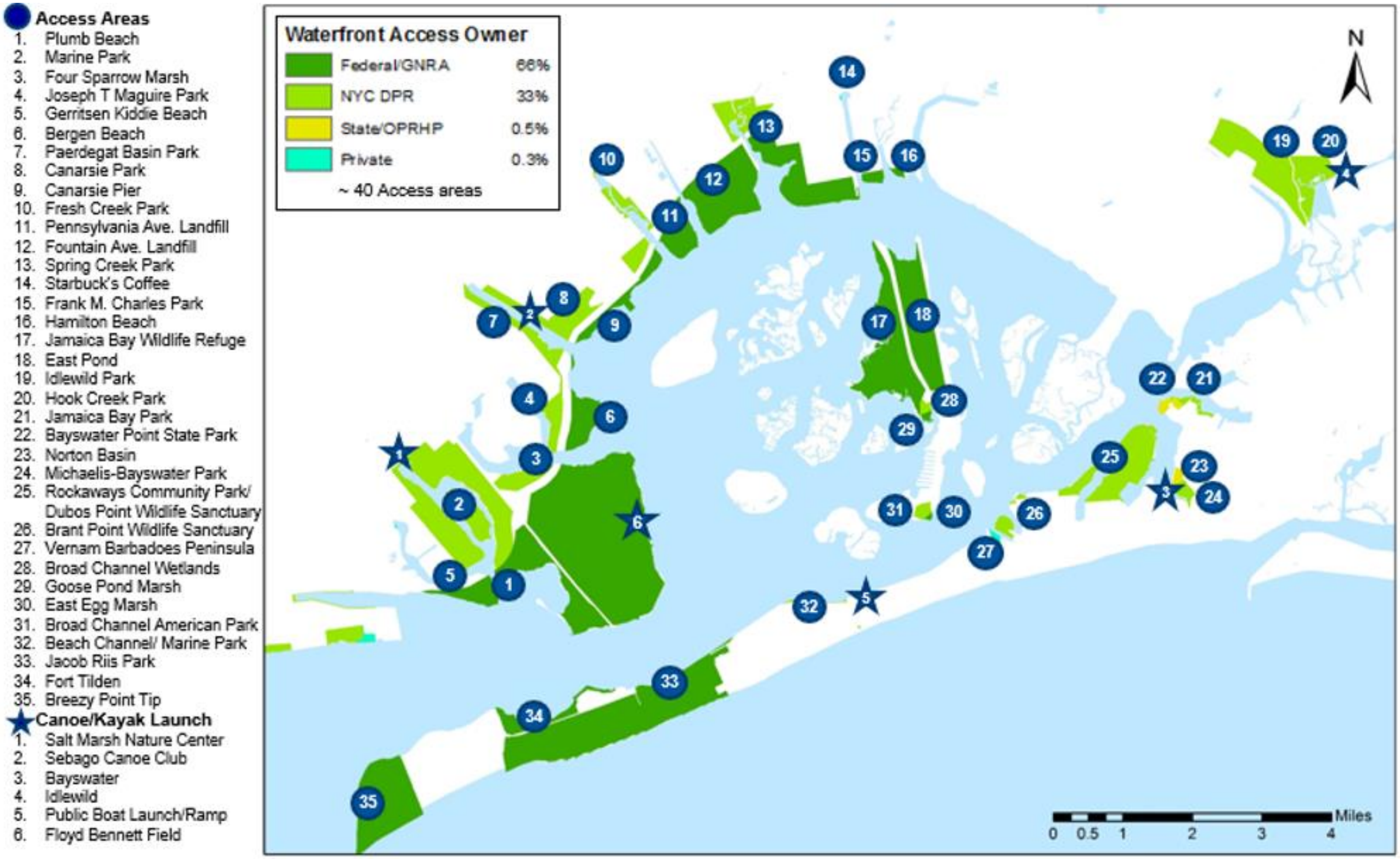

Figure 2-29. Public Access to the Waterfront in Jamaica Bay

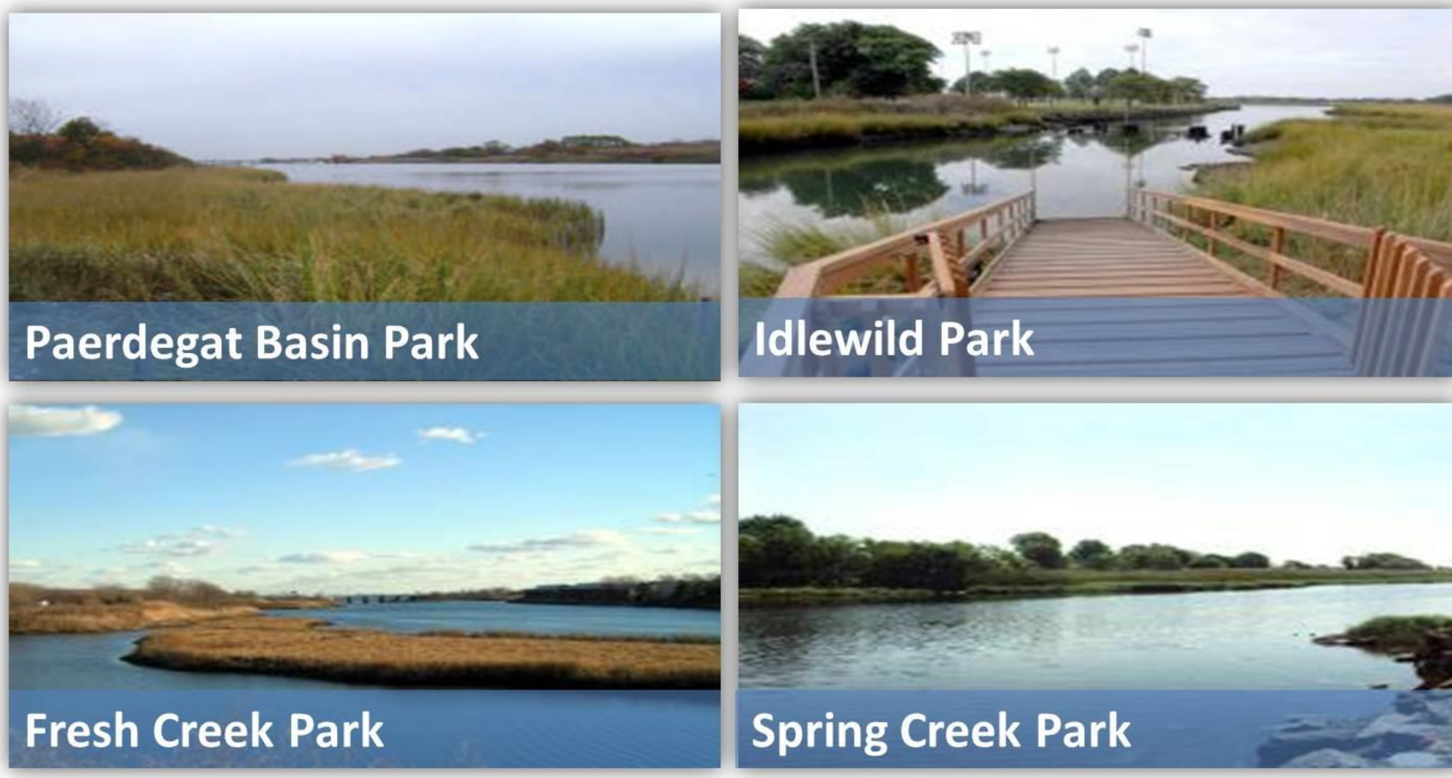

Figure 2-30. Photographs of Waterfront Parks

2.2.a.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).

General Assessment of Sensitive Areas

Jamaica Bay was analyzed for sensitive areas under the federal CSO Policy as set forth in Table 2-12.

Table 2-12. 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(2)	Threatened or Endangered Species and their Habitat(3)	Best Use - Primary Contact Recreation	Public Water Supply Intake	Public Water Supply Protected Area	Shellfish Bed
Jamaica Bay	No	No	Yes	Yes(4)	No(5)	No(5)	No(6)
Tributaries	No	No	Yes	No	No(5)	No(5)	No(6)

Notes:

(1) Classifications or Designations per CSO Policy.
(2) NOAA.
(3) DEC, USFWS.
(4) Existing uses include primary and secondary contact recreation and fishing, Class SB.
(5) These waterbodies contain salt water.
(6) None for commercial harvest due to water quality restrictions.

2.2.a.6 Tidal Flow and Background Harbor Conditions and Water Quality

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 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 five in 1909, to over 20 today.

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. The LTCP process has begun to focus on those areas that could be improved still further.

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 presented in four sections, each delineating a geographic region within the Harbor. Jamaica Bay is located at the southwestern end of Long Island, New York and contains 14 open-water monitoring stations and 20 tributary sites, as shown in Figure 2-12.

Fecal coliform and *Enterococci* are indicators of human waste and pathogenic bacteria. Based on HSM program data from 2013 through 2016, fecal coliform GMs at the sampling stations within Jamaica Bay and its tributaries ranged from 1 cfu/100mL at multiple stations to 200,000 cfu/100mL at Stations BB2, SP1, and HC1. The computed *Enterococci* GMs ranged from 1 cfu/100mL at multiple stations to 63,000 cfu/100mL at Station SP1.

DO is the oxygen in a waterbody available for aquatic life forms. Throughout recent years, average DO levels in the tributaries have been frequently measured below the Class I compliance requirement of 4.0 mg/L at stations within Thurston Basin, Bergen Basin, Spring Creek, Hendrix Creek, and Fresh Creek. Active CSO outfalls in Fresh Creek and Bergen Basin along with wastewater treatment plant effluent in Hendrix Creek and Bergen Basin may contribute to the low DOs seen in these tributaries. DO levels in

Jamaica Bay have also measured below the Class SB compliance chronic standard of 4.8 mg/L at all locations and below the acute standard of 3.0 mg/L at Stations J7, J8, and J12. Hypoxia is a water quality condition that is detrimental to aquatic life, and occurs when DO levels fall below 3.0 mg/L. In addition to the locations in Jamaica Bay, DO measurements below 3.0 mg/L were also recorded in Bergen Basin, Spring Creek, Hendrix Creek, Fresh Creek, and Paerdegat Basin throughout recent years.

Chlorophyll 'a' is the green pigment in algae and plankton. The amount of chlorophyll 'a' is a gage of primary productivity, which is used to measure ecosystem quality. A concentration of 20 μg/L or above is considered eutrophic. In a state of eutrophication, phytoplankton reproduction rates greatly increase, causing a depletion of DO when the phytoplankton die and decompose. Based on the HSM program data, the average chlorophyll 'a' concentration in the Bay from 2013 throughout 2016 was 23.0 μg/L.

Secchi transparency is a measure of the clarity of surface waters. Clarity is measured as a depth when the Secchi disk is no longer visible from the surface. Clarity is most affected by the concentrations of suspended solids and plankton. Lack of clarity limits sunlight, which inhibits the nutrient cycle. The average summer Secchi depth from 2013 throughout 2016 was 2.7 feet. All stations in Jamaica Bay and Tributaries reported a significant number of low transparency values (under 3.0 feet).

2.2.a.7 Compilation and Analysis of Existing Water Quality Data

To gain an understanding of recent water quality conditions, data collected within Jamaica Bay and its tributaries 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 October 2015 through November 2015 to support the Jamaica Bay and Tributaries LTCP. The sampling locations of both programs are shown in Figure 2-32 and identified in Table 2-13.

Table 2-13. Sampling Stations by Waterbody

Waterbody	LTCP Sampling Stations	HSM Sampling Stations
Thurston Basin	TB-9, TB-10, TB-11, TB-12	TB1(2), TB2(2)
Bergen Basin	BB-5, BB-6, BB-7, BB-8	BB2, BB4
Spring Creek		SP1, SP2
Hendrix Creek		HC1, HC2, HC3(2)
Fresh Creek	FC-1, FC-2, FC-3, FC-4	F1, F5
Paerdegat Basin		PB2, PB3
Northern Shore		J10, J3, J9A, J8, J7, JA1(1)
Inner Bay		J2, J12, J14, J16
Rockaway Shore(3)		J1, J5

Notes:

(1) Sampling began at this location in 2015.
(2) Sampling began at this location in 2016.
(3) Sampling began at this location in 2015.

Figure 2-31. DEP Harbor Survey Monitoring Program Sampling Locations within Jamaica Bay

Figure 2-33 through Figure 2-52 show the GM of both datasets over concurrent sampling periods along with data ranges (minimum to maximum and 25th percentile to 75th percentile) for fecal coliform and *Enterococci*, respectively.

Overall, the fecal coliform levels measured throughout the LTCP sampling program resulted in GMs indicative of the impacts of primarily wet-weather pollution sources on Fresh Creek, Bergen Basin, and Thurston Basin. The LTCP sampling program results show similar trends to the 2015 HSM Sampling data set. As shown in Figure 2-33, the wet-weather GMs at the LTCP Stations within Fresh Creek, Bergen Basin, and Thurston Basin Station TB-9 are above 200 cfu/100mL, while the dry-weather GMs at those stations are all below 200 cfu/100mL, except at Bergen Basin Stations BB-5 and BB-6. The LTCP *Enterococci* data generally follow a similar trend as the fecal coliform data, as shown in Figure 2-34, with wet-weather GMs higher than dry-weather GMs. The wet and dry weather GMs at the stations closer to the head end of each tributary are also generally higher than at the stations closer to the mouth of each tributary.

The HSM fecal coliform and *Enterococci* data presented in Figure 2-35 through Figure 2-52 are consistent with the LTCP data. HSM stations in Thurston Basin were newly sampled in 2016 and the fecal coliform GMs were lower than 200 cfu/100mL, during both dry and wet-weather. However, the sampling is not reflective of the conditions within the head of Thurston Basin. Access to the head of Thurston Basin is prohibited by JFK Airport security, and a fenced barrier crossing the waterway further restricts access (Figure 2-54).

Fecal coliform GMs in Bergen Basin were above 200 cfu/100mL during both dry- and wet-weather, except at Station BB4 during dry-weather in 2015 and both dry- and wet-weather in 2016. A consistent reduction in dry- and wet-weather GMs for both the fecal coliform and *Enterococci* data was observed from 2013 to 2016, indicating an improvement in water quality conditions over that time period.

Spring Creek and Hendrix Creek showed high wet-weather GMs during 2013 and 2014 with reductions in the GMs during 2015 and 2016 for both fecal coliform and *Enterococci*. Fresh Creek fecal coliform GMs were above 200 cfu/100mL for all years during wet-weather and in 2013-2015 for dry-weather.

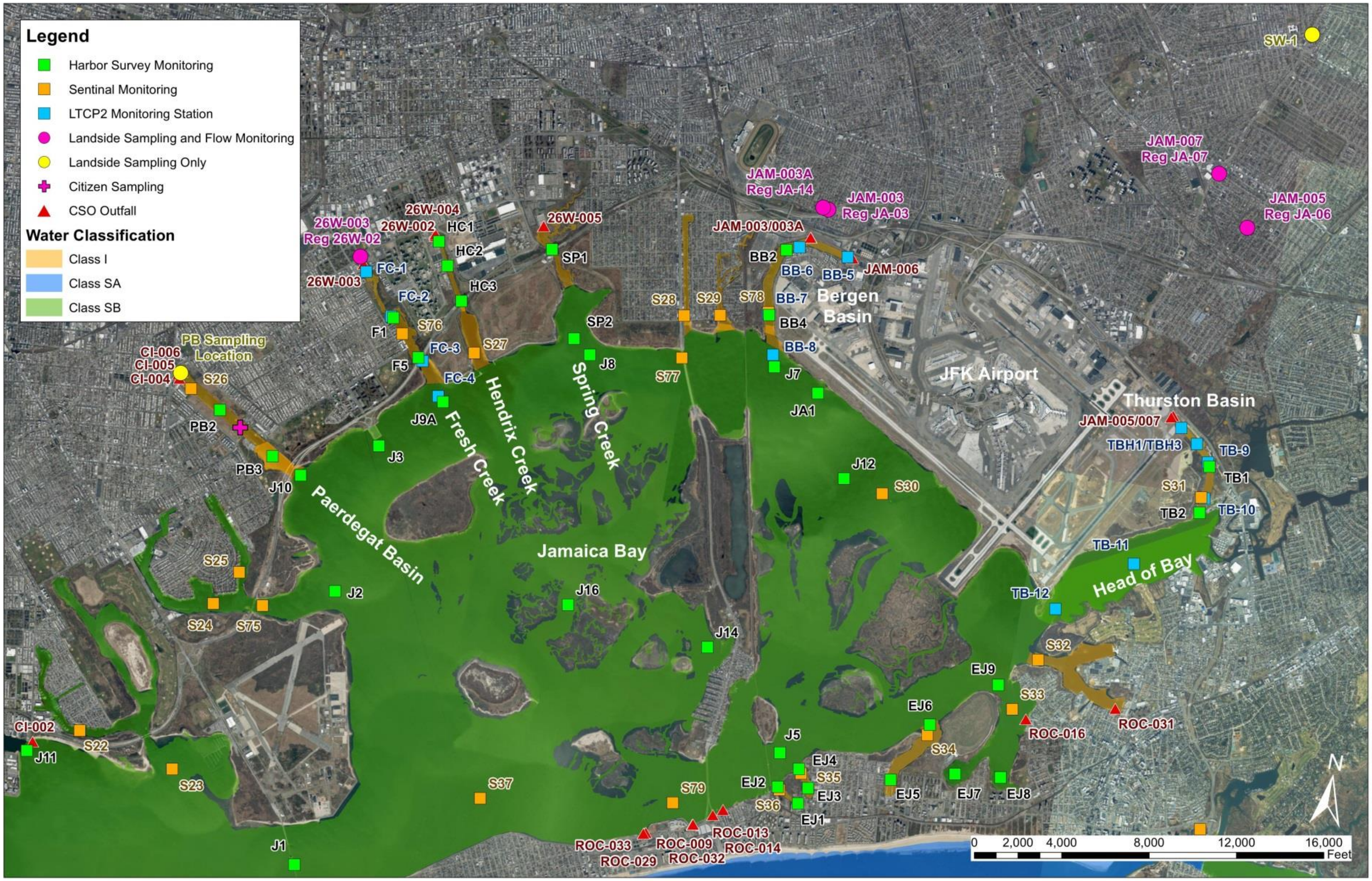

Figure 2-32. Water Quality Monitoring Sampling Locations within Jamaica Bay for the LTCP2, Harbor Survey and Third Party Monitoring Programs

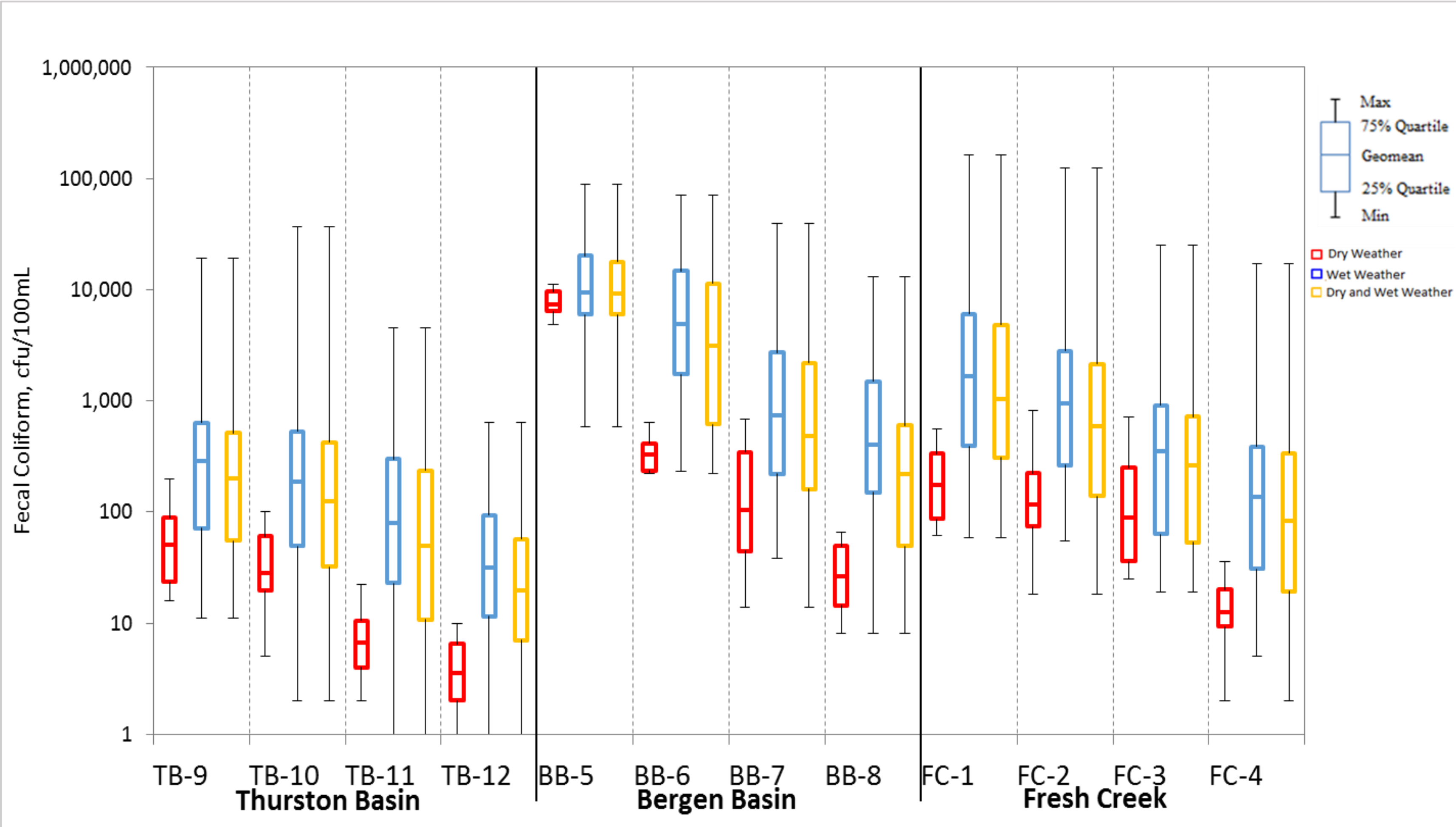

Figure 2-33. Fecal Coliform Concentrations at LTCP Sampling Stations in Thurston Basin, Bergen Basin, and Fresh Creek

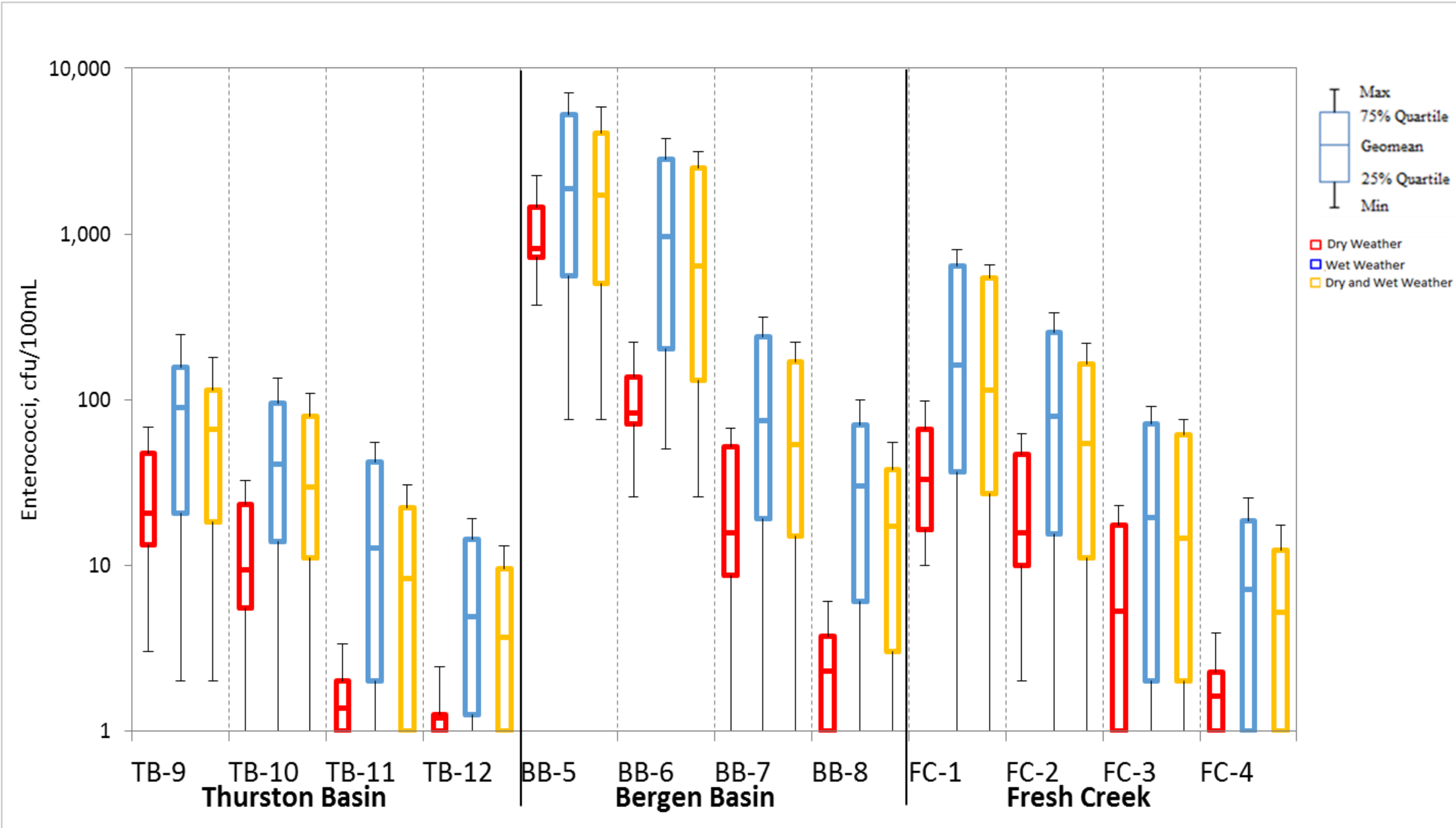

Figure 2-34. *Enterococci* Concentrations at LTCP Sampling Stations in Thurston Basin, Bergen Basin, and Fresh Creek

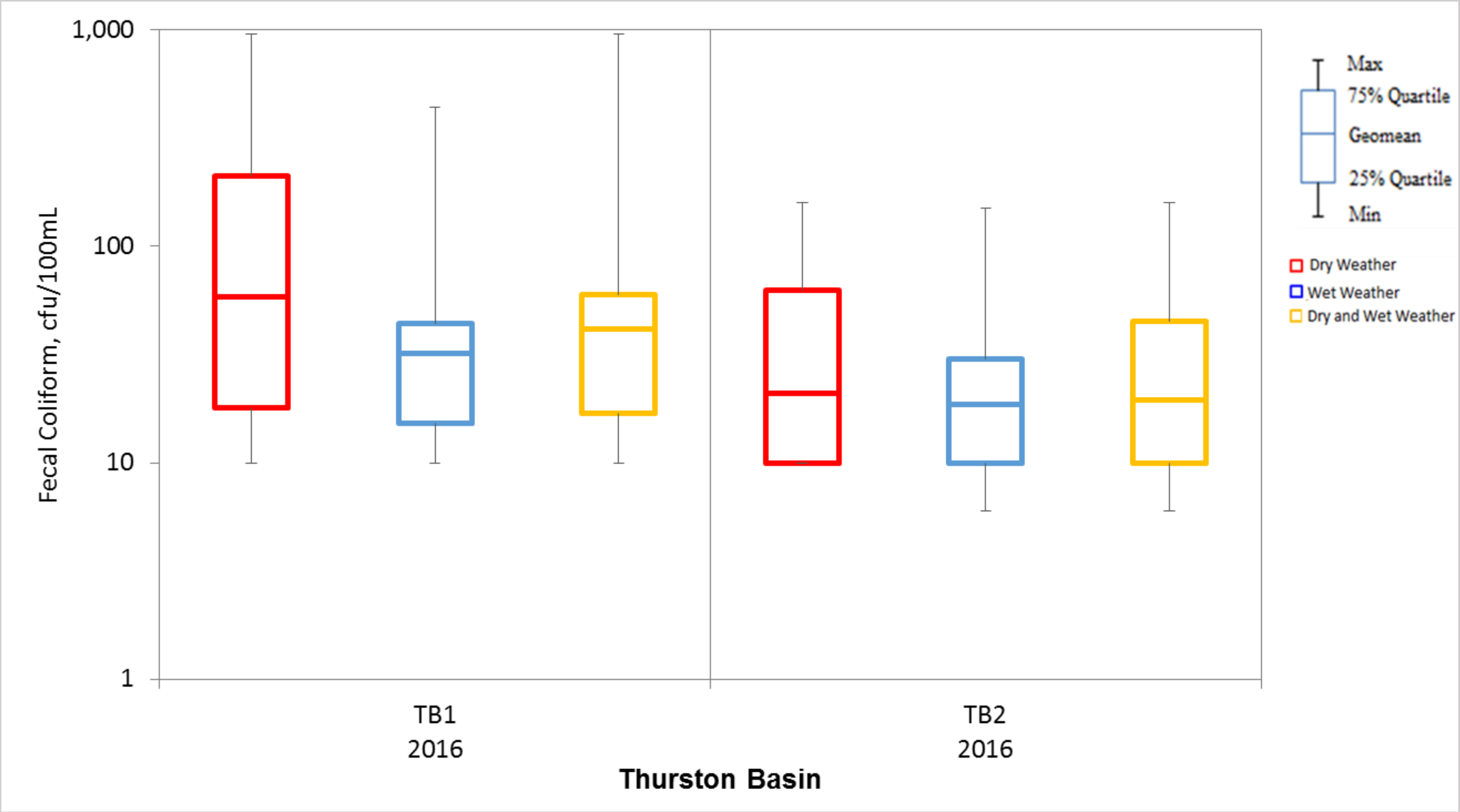

Figure 2-35. Fecal Coliform Concentrations at Thurston Basin Harbor Survey Monitoring Stations

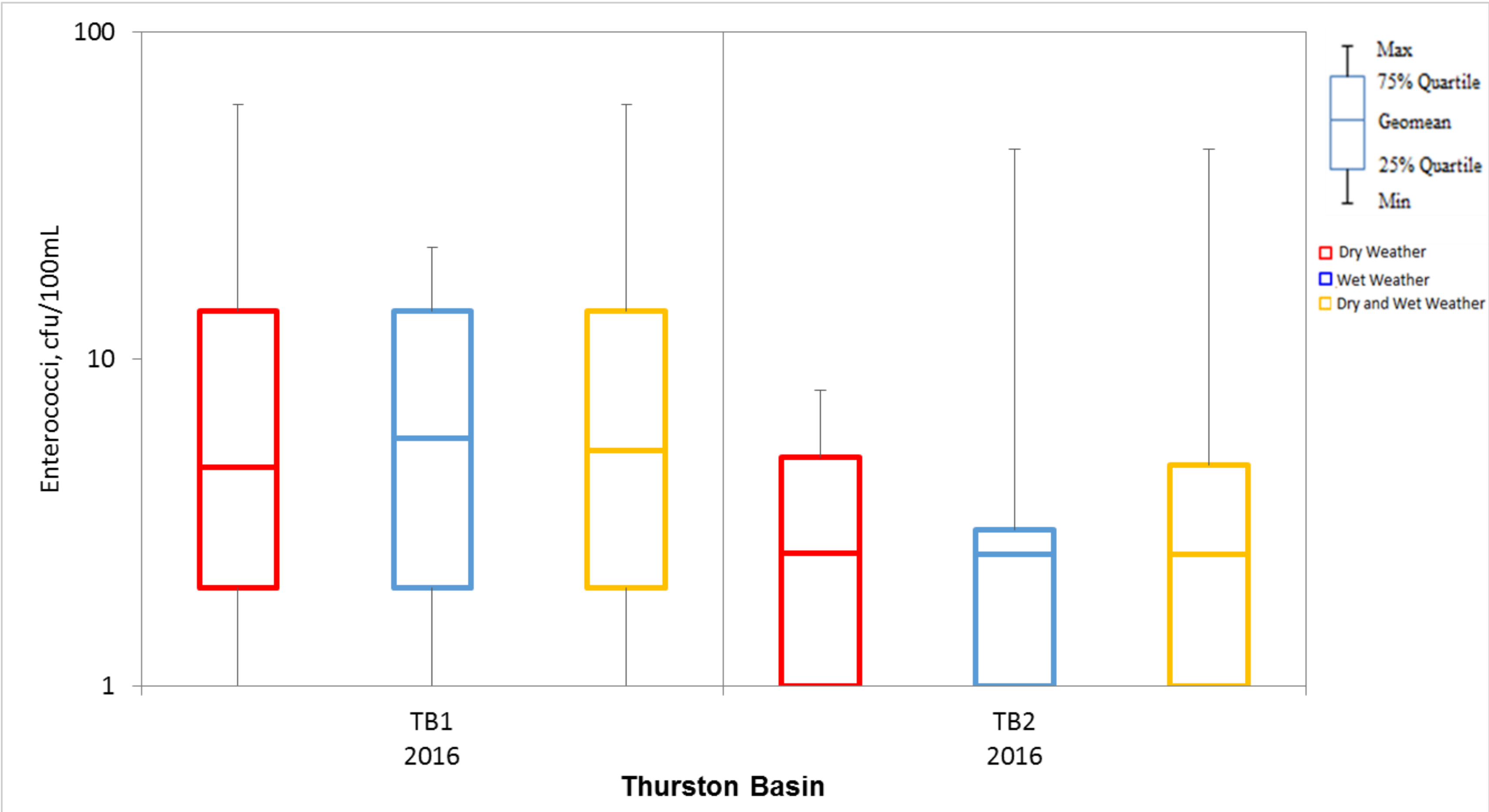

Figure 2-36. *Enterococci* Concentrations at Thurston Basin Harbor Survey Monitoring Stations

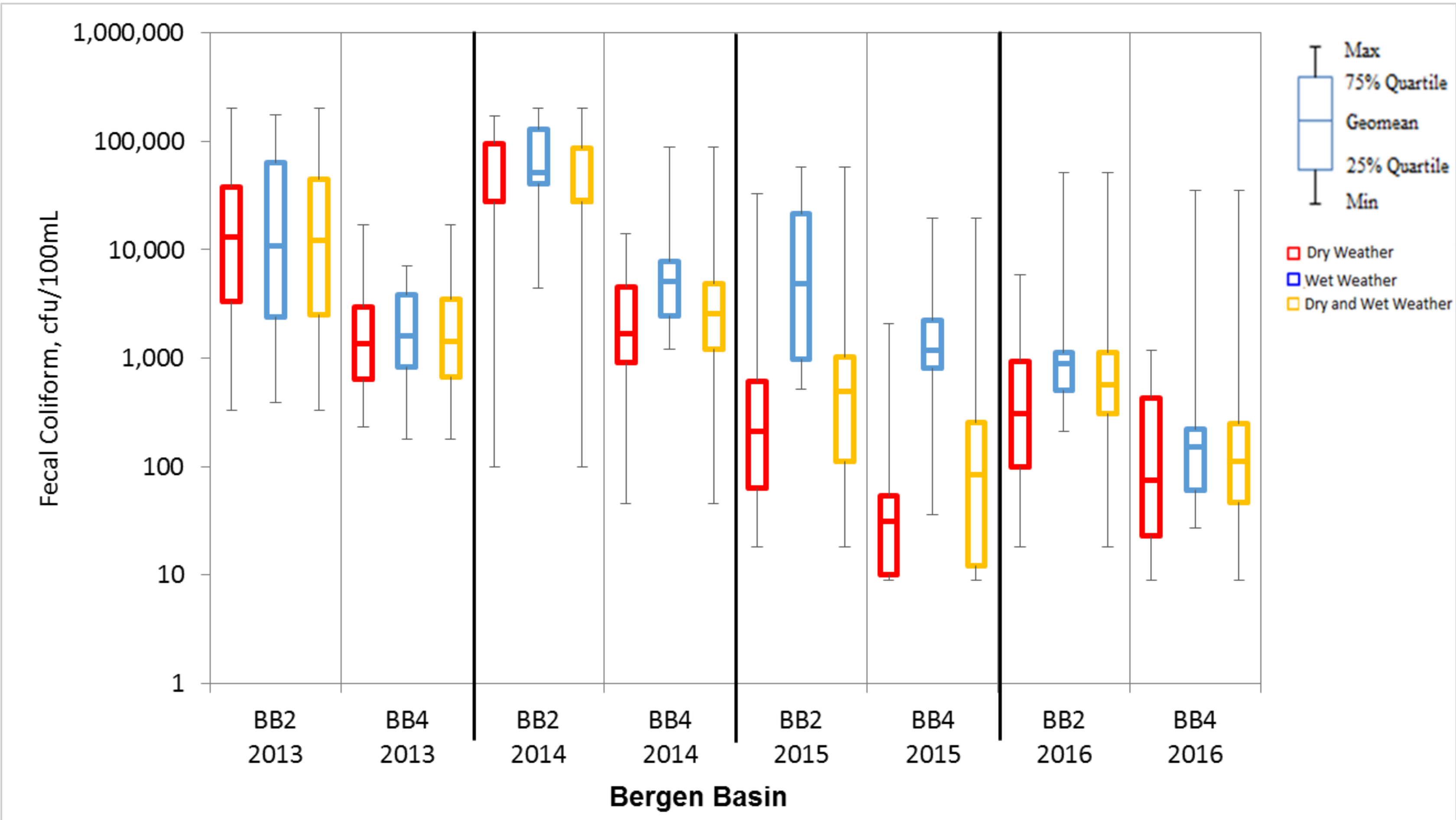

Figure 2-37. Fecal Coliform Concentrations at Bergen Basin Harbor Survey Monitoring Stations

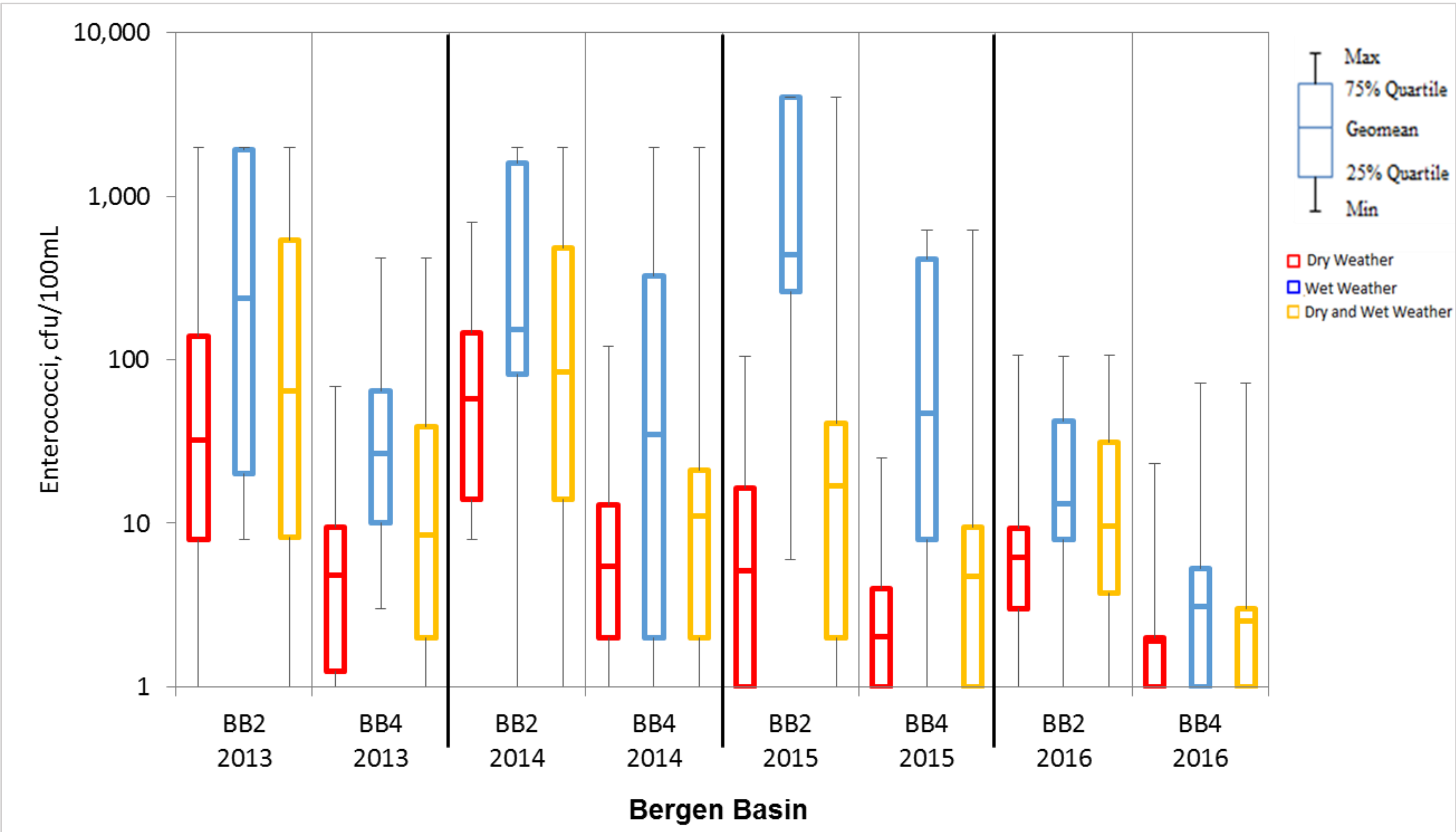

Figure 2-38. *Enterococci* Concentrations at Bergen Basin Harbor Survey Monitoring Stations

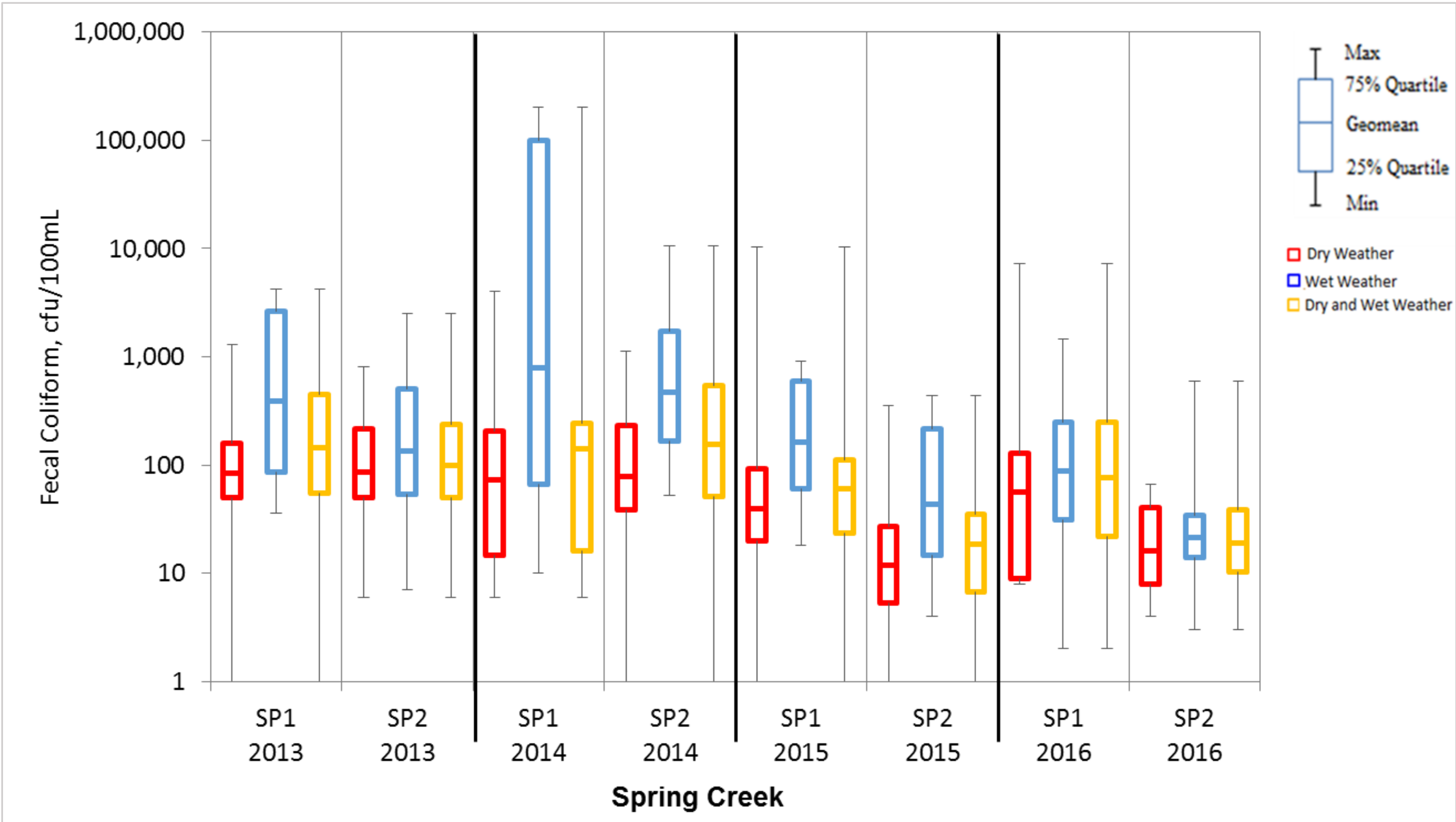

Figure 2-39. Fecal Coliform Concentrations at Spring Creek Harbor Survey Monitoring Stations

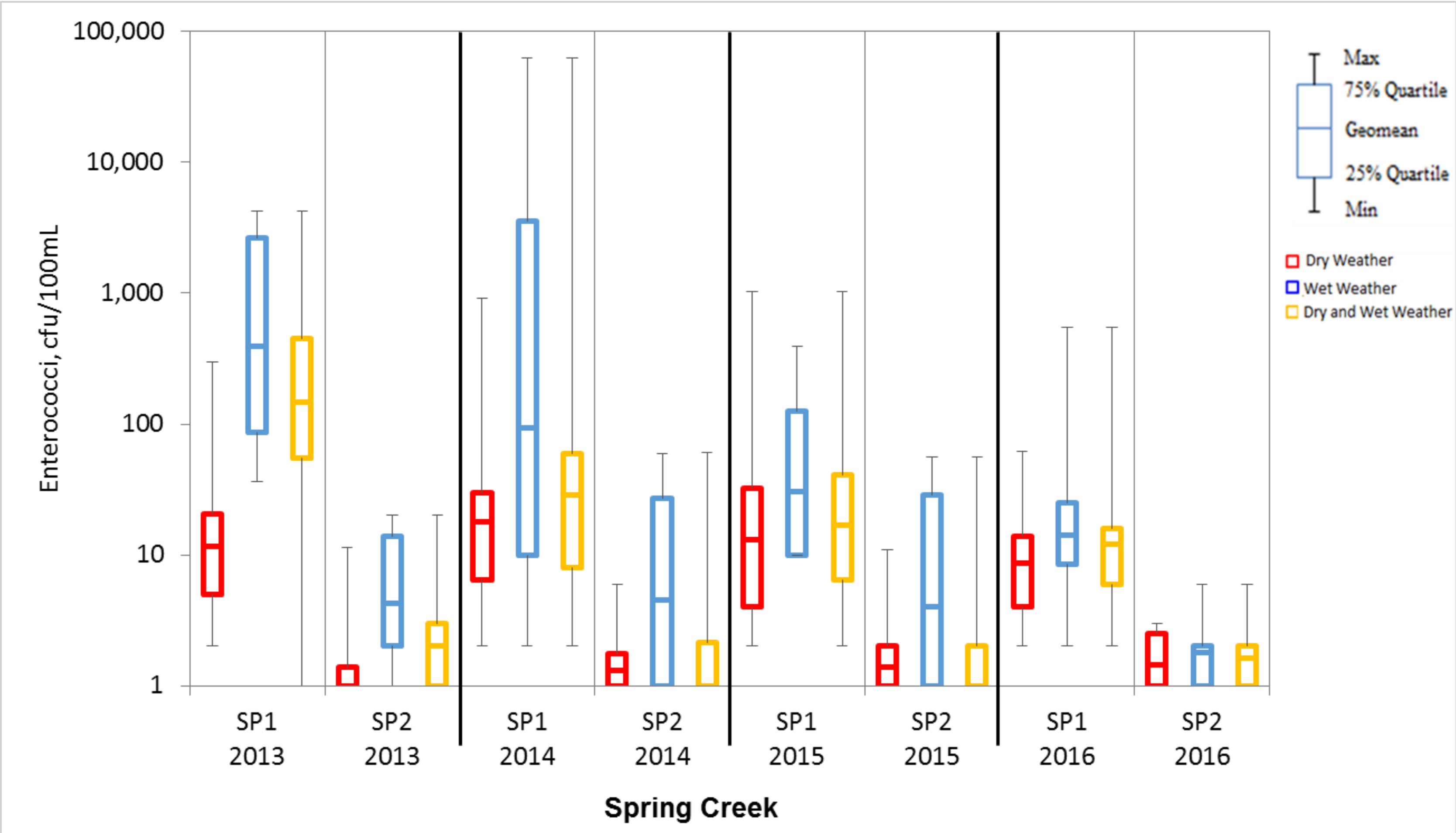

Figure 2-40. ***Enterococci*** **Concentrations at Spring Creek Harbor Survey Monitoring Stations**

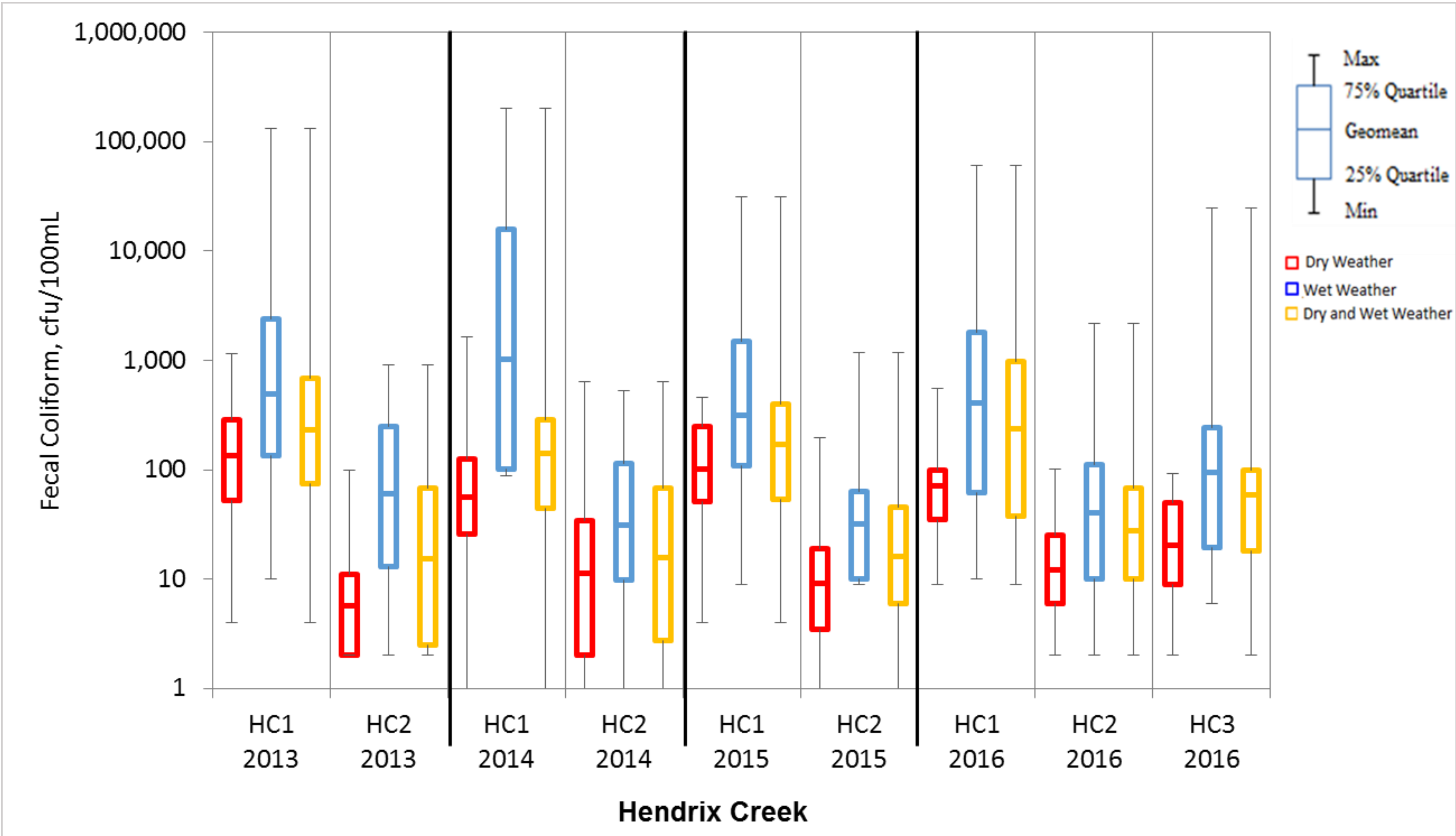

Figure 2-41. Fecal Coliform Concentrations at Hendrix Creek Harbor Survey Monitoring Stations

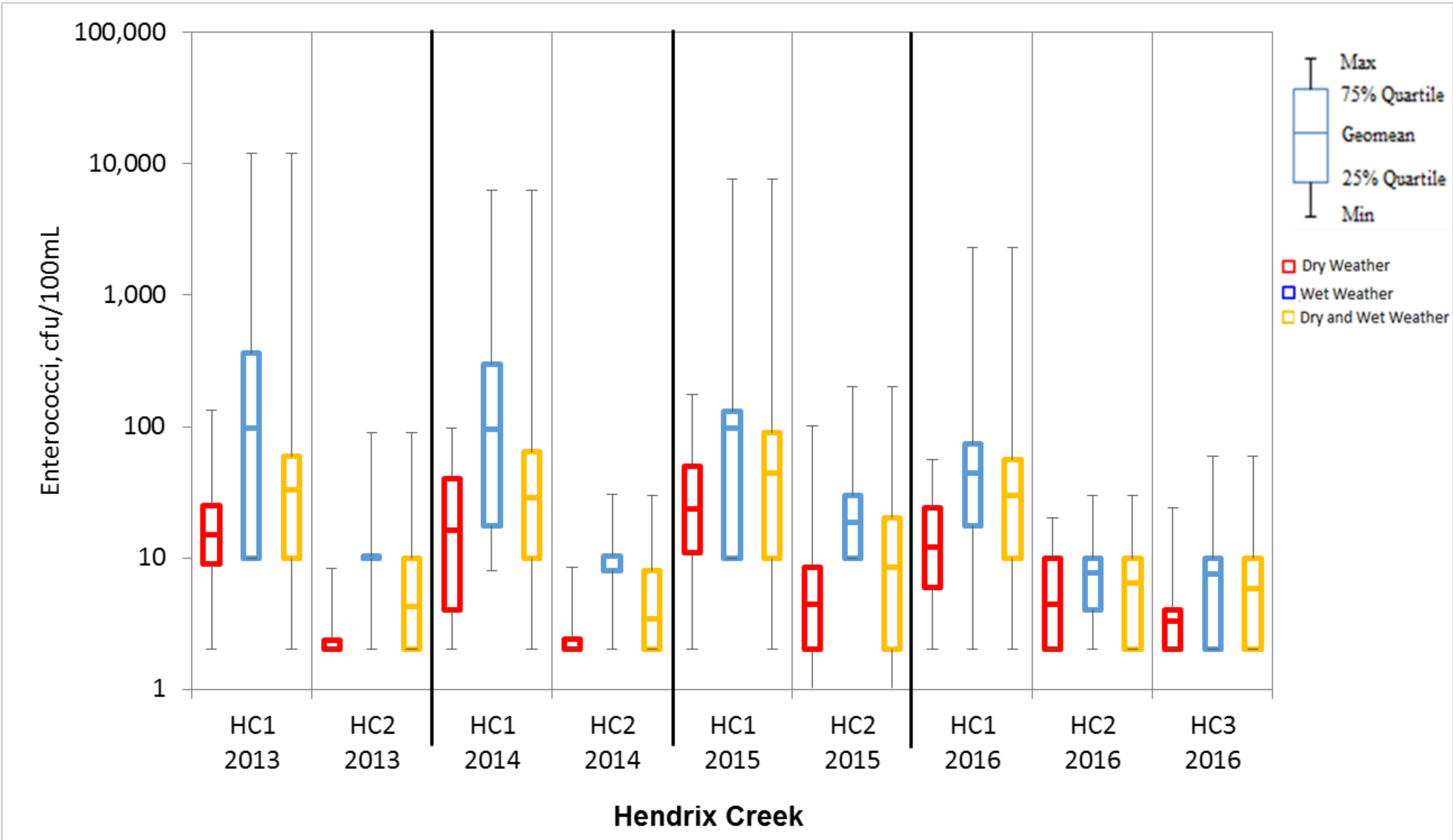

Figure 2-42. *Enterococci* Concentrations at Hendrix Creek Harbor Survey Monitoring Stations

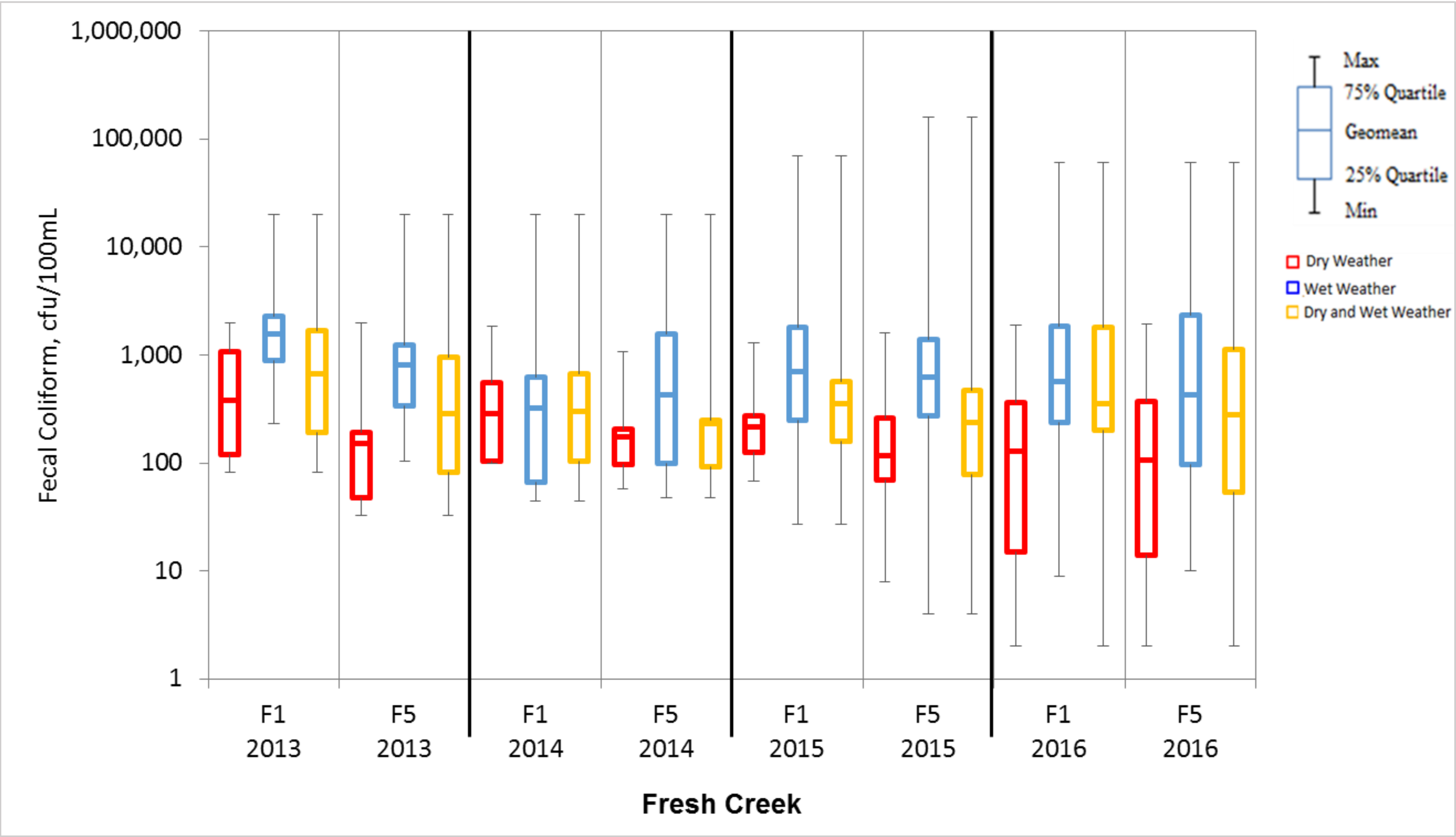

Figure 2-43. Fecal Coliform Concentrations at Fresh Creek Harbor Survey Monitoring Stations

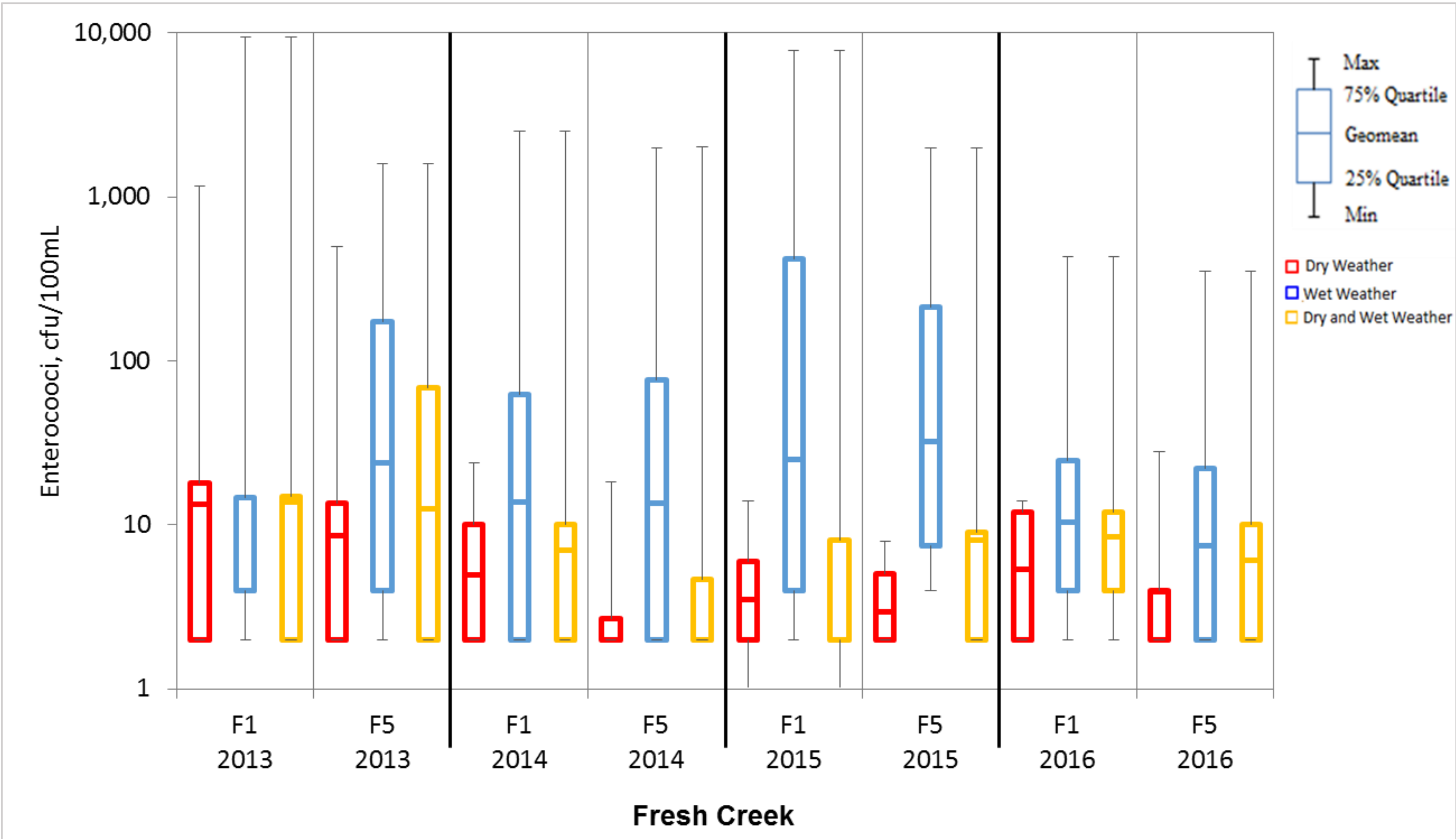

Figure 2-44. ***Enterococci*** **Concentrations at Fresh Creek Harbor Survey Monitoring Stations**

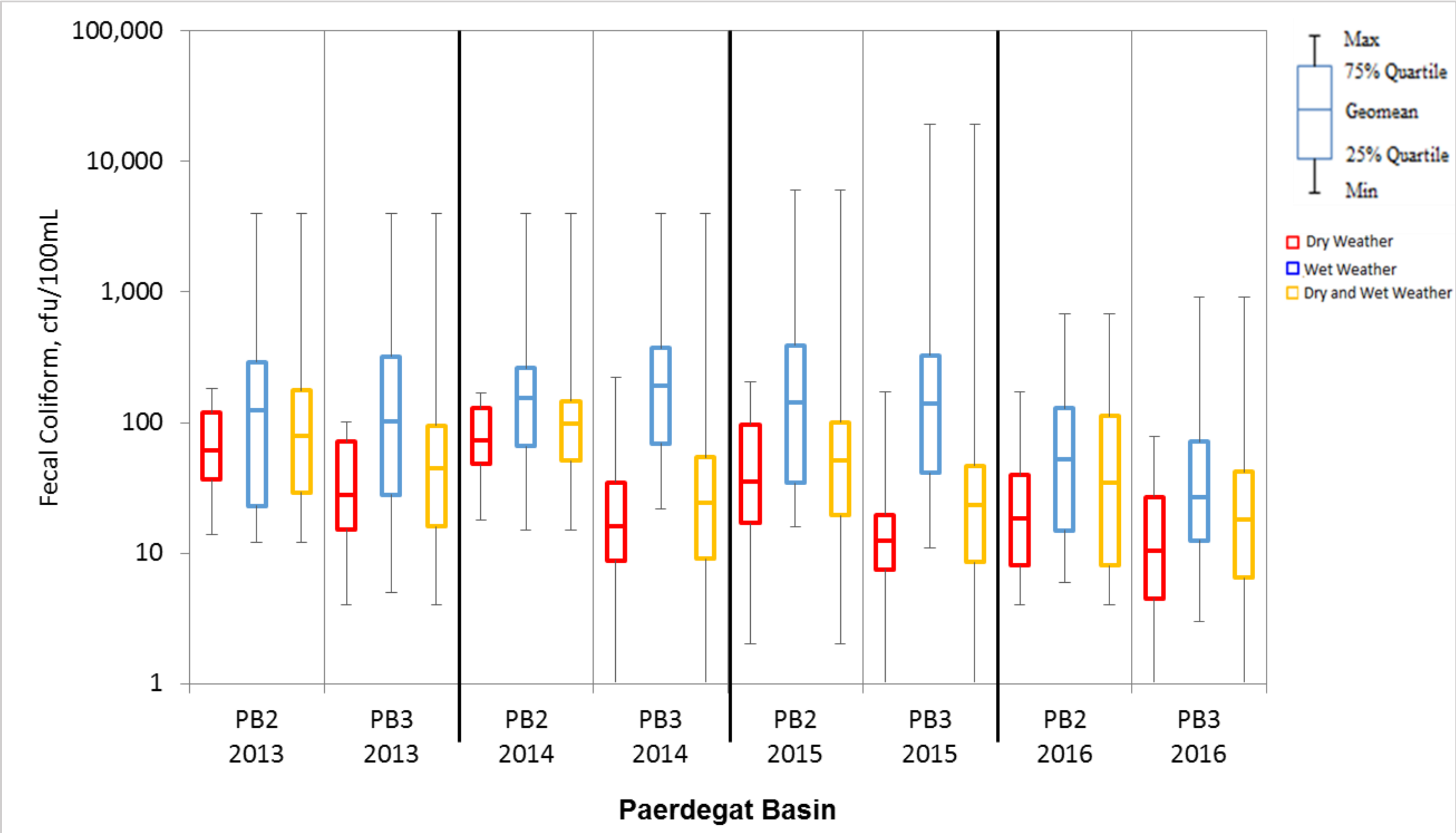

Figure 2-45. Fecal Coliform Concentrations at Paerdegat Basin Harbor Survey Monitoring Stations

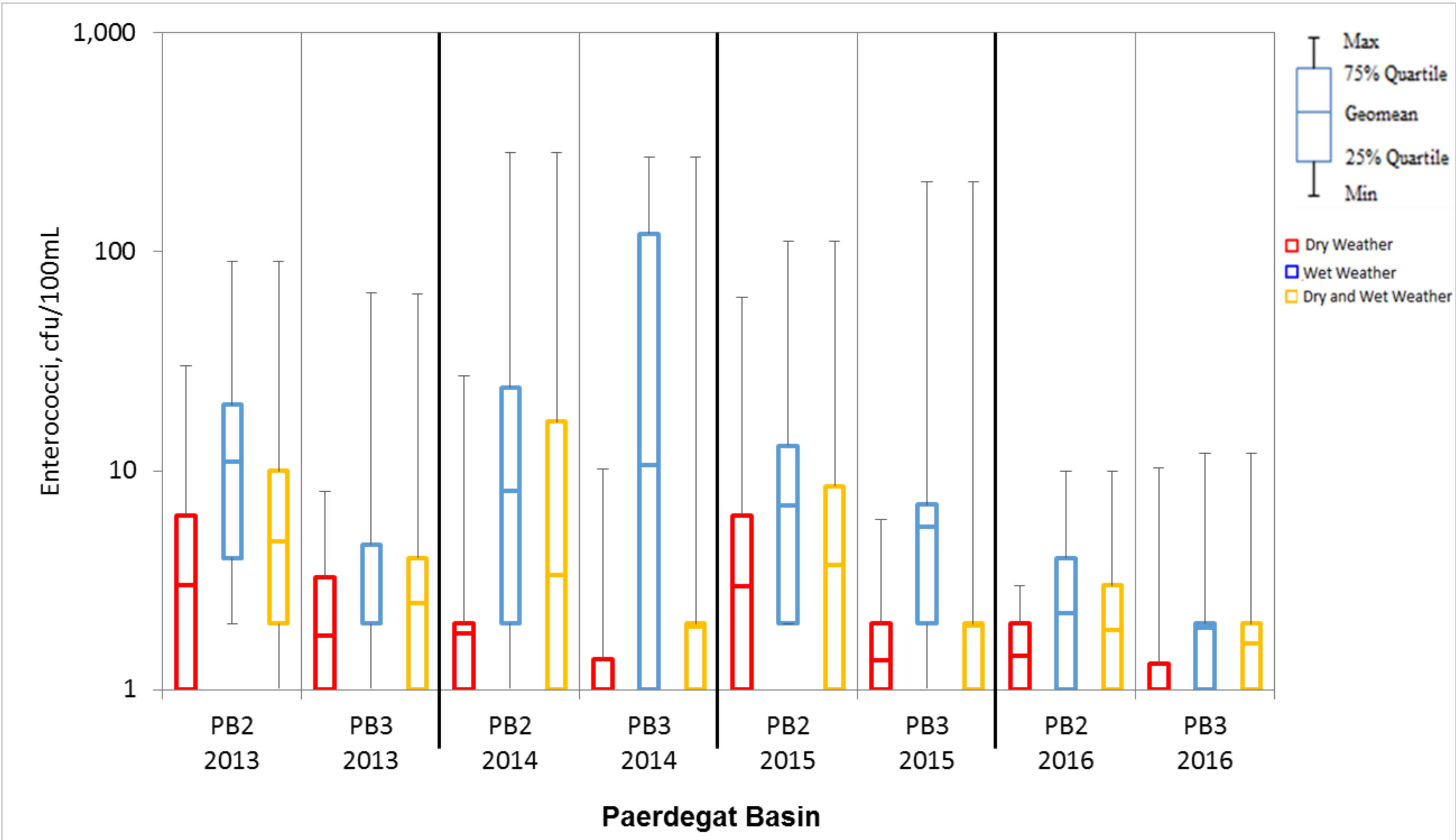

Figure 2-46. ***Enterococci*** **Concentrations at Paerdegat Basin Harbor Survey Monitoring Stations**

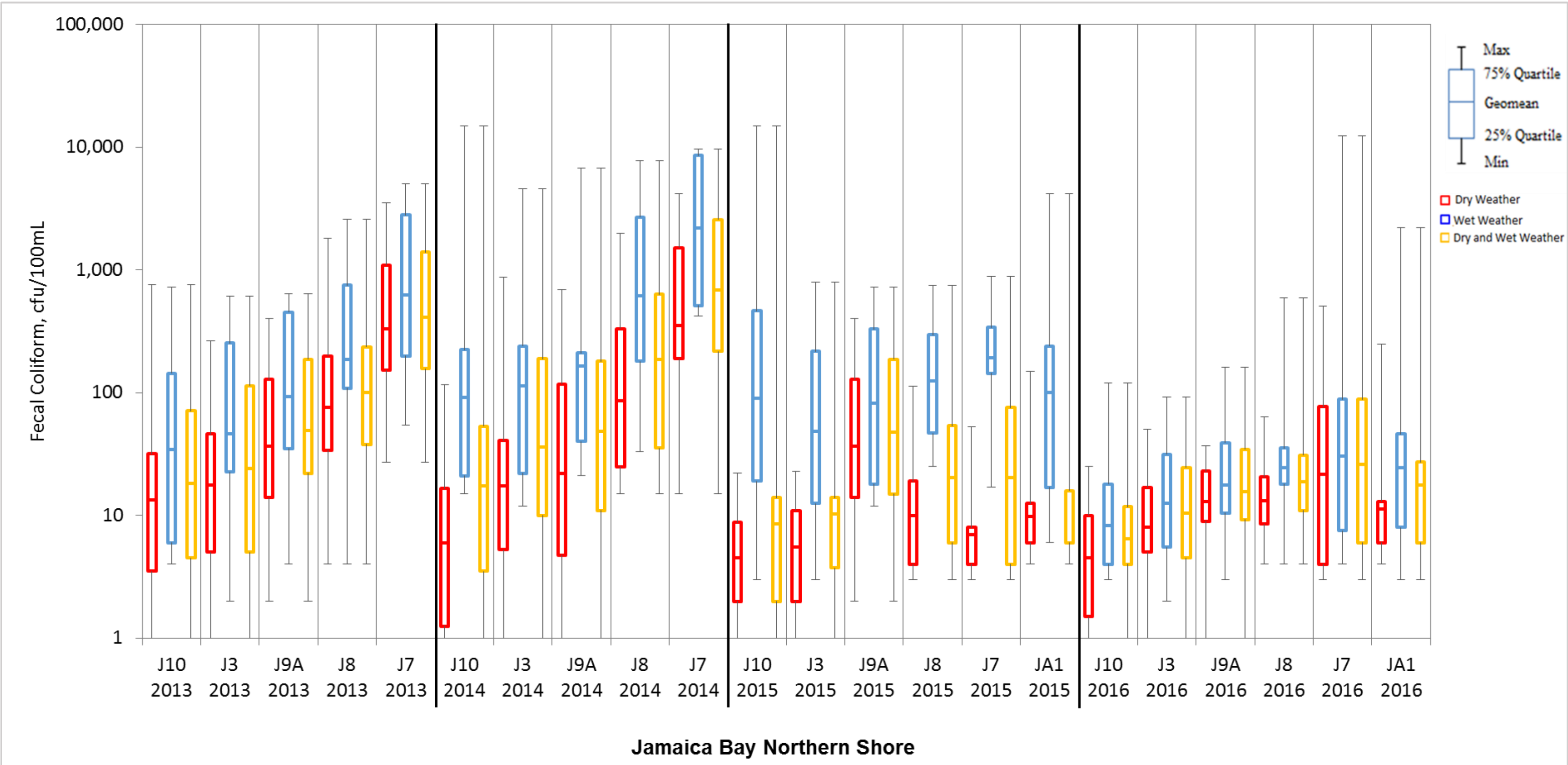

Figure 2-47. Fecal Coliform Concentrations at Northern Shore Harbor Survey Monitoring Stations

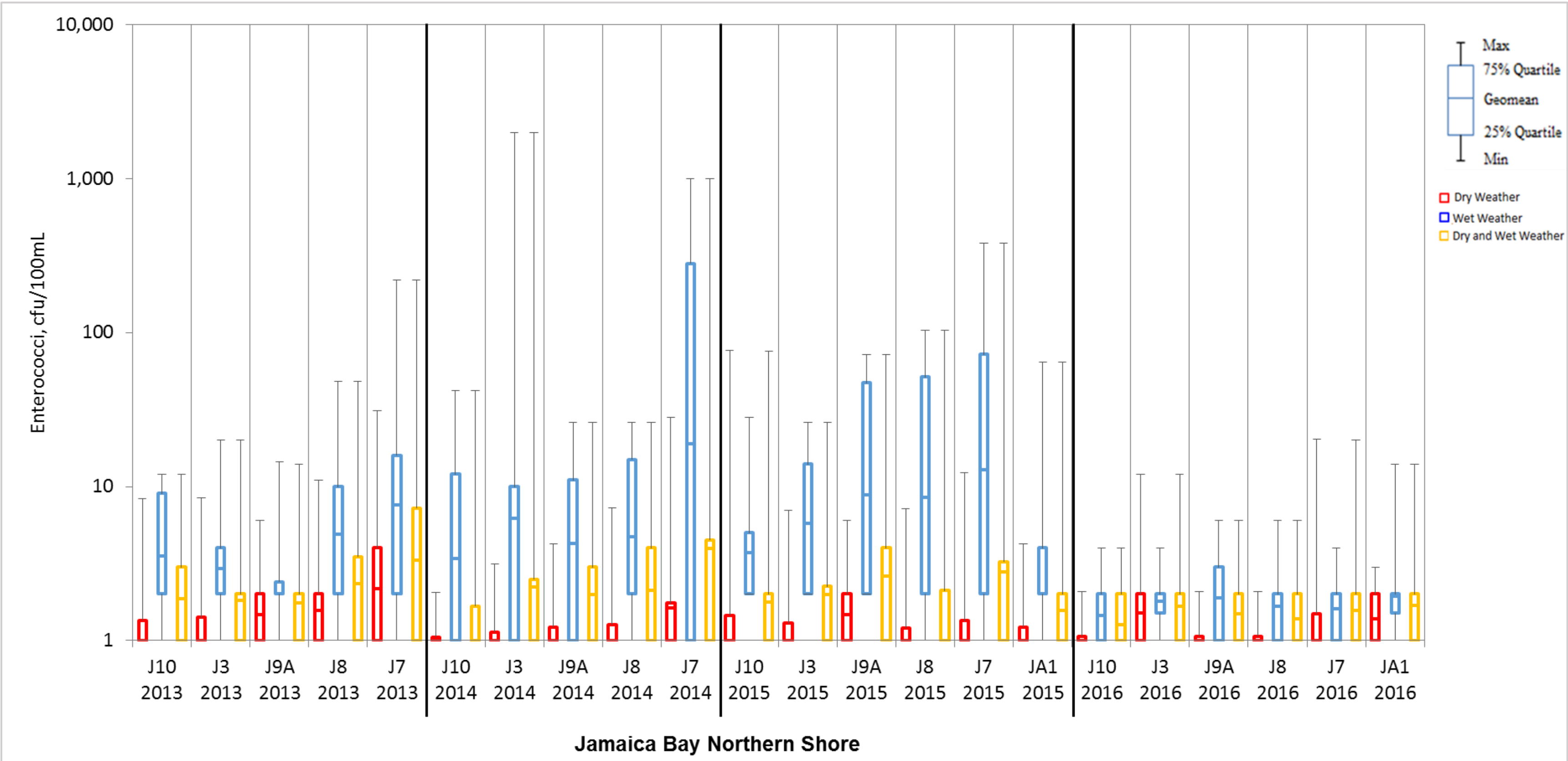

Figure 2-48. ***Enterococci*** **Concentrations at Northern Shore Harbor Survey Monitoring Stations**

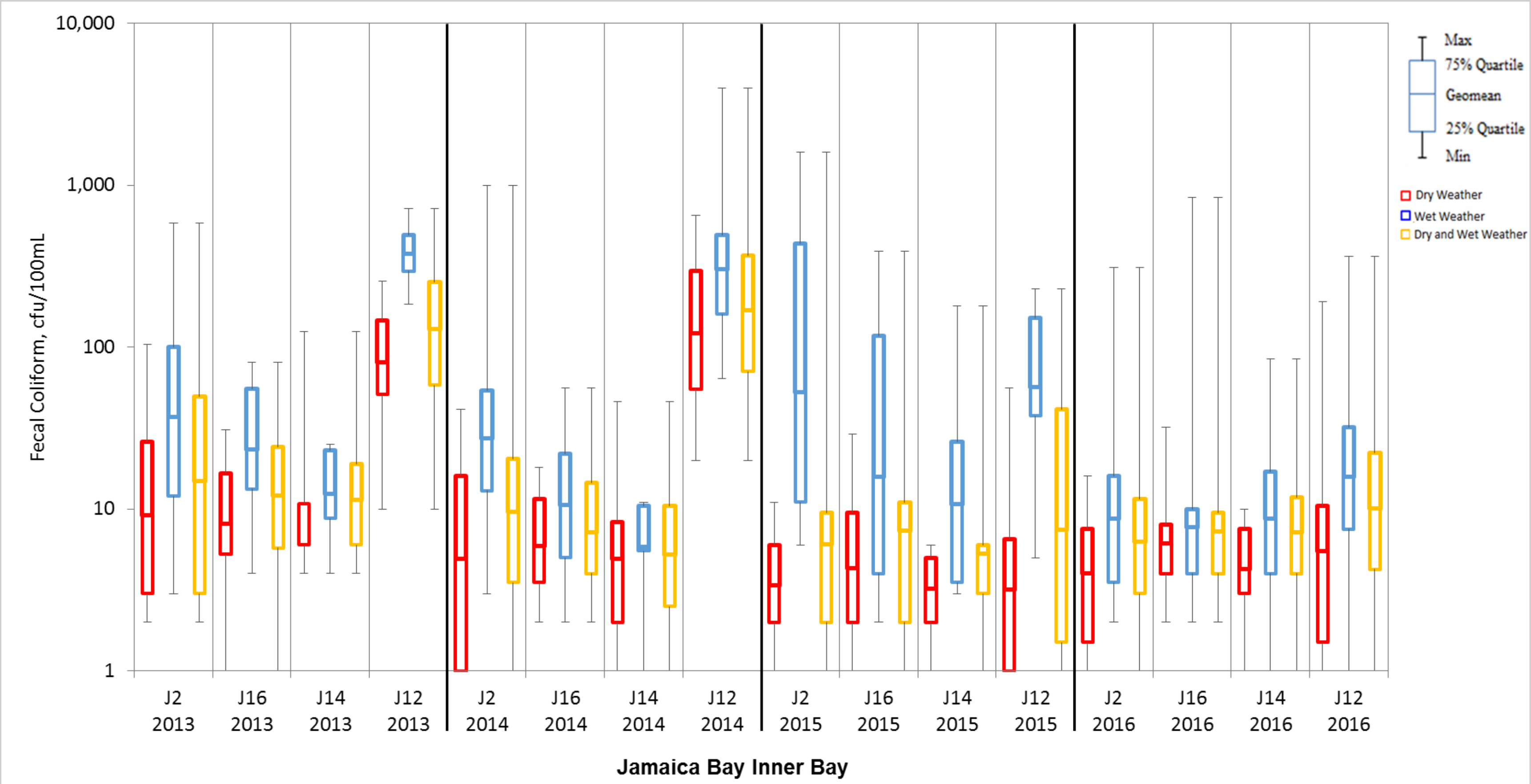

Figure 2-49. Fecal Coliform Concentrations at Inner Jamaica Bay Harbor Survey Monitoring Stations

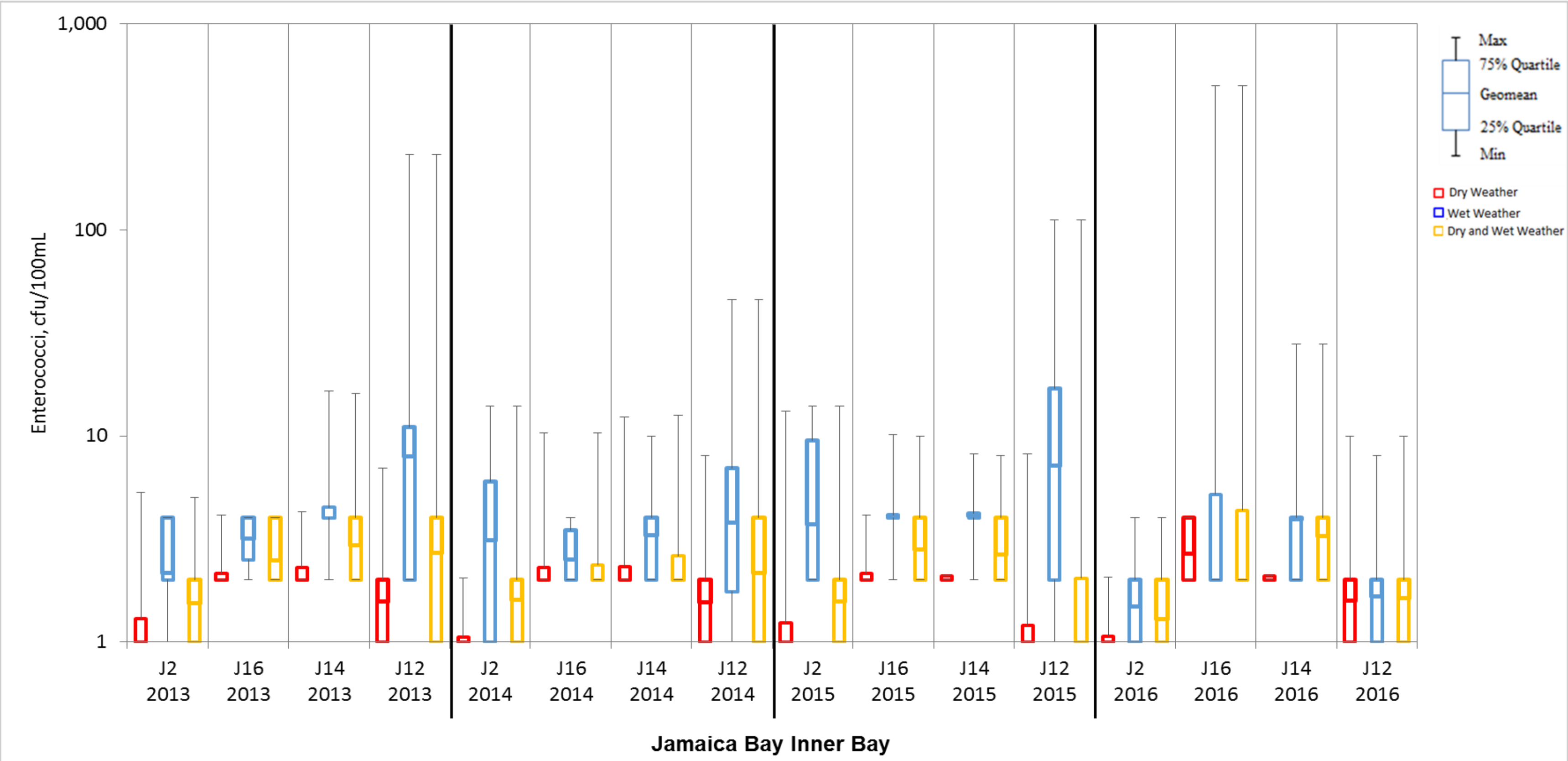

Figure 2-50. *Enterococci* Concentrations at Inner Jamaica Bay Harbor Survey Monitoring Stations

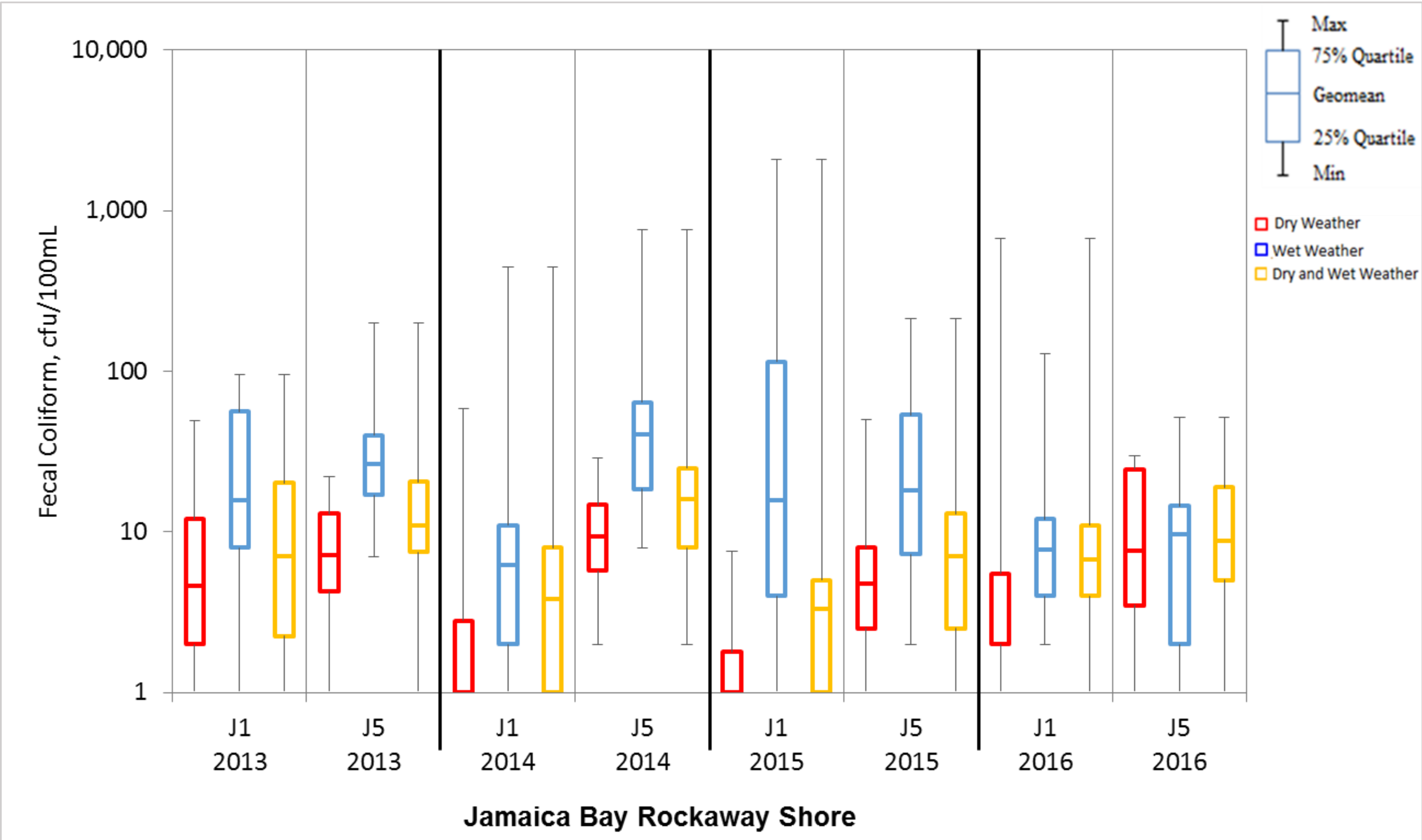

Figure 2-51. Fecal Coliform Concentrations at Rockaway Shore Harbor Survey Monitoring Stations

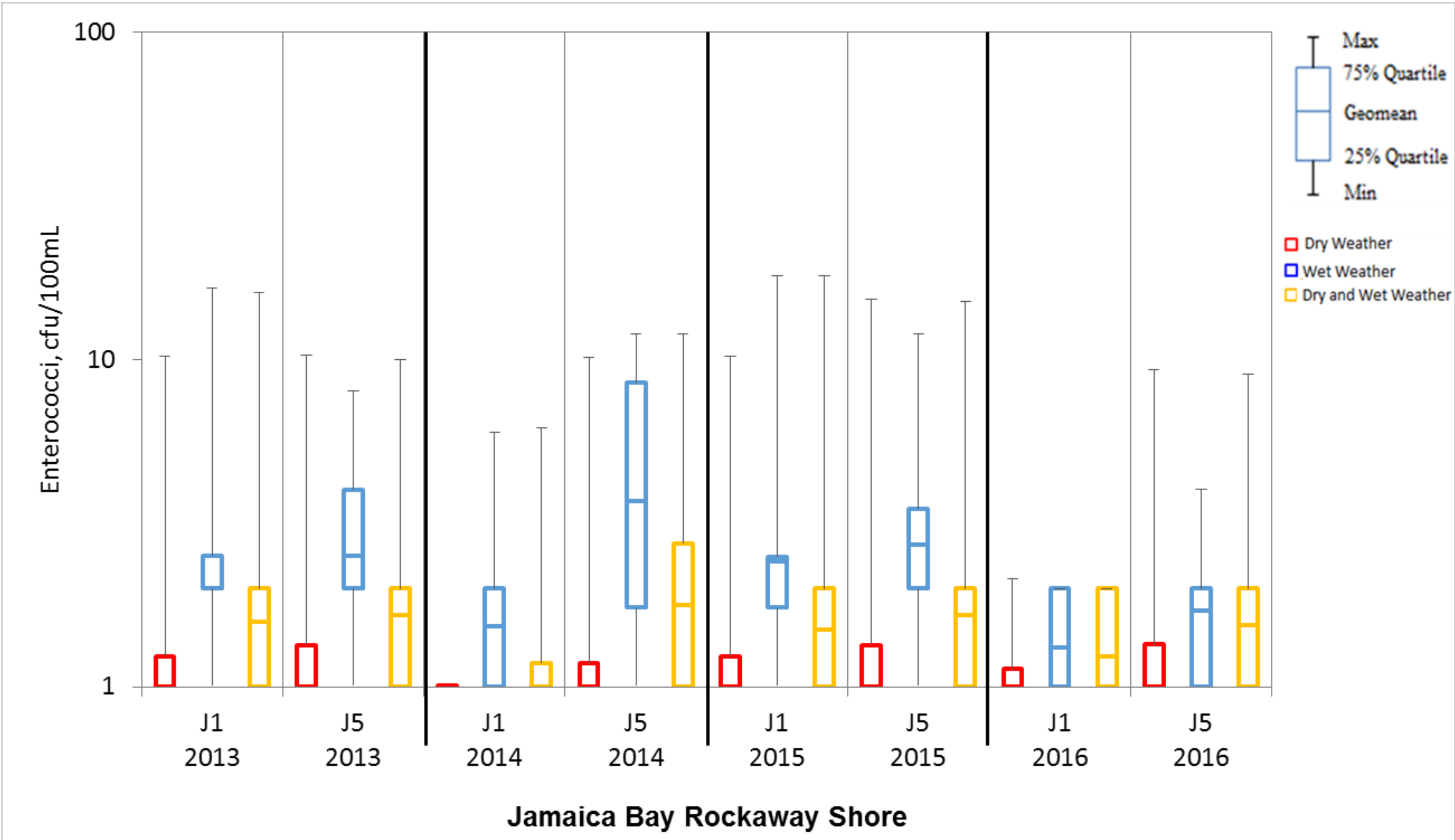

Figure 2-52. *Enterococci* Concentrations at Rockaway Shore Harbor Survey Monitoring Stations

Figure 2-53. Photograph of Head End of Thurston Basin, showing Fence Restricting Access

Fecal coliform GMs were below 200 cfu/100mLduring both dry- and wet-weather in Paerdegat Basin. An improvement in dry- and wet-weather GMs for both fecal coliform and *Enterococci* is observed from 2013 to 2016.

During dry- and wet-weather conditions, fecal coliform GMs were below 200 cfu/100mL along the Northern Shore, Inner Bay, and Rockaway Shore for all years, except at Northern Shore Stations J7 and J8 and Inner Bay Station J12, which had wet-weather fecal coliform GMs above 200 cfu/100mL in 2013-2014. Steady reductions in fecal coliform concentrations were observed for all Northern Shore Stations from 2013 to 2016, including Stations J7 and J8. Reduction in *Enterococci* GMs were observed in 2016 in comparison to the 2013-2015 data set for the Northern Shore. Wet-weather fecal coliform and *Enterococci* GMs at Station J12 within the Inner Bay were distinctly lower in 2016 compared to 2013 through 2015.

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 in Paerdegat Basin, located midway between HSM Stations PB2 and PB3, as shown in Figure 2-32. These data are available at the Riverkeeper Group's website http://www.riverkeeper.org/. Citizens Testing Group results were inconsistent with the HSM data. *Enterococci* GMs were considerably higher than the GMs at nearby HSM Stations PB2 and PB3 during both dry- and wet-weather. This may be due to the presence of an active storm sewer outfall just upstream of the sampling location, or the location of the Citizens

Testing Group samples at the shoreline. *Enterococci* GMs at the Citizens Testing Group location were also higher in dry-weather than in wet-weather.

Figure 2-54 depicts the DO averages derived from the LTCP dataset measured from October through November 2015. The data show averages and 25th percentiles above 4.0 mg/L at all stations. However, minimum DO values do fall below 4.0 mg/L at Bergen Basin Stations BB-5 to BB-7 and Fresh Creek Stations FC-1 to FC-3. The measured LTCP DO concentrations portray autumn conditions with cooler temperatures and hence do not capture the lower DO values expected to occur during the summer periods. Based on the HSM program DO dataset throughout 2013 and 2016, as shown in Figure 2-55 through Figure 2-63, DO values were observed below 4.0 mg/L in all sampled tributaries and below 3.0 mg/L at some locations (HSM Stations J7, J8, JA1, J12, J14, and J16) within Jamaica Bay's Northern Shore and Inner Bay.

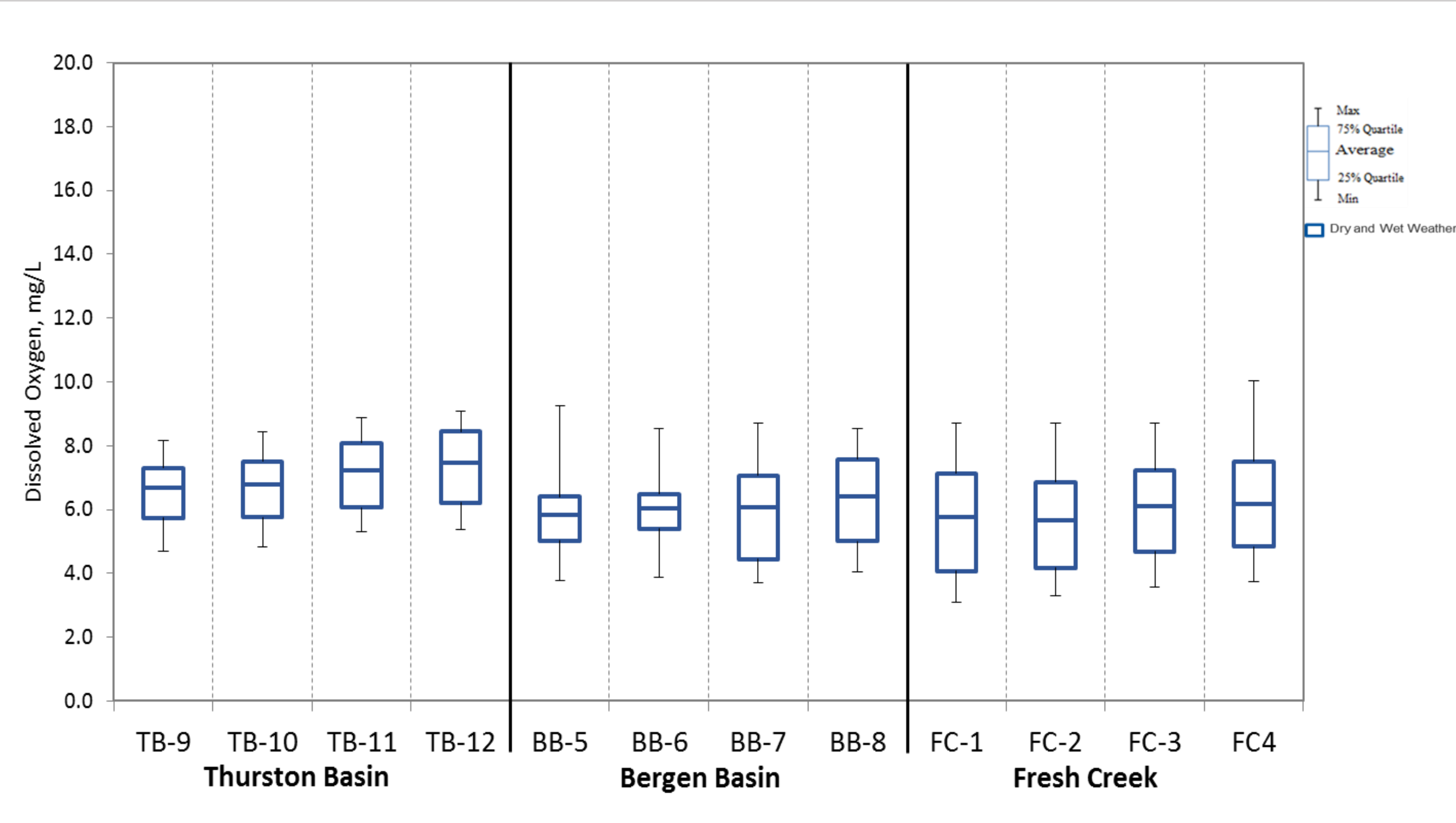

Figure 2-54. Dissolved Oxygen Concentrations at Thurston Basin, Bergen Basin, and Fresh Creek LTCP Monitoring Locations

Figure 2-55. Dissolved Oxygen Concentrations at Thurston Basin Harbor Survey Monitoring Stations

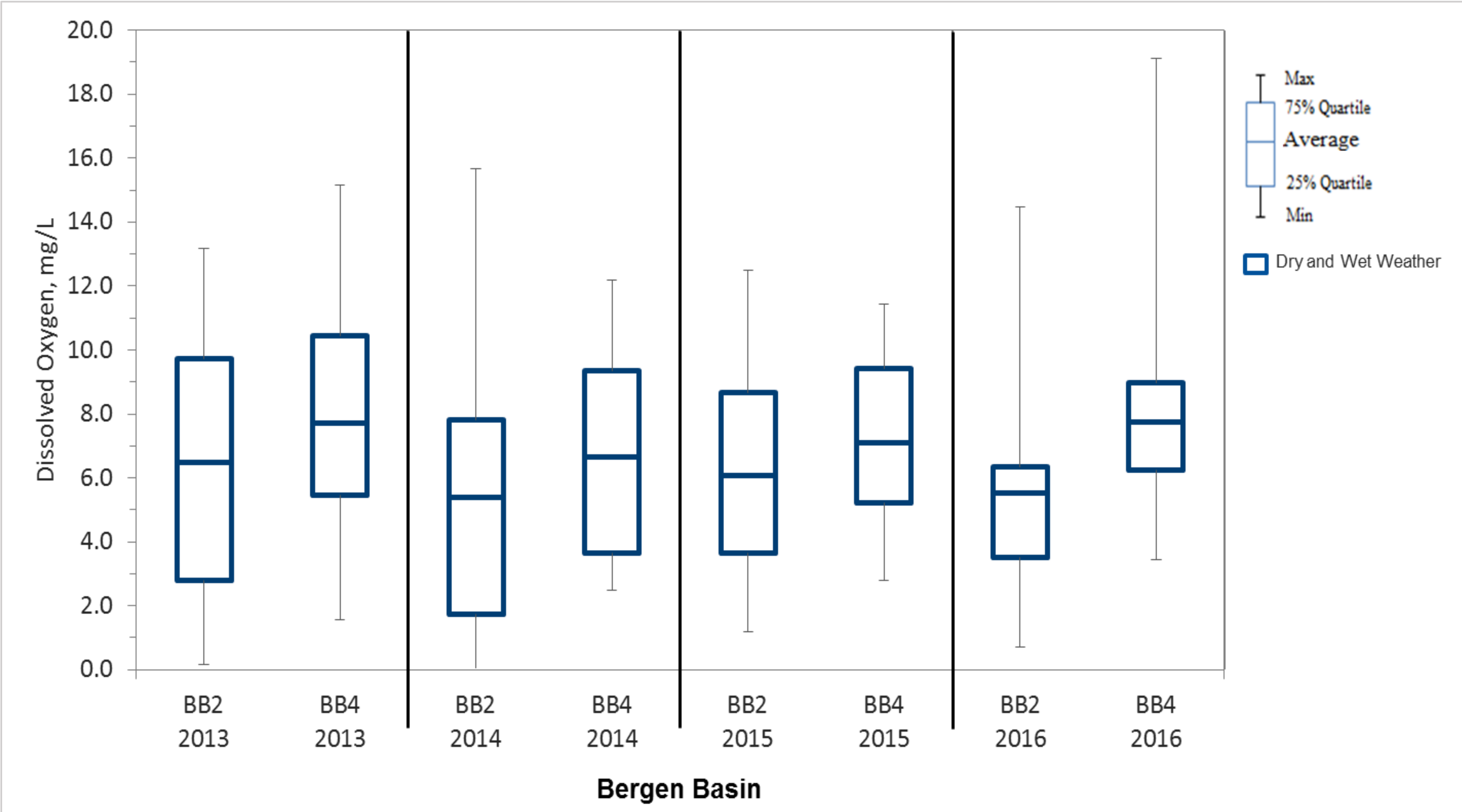

Figure 2-56. Dissolved Oxygen Concentrations at Bergen Basin Harbor Survey Monitoring Stations

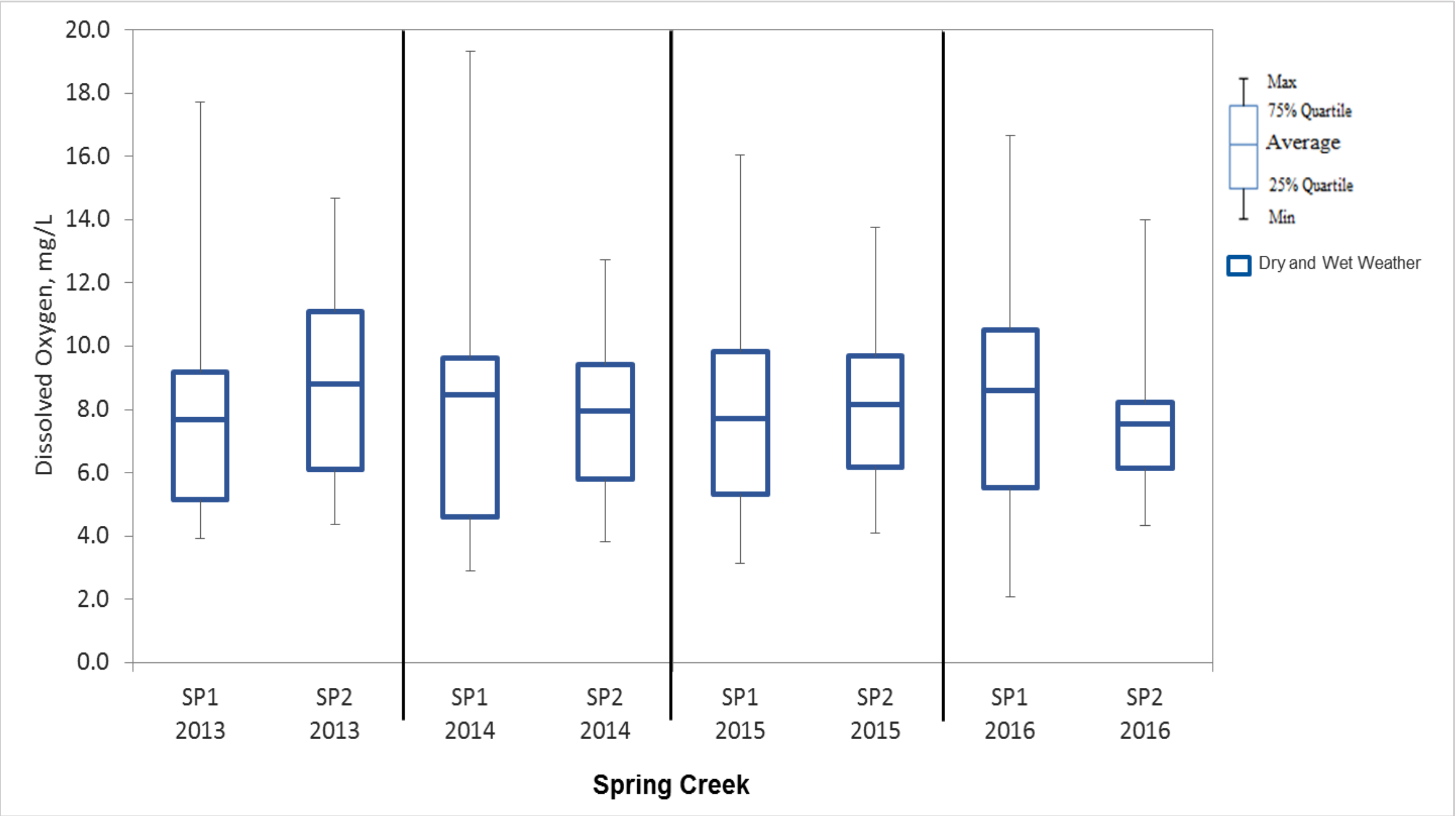

Figure 2-57. Dissolved Oxygen Concentrations at Spring Creek Harbor Survey Monitoring Stations

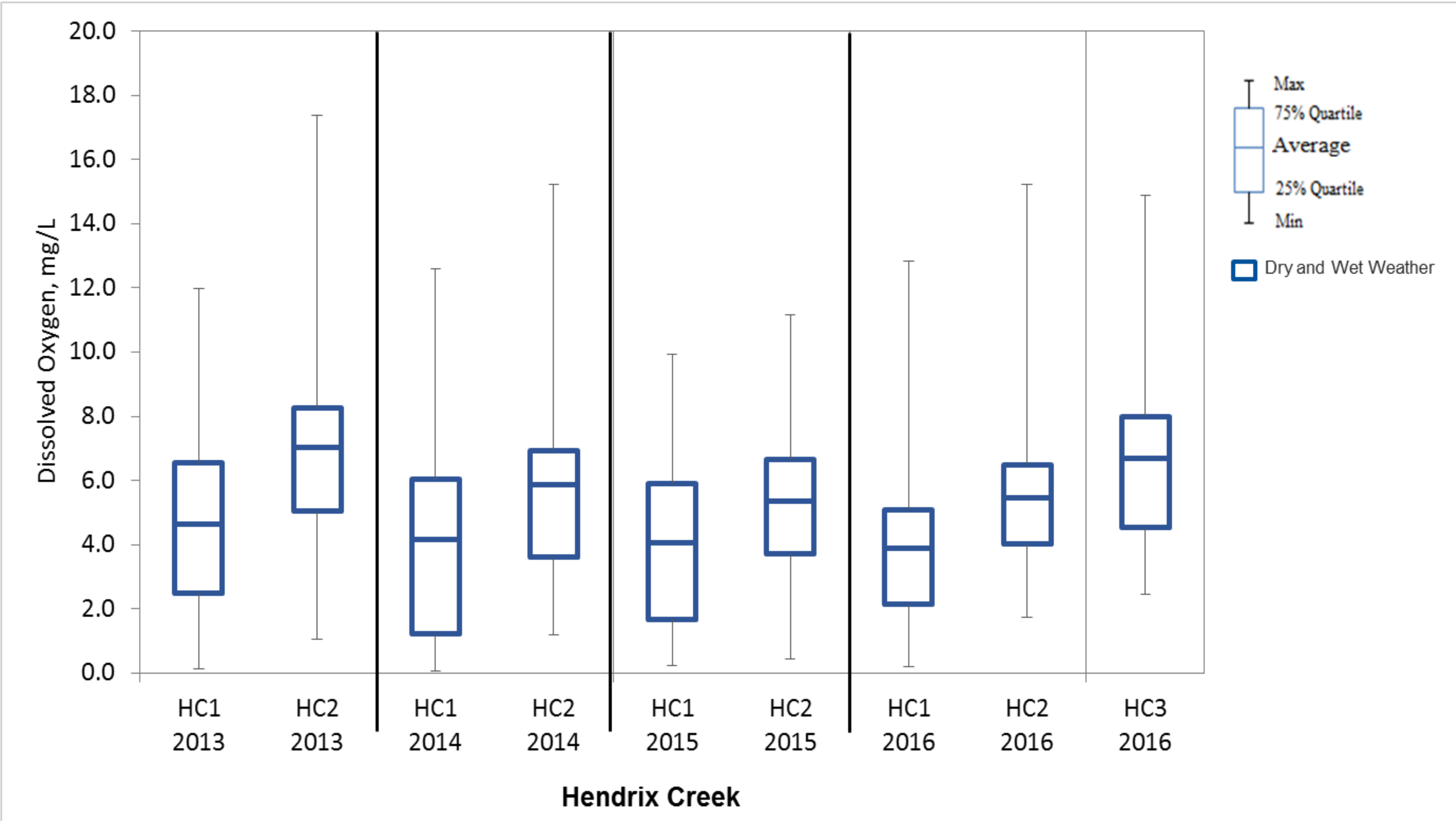

Figure 2-58. Dissolved Oxygen Concentrations at Hendrix Creek Harbor Survey Monitoring Stations

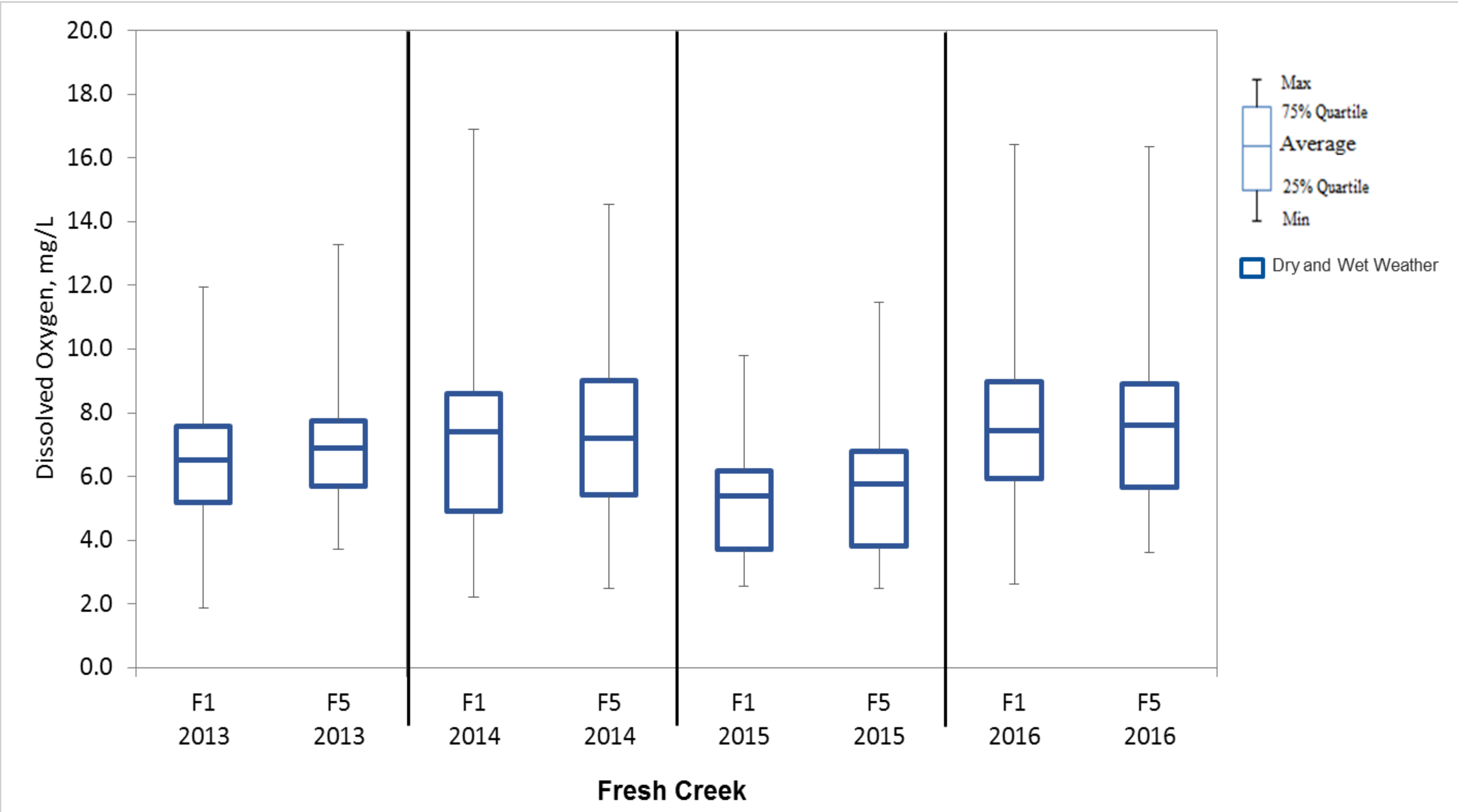

Figure 2-59. Dissolved Oxygen Concentrations at Fresh Creek Harbor Survey Monitoring Stations

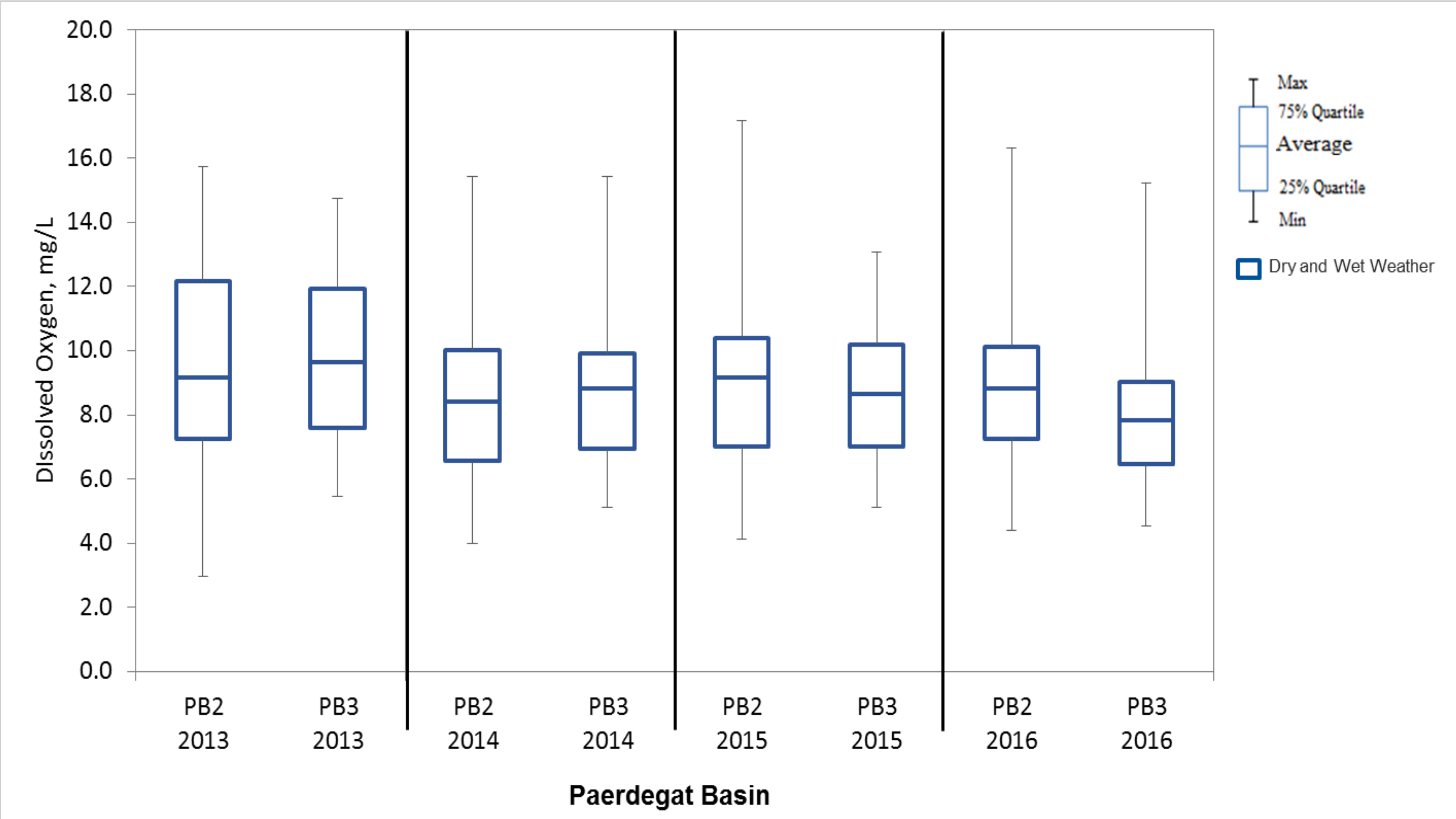

Figure 2-60. Dissolved Oxygen Concentrations at Paerdegat Basin Harbor Survey Monitoring Stations

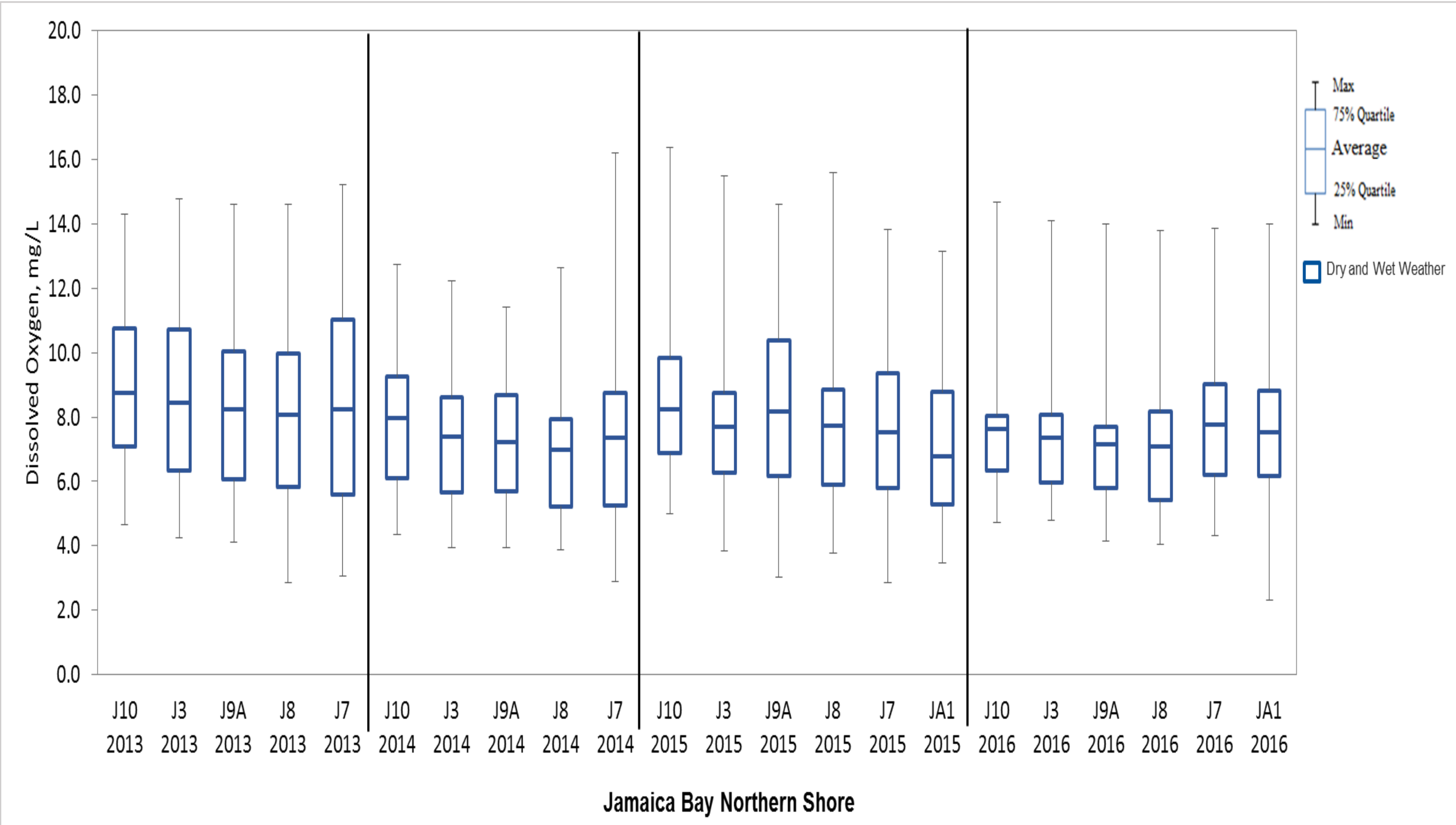

Figure 2-61. Dissolved Oxygen Concentrations at Northern Shore Harbor Survey Monitoring Stations

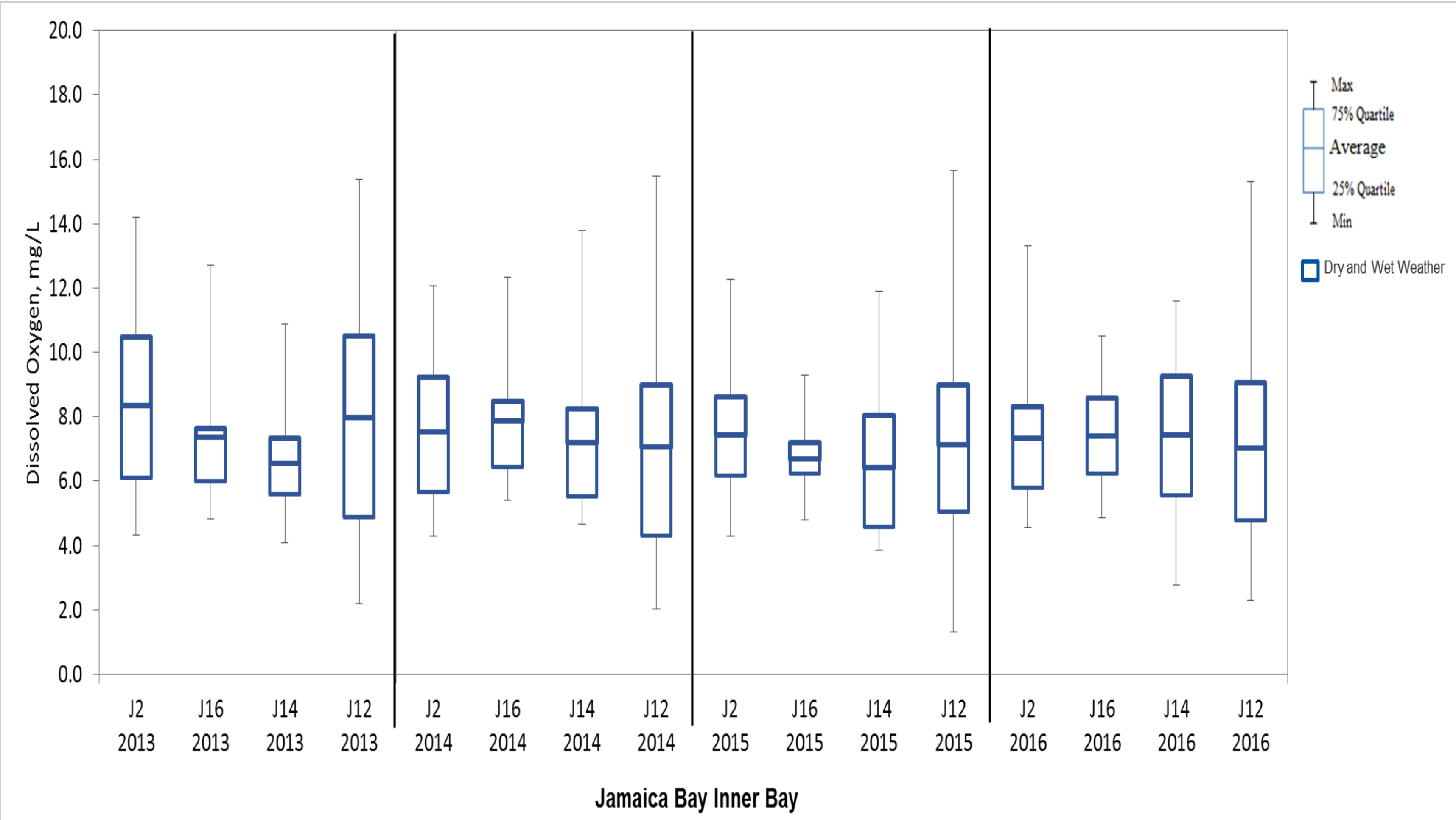

Figure 2-62. Dissolved Oxygen Concentrations at Inner Jamaica Bay Harbor Survey Monitoring Stations

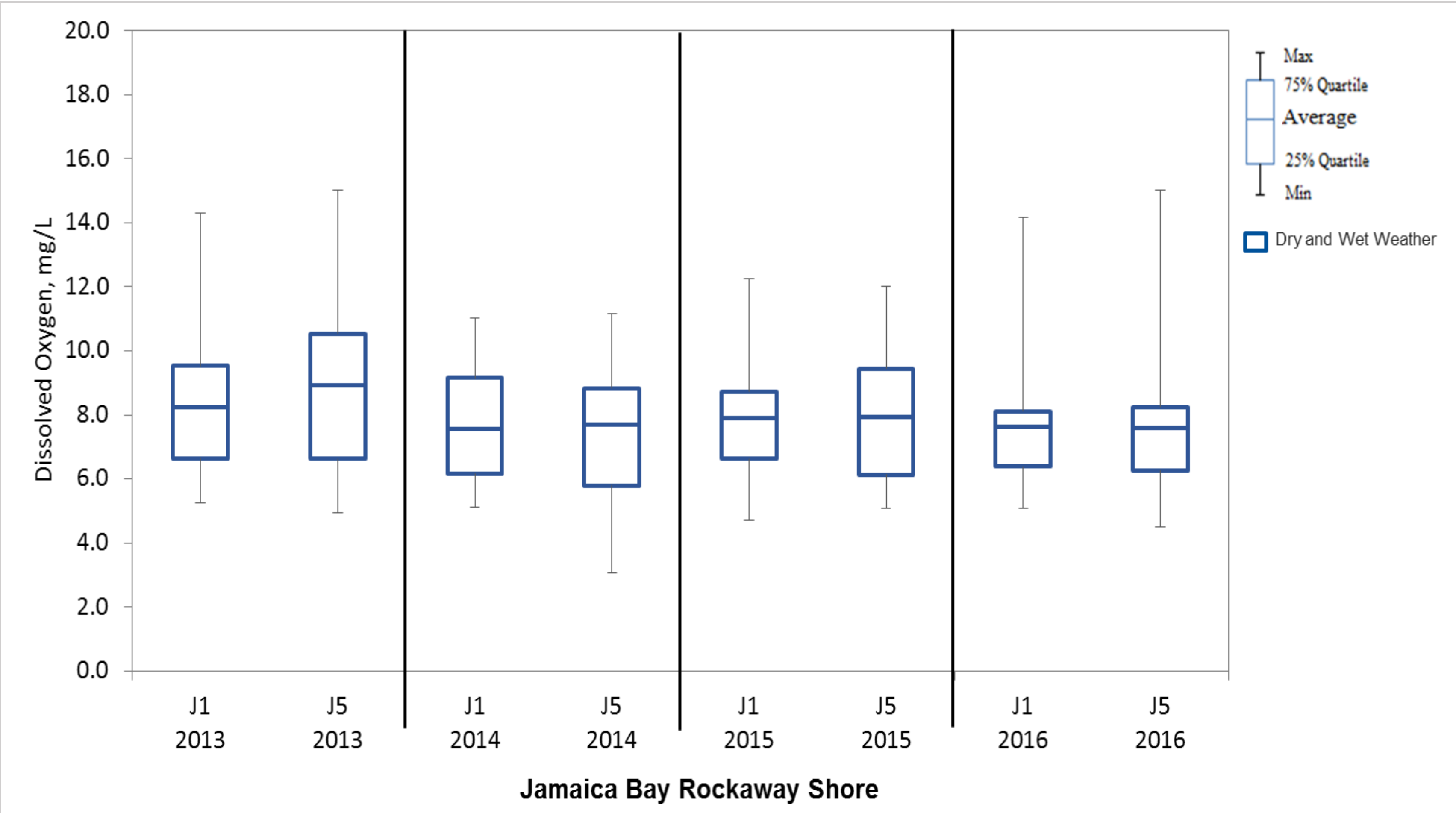

Figure 2-63. Dissolved Oxygen Concentrations at Rockaway Shore Harbor Survey Monitoring Stations

2.2.a.8 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 Jamaica Bay water quality. A model computational grid as part of the Jamaica Bay Eutrophication Model (JEM) was used in the LTCP analysis to represent Jamaica Bay. The model computational grid, shown in Figure 2-64, was used for LTCP hydrodynamic, pathogens, and DO modeling. The validation of these water quality models using measurements collected during 2015 and 2016 is described in the Jamaica Bay LTCP Sewer System and Water Quality Modeling Report (DEP, 2018). The measurements used for model calibration and validation include LTCP, DEP Harbor Survey and Sentinel Monitoring, with wet-weather volumetric loading information from validated IW models. Once calibrated and validated, the water quality models were used to aid in the assessment of water quality benefits associated with LTCP CSO control alternatives, as presented in Sections 6 and 8.

Figure 2-64. Computational Grid for Jamaica Bay Water Quality Modeling

3.0 CSO BEST MANAGEMENT PRACTICES

As a general matter, CSO Best Management Practices (BMPs) address operation and maintenance procedures, maximum 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 WWTPs 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 Plant (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 and 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 embodied 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 Wet 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 WWTP;
- Maximizing Flow at WWTP;

[1] 2014 CSO BMP Order on Consent, DEC File No. R2-20140203-112.

- CSO Monitoring and Equipment;
- 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.

This section 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.

3.1 Collection System 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 WWTP 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.

3.2 Maximizing 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 2017 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.

In-line storage is induced within the sewers upstream of the Paerdegat Basin CSO Retention Facility and the Spring Creek Auxiliary Wastewater Treatment Plant (AWWTP) when these facilities are operated in accordance with their WWOPs. The Paerdegat Basin CSO Retention Facility, completed in May 2011, can store up to 30 MG within the upstream sewers, while the Spring Creek AWWTP, completed in July 2009, can store up to 6.2 MG within the upstream sewers.

Additional data gathered in accordance with the requirements set forth in the Additional CSO BMP Special Conditions will be used to verify and/or further calibrate the hydraulic model developed for the CSO LTCPs.

3.3 Maximizing Wet WeatherFlow to WWTPs

This BMP addresses NMC 4 (Maximization of Flow to the Publicly Owned Treatment Works for Treatment), and reiterates the WWTP operating targets established by the SPDES permits for each WWTP's ability to receive and treat minimum flows during wet-weather. The WWTP 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 one and one-half times design dry-weather flow (1.5xDDWF) 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 WWTPs 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 WWTP 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 WWTP entrance to protect the WWTP from flooding and process upsets. DEP's operations staff is trained in how to maximize pumped flows 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 2017 BMP Annual Report indicate that DEP's WWTPs generally complied with this BMP during 2017.

The Additional CSO BMP Special Conditions have a number of requirements related to maximizing wet-weather flows to WWTPs including, but not limited to:

- An enforceable compliance schedule requiring DEP to maximize flow to and through the WWTP during wet-weather events;
- Incorporating throttling protocol and guidance at the WWTPs;
- Updating the critical equipment lists for WWTPs, which includes screening facilities at pump stations that deliver flow directly to the WWTP and at WWTP headworks; and
- Reporting bypasses to DEC.

The 2017 BMP Annual Report details the capital projects that have been completed or are underway within the Jamaica Bay and its tributaries sewershed. DEP certified completion in June 2016 of the construction of bending weirs that reduce CSO discharges into Thurston and Bergen Basins and convey additional wet-weather flow to the Jamaica WWTP. In December 2017 DEP certified completion of the new Bergen Basin Parallel Interceptor in accordance with the CSO Order. This interceptor in conjunction with previously certified Jamaica Bay bending weirs will reduce CSOs into the Bergen and Thurston tributaries and convey additional wet weather flow to the Jamaica WWTP. The 26th Ward WWTP is currently being upgraded to improve wet-weather performance. New main sewage pumps were installed in the Low Level Wet Well in April of 2015. Construction to replace the main sewage pumps in the High Level Wet Well is currently underway and projected for completion in February of 2018. A new primary settling tank is currently under construction and scheduled to be complete and operational in April 2020. Upon completion of these projects, a 12 month monitoring period will be performed to assess the improved wet-weather performance of the WWTP. The results of the analysis will be reported in a subsequent CSO BMP Annual Report.

3.4 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 WWTP 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.

3.5 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. No dry-weather overflows were identified specific to Jamaica Bay and its tributaries in the 2017 BMP report.

3.6 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 WWTP, 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 WWTP over residential/commercial sewersheds.

3.7 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 report must also include recommendations for alternative NYC programs and an implementation schedule to reduce the water quality impacts of street and toilet litter.

[2] Significant Industrial Users are defined by EPA under federal law.

3.8 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 to be approved by the New York City Department of Health and Mental Hygiene (DOHMH) and to be specified within DEP's Master Plan for Sewage and Drainage. Whenever possible, separate sanitary and storm sewers should be used to replace combined sewers. Each BMP Annual Report describes the citywide plan, and addresses specific projects occurring in the reporting year.

No projects are reported for the Jamaica Bay WWTP and 26th Ward WWTP sewersheds in the 2017 BMP Annual Report.

3.9 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 2017 BMP Annual Report, DEP reviewed and approved three private sewer extensions in 2017, but none were built.

3.10 Sewer Connection & Extension Prohibitions

This BMP addresses NMC 1 (Proper Operations and Regular Maintenance Programs for the Sewer System and the CSOs), and prohibits sewer connections and extensions that would exacerbate recurrent instances of either sewer back-up or manhole overflows upon letter notification from DEC. 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 2017, conditions did not require DEP to prohibit additional sewer connections or sewer extensions.

3.11 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 three 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 WWTP sewersheds. The program remained unchanged through the 2017 BMP Annual Report.

3.12 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 per impervious acre, whichever is higher (for cases when the allowable storm flow is more than 0.25 cfs per impervious acre)," was promulgated on January 4, 2012, and became effective on July 4, 2012.

3.13 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 in or near Jamaica Bay and its tributaries. The private Gerritson/Kiddie Beach, which is located near the Rockaway Inlet, is the only bathing beach closest to Jamaica Bay. In 2016, the Gerritson/Kiddie Beach had zero closures and 28 warnings due to significant rain events or *Enterococci* exceedences. In 2017, there were zero closures and 32 warnings due to significant rain events or *Enterococci* exceedences.

3.14 Characterization and Monitoring

Previous studies have characterized and described the Jamaica WWTP collection system, 26th Ward WWTP collection system, Rockaway WWTP collection system and the water quality for Jamaica Bay and its tributaries (see Chapters 3 and 4 of the Jamaica Bay WWFP, 2012). Additional data were collected and are analyzed in this LTCP (see Section 2.2). Continued monitoring occurs under a variety of DEP initiatives, such as floatables monitoring programs and the DEP Harbor Monitoring Survey, and is reported in the BMP Annual Reports under SPDES BMPs 1, 5, 6 and 7, as described above.

The Additional CSO BMP Special Conditions, described above, require future monitoring to include the installation of CSO monitoring equipment (Doppler sensors in the telemetry system and inclinometers where feasible) at key regulators for the purpose of detecting CSO discharges, which DEP completed in accordance with the 2014 CSO BMP Consent Order. 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 in accordance with the 2014 CSO

BMP Consent Order, as have the required quarterly reports. Beginning in 2016, DEP submitted annual reports summarizing one year of known or suspected CSO discharges, describing the cause of each, and providing options to reduce or eliminate similar future events, together with an implementation schedule. See Appendix B to the 2014 CSO BMP Consent Order, Items 3(a) and (b); 5(b).

In addition, on February 1, 2016, DEP complied with its Regulator(s) with CSO Monitoring Equipment Identification Program Reporting requirement. See Additional CSO BMP Special Conditions, Appendix B Item 5(c). That report identified four Category A early tipping regulators (26W-01, 26W-02, JA-03 and JA-14) with known or suspected discharges outside the period of a critical wet-weather event. Regulator 26W-01 overflows to Hendrix Creek, Regulator 26W-02 overflows to Fresh Creek and Regulators JA-03 and JA-14 overflow to Bergen Basin. Regulators 26W-01, 26W-02, and JA-03 were noted as key regulators, meaning that they are within close proximity to bathing beaches.

The Jamaica Bay WWFP recommended several projects that will address potential "early tipping" concerns at these four regulators. High Level Sewer Separation is currently being performed within portions of the combined sewer system upstream of Regulators 26W-01 and 26W-02. This three-phase project will divert stormwater from the combined sewer system reducing peak wet-weather flow to the 26^{th} Ward WWTP and CSOs at Outfalls 26W-003 and 26W-004. In addition, the 26^{th} Ward WWTP Wet Weather Stabilization Project is currently under construction to improve wet-weather treatment capacity. Bending weirs have been installed at Regulators JA-03 and JA-14 in conjunction with a parallel interceptor to provide supplementary conveyance capacity to the Jamaica WWTP (see Section 4.0 for further details). The evaluation of CSO control alternatives and selection of the LTCP Recommendation will both consider and seek to further address potential "early tipping" discharges from these four regulators.

3.15 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 15 annual reports to-date, covering calendar years 2003 through 2017. The 2017 BMP Annual Report 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.

4.0 GREY INFRASTRUCTURE

4.1 Status of Grey Infrastructure Projects Recommended in Facility Plans

Early CSO planning began in the 1950s and culminated with the construction of the Spring Creek AWWTP, a 12 MG CSO retention facility. Completed in 1972, this project was one of the first such facilities constructed in the United States. In the 1980s and early 1990s, additional CSO planning was performed for Paerdegat Basin and Jamaica Bay tributaries. In June 2006, DEP issued a watershed-specific LTCP for control of CSO discharges to Paerdegat Basin in accordance with the terms of the CSO Order. The LTCP recommended the construction of a 20 MG off-line storage tank with an additional 30 MG of storage provided within the influent channels and collections system. The Paerdegat Basin CSO Facility was certified complete in May 2011.

The Jamaica Bay WWFP was the next major step towards development of an LTCP and attainment of water quality standards in Jamaica Bay and its tributaries. This planning study focused on quantifying and assessing the impacts of CSO discharges to Jamaica Bay and certain tributaries, including Thurston Basin, Bergen Basin, Spring Creek, Hendrix Creek, and Fresh Creek. All CSO discharges to Jamaica Bay originate in its tributaries, specifically Thurston Basin and Bergen Basin within the Jamaica WWTP sewershed, Spring Creek, Hendrix Creek, and Fresh Creek within the 26th Ward WWTP sewershed, and Paerdegat Basin within the Coney Island WWTP sewershed. The Rockaway WWTP sewershed is a partially separated sewer system which also drains to Jamaica Bay; however, collection system modeling indicates that no combined sewer overflows are predicted during the typical rainfall year. Discharges to Paerdegat Basin were addressed as part of the separate LTCP for Paerdegat Basin. As a result, the Jamaica Bay WWFP focused on the evaluation of CSO control alternatives for the sewershed tributary to the 26th Ward and Jamaica WWTPs.

The Jamaica Bay WWFP, submitted in November 2012, recommended the following projects:

1. Meadowmere and Warnerville Dry Weather Overflow Abatement
2. Shellbank Basin Destratification System
3. Laurelton and Springfield Blvd Storm Sewer Buildout
4. Automation of Regulator JA-02
5. Spring Creek AWWTP and Upgrades
6. Sewer Cleaning in the 26th Ward Treatment Plant Drainage Area
7. Environmental Dredging of Hendrix Creek
8. Installation of a New Parallel Interceptor Sewer
9. Regulator Improvements at JA-03, JA-06 and JA-14
10. 26th Ward High Level Storm Sewers
11. 26th Ward WWTP Wet Weather Stabilization

12. 26th Ward Green Infrastructure Demonstration Project

4.1.a Completed Projects

The Paerdegat Basin CSO Facility and Spring Creek AWWTP were completed prior to development of the Jamaica Bay WWFP. The following section summarizes these two projects, along with the grey infrastructure projects from the Jamaica Bay WWFP completed to-date.

1. Paerdegat Basin CSO Facility:

   - *Project Summary*: This project is a 50 MG CSO retention facility with mechanical screens for capture of floatables. Four retention tanks provide 30 MG of storage, while an additional 20 MG can be stored in the connecting sewers. Carbon filters provide odor control of ventilation exhaust.

   - *Status*: Project was completed in May 2011.

Figure 4-1: Paerdegat Basin CSO Facility

2. Spring Creek AWWTP and Upgrades:

   - *Project Summary*: The Spring Creek AWWTP facility was placed into service in the early 1970s and has been upgraded to provide a minimum storage capacity of approximately 20 MG, with an additional 6.2 MG of storage in the upstream sewers. Upgrades to the facility included floatables control, high rate settling, and additional CSO storage capacity.

   - *Status*: The original facility was completed in 1972. Upgrades were completed in April 2007.

Figure 4-2: Spring Creek AWWTP

3. Automation of Regulator JA-02:

   - *Project Summary*: This project consisted of the installation of an electro-hydraulic actuator to control flow at the regulator. Under dry-weather conditions, the regulator conveys flow to the Jamaica WWTP via the Howard Beach Pumping Station. Under wet-weather conditions, the regulator diverts flow to the Spring Creek AWWTP for retention.

   - *Status*: Project was completed in June 2010.

4. Sewer Cleaning in the 26th Ward Treatment Plant Drainage Area:

   - *Project Summary:* Excess sediment was observed in Williams Street, Hegeman Avenue and Flatlands Avenue sewers during facility planning work in the 1990s. Debris profiles taken in 1994 showed accumulations as high as 5 feet in one barrel of the four-barrel sewer in Williams Avenue among other sections of the system. The project removed the sediment and debris to re-establish the conveyance capacity of the system and relieve upstream surcharging.

   - *Status:* Project was completed in June 2010.

5. Regulator Improvements at JA-03, JA-06 and JA-14:

   - *Project Summary*: Bending weirs were installed at Regulators JA-03, JA-06 and JA-14 (along with expansion of the regulator discharge orifices) to improve the conveyance of wet-weather flow to the Jamaica WWTP.

   - *Status*: Project completed in June 2016.

Figure 4-3: Bending Weir in Regulator JA-14

6. Installation of a New Parallel Interceptor Sewer

   - *Project Summary*: A new parallel interceptor sewer was constructed to provide supplementary capacity to the existing Jamaica WWTP West Interceptor. The new interceptor sewer originates downstream of Regulator JA-03 and JA-14 as a 54-inch sewer, and crosses beneath the Belt Parkway as a twin 36-inch sewer.

   - *Status*: Substantially complete in 2016 and activated in February 2017. Full functionality of the new parallel sewer is contingent on completion of a new sanitary sewer currently in design, with construction completion scheduled for October 2021.

Figure 4-4: Microtunneling of New Parallel Sewer

4.1.b Ongoing Projects

Below is a brief description of the projects recommended in the Jamaica Bay WWFP that have not yet been completed:

1. 26th Ward WWTP Wet Weather Stabilization:

    - *Project Summary*: The project involves the replacement of both low level and high level main sewage pumps, construction of a new primary settling tank, construction of a flow diversion structure to more evenly distribute flow to the primary settling tanks, and modifications to one of the aeration tanks to connect the common primary settling tank effluent channel to the aeration tank influent channel. The WWTP upgrades will improve operating flexibility and reliability during wet-weather conditions.

    - *Status*: Under construction with a completion milestone of July 2020.

Figure 4-5: 26th Ward WWTP Wet Weather Stabilization

2. 26th Ward High Level Storm Sewers:

    - *Project Summary*: This project involves constructing new storm sewers to capture street runoff that would otherwise drain to the combined sewer system. The new storm sewers will convey the stormwater runoff directly to Fresh Creek. The project is being implemented in a series of three phases, as shown in Figure 4-6.

    - *Status*: Construction is ongoing through milestone of December 2022.

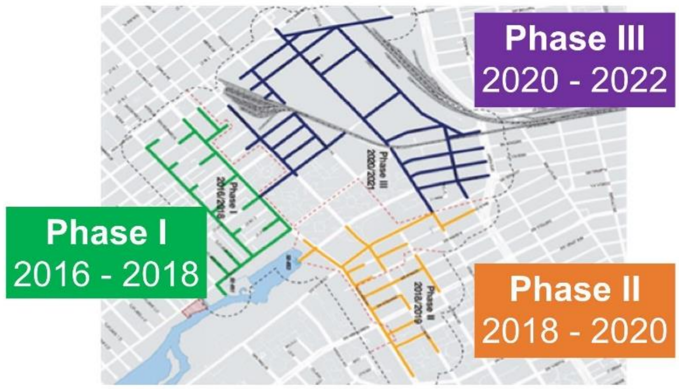

Figure 4-6: 26th Ward High Level Storm Sewers

4.1.c Planned Projects

Other planned projects affecting wet-weather flows that are not part of the Jamaica Bay WWFP include:

1. Laurelton and Springfield Boulevard Storm Sewer Buildout:

    - *Project Summary*: A drainage plan for 7,000 acres in Southeast Queens (Springfield-Laurelton neighborhoods) has been developed to address flooding and to construct high-level storm sewers in a 1,450 acre CSO drainage area tributary to Thurston Basin. The project includes construction of high level storm sewers within the Laurelton area of Southeast Queens and other improvements that will ultimately reduce CSO discharges to Thurston Basin. However, the downstream storm sewer infrastructure must be built to accommodate the stormwater to be diverted from the combined sewer system. As the schedule for design and construction of the supporting infrastructure has not been determined, this project has not been included in the LTCP Baseline Conditions or the LTCP Recommendation Plan.

    - *Status*: Ongoing long term program.

4.2 Other Water Quality Improvement Measures Recommended in Facility Plans (Dredging, Floatables, Aeration)

Other water quality improvement measures undertaken within the Jamaica Bay and its tributaries project area include the abatement of dry-weather overflows (DWO), aeration, environmental dredging, and green infrastructure as follows:

1. Meadowmere and Warnerville DWO Abatement:

    - *Project Summary*: Septic systems serving the Meadowmere and Warnerville neighborhoods failed, resulting in the discharge of wastewater to Jamaica Bay. This project included construction of a wastewater pumping station, force main system and a

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separate wastewater and stormwater collection system to convey sanitary flow to the Jamaica WWTP and storm flow to Jamaica Bay.

- *Status*: Project was completed in March 2009.

2. Shellbank Basin Destratification:

    - *Project Summary*: Due to the variable depth throughout Shellbank Basin, temperature stratification presented a major water quality issue resulting in depleted dissolved oxygen levels, aquatic species deaths, and odor complaints. The destratification project included the installation of air compressors, diffuser piping, and associated equipment at the head of Shellbank Basin to provide mixing of the entire water column to address temperature stratification issues.

    - *Status*: Project was completed in November 2010.

3. Environmental Dredging of Hendrix Creek:

    - *Project Summary*: Under this project, approximately 1,500 feet of Hendrix Creek was dredged to about 4.5 feet below mean low water. The dredging removed accumulated sediment mounds exposed at low tide in the area of CSO Outfalls 26W-002 and 26W-004, reducing associated nuisance odors.

    - *Status*: Project was completed in February 2012.

4. Environmental Dredging of Paerdegat Basin:

    - *Project Summary*: Under this project, dredging of the head end and mouth of Paerdegat Basin to 3.0 feet below mean low water was performed. The dredging removed accumulated sediment mounds exposed at low tide in the area of CSO outfalls, reducing associated nuisance odors. Additionally, an area by the mouth of the basin was dredged to improve navigation in the basin.

    - *Status*: Project was completed in May 2014.

5. 26th Ward Green Infrastructure Demonstration Project:

    - *Project Summary*: This project included installation of right-of-way bioswales and on-site green infrastructure retrofits on public properties to manage 10 percent of the impervious area within a project area of approximately 23 acres. Wet-weather flows were monitored within the combined sewer to document the change in flow before and after the implementation of the green infrastructure projects.

    - *Status*: Project was completed in December 2012.

4.3 Post-Construction Monitoring

The PCM Program is integral to the optimization of the Jamaica Bay and Tributaries LTCP, providing data for model validation, and feedback on system performance. Each year's data set has been compiled and evaluated to refine the understanding of the interaction between Jamaica Bay, its tributaries, and the actions identified in this LTCP. The ultimate goal is to fully attain compliance with current WQS or supporting a UAA or variance, if appropriate, if standards cannot be attained. The PCM program contains two basic components:

1. Receiving water data collection in Jamaica Bay and its tributaries using existing DEP Harbor Survey Monitoring (HSM) and Sentinel Monitoring (SM) stations; and

2. Modeling the collection system and receiving waters to characterize water quality using the existing InfoWorks CS™ (IW) and Jamaica Bay Eutrophication Model (JEM), respectively.

The details provided herein are limited to the Jamaica Bay and its tributaries PCM and may be modified as DEP's CSO planning advances through the completion of the Citywide/Open Waters LTCP.

PCM in Jamaica Bay and its tributaries commenced before the WWFP elements became fully operational and, therefore, precedes any additional CSO control measures proposed under this LTCP. Buildout of GI would be factored into the final scheduling. Monitoring will continue for several years after the controls are in place in order to quantify the difference between the expected and actual performance. Gaps identified by the monitoring program can then be addressed through operational adjustments, retrofitting additional controls, or through the implementation of additional technically feasible and cost-effective alternatives. If it becomes clear that CSO control will not result in full attainment of applicable WQS, DEP will pursue the necessary regulatory mechanism for a UAA or variance, as appropriate.

4.3.a Collection and Monitoring of Water Quality in the Receiving Waters

PCM sampling at the Jamaica Bay, Fresh Creek, Spring Creek, Hendrix Creek, and Bergen Basin HSM Stations commenced in summer 2007 when upgrades to the Spring Creek AWWTP Facility were completed. PCM sampling at the Paerdegat Basin HSM stations commenced in summer 2011 when the Paerdegat Basin CSO Retention Facility became fully operational. The Paerdegat Basin Post-Construction Compliance Monitoring Analysis Report was prepared and submitted to DEC in February 2016.

The PCM Sampling Program collects samples at the following HSM Stations in Jamaica Bay and its tributaries:

- Jamaica Bay – 12 stations (J1, JA1*, J2, J3, J5, J7, J8, J9A, J10, J12, J14, J16)
- Paerdegat Basin – 2 stations (PB2, PB3)
- Fresh Creek – 2 stations (F1, F5)
- Hendrix Creek – 3 stations (HC1, HC2, HC3*)
- Spring Creek – 2 stations (SP1, SP2)
- Bergen Basin – 2 stations (BB2, BB4)

- Thurston Basin – 2 stations (TB1*, TB2*)

** Sampling at HSM Stations JA1, TB1, TB2 and HC3 began in 2016.*

Figure 4-4 shows the locations of the PCM Stations (along with the LTCP2, Sentinel Monitoring, and citizens sampling locations) in Jamaica Bay and its tributaries. Sampling at all stations related to the Jamaica Bay PCM program 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). Additional ambient water quality data was also collected in Bergen Basin, Thurston Basin, and Fresh Creek by the LTCP2 team from October 1, 2015 through November 23, 2015 to calibrate and validate the landside and water quality models. It is anticipated that additional CSO controls identified for implementation as part of this LTCP would require a subsequent PCM program in Jamaica Bay and its tributaries.

Measured parameters relating to receiving water quality at the PCM 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.

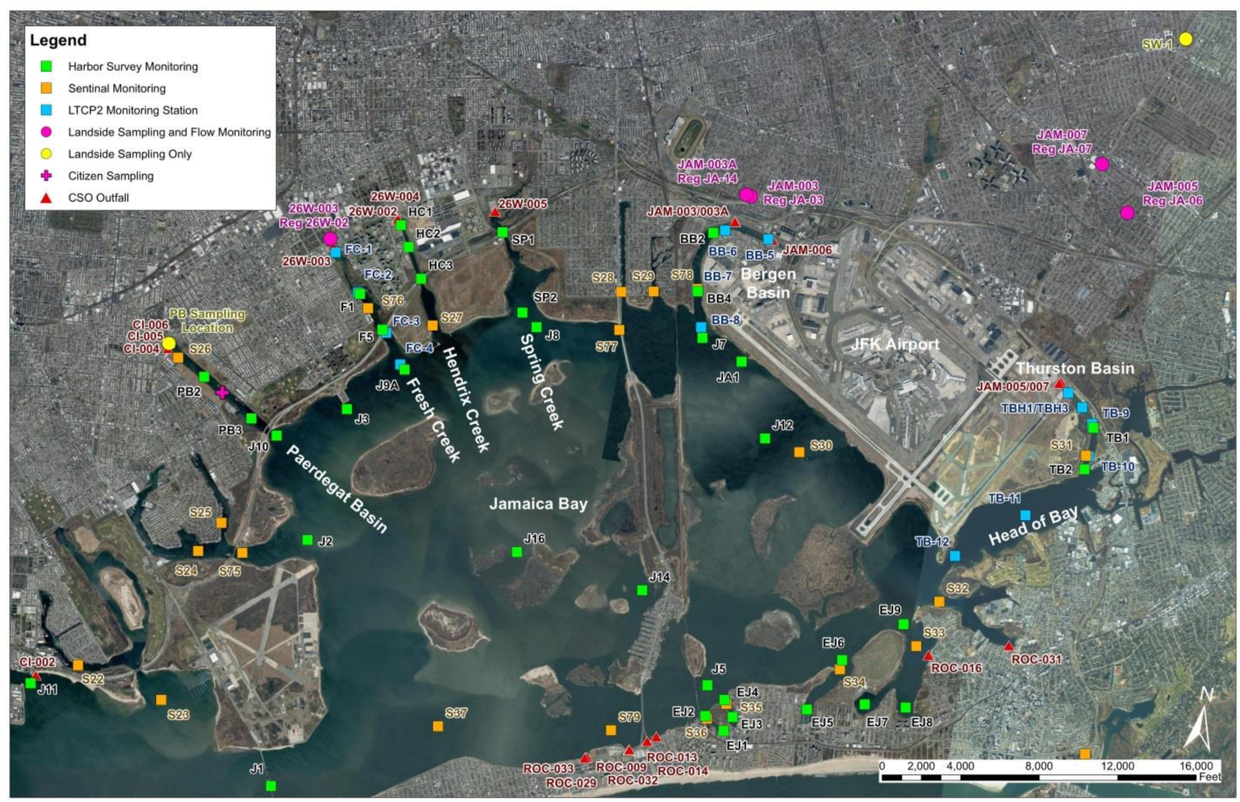

Figure 4-7: PCM, SM, LTCP2 and Citizens Sampling Locations in Jamaica Bay

4.3.b CSO Facilities Operations – Flow Monitoring and Effluent Quality

In support of the Spring Creek AWWTP and the Paerdegat Basin CSO Facility, DEP performed flow monitoring, modeling and water quality monitoring. The following reports were prepared and submitted to DEC on the performance of each facility:

- "Revised Spring Creek AWWTP Disinfection Demonstration Study," City of New York Department of Environmental Protection, December 2015.
- "Paerdegat Basin Post-Construction Compliance Monitoring Analysis," City of New York Department of Environmental Protection, Bureau of Wastewater Treatment, February 2016.

Any subsequent flow and effluent quality monitoring programs would be dependent on the types and sizes of proposed CSO controls recommended under this LTCP. Effluent quality data is not expected to be collected routinely at an unstaffed facility, nor is routine CSO flow and effluent quality data anticipated to be collected on outfalls for which no controls have been provided. If the implemented control is permitted under SPDES, the conditions of that permit regarding effluent monitoring would be followed.

4.3.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) that informs the design process. If no additional CSO controls are proposed, then affirmation of water quality projections would 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 comparison 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 National Oceanic and Atmospheric Administration (NOAA) rain gauge to represent the rainfall over the entire watershed. In reality, storms move through the area and are variable, 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 Jamaica Bay and its tributaries, the most representative long term rainfall data record is available from the National Weather Service's John F. Kennedy International Airport (JFK) 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 relative and peak intensities, will be used to classify the particular reporting year as wet or dry relative to the time series on which the concept was based. Uncertainty in the analysis may be supplemented with radar rainfall data where there is evidence of large spatial variations.

The reporting year will be modeled utilizing the existing IW/JEM 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 Plan (GI Plan)

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. 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 City-wide Coordination and Implementation

DEP works directly with its partner agencies on retrofit projects within ROW (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 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 recently launched its new public webmap which shows the status of GI assets (Final Design, In Construction, or Constructed). This addition now 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 also created an educational video about the GI Program. The video gives a brief explanation of the environmental challenges posed by CSOs, and features GI technologies such as retention/detention systems, green/blue roofs, rain gardens, porous paving and permeable pavers. The video is available on DEP's YouTube© page (https://www.youtube.com/user/nycwater).

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.

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 contain updated information on completed projects citywide and in Jamaica Bay, and can be found on DEP's website (www.nyc.gov/dep/greeninfrastructure). 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. 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 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 Jamaica Bay area, 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:

- WQS;
- 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 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 watershed of Jamaica Bay and its tributaries.

Green Infrastructure Baseline Implementation Rate – Jamaica Bay and its Tributaries

Jamaica Bay and its tributaries are priority watersheds for DEP's GI Program, and DEP seeks to saturate priority watersheds with GI based on the specific opportunities each watershed presents. DEP has over 1,081 GI assets in construction or constructed, including ROW practices, public property retrofits, and GI implementation on private properties as of 2017. In addition, thousands of additional assets are currently planned or in design. All built and planned GI assets are projected to result in a CSO volume reduction of approximately 202 MGY, based on the 2008 baseline rainfall condition.

For the Jamaica Bay and Tributaries LTCP, the baseline reduction is based on GI implementation constructed or planned in the watershed, primarily through retention practices including ROW rain gardens and public property retrofits, but also including an assumption that detention-based GI systems on private property will control runoff from 3 percent of the combined sewer impervious area tributary to Jamaica Bay and its tributaries. The GI Program will be implemented through 2030 and the final implementation rate will be reassessed as part of the adaptive management approach.

Figure 5-1 shows the current contracts in progress in the combined sewer areas tributary to Jamaica Bay and its tributaries. As more information on field conditions, feasibility, and costs becomes known, and as GI projects progress, DEP will continue to report on the progress of the GI in the watershed of Jamaica Bay and its tributaries through 2030.

Lastly, the Recommended Plan for Jamaica Bay and Tributaries (see Section 8) will also enable DEP to build GI in the combined sewer area within Thurston Basin (See Figure 5-2), which has been assumed in the GI baseline. However, without the alignment with the Recommended Plan DEP will not be able to build in this area due to its distance from the other GI baseline assets and maintenance will be costly and impractical.

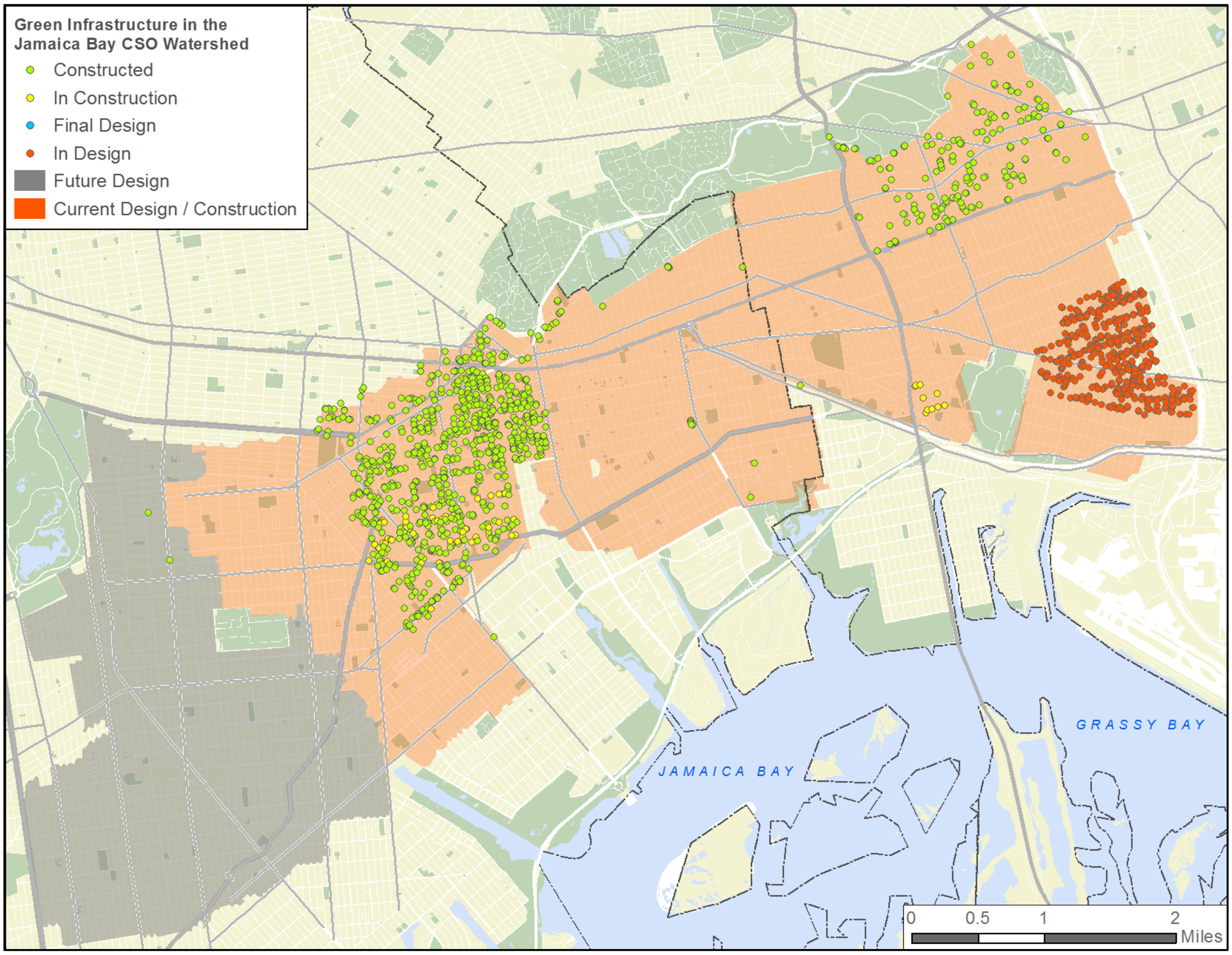

Figure 5-1. Green Infrastructure Projects in the Combined Sewer Areas of Jamaica Bay and its Tributaries

CSO GREEN INFRASTRUCTURE (GI) BASELINE (Current and Future)	
Greened Acres	877 ac.
CSO Reduction	201 MGY
Stormwater Reduction	Not applicable

RECOMMENDED PLAN		
Additional Benefits	**Thurston Basin**	**Bergen Basin**
Greened Acres	147 ac.	232 ac.
CSO Reduction	6 MGY	9 MGY
Stormwater Reduction	22 MGY	211 MGY

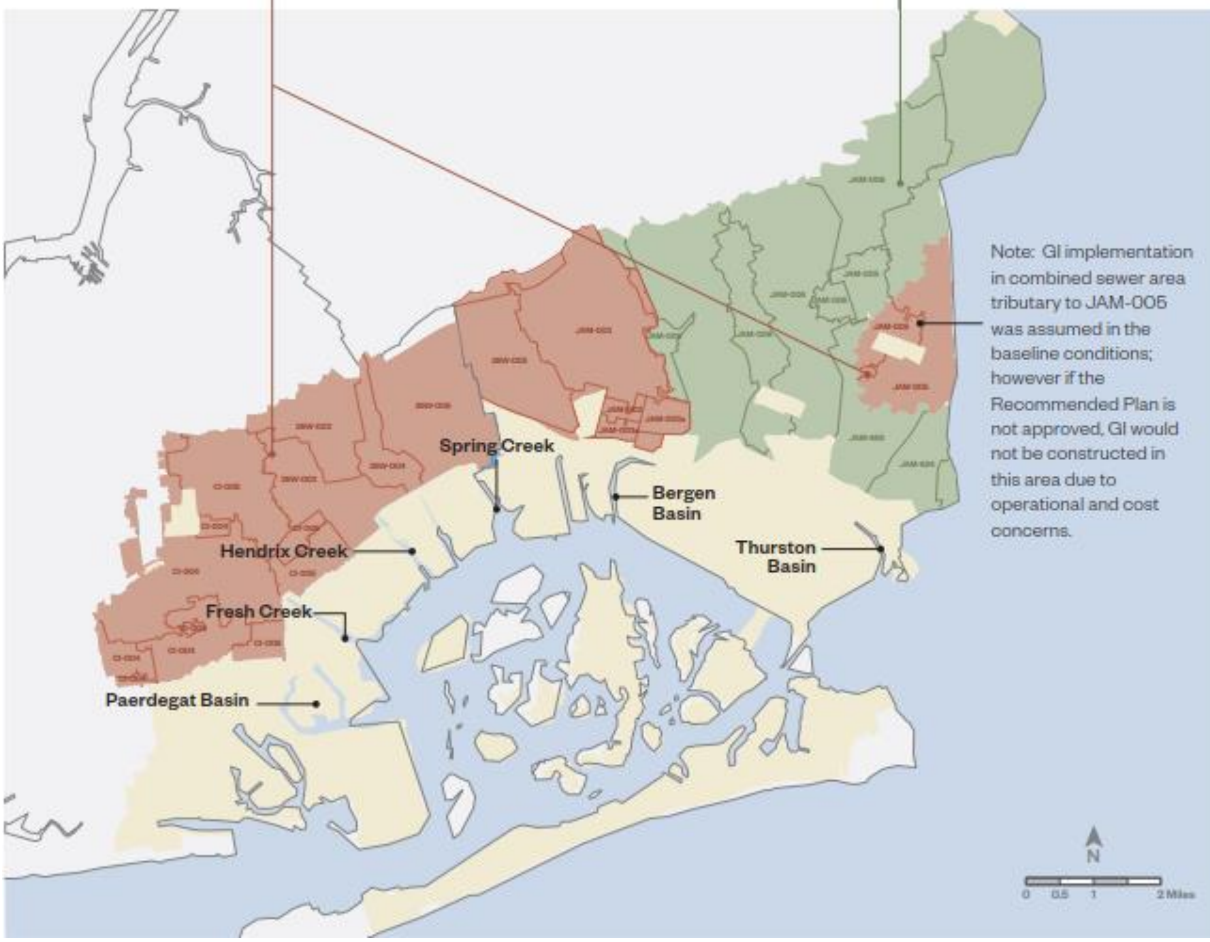

Figure 5-2. GI CSO Baseline and GI Expansion in Recommended Plan

6.0 BASELINE CONDITIONS AND PERFORMANCE GAP

A key element in the development of the Jamaica Bay and Tributaries LTCP was the assessment of water quality using applicable WQS within the waterbody. Water quality was assessed using the Jamaica Bay Eutrophication Model (JEM), which was recalibrated using data from the 2015 DEP HSM Program, the DEP Sentinel Monitoring Program, the National Park Service, and data collected as part of the LTCP program in 2015. The JEM water quality model was used to simulate ambient bacteria concentrations within Jamaica Bay for a set of baseline conditions as described in this section. The IW sewer system model was used to provide flows and loads from intermittent wet-weather sources as input to the JEM water quality model.

The assessment of water quality described herein started with a baseline condition simulation to determine future bacterial levels without additional CSO controls beyond those already required under the CSO Order as of the date of this LTCP. Simulations were then performed to determine bacteria and DO levels under the assumption of 100% CSO control. The baseline simulation results were compared to a 100% CSO control simulation results, and the gap between the two scenarios was then assessed to determine whether bacteria and DO criteria could be attained through application of CSO controls. Continuous water quality simulations were performed to evaluate the gap between the calculated baseline bacteria and DO levels and Existing WQ Criteria. For bacteria, the gap was also assessed for the Proposed *Enterococci* WQ Criteria*, while for DO, the gap was also assessed for Class SB criteria. 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. These simulations served as a basis for the evaluation of the control alternatives presented in Section 8.0.

This section of the LTCP describes the baseline conditions, the bacteria concentrations and loads calculated by the IW model, and the resulting bacteria concentrations calculated by the JEM water quality model. It further describes the gap between calculated baseline bacteria concentrations and both the Existing WQ Criteria and Proposed *Enterococci* WQ Criteria*. This section also assesses whether the gap can be closed through CSO reductions alone (100% CSO control).

It should be noted that the Proposed *Enterococci* WQ Criteria* would not apply to non-coastal waters and thus does not include the Jamaica Bay tributaries (such as Thurston Basin, Bergen Basin, Spring Creek, Hendrix Creek, Fresh Creek, and Paerdegat Basin). Therefore, Jamaica Bay tributaries water quality assessments for existing Class I criteria considered the Existing WQ Criteria for fecal coliform criterion only. However, DEP's assessment for the highest attainable use evaluated both the Proposed *Enterococci* WQ Criteria* and fecal coliform criteria for primary contact recreation.

6.1 Define Baseline Conditions

Establishing baseline conditions was an important step in the LTCP process because the baseline conditions were used to compare and contrast the effectiveness of CSO controls identified pursuant to the LTCP process and to predict whether water quality goals would be attained after implementation of the identified preferred alternative LTCP. 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:

*Proposed *Enterococci* WQ Criteria, if adopted as proposed, would only apply to coastal Class SB and SA waters.

- Dry-weather flow and loads to the Jamaica, 26th Ward, Coney Island, and Rockaway WWTPs were based on CY2040 projections, as follows:
    - Jamaica Bay WWTP - 76.5 MGD
    - 26th Ward WWTP - 44.9 MGD
    - Coney Island WWTP - 78.8 MGD
    - Rockaway WWTP - 20.7 MGD

- The Jamaica, 26th Ward, Coney Island, and Rockaway WWTPs can accept and treat peak flows at two times design dry-weather flow (2xDDWF). The rated wet-weather capacities of each WWTP are as follows:
    - Jamaica Bay WWTP - 200 MGD
    - 26th Ward WWTP - 170 MGD
    - Coney Island - 220 MGD
    - Rockaway - 90 MGD

- Constructed or planned GI projects resulting in 201 million gallons per year (MGY) reduction in baseline annual CSO volume in the watershed were included.

- Cost-effective Grey Infrastructure CSO controls included in the CSO Consent Order as summarized in Section 4.1.

- The precipitation characteristics from 2008 at 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 all conveyance elements generally greater than 48-inches in equivalent diameter, along with all regulator structures and CSO outfall pipes. Small diameter sewers are included for specific areas in Downtown Jamaica where greater model definition was desired. Post interceptor cleaning levels of sediments were also included for the interceptors in the collection system, to better reflect actual conveyance capacities to the WWTPs.

The IW model was used to develop stormwater flows, conveyance system flows, and CSO volumes for baseline conditions for the Jamaica, 26th Ward, Coney Island, and Rockaway sewersheds. For this LTCP, the baseline conditions were initially developed in a manner consistent with the earlier WWFPs for other waterbodies. However, based on more recent data and public comments received on the preceding WWFPs, it was recognized that some of the baseline condition model input data needed to be updated to reflect more recent meteorological conditions, as well as the current operating characteristics of various collection and conveyance system components. Furthermore, the mathematical models were updated from their configurations and levels of calibration developed and documented prior to this LTCP. IW model modifications for this LTCP reflected a better understanding of dry- and wet-weather pollutant sources, catchment areas, and new or upgraded physical components of the system. In addition, a model recalibration report was issued in 2012 (*InfoWorks Citywide Recalibration Report, 2012a*) that used improved impervious surface satellite data.

Minor improvements made as part of this LTCP to the water quality model included updating and refining the model segmentation. Changes to, and recalibration of, the IW and water quality models are discussed in detail in *CSO-LTCP: Basis for Modeling – Jamaica Bay and Tributaries (Submitted September 2015, Revised May 2018).*

The new IW model network was used to calculate CSO volumes and loads for the baseline conditions and was used as a tool to evaluate the impact of potential alternative operating strategies and other possible physical changes to the collection system on CSO activation frequencies and volumes. The improved water quality model was applied to evaluate the conditions in Jamaica Bay and its tributaries associated with baseline conditions and changes to baseline CSO and/or stormwater volumes associated with LTCP alternatives as represented in the IW model.

6.1.a Hydrological Conditions

For this LTCP, the precipitation characteristics for 2008, based on JFK Airport precipitation data, were used for the baseline condition, as well as for alternatives evaluations, and were considered to be representative of a typical rainfall year. In addition to the 2008 precipitation pattern, the observed tide conditions that existed in 2008 were also applied in the model. Baseline conditions, 100% CSO control (for the gap analysis), and the recommended plan were also assessed using 2002-2011 JFK Airport rainfall and the 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 WWTP sewersheds throughout NYC. For this analysis, Transportation Analysis Zones were overlaid with WWTP 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 WWTPs and freed capacity in the conveyance system.

6.1.c Best Management Practices Findings and Optimization

A list of BMPs pertaining to Jamaica Bay and its tributaries CSOs, along with a brief summary of each and their respective relationship to the EPA Nine Minimum Controls appear 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 Jamaica Bay:

- Sentinel Monitoring: In accordance with BMPs #1 and #5, DEP collects quarterly samples of bacteria water quality at 19 locations in Jamaica Bay and its tributaries (as shown in Figure 6-1) in dry-weather to assess whether dry-weather sewage overflows occur, or whether illicit connections to storm sewers exist. In Bergen Basin, Sentinel Monitoring Program samples, as well as dry-weather samples from the Harbor Survey Monitoring Program and the LTCP sampling program, all suggested the presence of dry-weather sources of bacteria. Since illicit discharges were suspected in Bergen and Thurston Basins, additional dry-weather sampling was conducted at LTCP2 sampling location BB-5 and along CSO JAM-005/007. 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.

- WWTP Flow Maximization: In accordance with BMP #3 and the 2014 CSO BMP Order on Consent, the Jamaica, 26th Ward, Coney Island, and Rockaway WWTPs 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 WWTP.

- Wet Weather Operating Plan (WWOP): The Jamaica, 26th Ward, Coney Island, and Rockaway WWOPs (BMP #4) establish procedures for pumping at the plant headworks to facilitate treatment of 2xDDWF.

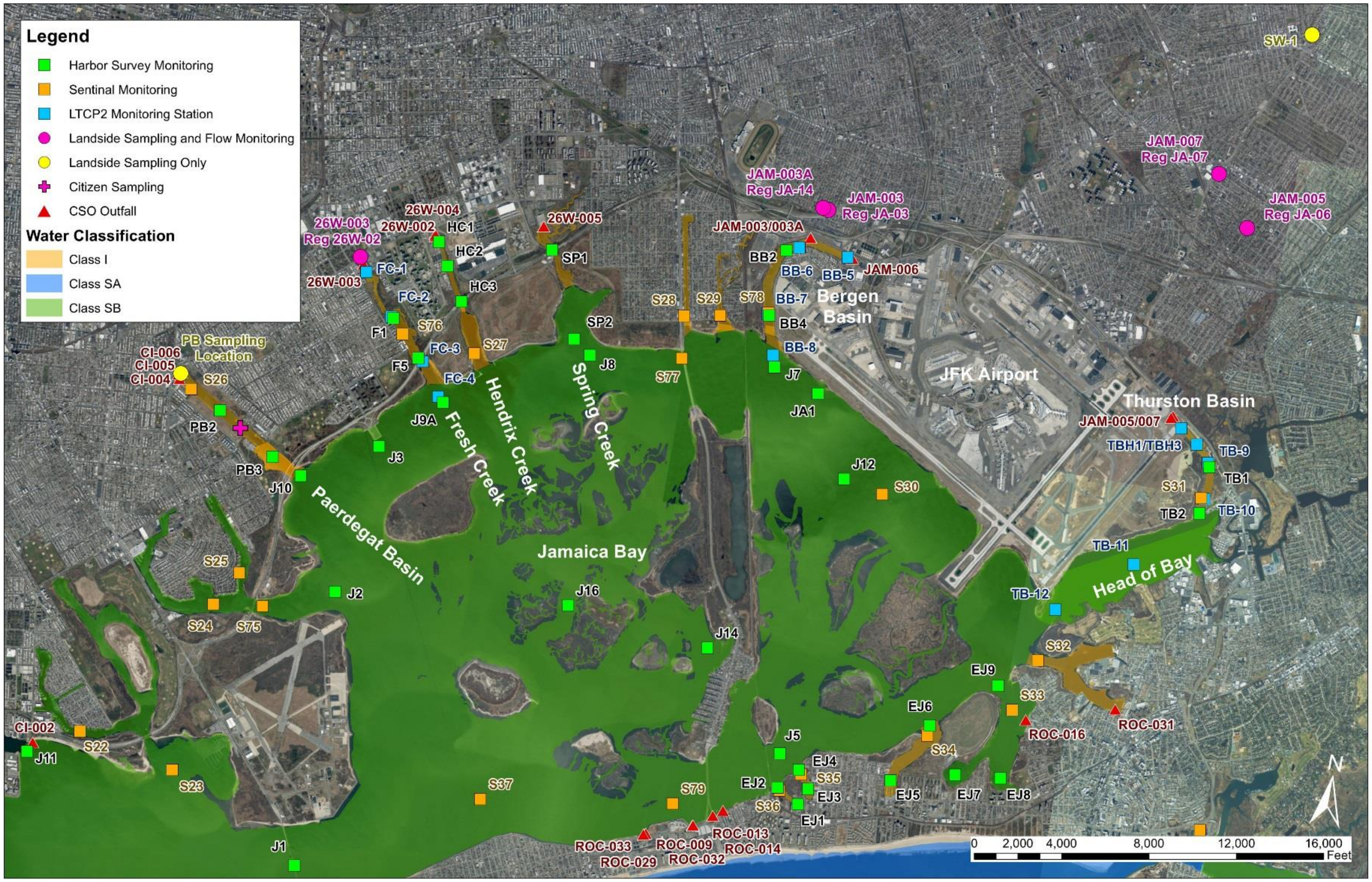

Figure 6-1. Sampling Locations in Jamaica Bay and its Tributaries

6.1.d Elements of Facility Plan and GI Plan

DEP maintains containment booms to control floatables at CSO Outfalls JAM-006, JAM003/003A, JAM-005/007, 26W-004, and 26W-003. The captured floatables are removed using skimmer vessels. Results of this program are provided in the SPDES Annual CSO BMP Report. The Jamaica Bay and Tributaries LTCP also includes the following projects from the WWFP and other LTCPs which have been expanded upon in Section 4.1:

- Construction of the Paerdegat Basin CSO Facility (50 MG storage)
- Environmental Dredging of Paerdegat Basin
- Meadowmere and Warnerville Dry Weather Overflow Abatement
- Shellbank Basin Destratification System
- Automation of Regulator JA-02
- Spring Creek AWWTP Upgrades
- Sewer Cleaning in the 26th Ward Treatment Plant Drainage Area
- Environmental Dredging of Hendrix Creek
- Installation of a New Parallel Interceptor Sewer
- Regulator Improvements at JA-03, JA-06 and JA-14
- 26th Ward High Level Storm Sewers
- 26th Ward WWTP Wet Weather Stabilization

As discussed in Section 5.0, both the Jamaica and 26th Ward sewersheds have been targeted for GI projects by DEP. The list of GI projects presented in Section 5 has been assumed to be fully implemented in the baseline model.

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 waterbody watershed facility planning 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 contained 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. Figure 6-2 presents the IW subcatchments within the Jamaica Bay drainage area.

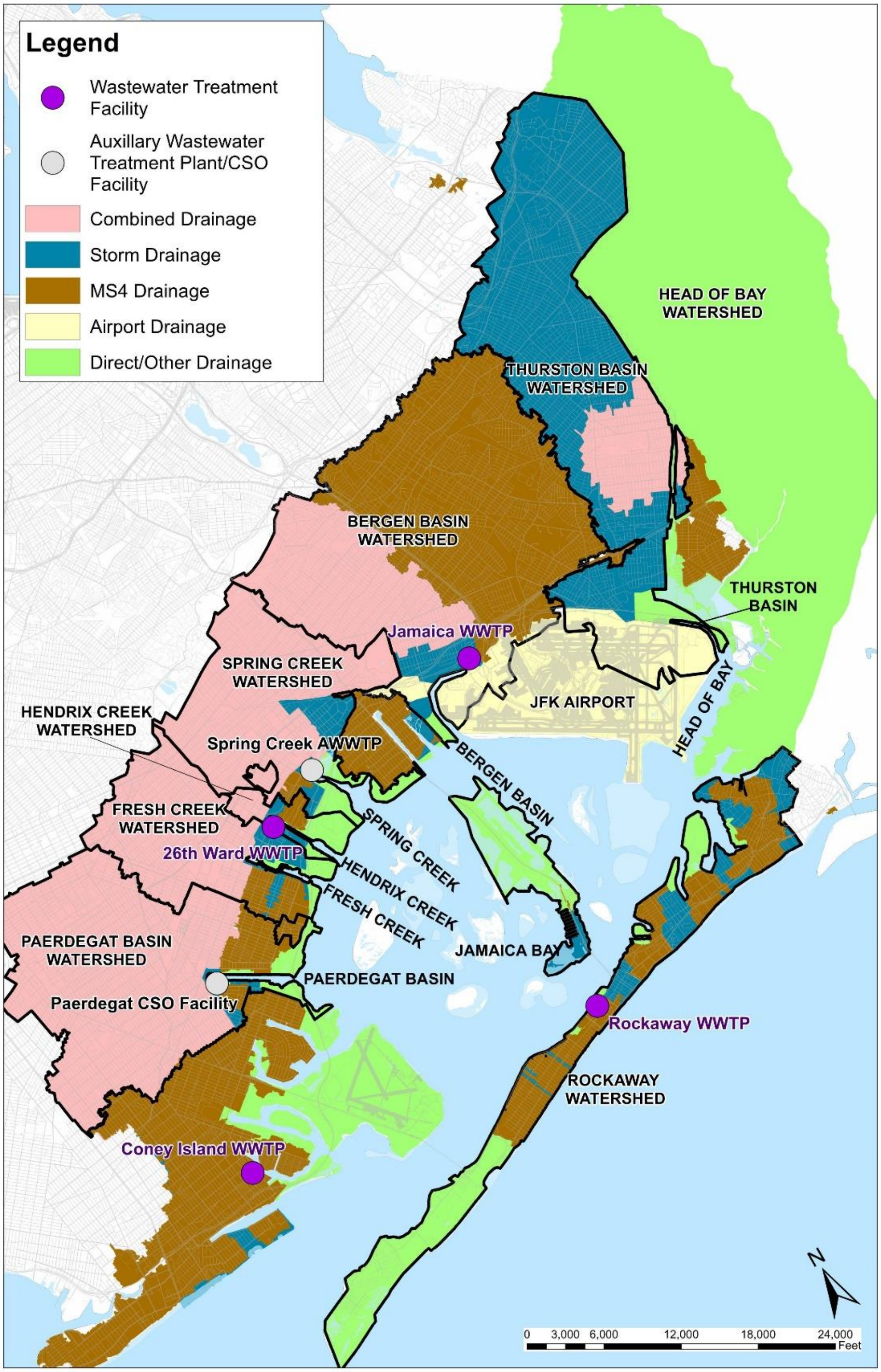

Figure 6-2. CSO and MS4 Subcatchments within Jamaica Bay Drainage Area

AECOM with Hazen

In several sections of the Jamaica Bay, 26th Ward, Rockaway, and Coney Island sewersheds, runoff drains directly to receiving waters via overland flow, open channels, or privately-owned pipes, without entering the CSS or separate storm sewer system. These areas were depicted as "Direct Drainage" in Figure 6-2 and were estimated based on topography and the direction of stormwater runoff flow in those areas. In general, shoreline areas adjacent to waterbodies comprise the direct drainage category, as they mainly consist of parks. However, JFK Airport covers a large portion of the shoreline area tributary to Bergen Basin, Grassy Bay, Grass Hassock Channel, Thurston Basin, and Head of Bay. In total, these areas comprise approximately 27,694 acres (41 percent) of the 67,718 acres of drainage area to Jamaica Bay.

MS4 areas in the IW model 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

As previously noted, the IW model was used to develop CSO volumes for baseline conditions. The model incorporated the implementation of planned GI and grey infrastructure within the Jamaica Bay, 26th Ward, and Coney Island sewersheds, respectively. Using these overflow volumes, CSO loadings were generated using measured *Enterococci*, fecal coliform, and BOD concentrations. These loadings provided input to the receiving water quality model. Fecal coliform, *Enterococci,* and BOD CSO loadings were developed by employing an hourly Monte Carlo randomization of the measured range of CSO concentrations assigned to the hourly overflows simulated by IW for four outfalls contributing the CSO to Fresh Creek (26W-003), Bergen Basin (JAM-003 and JAM-003A), and the Paerdegat CSO Retention Facility (PB-CSO). Other CSO outfalls were assigned loadings based on a mass balance procedure, described below.

In addition to CSO loadings, storm sewer discharges and direct drainage impact the water quality in Jamaica Bay and its tributaries. The concentrations assigned to the various discharge sources to each waterbody are summarized in Table 6-1. The concentrations represent typical stormwater, direct drainage, and sanitary sewage concentrations, based on water quality data collected for Jamaica Bay and its tributaries. Further details on the modeling validation analyses are provided in the technical memorandum *"Jamaica Bay LTCP Sewer System and Water Quality Modeling Report."*

For the outfalls where a mass balance approach was used, CSO concentrations were calculated using the stormwater and sanitary concentrations assigned in Table 6-2, multiplied by the flow calculated by the IW model.

Table 6-1. Source Concentrations

Source	Fecal Coliform (cfu/100mL)	*Enterococci* (cfu/100mL)	BOD_5 (mg/L)
Urban SW - Bergen Basin(1)	45,000	55,000	15
Urban SW - Rockaway(2)	35,000	15,000	
Urban SW - All Others(2)	120,000	50,000	
Sanitary for Mass Balance CSOs(3)	4,000,000	1,000,000	Mass Balance (Sanitary=110)
CSOs (26W-003, JAM-003, JAM-003A, PB-CSO)(4)	Monte Carlo	Monte Carlo	Mass Balance (Sanitary =110)
CSOs (All others)	Mass Balance	Mass Balance	Mass Balance (Sanitary=110)
Highway/ Airport Runoff (5)	20,000	8,000	15
Direct Drainage(6)	4,000	6,000	15
WWTP Effluent(7)	Monte Carlo	Monte Carlo	Quarterly

Notes:

(1) Stormwater bacteria concentrations based on 2015-2017 Jamaica Bay and Tributaries LTCP measurements. Stormwater BOD_5 based on Jamaica Bay Waterbody/Watershed Report (2012).
(2) Stormwater bacteria concentrations based HydroQual Memo to DEP, 2005a. Stormwater BOD_5 based on Jamaica Bay Waterbody/Watershed Report (2012).
(3) Sanitary bacteria concentrations from the HydroQual Memo to DEP, 2005a. BOD concentrations based on Jamaica Bay Waterbody/Watershed Report (2012).
(4) Monte Carlo based on 2015 LTCP CSO data.
(5) Highway/Airport runoff concentrations based on airport drainage data used in the Flushing Bay LTCP model estimated from NYS Stormwater Manual, Charles River LTCP, National Stormwater Data Base.
(6) Direct drainage bacteria concentrations based on NYS Stormwater Manual, Charles River LTCP, and National Stormwater Data Base for commercial and industrial land uses. Direct drainage BOD_5 concentrations specified as stormwater.
(7) WWTP effluent bacteria concentrations based on 2016 DMR measurements: Monte Carlo selection of daily averages for fecal coliform and median of several months for *Enterococci*. BOD concentrations based on quarterly BioWin model results from the FANCJ analysis.

The IW model provides a calculated fraction of flow from stormwater and flow from sanitary sources, 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

Baseline volumes of CSO and stormwater to Jamaica Bay and its tributaries for the 2008 typical year by outfall are summarized in Table 6-2 and Table 6-3, respectively. The total baseline volumes of CSO, stormwater and direct drainage to Jamaica Bay and its tributaries along with the associated fecal coliform, *Enterococci*, and BOD annual loadings, are summarized in Table 6-4 for the 2008 typical year. The specific SPDES permitted outfalls associated with these sources are shown in Figure 6-1. 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 6-2. 2008 CSO Volume and Overflows per Year

Waterbody	CSO	Volume(1)	Activation Frequency(1)
		Total Discharge (MG/yr)	Total (No./yr)
Thurston Basin	JAM-005/007	626 (213)	73 (25)
Bergen Basin	JAM-003	108	17
	JAM-003A	230	33
	JAM-006	2	14
	Subtotal	340	33
Spring Creek(2)	26W-005	310	7
Hendrix Creek	26W-004	104	30
Fresh Creek	26W-003	300	15
Paerdegat Basin(2)	Tank Overflow (PB-CSO)	553	12
	CI-004, CI-005, CI-006	38	5
	Subtotal	591	12
Jamaica Bay	Rockaway Outfalls (3)	0	0
Total		**2,271 (1,858)**	**73 (33) Max.**

Notes:

(1) CSO volumes and activation frequency are based upon overflow at the respective weirs and do not account for stormwater contributions to the outfall downstream of the regulator with the exception of Thurston Basin, which is based upon the sum of the CSO and stormwater discharges just downstream of Regulators JA-06, JA-07 and JA-08. The values in parentheses are the specific CSO AAOV and frequency of flow that tips over the weirs and diversion structures within the Thurston Basin drainage area.

(2) The Spring Creek AWWTP and the Paerdegat Basin CSO Retention Facility provide floatables control and settling prior to overflow of storms exceeding the tank storage capacity.

(3) The Rockaway CSOs do not activate during the typical 2008 rainfall year.

As indicated in Table 6-2, CSO discharges in the typical year occur only within the tributaries to Jamaica Bay. The largest and most active CSO is Outfall JAM-005/007, discharging 73 times for a total of 626 MG, under 2008 conditions. CSOs to Hendrix Creek and Bergen Basin also discharge relatively frequently, on the order of 30 to 33 times per year, respectively. CSO discharges from the Spring Creek AWWTP (26W-005) and the Paerdegat Basin CSO Retention Facility (PB-CSO) discharge relatively large volumes (310 and 553 MG, respectively) but at low frequencies of activation (7 and 12 times per year, respectively). Fresh Creek discharges 15 times for a total annual volume of 300 MG. CSO discharge to JAM-006 is very small (2 MG) and relatively infrequent (14 events) under 2008 conditions. Although JAM-

006 is identified as a permitted CSO outfall, it predominantly conveys stormwater from the collection system serving Southeast Queens.

Table 6-3 summarizes and categorizes the stormwater discharges to Jamaica Bay and its various tributaries. Jamaica Bay is heavily influenced by stormwater. The total volume of stormwater discharged from the Jamaica Bay watershed under 2008 conditions (18,692 MG), is approximately eight times greater than the CSO volume (2,271 MG). Approximately 6,469 MG of stormwater runoff from Nassau County is discharged to Head of Bay, which can influence the conditions in Jamaica Bay and Thurston Basin. Jamaica Bay receives an additional 6,645 MG of stormwater from other outfalls or direct runoff from Rockaway, Brooklyn, Queens, and JFK Airport. Of the tributaries, Bergen Basin receives the greatest stormwater discharge of 3,276 MG under 2008 conditions. Due to the high frequency of activation, stormwater can influence pathogen and DO attainment in waterbodies despite the lower concentration of pathogens and BOD.

Table 6-3. 2008 Stormwater Volume and Discharges per Year

Waterbody	Total (MG)	DEP MS4 (MG)	SW(4) (MG)	Airport (MG)	Direct(5) (MG)
Jamaica Bay(1)	6,656	2,489	1,243	957	1, 967
Bergen Basin	3,276	2, 835	117	302	22
Thurston Basin(3)	813 (1,226)	-	380 (793)	372	61
Fresh Creek	522	216	273	-	33
Hendrix Creek	111	36	41	-	34
Spring Creek	141	26	38	-	77
Paerdegat Basin	352	197	113	-	42
Head of Bay (Nassau Co.)	6,724	291	49	141	6,243
Other Tributaries(2)	362	326	36	-	-
Total	18,957 (19,370)	6,416	2,290 (2,703)	1,772	8,479

Notes:

(1) Grassy Bay, Hassock Creek, Grass Hassock Creek, Shell Bank Creek, Mill Basin, and Rockaway are included with Jamaica Bay.
(2) Other tributaries include Hawtree and Shellbank Basins.
(3) The values shown are the model predicted stormwater volumes based upon the inclusion of stormwater discharges just downstream of Regulators JA-06, JA-07 and JA-08 in the CSO AAOV for Thurston Basin. The values in parenthesis are the estimated stormwater flow coming out of outfalls JAM 005/007 excluding the 213 MGY of CSO that tips over the weirs and diversion structures in the upstream sewers.
(4) Stormwater (SW) consists of all outfalls except for DEP MS4 and airport stormwater sources.
(5) Direct drainage consists of all remaining drainage areas not tributary to defined CSO, MS4, and SW subcatchments.

Loadings by source for *Enterococci*, fecal coliform, and BOD are presented in Table 6-4. In tributaries with CSOs, the CSOs are generally the largest contributor of bacteria to the waterbody. While CSOs are a major source of bacteria, they are not always the cause for non-attainment of bacteria standards because other sources discharge more frequently. The major sources of BOD vary from tributary to tributary; for Jamaica Bay as a whole, WWTPs are the major source of BOD.

Table 6-4. 2008 Baseline Loading Summary

Totals by Source by Waterbody		Volume	*Enterococci*	Fecal Coliform	BOD
Waterbody	**Source**	**Total Discharge (MG/yr)**	**Total Org (10^12/yr)**	**Total Org (10^12/yr)**	**Total (lbs/yr)**
Thurston Basin	CSO	213	821	2,673	38,788
	MS4 SW	-	-	-	-
	Non-MS4 SW	793	1,522	3,653	100,473
	Airport	372	113	282	46,461
	Direct Drainage	61	14	9	7,622
	Subtotal	1,439	2,470	6,617	193,344
Bergen Basin	CSO	340	13,517	17,658	85,333
	MS4 SW	2,835	5,907	4,833	354,518
	Non-MS4 SW	117	243	199	14,603
	Airport	302	92	229	37,840
	Direct Drainage	22	5	3	2,803
	Jamaica WWTP	5,454	4	8	329,691
	Subtotal	9,070	19,768	22,930	824,788
Spring Creek	CSO	310	1,566	5,406	67,080
	MS4 SW	26	50	120	3,299
	Non-MS4 SW	38	72	173	4,764
	Airport	-	-	-	-
	Direct Drainage	77	18	12	9,794
	Subtotal	451	1,706	5,711	84,937
Hendrix Creek	CSO	104	587	2,067	24,307
	MS4 SW	36	68	164	4,514
	Non-MS4 SW	41	80	191	5,255
	Airport	-	-	-	-
	Direct Drainage	34	8	5	4,391
	26th Ward WWTP	19,622	15	31	529,159
	Subtotal	19,837	758	2,458	567,626
Fresh Creek	CSO	300	4,826	4,014	61,702
	MS4 SW	216	408	978	26,897
	Non-MS4 SW	273	517	1,241	34,126
	Airport	-	-	-	-

Table 6-4. 2008 Baseline Loading Summary

Totals by Source by Waterbody		Volume	*Enterococci*	Fecal Coliform	BOD
Waterbody	**Source**	**Total Discharge (MG/yr)**	**Total Org (10^12/yr)**	**Total Org (10^12/yr)**	**Total (lbs/yr)**
	Direct Drainage	33	8	5	4,227
	Subtotal	822	5,759	6,238	126,952
Paerdegat Basin	CSO	591	16,113	36,432	148,384
	MS4 SW	197	372	892	24,534
	Non-MS4 SW	113	215	515	14,168
	Airport	-	-	-	-
	Direct Drainage	42	10	7	5,384
	Subtotal	943	16,710	37,846	192,470
Jamaica Bay[1]	CSO	0	-	-	-
	MS4 SW	2,489	3,535	8,449	311,973
	Non-MS4 SW	1,243	1,331	3,165	160,673
	Airport	957	290	724	119,550
	Direct Drainage	1967	452	329	246,506
	Jamaica WWTP	24,650	18	35	1,486,683
	Rockaway WWTP	7,876	6	13	332,734
	Subtotal	39,182	5,632	12,715	2,658,119
Hawtree Basin	CSO	0			
	MS4 SW	45	81	195	5,360
	Non-MS4 SW	30	58	139	3,832
	Airport	-			
	Direct Drainage	-			
	Subtotal	75	139	334	9192
Shellbank Basin	CSO	0			
	MS4 SW	281	537	1,289	35,460
	Non-MS4 SW	6	12	29	785
	Airport	-			
	Direct Drainage	-			
	Subtotal	287	549	1318	36245
Total		72,106	53,491	96,167	4,693,673

Notes:

(1) Grassy Bay, Hassock Creek, Grass Hassock Creek, Shell Bank Creek, Mill Basin, and Rockaway are included with Jamaica Bay.

6.3 Performance Gap

Bacteria and DO concentrations in Jamaica Bay and its tributaries are affected by a number of factors, including the volumes of all sources, the concentrations of the respective loadings, flow entering from Head of Bay (Nassau County), man-made features such as the borrow pits excavated in the bottom of Jamaica Bay, and the exchange of tidal flow with the Lower Bay. 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 Jamaica Bay and its tributaries.

The JEM 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, Primary Contact WQ Criteria, and the Proposed *Enterococci* WQ Criteria* for bacteria, as well as designated and next higher use classifications for DO, as discussed in Section 6.3.c. The performance gap was then developed as the difference between the model calculated baseline waterbody DO and bacteria concentrations and the applicable numerical WQS. The analysis was developed to address the following three sets of criteria:

- Existing WQ Criteria (Jamaica Bay - Class SB, Tributaries - Class I);
- Bacteria Primary Contact WQ Criteria and DO next higher use classification (Class SB); and
- Proposed *Enterococci* WQ Criteria*.

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 1st through October 31st. For *Enterococci*, the temporal assessment focuses on compliance during the recreational season of May 1st through October 31st. A summary of the criteria that were applied is shown in Table 6-5.

Table 6-5. Classifications and Standards Applied

Analysis	Numerical Criteria Applied	
Existing WQ Criteria - Tributaries	Class I	Fecal Monthly GM ≤ 200; DO never < 4.0 mg/L
Existing WQ Criteria – Jamaica Bay	Class SB	Fecal Monthly GM ≤ 200 DO between > 3.0 & ≤4.8 mg/L[3]; DO never < 3.0 mg/L
Bacteria Primary Contact WQ Criteria – Class SB for Tributaries and Jamaica Bay[1]	Class SB	Fecal Monthly GM ≤ 200 DO between > 3.0 & ≤4.8 mg/L[1, 3]; DO never < 3.0 mg/L[1]
Proposed *Enterococci* WQ Criteria[2]	Coastal Class SB	*Enterococci*: rolling 90-day GM – 35 cfu/100mL *Enterococci*: STV – 130 cfu/100mL

*Proposed *Enterococci* WQ Criteria, if adopted as proposed, would only apply to coastal Class SB and SA waters.

Notes:

(1) This WQS is not currently assigned to the tributaries of Jamaica Bay.
(2) DEC has not yet adopted the Proposed *Enterococci* WQ Criteria*.
(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 on Table 2-7 in Section 2.

6.3.a CSO Volumes and Loadings Needed to Attain Current Water Quality Standards

To assess the performance gap, fecal coliform concentrations were calculated under baseline conditions for Jamaica Bay and its tributaries, and DEP analyzed whether the gap could be closed through reductions to, or control of, CSOs. The assessment was completed to determine if the water quality of Jamaica Bay and its tributaries would comply with Existing WQ Criteria. The water quality monitoring stations are shown in Figure 6-3.

10-Year Annual Rainfall Simulation – Bacteria

A ten-year simulation of bacteria water quality was performed for the 2002-2011 baseline loading conditions, assuming all dry-weather illicit discharges have been eliminated. The results of these simulations are summarized in Table 6-6. The results shown in this table summarize the highest calculated monthly GM during the 10-year period on an annual basis (recreational and non-recreational seasons) and during the recreational season (May 1st through October 31st). The maximum monthly GM is presented for each sampling location in Jamaica Bay and its tributaries.

*Proposed *Enterococci* WQ Criteria, if adopted as proposed, would only apply to coastal Class SB and SA waters.

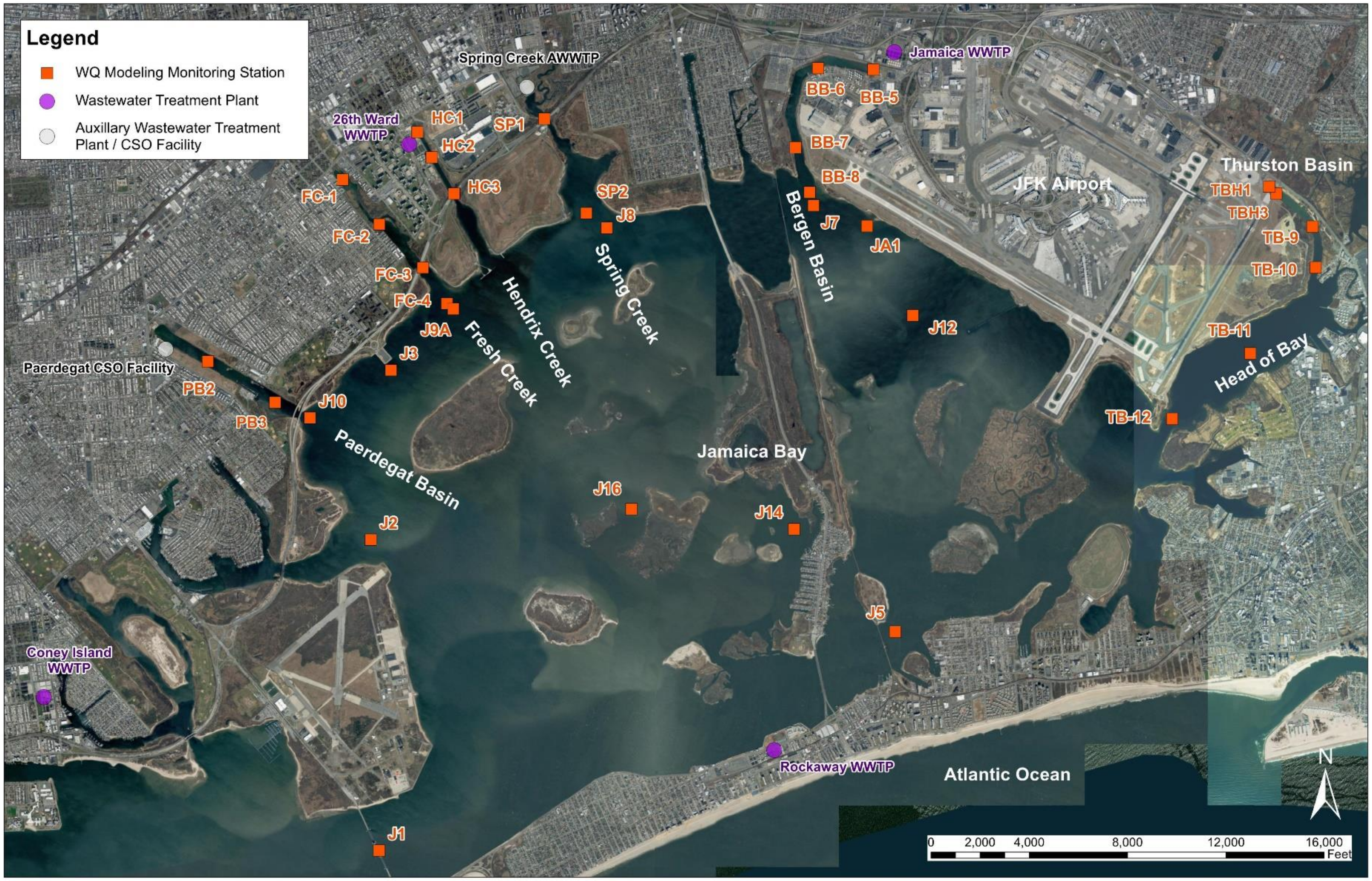

Figure 6-3 LTCP2 Water Quality Monitoring Stations in Jamaica Bay and its Tributaries

Table 6-6 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 highest GMs were found to occur in the Bergen Basin and Thurston Basin near the CSOs and stormwater outfalls. However, these monitoring stations are located within portions of these tributaries that are restricted from public access by airport security. Annual and recreational season (May 1st through October 31st) attainment was less than 95 percent at the head ends of Bergen Basin, Thurston Basin, and Fresh Creek. In contrast, 100 percent attainment is achieved at all of the stations within the Bay and near the confluence of each tributary with the Bay during the recreational season (May 1st through October 31st) and on an annual basis.

Table 6-6. Model Calculated 10-Year Baseline Fecal Coliform Maximum Monthly GM and Attainment of Existing WQ Criteria

Station	Maximum Monthly GMs (cfu/100mL)		% Attainment (GM<200 cfu/100mL)	
	Annual	Recreational Season(2)	Annual	Recreational Season(2)
Thurston Basin				
TBH1(1)	1,311	1,311	71	85
TBH3(1)	666	666	84	92
TB9(1)	505	505	87	92
TB10(1)	226	226	96	97
TB11	62	52	100	100
TB12	39	36	100	100
Bergen Basin				
BB5(1)	1,297	1,297	51	70
BB6(1)	396	396	90	93
BB7(1)	154	154	100	100
BB8	68	68	100	100
Spring Creek				
SP1	204	204	99	98
SP2	44	44	100	100
Hendrix Creek				
HC1	237	237	98	97
HC2	174	174	100	100
HC3	92	92	100	100
Fresh Creek				
FC1	498	467	86	93
FC2	272	216	96	98
FC3	128	99	100	100
FC4	45	45	100	100
Paerdegat Basin				
PB2	252	221	97	95
PB3	104	104	100	100

Table 6-6. Model Calculated 10-Year Baseline Fecal Coliform Maximum Monthly GM and Attainment of Existing WQ Criteria

Station	Maximum Monthly GMs (cfu/100mL)		% Attainment (GM<200 cfu/100mL)	
	Annual	Recreational Season(2)	Annual	Recreational Season(2)
Jamaica Bay (Northern Shore)				
J10	62	62	100	100
J3	36	36	100	100
J9a	45	45	100	100
J8	43	43	100	100
J7	68	68	100	100
JA1	53	53	100	100
Jamaica Bay (Inner Bay)				
J2	30	30	100	100
J12	29	26	100	100
J14	21	21	100	100
J16	27	27	100	100
Jamaica Bay (Rockaway Shore)				
J1	19	19	100	100
J5	20	20	100	100

Notes:
(1) Monitoring station is located in a portion of the waterbody that is restricted by airport security and/or a physical barrier.
(2) The recreational season is from May 1st through October. 31st.

DEP reran the 10-year baseline condition scenario with the CSO loadings to Jamaica Bay tributaries removed. This projection represents the maximum possible reduction of CSO loads to the tributaries of Jamaica Bay and is referred to as the 100% CSO control scenario. All other conditions from the baseline projection remain unchanged in the 100% CSO control scenario. Table 6-7 presents the maximum monthly fecal coliform GM concentration and the annual and recreation season (May 1st through October 31st) attainment of the Existing WQ Criteria (primary contact criterion for fecal coliform) for baseline conditions and the 100% CSO control scenario.

Table 6-7. Comparison of the Model Calculated 10-Year Baseline and 100% Jamaica Bay and its Tributaries CSO Control Fecal Coliform Maximum Monthly GM and Attainment of Existing WQ for Fecal Coliform Bacteria

Station	Maximum Monthly GMs (Annual - cfu/100mL)		% Attainment - Annual (GM<200 cfu/100mL)		% Attainment – Recreational Season[2] (GM<200 cfu/100mL)	
	Baseline	100% CSO Control	Baseline	100% CSO Control	Baseline	100% CSO Control
Thurston Basin						
TBH1[1]	1,311	924	71	74	85	87
TBH3[1]	666	457	84	88	92	93
TB9[1]	505	345	87	91	92	95
TB10[1]	226	166	96	100	97	100
TB11	62	44	100	100	100	100
TB12	39	31	100	100	100	100
Bergen Basin						
BB5[1]	1,297	1,141	51	57	70	73
BB6[1]	396	305	90	94	93	98
BB7[1]	154	104	100	100	100	100
BB8	68	44	100	100	100	100
Spring Creek						
SP1	204	114	99	100	98	100
SP2	44	24	100	100	100	100
Hendrix Creek						
HC1	237	117	98	100	97	100
HC2	174	99	100	100	100	100
HC3	92	47	100	100	100	100
Fresh Creek						
FC1	498	428	86	91	93	98
FC2	272	202	96	98	98	100
FC3	128	90	100	100	100	100
FC4	45	25	100	100	100	100
Paerdegat Basin						
PB2	252	109	97	100	95	100
PB3	104	46	100	100	100	100
Jamaica Bay (Northern Shore)						
J10	62	26	100	100	100	100
J3	36	19	100	100	100	100
J9a	45	25	100	100	100	100
J8	43	24	100	100	100	100
J7	68	44	100	100	100	100
JA1	53	38	100	100	100	100
Jamaica Bay (Inner Bay)						

Table 6-7. Comparison of the Model Calculated 10-Year Baseline and 100% Jamaica Bay and its Tributaries CSO Control Fecal Coliform Maximum Monthly GM and Attainment of Existing WQ for Fecal Coliform Bacteria

Station	Maximum Monthly GMs (Annual - cfu/100mL)		% Attainment - Annual (GM<200 cfu/100mL)		% Attainment – Recreational Season[(2)] (GM<200 cfu/100mL)	
	Baseline	100% CSO Control	Baseline	100% CSO Control	Baseline	100% CSO Control
J2	30	16	100	100	100	100
J12	29	18	100	100	100	100
J14	21	18	100	100	100	100
J16	27	16	100	100	100	100
Jamaica Bay (Rockaway Shore)						
J1	19	13	100	100	100	100
J5	20	16	100	100	100	100

Notes:
(1) Monitoring station is located in a portion of the waterbody that is restricted by airport security and/or a physical barrier.
(2) The recreational season is from May 1st through October 31st.

As indicated in Table 6-7, 100% CSO control of the bacteria loading results in some improvement in the CSO-affected tributaries. However, on an annual basis, the head ends of Fresh Creek, Bergen Basin, and Thurston Basin do not achieve 95 percent attainment of the criterion even with 100% CSO control. This is also the case for the recreational period with the exception of the head end of Fresh Creek, which improves from 93 to 98 percent attainment. This analysis indicates that CSO controls cannot completely close the gap between attainment and non-attainment of the fecal coliform WQ Criteria.

2008 Annual Rainfall Simulation – Dissolved Oxygen

The average annual attainment of DO criteria based on the water quality model simulation is presented in Table 6-8 for year 2008 conditions. The average annual attainment is calculated by averaging the calculated attainment in each of 10 modeled depth layers, comprising the entire water column. When assessing the water column in its entirety, attainment of the DO criterion is very high, with the exception of the head ends of Bergen Basin, Thurston Basin, and Hendrix Creek. All other monitoring station locations that were assessed have a water column annual attainment of 95 percent or greater for year 2008 conditions.

Table 6-8. Model Calculated Baseline DO Attainment – Existing WQ Criteria (2008)

Annual Attainment (%) (Entire Water Column)				
Tributaries – Class I		Jamaica Bay - Class SB		
Station	Instantaneous (>=4.0 mg/L)	Station	Instantaneous (>=3.0 mg/L)	Daily Ave. (>=4.8 mg/L)
Thurston Basin		**Jamaica Bay (Northern Shore)**		
TBH1(1)	90	J10	100	100
TBH3(1)	90	J3	100	100
TB9(1)	92	J9a	100	100
TB10(1)	92	J8	100	100
TB11	97	J7	100	100
TB12	99	JA1	100	99
Bergen Basin		**Jamaica Bay (Inner Bay)**		
BB5(1)	89	J2	100	100
BB6(1)	95	J12	100	100
BB7(1)	99	J14	100	100
BB8	100	J16	100	100
Spring Creek		**Jamaica Bay (Rockaway Shore)**		
SP1	99	J1	100	100
SP2	100	J5	100	100
Hendrix Creek				
HC1	94			
HC2	98			
HC3	100			
Fresh Creek				
FC1	99			
FC2	100			
FC3	100			
FC4	100			
Paerdegat Basin				
PB2	99			
PB3	100			

Note:
(1) Monitoring station is located in a portion of the waterbody that is restricted by airport security and/or a physical barrier.

Table 6-9 presents a comparison of the Class I DO criterion attainment for the tributaries and the Class SB DO criteria attainment for Jamaica Bay under baseline conditions and 100% CSO control. The model generally calculates improvements of at most only a few percentage points in attainment with the DO criteria. Thus, CSO loads are not the controlling factor for DO concentrations and CSO controls will not improve DO concentrations substantially. This finding is not unexpected as DO in Jamaica Bay is

Table 6-9. Model Calculated Baseline and 100% CSO Control DO Attainment – Existing WQ Criteria (2008)

Annual Attainment (%) (Entire Water Column)							
Tributaries – Class I			**Jamaica Bay - Class SB**				
Station	**Baseline**	**100% Control**	**Station**	**Baseline**		**100% Control**	
	Instantaneous (>=4.0 mg/L)			**Instantaneous (>=3.0 mg/L)**	**Daily Ave. (>=4.8 mg/L)**	**Instantaneous (>=3.0 mg/L)**	**Daily Ave. (>=4.8 mg/L)**
Thurston Basin			**Jamaica Bay (Northern Shore)**				
TBH1[1]	90	91	J10	100	100	100	100
TBH3[1]	90	91	J3	100	100	100	100
TB9[1]	92	93	J9a	100	100	100	100
TB10[1]	92	93	J8	100	100	100	100
TB11	97	97	J7	100	100	100	100
TB12	99	99	JA1	100	99	100	99
Bergen Basin			**Jamaica Bay (Inner Bay)**				
BB5[1]	89	92	J2	100	100	100	100
BB6[1]	95	96	J12	100	100	100	100
BB7[1]	99	100	J14	100	100	100	100
BB8	100	100	J16	100	100	100	100
Spring Creek			**Jamaica Bay (Rockaway Shore)**				
SP1	99	100	J1	100	100	100	100
SP2	100	100	J5	100	100	100	100
Hendrix Creek							
HC1	94	95					
HC2	98	98					
HC3	100	100					
Fresh Creek							
FC1	99	100					
FC2	100	100					
FC3	100	100					
FC4	100	100					
Paerdegat Basin							
PB2	99	100					
PB3	100	100					

Note:
(1) Monitoring station is located in a portion of the waterbody that is restricted by airport security and/or a physical barrier.

influenced by many factors including stormwater loads, tidal flushing, man-made features such as the borrow pits excavated in the bottom of Jamaica Bay, and the nitrogen discharged from WWTPs.

6.3.b CSO Volumes and Loadings That Would be Needed to Support the Next Highest Use or Swimmable/Fishable Uses

Bacteria

Current WQS provide that Class I waterbodies must meet the primary contact (Class SB) bacteria criteria[1]. The primary contact fecal coliform criterion is a monthly GM less than, or equal to, 200 cfu/100mL. Since the Class I bacteria criteria are now the same as the Class SB criteria, the performance gap to attain Class SB bacteria criteria would be the same as presented in Table 6-9 above.

Dissolved Oxygen

The average annual attainment of the DO Class SB criteria for the entire water column is presented in Table 6-10, for the baseline and 100% CSO control conditions. Determination of attainment with Class SB DO criteria can be very complex as the standard allows for excursions from the daily average limit of 4.8 mg/L for a limited number of consecutive calendar days. As noted above, the average annual attainment is calculated by averaging calculated attainment in each of 10 modeled depth layers, comprising the entire water column. To simplify the analysis, attainment was based solely upon attainment of the daily average without the allowed excursions. While the analysis performed was conservative, the results indicate full attainment with the chronic DO criterion at most stations. Under baseline conditions, stations in Jamaica Bay and each of the tributaries have a greater than 95 percent attainment of the chronic DO criterion (greater than or equal to 4.8 mg/L), while Stations TBH1, TBH2, TH9, and TB10 in Thurston Basin, Stations BB5 and BB6 in Bergen Basin, and Stations HC1 and HC2 in Hendrix Creek have attainment less than 95 percent on an annual basis. 100% CSO control results in improvements of generally less than 2 percent annual attainment of the chronic DO criterion.

All of the stations have greater than 95 percent attainment of the acute criterion (never less than 3.0 mg/L) under baseline conditions based on the entire water column, with the exception of the head end of Thurston Basin. Since 100% CSO control does not result in improvements in attainment of the Class SB criterion, the gap between attainment and non-attainment at all monitoring locations within Jamaica Bay and its tributaries, cannot be closed regardless of the level of CSO control implemented.

Table 6-10. Model Calculated 2008 Baseline and 100% CSO Control DO Attainment of Class SB WQ Criteria

Station	Annual % Attainment (Water Column)			
	Baseline		100% Jamaica Bay CSO Control	
	Chronic(1)	Acute(2)	Chronic(1)	Acute(2)
Thurston Basin				
TBH1(3)	86	94	87	95
TBH3(3)	87	94	88	94

[1] *As part of DEC's March 2018 proposed rulemaking, DEC has proposed that the primary contact WQS for Class I should be applied only during the recreation season (May 1st to October 31st).*

Table 6-10. Model Calculated 2008 Baseline and 100% CSO Control DO Attainment of Class SB WQ Criteria

Station	Annual % Attainment (Water Column)			
	Baseline		100% Jamaica Bay CSO Control	
	Chronic(1)	Acute(2)	Chronic(1)	Acute(2)
TB9(3)	89	96	90	96
TB10(3)	89	96	90	96
TB11	95	99	95	99
TB12	97	100	98	100
Bergen Basin				
BB5(3)	81	95	85	97
BB6(3)	91	98	93	99
BB7(3)	98	100	98	100
BB8	100	100	100	100
Spring Creek				
SP1	98	100	100	100
SP2	100	100	100	100
Hendrix Creek				
HC1	90	98	92	99
HC2	95	100	96	100
HC3	99	100	99	100
Fresh Creek				
FC1	99	100	100	100
FC2	100	100	100	100
FC3	100	100	100	100
FC4	100	100	100	100
Paerdegat Basin				
PB2	99	100	99	100
PB3	100	100	100	100
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	100	100	100
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:

AECOM with Hazen

Table 6-10. Model Calculated 2008 Baseline and 100% CSO Control DO Attainment of Class SB WQ Criteria

Station	Annual % Attainment (Water Column)			
	Baseline		100% Jamaica Bay CSO Control	
	Chronic(1)	Acute(2)	Chronic(1)	Acute(2)

(1) Chronic Criteria: 24-hr average DO≥ 4.8 mg/L with allowable excursions to ≥ 3.0 mg/L for certain periods of time.
(2) Acute Criteria: DO≥ 3.0 mg/L.
(3) Monitoring station is located in a portion of the waterbody that is restricted by airport security and/or a physical barrier.

6.3.c Proposed *Enterococci* WQ Criteria*

As noted in Section 2.0, EPA released its RWQC recommendations in December 2012. That document included recommendations for RWQC for protecting human health in all coastal waters designated for primary contact recreation use, based on *Enterococci*. On March 21, 2018, DEC publicly noticed a proposed rulemaking for revised WQS and re-classifications for certain coastal waterbodies. It is anticipated that formal revision to the WQS will be promulgated after the submittal date of the Jamaica Bay and Tributaries LTCP. The Proposed *Enterococci* WQ Criteria* for coastal Class SB waters is a 90-day GM of 35 cfu/100mL and an STV of 130 cfu/100mL. As proposed, these criteria apply to coastal Class SB waters and would not apply to the tributaries of Jamaica Bay which are non-coastal Class I waters. As requested by DEC, the LTCP has analyzed the proposed criteria with a rolling 90-day GM and STV, and also evaluated the level of attainment of the proposed criteria for the tributaries. An analysis using the 10-year rainfall baseline and 100% CSO control model simulation results was conducted to assess attainment with the proposed WQ criteria.

6.3.d Load Reductions Needed to Attain the Proposed *Enterococci* WQ Criteria*

Additional water quality modeling analyses were performed to assess the extent to which CSO and non-CSO sources impact *Enterococci* concentrations at key locations in Jamaica Bay and its tributaries. Those analyses consisted of first assessing the baseline conditions for *Enterococci* and then determining whether complete CSO reduction (100% CSO control) in the tributaries of Jamaica Bay could close the gap between the baseline conditions and the Proposed *Enterococci* WQ Criteria* applying a 90-day rolling GM *Enterococci* concentration of 35 cfu/100mL and 90th percentile STV of 130 cfu/100mL. Table 6-11 presents the calculated maximum 90-day GM and 90th percentile STV and the percent attainment of the rolling 90-day GM of 35 cfu/100mL and 90th percentile STV of 130 cfu/100mL criteria for baseline conditions and 100% CSO control at each of the stations in Jamaica Bay and the tributaries. Attainment for the tributaries of Jamaica Bay is shown for informational purposes, as the Proposed *Enterococci* WQ Criteria* is not applicable to the tributaries as non-coastal Class I waters. All results are for the attainment of the Proposed *Enterococci* WQ Criteria* during the May 1st through October 31st primary contact recreational season defined by the DEC.

*Proposed *Enterococci* WQ Criteria, if adopted as proposed, would only apply to coastal Class SB and SA waters.

Table 6-11. Model Calculated 10-Year Baseline *Enterococci* Maximum 90-day GM and STV and Attainment of Proposed *Enterococci* WQ Criteria*

Station	Maximum Recreational Season(2) 90-day *Enterococci* (cfu/100mL)		% Attainment(3)	
	GM	90th Percentile STV	GM	90th Percentile STV
Thurston Basin				
TBH1(1)	122	4,400	55	0
TBH3(1)	70	2,860	83	0
TB9(1)	62	2,208	90	1
TB10(1)	41	1,305	100	11
TB11	10	300	100	93
TB12	6	184	100	99
Bergen Basin				
BB5(1)	312	17,952	16	0
BB6(1)	129	7,216	71	0
BB7(1)	51	2,951	99	3
BB8	12	580	100	51
SP1	6	320	100	84
SP2	5	131	100	100
Hendrix Creek				
HC1	21	1,788	100	16
HC2	26	1,064	100	23
HC3	14	319	100	72
Fresh Creek				
FC1	27	2,637	100	4
FC2	26	1,729	100	5
FC3	13	558	100	34
FC4	5	91	100	100
Paerdegat Basin				
PB2	23	1,778	100	12
PB3	9	406	100	67
Jamaica Bay (Northern Shore)				
J10	5	154	100	99
J3	3	55	100	100
J9a	5	91	100	100
J8	5	136	100	100
J7	12	580	100	51
JA1	9	217	100	92

*Proposed *Enterococci* WQ Criteria, if adopted as proposed, would only apply to coastal Class SB and SA waters.

Table 6-11. Model Calculated 10-Year Baseline *Enterococci* Maximum 90-day GM and STV and Attainment of Proposed *Enterococci* WQ Criteria*

Station	Maximum Recreational Season(2) 90-day *Enterococci* (cfu/100mL)		% Attainment(3)	
	GM	90^{th} Percentile STV	GM	90^{th} Percentile STV
Jamaica Bay (Inner Bay)				
J2	3	24	100	100
J12	5	100	100	100
J14	3	47	100	100
J16	2	16	100	100
Jamaica Bay (Rockaway Shore)				
J1	2	8	100	100
J5	2	24	100	100

Notes:
(1) Monitoring station is located in a portion of the waterbody that is restricted by airport security and/or a physical barrier.
(2) The recreational season is from May 1^{st} through October. 31^{st}.
(3) Percent attainment with Proposed *Enterococci* WQ Criteria* of 90-day GM of 35 cfu/100mL, and 90-day STV of 130 cfu/100mL, for the recreational season (May 1^{st} through October 31^{st}). These proposed criteria, if adopted as proposed, will not apply to the tributaries to Jamaica Bay.

Under ten-year baseline conditions, greater-than 95 percent attainment of the rolling 90-day GM *Enterococci* criterion of 35 cfu/100mL is achieved during the recreational season (May 1^{st} through October 31^{st}) in Jamaica Bay and its tributaries, except for Thurston and Bergen Basins. Attainment of the rolling 90-day GM criterion ranges from 55 percent to 99 percent between Station TBH1 andTB10 in Thurston Basin and from 16 percent to 99 percent between Stations BB5 and BB7 in Bergen Basin. Attainment of the 90^{th} percentile STV criterion of 130 cfu/100mL within the tributaries generally ranges from as low as 0 to 100 percent, while Jamaica Bay stations range from 50 to 100 percent. These results indicate that while rainfall events have significant short term impacts, particularly within the tributaries, bacteria impacts generally dissipate before the 90-day GM criterion is exceeded.

Water quality modeling analyses conducted to assess attainment of the Proposed *Enterococci* WQ Criteria* with complete removal of the CSO *Enterococci* loadings, as provided in Table 6-12, show that 100% CSO control would result in full attainment of the 90-day rolling GM *Enterococci* criterion in Jamaica Bay and its tributaries, except for Thurston and Bergen Basins. Attainment of the rolling 90-day GM criterion improves at each station by 1 to 5 percent at Station TBH1 through TB10 in Thurston Basin and from 0 to 7 percent at Stations BB5 through BB7 in Bergen Basin. Improvement in attainment of the 90^{th} percentile STV *Enterococci* criterion is generally less than 10 percent in Thurston Basin, Bergen Basin, and Jamaica Bay, and less than 20 percent in Hendrix Creek and Fresh Creek. These areas had generally high stormwater-to-CSO ratios. The low degree of attainment with 100% CSO control indicates that the 90^{th} percentile *Enterococci* concentrations are predominantly influenced by non-CSO sources of bacteria, such as storm sewers, airport runoff, and direct drainage, and therefore will receive limited benefit from CSO control. This finding is further supported by Table 6-5 above, which shows that stormwater is a sizable source of bacteria loading to Jamaica Bay and many of the tributaries.

*Proposed *Enterococci* WQ Criteria, if adopted as proposed, would only apply to coastal Class SB and SA waters.

Table 6-12. Model Calculated 10-Year 100% CSO Control Maximum 90-day GM and STV, and Attainment of Proposed *Enterococci* WQ Criteria*

Station	Maximum Recreational Season(2) 90-day *Enterococci* (cfu/100mL)		% Attainment(3)	
	GM	90th Percentile STV	GM	90th Percentile STV
Thurston Basin				
TBH1(1)	111	2,919	60	0
TBH3(1)	64	1,895	88	1
TB9(1)	57	1,564	92	3
TB10(1)	37	921	100	11
TB11	10	254	100	95
TB12	6	163	100	99
Bergen Basin				
BB5(1)	289	15,957	17	0
BB6(1)	107	4,232	78	0
BB7(1)	40	1,516	100	6
BB8	9	306	100	86
Spring Creek				
SP1	5	238	100	95
SP2	4	58	100	100
Hendrix Creek				
HC1	15	795	100	34
HC2	20	504	100	42
HC3	11	131	100	100
Fresh Creek				
FC1	18	1,296	100	9
FC2	19	1,159	100	10
FC3	9	380	100	63
FC4	3	47	100	100
Paerdegat Basin				
PB2	15	620	100	27
PB3	6	167	100	99
Jamaica Bay (Northern Shore)				
J10	4	57	100	100
J3	3	23	100	100
J9a	3	47	100	100
J8	4	64	100	100
J7	9	306	100	86
JA1	7	128	100	100

*Proposed *Enterococci* WQ Criteria, if adopted as proposed, would only apply to coastal Class SB and SA waters.

Table 6-12. Model Calculated 10-Year 100% CSO Control Maximum 90-day GM and STV, and Attainment of Proposed *Enterococci* WQ Criteria*

Station	Maximum Recreational Season(2) 90-day *Enterococci* (cfu/100mL)		% Attainment(3)	
	GM	90th Percentile STV	GM	90th Percentile STV
Jamaica Bay (Inner Bay)				
J2	2	14	100	100
J12	3	52	100	100
J14	3	45	100	100
J16	2	9	100	100
Jamaica Bay (Rockaway Shore)				
J1	2	6	100	100
J5	2	20	100	100

Notes:
(1) Monitoring station is located in a portion of the waterbody that is restricted by airport security and/or a physical barrier.
(2) The recreational season is from May 1st through October. 31st.
(3) Percent attainment with Proposed *Enterococci* WQ Criteria* of 90-day GM of 35 cfu/100mL, and 90-day STV of 130 cfu/100mL. These criteria as proposed are not applicable to the tributaries to Jamaica Bay.

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 Jamaica Bay and its tributaries. The source types include CSOs, stormwater, direct drainage, Airport, WWTP, and other (outfalls not classified as any of the other categories in InfoWorks). Boundary conditions generally contribute an insignificant amount to the concentrations in Jamaica Bay, so they were not included in the table. 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) 90-day GM basis. The 90-day period chosen for the *Enterococci* component analysis included both the maximum 90-day period and the 90-day period where the maximum contribution of CSOs to the GM was observed. Since the maximum 90-day period is not always the same in each tributary, the period chosen was based on the maximum 90-day period for Bergen and Thurston Basins, which have the highest calculated bacteria concentrations.

Table 6-13 summarizes the fecal coliform component analysis at selected water quality stations for the maximum winter month during 2008. As indicated in Table 6-13, for 2008, the fecal coliform criterion (monthly GM less than or equal to 200 cfu/100mL) is exceeded in Thurston Basin (TBH1, TB9, and TB10), Bergen Basin (BB5), and Fresh Creek (FC1). In each of those cases, the major contributor to the fecal coliform GM is MS4 stormwater or, for Fresh Creek, non-MS4 stormwater. At none of those stations does the fecal coliform component exceed 200 cfu/100ml.

Table 6-13 also summarizes the *Enterococci* component analysis. The rolling 90-day GM of 35 cfu/100mL is exceeded in Thurston Basin (TBH1 and TB9), and in Bergen Basin (BB5). In each case, MS4

*Proposed *Enterococci* WQ Criteria, if adopted as proposed, would only apply to coastal Class SB and SA waters.

stormwater is the largest contributor to the rolling 90-day GM. The CSO component does not exceed 35 cfu/100mL at any of the stations shown.

Table 6-13 indicates that the relative impacts of CSO on attainment are most evident within Bergen Basin and Fresh Creek, although the extent of CSO contribution varies both spatially and temporally. In no case does the CSO influence by itself contribute more than 200 cfu/100mL to the fecal coliform GM.

Table 6-13. 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	Max 90-Day Rolling GM during the Recreational Season (May 1st through October 31st)
Thurston Basin			
Airport	TBH1	45	4
CSO	TBH1	38	3
Direct Drainage	TBH1	11	4
MS4	TBH1	269	36
Other	TBH1	0	0
Storm	TBH1	79	8
WWTP	TBH1	0	0
Total	TBH1	**442**	**55**
Airport	TB9	26	3
CSO	TB9	28	2
Direct Drainage	TB9	17	5
MS4	TB9	180	21
Other	TB9	0	0
Storm	TB9	53	5
WWTP	TB9	0	0
Total	TB9	**304**	**36**
Airport	TB10	15	2
CSO	TB10	19	1
Direct Drainage	TB10	21	6
MS4	TB10	114	13
Other	TB10	0	0
Storm	TB10	34	3
WWTP	TB10	0	0
Total	TB10	**203**	**25**
Bergen Basin			
Airport	BB5	24	2
CSO	BB5	147	7

Table 6-13. 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	Max 90-Day Rolling GM during the Recreational Season (May 1st through October 31st)
Direct Drainage	BB5	1	0
MS4	BB5	1,102	103
Other	BB5	0	0
Storm	BB5	3	1
WWTP	BB5	4	1
Total	BB5	**1,281**	**114**
Airport	BB7	8	1
CSO	BB7	50	4
Direct Drainage	BB7	0	0
MS4	BB7	81	14
Other	BB7	0	0
Storm	BB7	5	1
WWTP	BB7	0	0
Total	BB7	**144**	**20**
Fresh Creek			
Airport	FC1	0	0
CSO	FC1	148	2
Direct Drainage	FC1	1	0
MS4	FC1	102	2
Other	FC1	0	0
Storm	FC1	238	7
WWTP	FC1	0	0
Total	FC1	**489**	**11**
Hendrix Creek			
Airport	HC1	0	0
CSO	HC1	76	2
Direct Drainage	HC1	1	0
MS4	HC1	28	1
Other	HC1	0	0
Storm	HC1	75	6
WWTP	HC1	9	2
Total	HC1	**189**	**11**
Spring Creek			
Airport	SP1	0	0

Table 6-13. 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	Max 90-Day Rolling GM during the Recreational Season (May 1st through October 31st)
CSO	SP1	65	1
Direct Drainage	SP1	4	1
MS4	SP1	41	1
Other	SP1	0	0
Storm	SP1	60	1
WWTP	SP1	0	0
Total	SP1	**166**	**4**
Paerdegat Basin			
Airport	PB2	0	0
CSO	PB2	94	4
Direct Drainage	PB2	0	0
MS4	PB2	54	4
Other	PB2	0	0
Storm	PB2	39	4
WWTP	PB2	0	0
Total	PB2	**187**	**12**
Jamaica Bay			
Airport	J1	0	0
CSO	J1	3	0
Direct Drainage	J1	0	0
MS4	J1	1	0
Other	J1	0	0
Storm	J1	1	0
WWTP	J1	0	0
Total	J1	**5**	**1**
Airport	J5	0	0
CSO	J5	5	0
Direct Drainage	J5	0	2
MS4	J5	2	1
Other	J5	0	0
Storm	J5	1	0
WWTP	J5	0	0
Total	J5	**8**	**4**
Airport	J7	4	1

Table 6-13. 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	Max 90-Day Rolling GM during the Recreational Season (May 1st through October 31st)
CSO	J7	22	2
Direct Drainage	J7	0	0
MS4	J7	20	4
Other	J7	0	0
Storm	J7	3	1
WWTP	J7	0	0
Total	J7	**49**	**8**

6.3.d Time to Recovery

The analyses provided above focused on the long term impacts of wet-weather sources, as is required by Existing and Proposed *Enterococci* WQ Criteria* (monthly GM and 90-day GM). 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.

> **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; ….

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 Jamaica Bay and its tributaries to recover and return to concentrations of less than 1,000 cfu/100mL.

The approach to developing a "Time to Recovery" began with an analysis of LaGuardia Airport rainfall data for the period of 2002-2011. The Synoptic Surface Plotting (SYNOP) model was used to identify each 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 Jamaica Bay, the JFK Airport rainfall event 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 6-13 presents the results for the greater than 1.0 to 1.5 inch rainfall bin, which includes the 90th percentile event.

Table 6-13 presents the time to recovery for the baseline condition and the 100% CSO control scenario for Jamaica Bay and its tributaries. DEC has indicated that it seeks to have a time to recovery of less than 24 hours. Under the baseline conditions, Stations TBH1, TBH3, TB9, BB5, BB6, FC1, and FC2 have time to recovery greater than 24 hours, with values ranging from 25 to 43 hours. The other Jamaica Bay and its tributaries stations have time to recovery ranging between 0 and 20 hours.

*Proposed *Enterococci* WQ Criteria, if adopted as proposed, would only apply to coastal Class SB and SA waters.

Removal of CSOs from the Jamaica Bay tributaries (100% CSO control) results in a wide range of reduction in the time to recovery compared to baseline conditions. The time to recovery would be decreased by 0 to 14 hours, with the greatest reduction generally observed at the head ends of the tributaries. In the head ends of tributaries influenced by other sources (Thurston Basin and Bergen Basin), the time to recovery would still exceed 24 hours despite the removal of all CSO discharges.

Table 6-13. Time to Recovery

Station	Time to Recovery (hours) Fecal Coliform Threshold (1,000 cfu/100mL)(2)	
	Baseline	100% CSO Control
Thurston Basin		
TBH1(1)	38	35
TBH3(1)	35	30
TB9(1)	31	26
TB10(1)	18	14
TB11	0	0
TB12	0	0
Bergen Basin		
BB5(1)	43	38
BB6(1)	35	26
BB7(1)	20	12
BB8	7	0
Spring Creek		
SP1	7	7
SP2	1	0
Hendrix Creek		
HC1	19	11
HC2	18	8
HC3	10	1
Fresh Creek		
FC1	37	25
FC2	25	18
FC3	10	7
FC4	1	0
Paerdegat Basin		
PB2	19	9
PB3	6	3

Table 6-13. Time to Recovery

Station	Time to Recovery (hours) Fecal Coliform Threshold (1,000 cfu/100mL)(2)	
	Baseline	100% CSO Control
Jamaica Bay (Northern Shore)		
J10	3	1
J3	0	0
J9a	0	0
J8	0	0
J7	7	0
JA1	1	0
Jamaica Bay (Inner Bay)		
J2	0	0
J12	0	0
J14	0	0
J16	0	0
Jamaica Bay (Rockaway Shore)		
J1	0	0
J5	0	0

Notes:
(1) Monitoring station is located in a portion of the waterbody that is restricted by airport security and/or a physical barrier.
(2) Time to recovery values presented for 2008 storms in the size range of >1.0 to 1.5-inches of rainfall, which includes the 90th percentile rain event.

In summary, the time to recovery for most of the monitoring stations under baseline conditions appears to be on the order of DEC's desired target of 24 hours, except for the head ends of Thurston Basin, Bergen Basin, and Fresh Creek. However, stations located near the head ends of Thurston Basin and Bergen Basin would still exceed the 24 hour target upon 100 percent removal of CSO loadings, indicating that non-CSO sources influence time to recovery following wet-weather events.

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 WQS, consistent with the Federal CSO Control Policy and the CWA, and in accordance with EPA and DEC mandates.

DEP's Public Participation Plan was released to the public on June 26, 2012, and describes the tools and activities DEP uses to inform, involve, and engage a diverse group of stakeholders and the broader public throughout the LTCP process. The purpose of the Plan 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. As described in the Public Participation Plan, DEP will strategically and systematically implement activities that meet the public's information needs and meet 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 outlined in the Public Participation Plan, and summarizes public participation activities.

7.1 Local Stakeholder Team

DEP began the public participation process for the Jamaica Bay and Tributaries LTCP by reaching out to the local Community Boards to identify the stakeholders who would be instrumental to the development of this LTCP. Identified stakeholders included both citywide and regional groups such as: environmental organizations (Stormwater Infrastructure Matters [SWIM] Coalition, Riverkeeper, Jamaica Bay Ecowatchers); community planning organizations (Community Boards 10 and 12 located in Queens and Community Boards 5 and 18 located in Brooklyn); academic and research organizations (The Science and Resilience Institute at Jamaica Bay, York College); and City governmental agencies (NYC Department of Parks and Recreation, NYC Department of City Planning, the Economic Development Corporation, the Mayor's Office of Recovery and Resiliency and the New England Interstate Water Pollution Control Commission).

7.2 Summaries of Stakeholder Meetings

DEP held three public meetings and several stakeholder meetings to aid in the development and execution of the LTCP. The objective of the public meetings and a summary of the discussions are presented below.

Public Meetings

- Public Meeting #1: Jamaica Bay and Tributaries LTCP Kickoff Meeting (September 22, 2016)

  Objectives: Provide overview of LTCP process, public participation schedule, watershed characteristics and sampling program.

  DEP hosted a Public Kickoff Meeting to initiate the water quality planning process for the Jamaica Bay and Tributaries LTCP. Approximately 15 stakeholders from different non-profit, community, planning, environmental, economic development, governmental organizations, and the broader public, attended the event, as did representatives from DEC. The two-hour event, held at the Jamaica Chamber of Commerce, Queens, provided stakeholders with information about DEP's LTCP Program, Jamaica Bay and surrounding tributaries watershed characteristics, green infrastructure implementation, and the status of waterbody improvement projects. The presentation is available on DEP's LTCP Program website: http://www.nyc.gov/dep/ltcp.

  The Jamaica Bay and Tributaries LTCP Kickoff Public Meeting was the first opportunity for public participation in the development of this LTCP. As part of the development of the LTCP, and in response to stakeholder comments, DEP provided detailed information about each of the following:

  - Overview of Consent Order and LTCP Process;
  - Jamaica Bay and Tributaries Waterbody and Watershed Characteristics;
  - Jamaica Bay and Tributaries Classification and Water Quality Standard;
  - Jamaica Bay and Tributaries Sampling and Monitoring Program;
  - Jamaica Bay and Tributaries Water Quality Sampling Results;
  - Jamaica Bay and Tributaries Water Quality Programs and CSO Mitigation Projects;
  - Jamaica Bay and Tributaries Green Infrastructure Projects & GI Opportunities;
  - LTCP Modeling and the Alternatives Development Process; and
  - Summary of Next Steps, Additional Information and Resources.

  Stakeholder questions and DEP's responses provided during the meeting are posted to DEP's LTCP Program website (http://www.nyc.gov/dep/ltcp) and are included in Appendix B, Public Participation Materials.

- Public Meeting #2: Jamaica Bay and Tributaries LTCP Public Status Update Meeting (October 19, 2017)

  Objectives: Present information regarding one-year extension for Jamaica Bay and Tributaries LTCP.

  DEP hosted a Public Status Update Meeting to present information regarding the one-year extension to the schedule for submittal of the Jamaica Bay and Tributaries LTCP. Approximately 15 stakeholders from different non-profit, community, planning, environmental, economic development, governmental organizations, and the broader public, attended the event, as did representatives from DEC. The two-hour event, held at the Jamaica Bay Wildlife Refuge Center in

Broad Channel, Queens, provided information regarding the one-year time extension for the Jamaica Bay and Tributaries LTCP, details about planned projects in the Jamaica Bay watershed, an overview of Southeast Queens Green Infrastructure and Bluebelt Projects, and described additional opportunities for public input and outreach. The presentation is available on DEP's LTCP Program website: http://www.nyc.gov/dep/ltcp.

The Jamaica Bay and Tributaries LTCP Public Status Update Meeting provided an opportunity for DEP and the public to discuss the extension and other projects within Jamaica Bay watershed. DEP provided detailed information about each of the following:

- Jamaica Bay and Tributaries Committed CSO Mitigation Projects;
- Jamaica Bay and Tributaries Projected Wet Weather Volumes;
- Jamaica Bay and Tributaries Revised CSO LTCP Submittal Date;
- Jamaica Bay and Tributaries LTCP Status and Schedule Update;
- Jamaica Bay and Tributaries Regional Ongoing and New Projects;
- Southeast Queens Program Overview;
- Jamaica Bay and Tributaries Green Infrastructure and Bluebelt Projects;
- Jamaica Bay and Tributaries Public Outreach and Education;
- Summary of Next Steps, Additional Information and Resources; and
- Discussion and Q&A Session.

Stakeholder questions and DEP's responses provided during the meeting are posted to DEP's LTCP Program website (http://www.nyc.gov/dep/ltcp) and are included in Appendix B, Public Participation Materials.

- Public Meeting #3: Jamaica Bay and Tributaries LTCP Alternatives and Recommended Plan Meeting (April 18, 2018)

  Objectives: Review alternatives and recommended plan.

  DEP hosted a third Public Meeting to continue discussion of the water quality planning process. Approximately 12 stakeholders from the general public attended the event. The purpose of the nearly two-hour event, held at the Jamaica Bay Wildlife Refuge Center in Broad Channel, Queens, was to describe the alternatives identification and selection processes, present the Recommended Plan, and solicit public comment and feedback. The presentation is available on DEP's LTCP Program website: http://www.nyc.gov/dep/ltcp.

  As part of the development of the LTCP, and in response to stakeholder comments, DEP provided detailed information about each of the following:

  - Overview of Consent Order and Recap of LTCP Process;
  - Southeast Queens Proposed Sewer Buildout;
  - Jamaica Bay and Tributaries Watershed Protection Plan;

- Review of Jamaica Bay and Tributaries Public Comments Received;
- Review of Waterbody Classification, Water Quality Standards and LTCP Goals for Jamaica Bay and Tributaries;
- Jamaica Bay and Tributaries CSO Mitigation Projects and GI Commitments;
- Jamaica Bay and Tributaries Annual CSO and Stormwater Volumes;
- Jamaica Bay and Tributaries Fecal, Entero and Dissolved Oxygen Attainment of Existing Water Quality Standards;
- Jamaica Bay and Tributaries Evaluation of Watershed Based Alternatives;
- Jamaica Bay and Tributaries Evaluation of Retained Grey Alternatives;
- Jamaica Bay and Tributaries Watershed Protection Plan;
- Jamaica Bay and Tributaries LTCP Recommended Plan; and
- Summary of Next Steps, Additional Information and Resources.

Stakeholder questions and DEP's responses provided during the meeting are posted on DEP's website (http://www.nyc.gov/dep/ltcp), and are included in Appendix B, Public Participation Materials.

Stakeholder Meetings

In addition to the public meetings listed above, DEP convened additional meetings and phone calls to discuss the Recommended Plan with local elected officials, community stakeholders, and environmental advocates such as the Jamaica Bay Ecowatchers and the SWIM Coalition.

Public Comments Received

DEP received the following comments:

- Email from Ira Gershenhorn. Jamaica Bay LTCP. April 19, 2018.
- Email from Dr. Harold Paez. Jamaica Bay LTCP. May 16, 2018.
- SWIM Coalition. NYC DEP Jamaica Bay LTCP Alternatives and Recommended Plan. June 4, 2018.
- Letter from Marcha Johnson. Jamaica Bay Planning. May 17, 2018.
- Jamaica Bay Ecowatchers. Jamaica Bay Ecowatcher's Comments on the DEP Long Term Control Plan (LTCP) for Jamaica Bay. June 26, 2018.

These comments are posted to DEP's website (http://www.nyc.gov/dep/ltcp) and are included in Appendix B, Public Participation Materials along with responses.

7.3 Coordination with Highest Attainable Use

Jamaica Bay is a Class SB water, with the best usages defined by DEC as: "primary and secondary contact recreation and fishing. These waters shall be suitable for fish, shellfish, and wildlife propagation and survival." Each of the Jamaica Bay tributaries is classified as a Class I water, with the best usage defined by DEC as "secondary contact recreation and fishing. These waters shall be suitable for fish, shellfish, and wildlife propagation and survival. In addition, the water quality shall be suitable for primary contact recreation, although other factors may limit the use for this purpose."

Jamaica Bay can fully support existing uses, including kayaking and wildlife survival, and the waterbody is in full attainment with existing Class SB water quality criteria for fecal coliform bacteria and DO. Among the tributaries to Jamaica Bay, the existing Class I water quality criteria for fecal coliform bacteria are projected to be attained except in the most upstream reaches of Thurston Basin, Bergen Basin and Fresh Creek. The parts of Thurston and Bergen Basins that will not be in attainment are in areas that are not accessible to the public due to physical barriers and/or security restrictions associated with JFK International Airport. Paerdegat Basin, Fresh Creek, and Spring Creek are in full attainment with existing Class I water quality criteria for DO; however, Hendrix Creek, Bergen and Thurston Basins are not in attainment with its current Class I water quality criteria for DO.

This LTCP further investigated the spatial and temporal attainment with the Proposed *Enterococci* WQ Criteria* which, if adopted, would be applicable only to Coastal Waterbodies that would include Jamaica Bay proposer, which is currently classified as a Class SB waterbody. Based on 10-year model simulations with the Recommended Plan conducted as part of this LTCP, Jamaica Bay is currently projected to be in full attainment with the proposed 90-day geometric mean *Enterococci* criterion of 35 cfu/100mL during the recreational season (May 1st through October 31st). Most of Jamaica Bay is also projected to be in full attainment with the 90-day STV of 130 cfu/100mL during the recreational season (May 1st through October 31st), but some excursions from the 90-day STV are projected near the mouth of Bergen Basin.

The Proposed *Enterococci* WQ Criteria* would not apply to any of the Jamaica Bay tributaries that are classified as Class I waterbodies. DEP did conduct an analysis of attainment if these standards were adopted in the future for Class I waterbodies. Based on this analysis, the Class I waterbodies Paerdegat Basin, Fresh Creek, Spring Creek, and Hendrix Creek are projected to be in full attainment with the proposed 90-day geometric mean *Enterococci* criterion of 35 cfu/100mL during the recreational season (May 1st through October 31st), but they are not projected to attain the 90-day STV criterion of 130 cfu/100mL.

The inaccessible portions of Bergen and Thurston Basins, which are also Class I waterbodies, are not projected to be attainment with either the 90-day geometric mean criterion of 35 cfu/100mL or the 90-day STV value of 130 cfu/100mL during the recreational season (May 1st through October 31st). However, the accessible reaches of those basins would be projected to be in attainment of the 90-day geometric mean criterion of 35 cfu/100mL but not the 90-day STV value of 130 cfu/100mL.

DEP is committed to improving water quality in Jamaica Bay and its tributaries, and the Recommended Plan presented herein will significantly reduce the wet-weather pollutant loads. In addition, the wetlands restoration work and ribbed mussel installations will provide a potential benefit during dry weather as well as wet weather. Water quality evaluations conducted as part of the LTCP have demonstrated that short-term impacts to water quality will continue to occur during wet-weather events. As a result, wet-weather advisories based on time to recovery analysis are recommended for consideration for this waterbody.

7.4 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

*Proposed *Enterococci* WQ Criteria, if adopted as proposed, would only apply to coastal Class SB and SA waters.

widely distributed and easily accessible. Table 7-1 presents a summary of Jamaica Bay and Tributaries LTCP public participation activities.

Table 7-1. Summary of Jamaica Bay and Tributaries 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
Waterbody-specific Community Outreach	Public Meetings and Open Houses	• Kickoff Meeting: September 22, 2016 • Meeting #2: October 19, 2017 • Meeting #3: April 18, 2018
	Stakeholder Meetings and Forums	• SWIM Coalition and Jamaica Bay Ecowatchers: May 9, 2018 • Jamaica Bay Ecowatchers: May 15, 2018 • SWIM Coalition and Jamaica Bay Ecowatchers: May 29, 2018
	Elected Officials Briefings	• Brooklyn Borough President and Borough Service Cabinet: November 9, 2016 • Queens Borough President and Borough Service Cabinet: November 15, 2016 • Council Members Ulrich, Constantinides and Richards: May 18, 2018
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 • Newtown Creek LTCP web page launched October 2015
	Social Media	• Facebook and Twitter announcements of meetings
	FAQs	• LTCP FAQs developed and disseminated beginning June 2014 via

Table 7-1. Summary of Jamaica Bay and Tributaries LTCP Public Participation Activities Performed

Category	Mechanisms Utilized	Dates (if applicable) and Comments
		website, meetings, and email
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: November 15, 2017 • Glossary of Modeling Terms: February 28, 2013 • CSO LTCP Fact Sheet (Jamaica Bay Specific) • Recommended Plan Fact Sheet (Jamaica Bay Specific) • Meeting advertisements, agendas, and presentations • PDFs of poster board displays from meetings • Meeting summaries and responses to comments • Quarterly Reports • WWFPs
	Portable Informational Displays	• Poster board displays at meetings
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 Jamaica Bay and Tributaries LTCP webpage was created on October 1, 2015 and includes the following information:

- Jamaica Bay and Tributaries public participation and education materials
  - Jamaica Bay and Tributaries Fact Sheet
  - LTCP Public Participation Plan
- Jamaica Bay and Tributaries LTCP Meeting Announcements
- Jamaica Bay and Tributaries Meeting #1 Meeting Documents – September 22, 2016
  - Meeting Advertisement
  - Meeting Presentation
  - Meeting Summary
  - Video of Public Meeting
- Jamaica Bay and Tributaries Meeting #2 Meeting Documents – October 19, 2017
  - Meeting Advertisement
  - Meeting Presentation
  - Meeting Summary
- Jamaica Bay and Tributaries Meeting #3 Meeting Documents – April 18, 2018
  - Meeting Advertisement
  - Meeting Presentation
  - Meeting 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 Jamaica Bay and its tributaries.

This section contains the following information:

- Process for developing and evaluating CSO control alternatives that reduce CSO discharges and improve water quality (Section 8.1).
- CSO control alternatives and their evaluation (Section 8.2).
- CSO reductions and water quality benefits achieved by the higher-ranked alternatives, as well as their estimated costs (Sections 8.3 and 8.4).
- Cost-performance and water quality attainment assessment for the higher-ranked alternatives for the selection process of the preferred alternative (Section 8.5).

As presented in Section 6.2, Table 6-4, existing and proposed WQ criteria, for fecal coliform and *Enterococci* bacteria WQ criteria and DO WQ criteria, were used to evaluate CSO control alternatives and their corresponding levels of attainment. These evaluations include both Existing WQ Criteria for fecal coliform as currently applicable to the waters considered in this LTCP and Proposed *Enterococci* WQ Criteria* that, if adopted, would only apply to Jamaica Bay (a coastal Class SB waterbody) on a recreation seasonal basis, but not the tributaries (all Class I waterbodies).

8.1 Considerations for LTCP Alternatives under the Federal CSO Policy

This LTCP addresses the water quality objectives of the CWA and the New York State Environmental Conservation Law. This LTCP also builds upon the conclusions presented in DEP's November 2012 Jamaica Bay WWFP.

As required by the 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 discusses the development and evaluation of CSO control measures and watershed-wide alternatives in accordance with the CWA in general, and with the CSO Control Policy in particular. This section describes the evaluation factors considered for each alternative and a description of the process for evaluating the alternatives.

*Proposed *Enterococci* WQ Criteria, if adopted as proposed, would only apply to coastal Class SB and SA waters.

8.1.a Performance

A summary of the IW model output data for volume and frequency of discharge of the CSO outfalls to Jamaica Bay and its tributaries is provided in Table 8-1. The locations of these outfalls are shown in Figure 8-1.

Table 8-1. CSO Discharges Tributary to Jamaica Bay and its Tributaries (2008 Typical Year)

Receiving Waters	Combined Sewer Outfalls	Discharge Volume(1) (MGY)	No. of Discharges(1)	Percentage of Total CSO Discharge to Jamaica Bay
Thurston Basin	**JAM-005/007**	**626 (213)**	**73 (25)**	**27.6%**
Bergen Basin	JAM-003	108	17	4.8%
	JAM-003A	230	33	10.1%
	JAM-006	2	14	0.1%
	Subtotal	**340**	**33**	**15.0 %**
Spring Creek(2)	**26W-005**	**310**	**7**	**13.6%**
Hendrix Creek	**26W-004**	**104**	**30**	**4.6%**
Fresh Creek	**26W-003**	**300**	**15**	**13.2%**
Paerdegat Basin(2)	Tank Overflow	553	12	24.3%
	CI-004/005/006	38	5	1.7%
	Subtotal	**591**	**12**	**26.0%**
Jamaica Bay	**Rockaway Outfalls(3)**	**0**	**0**	**0.0%**
Jamaica Bay and its Tributaries	**Total CSO**	**2,271 (1,858)**	**73 (33) max.**	**100%**

Notes:

(1) CSO volumes and activation frequency are based upon overflow at the respective weirs and do not account for stormwater contributions to the outfall downstream of the regulator with the exception of Thurston Basin, which is based upon the sum of the CSO and stormwater discharges just downstream of Regulators JA-06, JA-07 and JA-08. The values in parentheses are the specific CSO AAOV and frequency of flow that tips over the weirs and diversion structures within the Thurston Basin drainage area.

(2) The Spring Creek AWWTP and the Paerdegat Basin CSO Retention Facility provide floatables control and settling prior to overflow of storms exceeding the tank storage capacity.

(3) The Rockaway CSOs do not activate during the typical 2008 rainfall year.

As indicated in Table 8-1, six CSO discharge points - JAM-005/007, JAM-003, JAM-003A, 26W-003, 26W-005 and tank overflows at Paerdegat Basin - generate approximately 94 percent of the total annual CSO discharge volume. These overflows generally contribute the largest volume of CSO and are located near the head ends of five Jamaica Bay tributaries: Thurston Basin, Bergen Basin, Fresh Creek, Spring Creek, and Paerdegat Basin, respectively.

CSO facilities currently exist at the head ends of Spring Creek and Paerdegat Basin. Under 2008 conditions, the Spring Creek AWWTP discharges approximately 310 MG of CSO, while the Paerdegat CSO Retention Facility discharges 553 MG. While the discharge volumes from these two CSO facilities make up about 38 percent of the total CSO volume, the frequency is 12 events or less per year. Outfalls JAM-005, JAM-007, JAM-003, JAM-003A, and 26W-003 account for 56 percent of the CSO volume and activate 15 to 73 times in response to wet-weather events under 2008 conditions.

DEP's analysis indicates that CSO Outfall 26W-004 discharges an estimated 30 times to Hendrix Creek for a total annual volume of 104 MG under 2008 conditions. CSO discharge from JAM-006 to Bergen

Basin is very small (2 MG), primarily stormwater and relatively infrequent (14 events) under 2008 conditions. Although JAM-006 is identified as a permitted CSO outfall, it predominantly conveys stormwater from the collection system serving Southeast Queens.

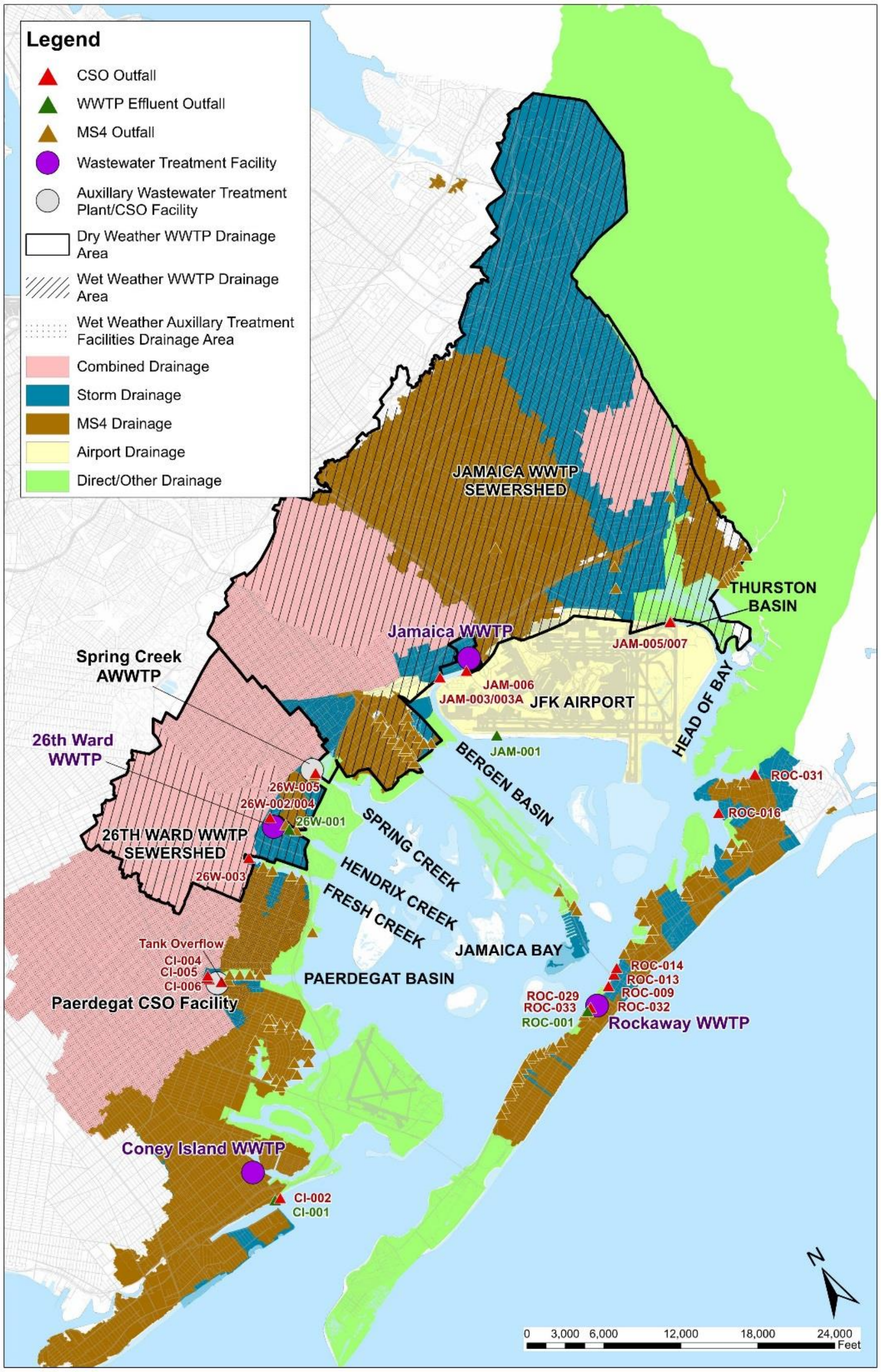

Figure 8-1. CSO Discharges to Jamaica Bay and its Tributaries

Stormwater flows also heavily influence Jamaica Bay and its tributaries. Table 8-2 summarizes and categorizes all wet-weather discharges to Jamaica Bay, its tributaries that receive CSO, as well as Head of Bay and other tributaries which only receive stormwater discharges. The total model predicted volume of stormwater discharged to the Jamaica Bay watershed, under 2008 typical year rainfall conditions, is 19,370 MG, which is approximately 10 times greater than the modeled CSO volume of 1,858 MG. Approximately 6,724 MG of stormwater runoff from Nassau County is discharged to Head of Bay, which can influence the conditions in Jamaica Bay and Thurston Basin. Jamaica Bay receives an additional 6,656 MG of stormwater from DEP MS4 outfalls, other outfalls, or direct runoff from Rockaway, Brooklyn, Queens, and JFK Airport. Of the tributaries that receive CSO, Bergen Basin receives the greatest stormwater discharge of 3,276 MG under 2008 typical year rainfall conditions. Due to the high frequency of activation, stormwater can influence pathogen and dissolved oxygen (DO) attainment in waterbodies despite the lower concentration of pathogens and biochemical oxygen demand (BOD).

Table 8-2. Estimated Stormwater Discharges Tributary to Jamaica Bay and its Tributaries (2008 Typical Year)

Waterbody	Total (MG)	DEP MS4 (MG)	SW[4] (MG)	Airport (MG)	Direct[5] (MG)
Jamaica Bay[1]	6,656	2,489	1,243	957	1,967
Bergen Basin	3,276	2,835	117	302	22
Thurston Basin[3]	813 (1,226)	-	380 (793)	372	61
Fresh Creek	522	216	273	-	33
Hendrix Creek	111	36	41	-	34
Spring Creek	141	26	38	-	77
Paerdegat Basin	352	197	113	-	42
Head of Bay (Nassau Co.)	6,724	291	49	141	6,243
Other Tributaries[2]	362	326	36	-	-
Total	18,957 (19,370)	6,416	2,290 (2,703)	1,772	8,479

Notes:
(1) Grassy Bay, Hassock Creek, Grass Hassock Creek, Shell Bank Creek, Mill Basin, and Rockaway are included with Jamaica Bay.
(2) Other tributaries include Hawtree and Shellbank Basins.
(3) The values shown are the model predicted stormwater volumes based upon the inclusion of stormwater discharges just downstream of Regulators JA-06, JA-07 and JA-08 in the CSO AAOV for Thurston Basin. The values in parenthesis are the estimated stormwater flow coming out of Outfalls JAM 005/007 excluding the 213 MGY of CSO that tips over the weirs and diversion structures in the upstream sewers.
(4) Stormwater (SW) consists of all outfalls except for DEP MS4 and airport stormwater sources.
(5) Direct drainage consists of all remaining drainage areas not tributary to defined CSO, MS4, and SW subcatchments.

To determine the influence of CSO control on the attainment of existing and currently proposed WQ criteria, a Performance Gap Analysis was performed for Jamaica Bay and the tributaries. The results of the analysis are summarized in Section 6.3. The evaluations concluded that a performance gap exists because, under baseline conditions, the Primary Contact WQ Criteria for fecal coliform bacteria will not be attained in Thurston Basin, Bergen Basin, and Fresh Creek, and the Class I DO criterion will not be attained in Thurston Basin, Bergen Basin, and Hendrix Creek. As a result, the evaluation of performance for the LTCP alternatives related to bacteria focused on improving the attainment of Primary Contact

Bacteria WQ Criteria for fecal coliform and the designated Class I DO criterion (>4.0 mg/L) for these tributaries. 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. Additionally, DEP evaluated projected attainment with DEC's Proposed *Enterococci* WQ Criteria* and the Class SB DO criterion that would be realized by the selected CSO mitigation alternatives for Jamaica Bay and its tributaries, although, if adopted as proposed, the Proposed *Enterococci* WQ Criteria* would apply to coastal Class SB waters during the recreation season and not to Class I waters.

The analyses in Section 6 showed that under baseline conditions, annual attainment with Existing WQ Criteria for fecal coliform ranged from 51 to 100 percent, with lower attainment projected towards the head end of the receiving waters. While 100% CSO control would be expected to improve overall annual attainment with the Existing WQ Criteria for fecal coliform, modeling still projects non-attainment in Bergen Basin, Thurston Basin, and Fresh Creek, with an annual attainment of 57 percent, 74 percent and 91 percent, respectively. Under baseline conditions during the recreational season (May 1st through October 31st), attainment with Existing WQ Criteria for fecal coliform ranged from 70 to 100 percent, with lower attainment projected towards the head ends of the waterbodies. While 100% CSO control would improve projected recreational season (May 1st through October 31st) attainment with Existing WQ Criteria for fecal coliform, modeling still projected non-attainment in Bergen and Thurston Basins, with a recreational season attainment of 73 percent and 87 percent for these waterbodies.

Annual attainment is achieved at all stations in Jamaica Bay for Existing Class SB bacteria and DO WQ criteria. Annual attainment in the tributaries for the Existing Class I WQ Criteria for DO is projected to range between 89 and 100 percent under baseline conditions. Based on a modeled100% CSO control, improvements in dissolved oxygen attainment are projected to be in the range of 1 to 3 percent.

The primary goals for the development and evaluation of control alternatives are to achieve bacteria load reduction and to attain applicable WQ criteria. The control of floatables is also an important goal and is a consideration for all alternatives. The evaluation of control alternatives typically follows a two-step process. First, based upon IW watershed model runs for the 2008 typical year rainfall, the level of CSO control of each alternative is established, including the reduction of CSO volume, fecal coliform, and *Enterococci* loading. The second step uses the estimated levels of CSO control to project levels of attainment in the receiving waters. This latter step uses the Jamaica Eutrophication Model (JEM) Water Quality Model. LTCPs are typically developed with alternatives that span a range of CSO volumetric (and loadings) reductions. Accordingly, this LTCP includes alternatives that consider a wide range of reductions in CSO loadings - up to 100% CSO control - including investments in green and grey infrastructure. Intermediate levels of CSO volume control, approximately 25, 50 and 75 percent, are typically also evaluated. Table 8-3 provides a summary of the required storage volume and associated peak flow rates that would have to be diverted from the outfalls for each of these levels of CSO control for the six largest CSO outfalls.

*Proposed *Enterococci* WQ Criteria, if adopted as proposed, would only apply to coastal Class SB and SA waters.

Table 8-3. Summary of Storage and Peak Flow Rates Required for Each Level of CSO Control for the Six Largest Outfalls

Waterbody	Required Capacity(1)	25% CSO Control	50% CSO Control	75% CSO Control	100% CSO Control
Thurston Basin (JAM-005/007)	Storage Capacity (MG)	6	9	29	91
	Peak Flow (MGD)(2)	5	17	54	280
Bergen Basin (JAM-003/003A)	Storage Capacity (MG)	4	8	19	45
	Peak Flow (MGD)(2)	22	55	121	555
Fresh Creek (26W-003)	Storage Capacity (MG)	6	15	28	53
	Peak Flow (MGD)(2)	35	90	175	710
Spring Creek (26W-005)	Storage Capacity (MG)	11	26	37	72
	Peak Flow (MGD)(2)	71	154	256	454

Note:

(1) The storage capacity and peak flow rates are based upon the points along the outfall where CSO would be diverted for a storage or treatment alternative.

(2) Peak flow that would have to be conveyed to storage or treatment to provide the targeted level of CSO control.

Figure 8-2 and Figure 8-3 show plots of the required volumes and flow rates for these six outfalls.

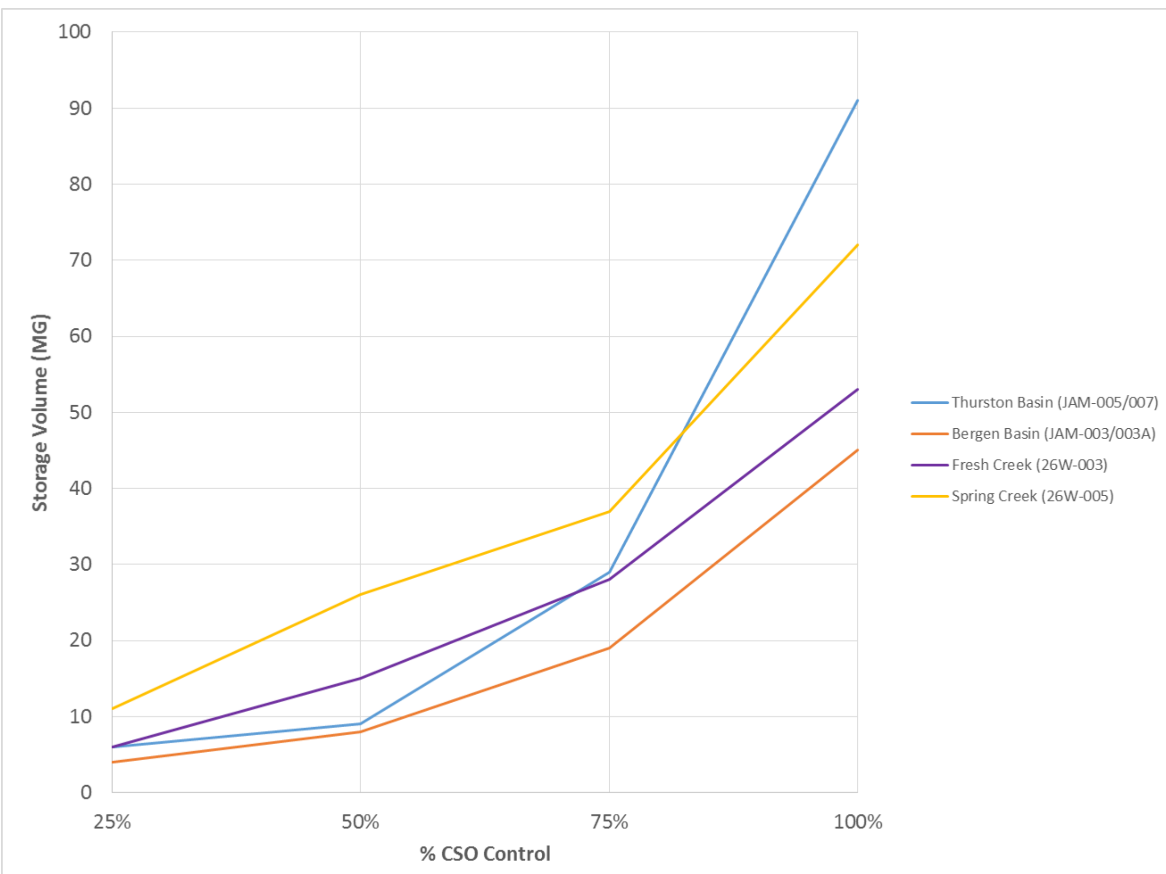

Figure 8-2. Required Storage Volume for Various Levels of CSO Control for Six Largest Outfalls

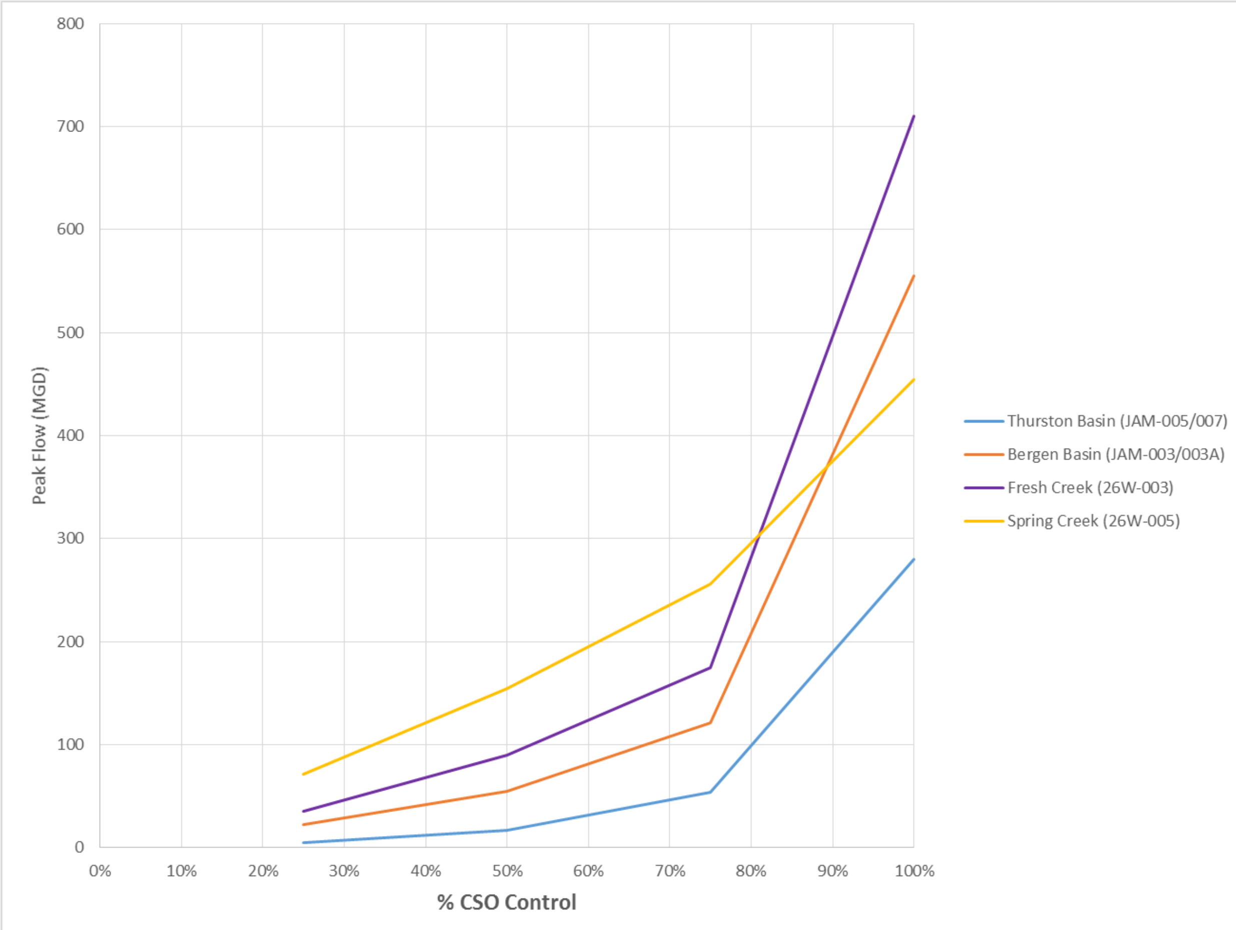

Figure 8-3. Required Flow Rates for Various Levels of Control for Six Largest Outfalls

8.1.b Impact on Sensitive Areas

In developing LTCP alternatives, special effort was made to enhance water quality in sensitive areas and to minimize the impact of construction, to protect existing sensitive areas. As described in Section 2.0, Jamaica Bay and its tributaries were identified as a sensitive area based on the presence of “Threatened or Endangered Species and their Habitat.” Jamaica Bay is also classified as a ‘Best Use – Primary Contact Recreation’ area. Thus, DEP prioritized alternatives based on controlling overflows in the tributaries, while also considering construction impacts, as appropriate. No CSOs currently discharge directly to Jamaica Bay during the typical year.

8.1.c Cost

Cost estimates for the alternatives were computed using a costing tool based on parametric costing data. This approach provides an Association for the Advancement of Cost Engineering (AACE) International 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 cost estimates developed for the evaluation of alternatives are in June 2018 dollars unless specifically noted otherwise.

For the estimate of the construction costs for the LTCP alternatives, DEP used the June 2018 Probable Bid Cost (PBC). 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. A lifecycle of 100 years and an interest rate of 4.0 percent were assumed resulting in a Present Worth Factor of 24.505. A 100-year lifecycle was applied for all alternatives, for consistency with the longer service life of the tunnel alternatives.

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 recommended plan. The recommended plan must be capable of improving water quality in a fiscally responsible and affordable manner to ensure that resources are properly allocated across the overall citywide LTCP program. 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
- Implementability

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 control measure. Therefore, DEP reviewed past reliability and historical operational records when reviewing the technical feasibility of a CSO control measure.

DEP considered several site-specific factors to evaluate an alternative’s implementability, including available space, neighborhood assimilation, impact on parks and green space, and overall practicability of installing - and later 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 and 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 can 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 can be expanded, the LTCP takes 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 identification of the recommended plan 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. 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 ensure proper coordination with other government entities.

8.1.g Other Environmental Considerations

DEP has considered minimizing impacts on the environment and surrounding neighborhood during construction. These impacts could potentially include traffic, site access issues, park and wetland disruption, noise pollution, air quality, and odor emissions. To minimize environmental impacts, they will be identified with the selection of the recommended 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 rerouting of traffic are 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, WQ Criteria and the development and evaluation of alternatives to the public and to solicit its support and feedback. The Jamaica Bay 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 quality of life in communities as well as increasing local property values. As such, the benefits of GI were considered in the formation of the baseline and the final recommended plan. Environmental improvements have been also considered, such as restoration of tidal wetlands and shellfish beds to provide bioextractor elements for improving water quality and to enhance aquatic and wildlife habitat.

8.1.i Methodology for Ranking Alternatives

The multi-step evaluation process DEP used to develop the Jamaica Bay LTCP included meetings with DEP staff, regulators and stakeholders as listed below:

1. Evaluated benchmarking scenarios, including baseline and 100% CSO control, to establish a range of controls within the Jamaica Bay watershed for consideration. The results of this step are described in Section 6.
2. Used baseline conditions to prioritize the CSO outfalls for possible controls.
3. Developed a list of promising 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% CSO control for the receiving water quality simulations that were conducted.
5. Held a technical workshop with DEC staff on March 30, 2017, to present water quality sampling results, baseline modeling, WQ Criteria attainment, preliminary gap analysis, and to review the progress to-date on the alternatives development.
6. Evaluated impacts of DEP's Sewer Build-out Program, Downtown Jamaica Rezoning and GI on the LTCP IW Modeling.
7. Toured the Monroe County (Rochester, NY) CSO tunnel on May 10, 2017, to solicit feedback and lessons learned.
8. Conducted a workshop with DEP operations staff on May 24, 2017, to review the progress to-date on the alternatives development and to solicit input on operability.
9. Conducted a technical workshop with DEC staff on October 18, 2017, to discuss model updates to account for up-zoning in Downtown Jamaica, present water quality modeling results, modeled WQ Criteria attainment projections, and the updated gap analyses.
10. Conducted a workshop with DEP operations staff on November 16, 2017, to review the progress to-date on the alternatives development and to solicit input on operability, and to select a shortlist of retained alternatives.
11. Conducted a DEP Inter-Bureau Workshop on January 26, 2017, to review the progress to-date on the alternatives development and to solicit input on operability.
12. Held an Inter-Bureau Workshop on March 22, 2018 to present the Recommended Plan and solicit comments from DEP operations staff.
13. Conducted a technical workshop with DEC staff on April 4, 2018 to present updated IW and water quality modeling, evaluation of retained alternatives, and present the Recommended Plan.
14. Held a supplemental technical workshop with DEC staff on April 13, 2018 to address comments received at the prior meeting.
15. Conducted a public meeting on April 18th to discuss the Jamaica Bay LTCP Alternatives.
16. Met with various public interest groups and other stakeholders throughout the month of May 2018 to present the Recommended Plan and solicit comments.

17. Conducted an additional technical workshop with DEC staff on May 31, 2018 to present further details on the evaluation of retained alternatives, discuss public comments, and provide additional support for the Recommended Plan.
18. See Section 7 for additional stakeholder meetings.

The focal points of this process were the meetings and workshops listed above. Prior to the first meeting, the control measures evaluated in the Jamaica Bay WWFP were revisited from the perspective of the LTCP goal statement and in light of the implemented WWFP controls. Additional control measures were also identified and assessed. The resultant control measures were introduced at the first meeting. Based on discussions at that meeting, further additional control measures were identified. A preliminary evaluation of these control measures was then conducted including an initial estimation of costs and water quality CWA impacts. During the subsequent meetings, promising alternatives were reviewed in more detail. The LTCP workshops, attended by a broader array of DEP operational and engineering staff, included updated alternative assessments. Meetings with DEC and public interest groups and other stakeholders were held to communicate the status of the LTCP development and solicit feedback on retained alternatives and the Recommended Plan.

Categories of control measures considered include: Source Control, System Optimization, CSO Relocation, Water Quality/Ecological Enhancement, and Treatment and Storage. Specific control measures considered under each category were as follows:

Source Control

- Additional and Existing Green Infrastructure
- High Level Storm Sewers

System Optimization

- Fixed Weir Modifications
- Bending Weirs or Control Gates
- Pumping Station Modifications
- Parallel Interceptor/Sewer

CSO Relocation

- Gravity Flow Tipping to Other Watersheds
- Flow Tipping with Conduit/Tunnel and pumping

Water Quality/Ecological Enhancement

- Floatables Control
- Environmental Dredging
- Mechanical Aeration
- Tidal Wetlands
- Bioextractors (ribbed mussels)

Treatment

- Outfall Disinfection
- Retention Treatment Basin
- High Rate Clarification
- WWTP Upgrades

Storage

- In-System
- Shaft
- Tank
- Tunnel

Figure 8-4 presents these control measures by category.

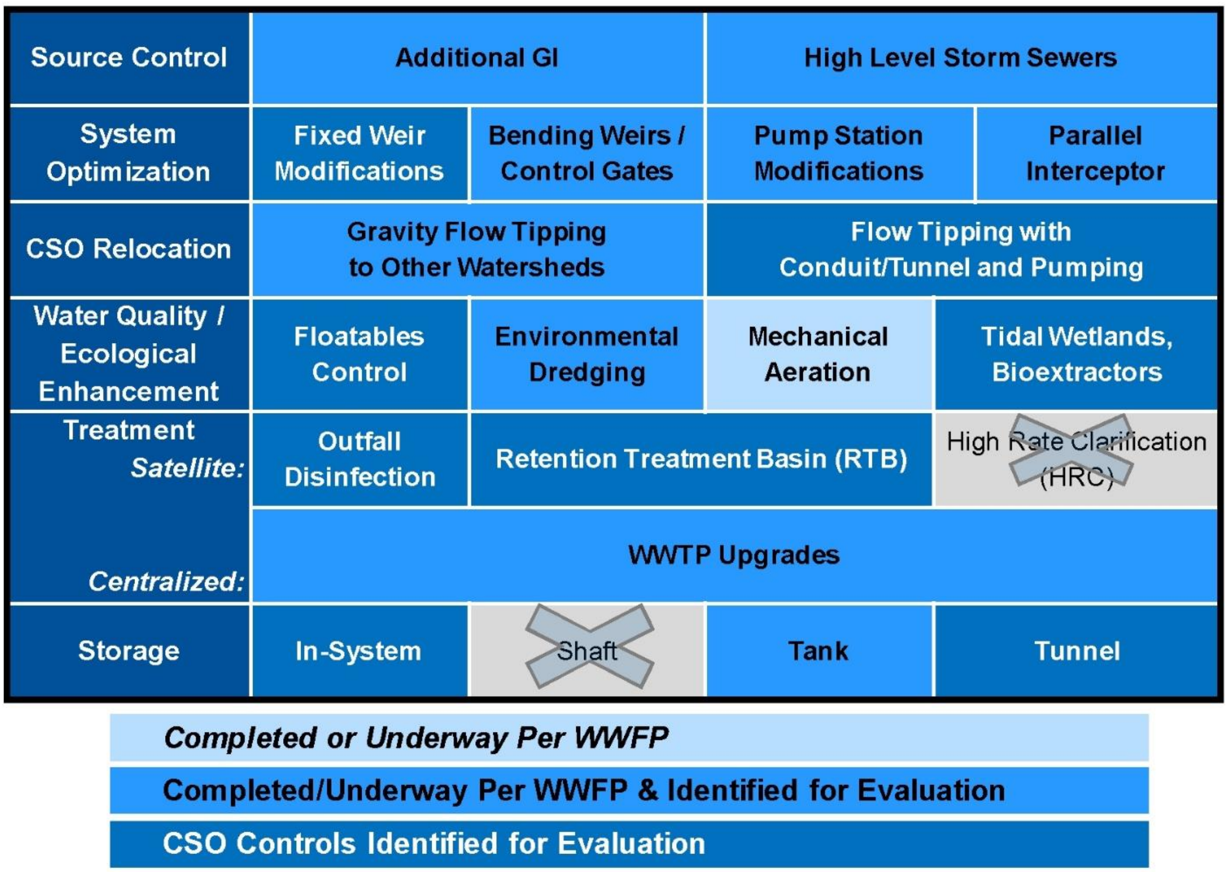

Figure 8-4. Matrix of CSO Control Measures for Jamaica Bay

Following the initial screening meeting, control measures were advanced to a second level of evaluation with the exception of the following (either marked with an "X" or highlighted as an ongoing project in Figure 8-4):

- *Mechanical Aeration*: Based on the Water Quality Analysis presented in Section 6, impacts to DO levels in the Jamaica Bay tributaries were not found to be significantly influenced by the CSO discharges in these waterbodies. Modeling a 100% CSO capture had negligible improvements to DO contents. As a result, this alternative was eliminated from further consideration.
- *High Rate Clarification*: High rate clarification is typically employed for CSO discharges when high levels of suspended solids and BOD reductions are targeted for control in addition to bacteria and floatables. Due to space constraints for remote application and at existing WWTPs, this technology was eliminated form further consideration.

- *Storage Shafts*: Shaft storage involves constructing a deep circular shaft to provide storage, with pump-out facilities to dewater the shaft after the storm event. Shaft storage construction techniques would be similar to those used to construct deep tunnel drop or access shafts. The benefit of shaft storage is that it allows for relatively large storage volumes with relatively small facility footprints. Disadvantages of shaft storage include limits to the depth of shafts, complex dewtering pumping operations, and difficult maintenance. Another disadvantage is that very few operating shaft storage systems exist from which to gain insight on operational issues and experience. Finally, the largest shaft currently in operation is 7.5 MG. Using that size as a maximum, multiple units would be required at the largest Jamaica Bay outfalls. Because the range of levels of CSO control could be provided by more conventional tunnels, storage shafts do not offer advantages sufficient to outweigh their disadvantages. For these reasons, shaft storage was eliminated from further evaluation.

The evaluation of the retained control measures is described in Section 8.2.

8.2 Matrix of Potential CSO Reduction Alternatives to Close Performance Gap from Baseline

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 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.

Following the LTCP outline, these control measures are described under the following categories: Other Future Grey Infrastructure, Other Future Green Infrastructure and subsets thereof.

8.2.a Other Future Grey Infrastructure

For the purpose of this LTCP, “Other Future Grey Infrastructure” refers to potential grey infrastructure beyond existing control measures implemented based on previous planning documents. “Grey infrastructure” refers to systems used to control, reduce, or eliminate discharges from CSOs. These are the technologies that DEP and other wastewater utilities typically have used in their CSO planning and implementation programs. They include retention tanks, tunnels and treatment facilities, including satellite facilities, and other similar capital-intensive facilities.

Grey infrastructure projects implemented under previous CSO control programs and facility plans, such as the Jamaica Bay WWFP, are described in Section 4. To summarize, those projects include:

1. Spring Creek AWWTP Upgrades – provides 20 MG of storage capacity and was completed in April 2007;

2. Meadowmere and Warnerville DWO Abatement – addressed dry and wet-weather overflows to Jamaica Bay by separating sewers and redirecting flows to the WWTP. The project was completed in 2009;

3. Automation of Regulator JA-02 – installed an electro-hydraulic actuator for automation and was completed in June 2010;

4. Paerdegat Basin CSO Facility – provides 50 MG of storage capacity and was completed in 2011;

5. Paerdegat Basin Dredging – removed approximately 20,000 cubic yards of accumulated sediment mounds at the mouth and head end of the basin. The project was completed in 2014;

6. Hendrix Creek Dredging – removed accumulated sediment mounds exposed at low tide in the area of CSO outfalls. The project was completed in 2012;

7. New 48" Parallel Sewer to Jamaica WWTP – installed to provide supplementary capacity to the existing West Interceptor and improve conveyance of wet-weather combined flow to the WWTP. The 3,500 linear feet (LF) parallel dry-weather sewer was substantially complete in 2016; Full functionality of the new parallel sewer is contingent on completion of a new sanitary sewer currently in design, with construction completion scheduled for October 2021.

8. Regulator Improvements at JA-03, JA-06, and JA-14 –installed bending weirs to improve conveyance of wet-weather flow to Jamaica WWTP. The project was completed in 2017;

9. 26th Ward WWTP Wet-Weather Stabilization – will improve flow distribution and increase reliability of preliminary treatment. Construction is ongoing and expected to continue through 2020;

10. 26th Ward High Level Storm Sewers – will divert stormwater from the combined sewer system to reduce CSO discharges and alleviate street flooding. The project is scheduled to be completed in 2022;

11. Laurelton and Springfield Boulevard Storm Sewer Build-out - will reduce volume of CSO discharges and alleviate flooding. The project is ongoing and is expected to take several decades to complete. Given the schedule for this project, it has not been included in the LTCP Baseline Conditions or the LTCP Recommendation Plan.

The technologies identified in the Matrix of CSO Control Measures for Jamaica Bay (Figure 8-4) fall into six broad categories:

Source Controls capture or manage pollutants at their source. GI and high level storm sewers manage stormwater runoff and may be implemented to reduce both CSO and stormwater discharges.

CSO Relocation, involves the transfer of flow between drainage areas to optimize collection system performance and flow to the WWTP or to divert CSO to other waterbodies that are less sensitive or provide greater dilution/assimilation than the one from which the CSO is being diverted.

Water Quality/Ecological Enhancement alternatives improve water quality through mechanical operations such as floatables control baffles, nets or booms, dredging and aeration. These alternatives also include natural methods such as restoration of tidal wetlands and bioextractors (*Guekensis demissa* a.k.a ribbed mussels). While these alternatives do not reduce CSO volumes to the waterbodies, they provide water quality improvements through extraction and uptake, restore or improve existing habitat, and/or address man-made or naturally occurring conditions that impact the attainment of WQ criteria.

Treatment includes satellite facilities, centralized facilities at the treatment plant, as well as disinfection of CSO. These technologies may not necessarily reduce CSO volumes to the waterbodies, but provide various levels of treatment to reduce pollutant loads and water quality impacts.

Storage may include the modification of existing infrastructure to create in-system storage or off-line shafts, tanks or tunnels. Storage facilities capture CSO during peak flow conditions where the collection system or WWTP treatment capacity is exceeded. Captured CSO is pumped back to the collections system or directly to the WWTP after wet-weather flows subside and capacity becomes available for conveyance and treatment.

Additional grey infrastructure alternatives were evaluated in the development of this LTCP. Considering the varying levels of water quality attainment for each of the Jamaica Bay tributaries and the waterbody and collections system-specific CSO control measures recommended in the Jamaica Bay WWFP, the evaluation of CSO control alternatives were prioritized to focus on Thurston and Bergen Basins, which were found in Section 6 to fall short of the 95 percent attainment goal for Existing WQ Criteria. As a result, alternatives evaluations were performed using the following hierarchy:

1. Optimization of existing collection systems tributary to the Jamaica and 26th Ward WWTPs;

2. Collections system and Jamaica WWTP specific alternatives for control of CSO discharges to Thurston Basin and Bergen Basin; and

3. Regional control measures spanning the collection system and treatment facilities serving Jamaica Bay and each of the tributaries.

8.2.a.1 Source Control

Source control includes technologies that capture sources of pollution before they enter the sewer system. These technologies include green infrastructure and high level storm sewers, which focus on keeping stormwater out of the combined sewer system.

Green Infrastructure: consists of rain gardens, porous pavement, bioinfiltration systems, and other strategies for capturing stormwater runoff and directing it to pervious surfaces for retention and infiltration into the ground. In addition to its primary objective of improving water quality, GI can yield climate change resiliency co-benefits including: improved air quality; urban heat island mitigation; carbon sequestration and biodiversity co-benefits, including increased urban habitat for pollinators and wildlife. EPA’s Green Infrastructure for Climate Resiliency handbook also includes managing flooding with infiltration-based practices and spending less energy through managing water by reducing rainwater flows into sewer systems where Green infrastructure can reduce pumping and treatment demands for municipalities. Opportunities for application of additional GI will be addressed for each waterbody under the heading “Other Future Green Infrastructure.”

High Level Storm Sewers: remove stormwater from the combined sewer system by diverting catch basins, and other sources of stormwater to new storm sewers. As part of the Jamaica Bay WWFP, high level storm sewers (HLSS) were recommended within the Fresh Creek and Thurston Basin sewersheds. HLSS is currently being implemented in portions of the Fresh Creek sewershed tributary to CSO 26W-003 with an anticipated construction completion date of December 2022. However, HLSS within the Springfield/Laurelton area of the Thurston Basin sewershed cannot be advanced until storm trunk sewers, proposed under the Southeast Queens (SEQ) Storm Sewer Build-out Program, are extended to this area. The program includes the construction of sanitary and storm sewers for the purposes of improving drainage and reducing flooding throughout SEQ. A portion of this program is currently funded in the 10 year capital budget for $1.9B but the implementation schedule for the entire build-out is not known. However, the sewer build-out is projected to require several decades to complete and when completed will further reduce CSO discharges into Thurston Basin. As the HLSS planned within the Springfield/Laurelton Area will address the remaining combined sewer area within the Thurston Basin and the timing for construction of major storm trunk sewers through the Bergen Basin sewershed are not known at this time, HLSS was eliminated from further consideration for the Recommended Plan under the LTCP.

8.2.a.2 Collection System Optimization

System optimization typically includes measures to enhance the sewer system performance by taking advantage of in-system storage capacity to reduce CSO through automated controls or modifications to the existing collection system infrastructure. Examples include: regulator or weir modifications including fixed and bending weirs; control gate modifications; real time control; and increasing the capacity of select conveyance system components, such as gravity lines, pumping stations, and/or force mains. Force main relocation or interceptor flow regulation would also fall under this category. These control measures generally retain more of the combined sewage within the collection system during storm events. The benefits of retaining this additional volume must be balanced against the potential for sewer backups and flooding, or the relocation of the CSO discharge elsewhere in the watershed or to an adjacent watershed. Viability of these control measures is system-specific, depending on existing physical parameters such as pipeline diameter, length, slope, and elevation.

<u>Jamaica WWTP Collection System Optimization</u>

Regulator Improvements: In accordance with the recommendations of the Jamaica Bay WWFP, Regulators JA-02, JA-03, JA-06, JA-07 and JA-14 were modified for the purposes of diverting more wet-weather flow to the Jamaica WWTP and reducing the frequency and volume of CSOs to Thurston and Bergen Basins. Considering the improvements in collection system performance and CSO capture related to these projects, additional opportunities for optimization of the collection system tributary to the Jamaica WWTP were evaluated. Model simulations were performed to assess the performance of system optimization controls in the Matrix of CSO Control Measures for Jamaica Bay (Figure 8-4), such as, fixed weir modifications, bending weirs, control gates, pumping station modifications, floatables control and parallel interceptors as identified to divert additional flow from the CSO outfalls to the interceptor sewer system.

The results for each alternative evaluated and recommendations are summarized in Table 8-4. Many of the alternatives create increases in the hydraulic grade line (HGL) of the East and/or West Interceptor potentially increasing the risk of flooding along upstream contributing sewers. The HGL of the East and West Interceptors is particularly sensitive because no regulator or WWTP bypass is located in close proximity to the Jamaica WWTP. While Regulator JA-01 is the closest overflow point, the weir crest is set at an elevation such that no overflows occur during the 2008 typical year rainfall. During periods of peak wet-weather flow in excess of 2xDDWF at the Jamaica WWTP, the East and West Interceptors surcharge until the wet-weather event subsides. As the peak wet-weather flows tend to range in duration of 1-3 hours, the collection system experiences relatively short duration peaks that result in a backup of the interceptor until the storm event and flow subsides. The optimization alternatives tend to increase the peak flows and create a rise in the HGL, with the exception of Alternative B-2d1. This alternative is discussed in more detail later in this section.

Pumping Station Modifications: During wet-weather events, the convergence of the Howard Beach Pumping Station (HBPS) force main with the West Interceptor is capacity limited, resulting in backups at Regulators JA-03 and JA-14 and overflows to Bergen Basin. As identified in Table 8-4, Alternative B-2c evaluated the benefits of extending this force main directly to the Jamaica WWTP, bypassing the West Interceptor completely. Modeling indicated that during wet-weather events the timing of the peak from the

HBPS coincides with the peak from the East Interceptor resulting in surcharging and an increase in the HGL of the East Interceptor. As a result, this alternative was eliminated from further consideration. Other alternatives for modifications to the HBPS involve transferring flows between sewersheds and are discussed further in the "CSO Relocation" section.

Parallel Interceptor/Sewer: Construction of major relief sewers parallel to the existing interceptors was evaluated for Thurston and Bergen Basins. Alternatives T-2a through T-2c evaluated the construction of a sewer parallel to the East Interceptor to allow for additional wet-weather flow to be conveyed to the Jamaica WWTP. Three variations of this alternative were developed to divert existing trunk sewers from the East Interceptor to increase wet-weather capacity to accommodate a new regulator to be installed along Outfall JAM-005/007. Alternatives T-2d through T-2f, evaluated replacing portions of the East Interceptor with larger sewers to improve wet-weather conveyance to the WWTP. Each of these alternatives was modeled as a gravity conveyance that would reconnect to the collection system at the Jamaica WWTP. Model runs indicated that increasing the sewer conveyance capacity of the East Interceptor would result in HGL increases during periods of peak wet-weather flow. In addition, there are concerns with constructability due to the potential for conflicts with existing utilities that cross the proposed sewer alignment, as well as sewers proposed under the Southeast Queens Sewer Build-out Program. As a result, gravity driven parallel interceptor and replacement interceptor options were eliminated from further consideration. However, the sewer alignments will be considered in the evaluation of CSO tunnel options. The deeper tunnel construction avoids conflicts with existing utilities, while the storage within the tunnel equalizes peak flows to the WWTP. In addition, the dewatering pumping station activation can be timed to manage peak flows to the WWTP.

Table 8-4. Jamaica WWTP Collection System Optimization Alternatives

Alternative ID	Description	Impacted Outfalls	Observations	Status
Thurston Basin				
T-1a	Install a new regulator with fixed weir and underflow baffle for floatables along the outfall with an underflow sewer to the existing branch interceptor	JAM-005/007	Reduction in CSOs, but an increase in hydraulic grade line (HGL)	Abandoned due to HGL impacts
T-1b	Installation of a bending weir at the new regulator under Alt T-1a	JAM-005/007	Reduction in CSOs, but an increase in HGL	Abandoned due to HGL impacts
T-1c	Installation of underflow baffles for floatables control at Regulators JA-06, JA-07, JA-08 and JA-09	JAM-005/007	No reduction in CSOs and an increase in HGL	Abandoned due to HGL impacts
T-2a, 2b, 2c	Construction of a new interceptor parallel to the East Interceptor with a new dedicated pumping station at the Jamaica WWTP	JAM-005/007	Reduction in CSOs, but an increase in HGL	Abandoned due to HGL impacts

Table 8-4. Jamaica WWTP Collection System Optimization Alternatives

Alternative ID	Description	Impacted Outfalls	Observations	Status
T-2d, 2e, 2f	Replacement of the East Interceptor along Rockaway Boulevard and Nassau Expressway with a dedicated pumping station at the Jamaica WWTP. Includes diversion of all connections from the existing interceptor, which is then abandoned.	JAM-005/007	Reduction in CSOs, but an increase in HGL	Abandoned due to HGL impacts
Bergen Basin				
B-1a	Plugging of CSO discharges at Regulator JA-10 to direct all flow to the Merrick Baisley branch interceptor	JAM-006 & JAM-005/007	Minimal reduction in CSOs and an increase in HGL	Abandoned due to HGL impacts
B-1b	Installation of a bending weir at Regulator JA-10	JAM-006 & JAM-005/007	No reduction in CSOs and an increase in HGL	Abandoned due to HGL impacts
B-1c	Installation of bending weirs at Regulators JA-09 and JA-10	JAM-006 & JAM-005/007	No reduction in CSOs and an increase in HGL	Abandoned due to HGL impacts
B-1d	Plugging of CSO discharges at Regulator JA-04 to direct all flow to the conveyance system tributary to the West Interceptor	JAM-006 & JAM-003/ 003A	No reduction in CSOs and an increase in HGL	Abandoned due to HGL impacts
B-1e	Installation of a bending weir at Regulator JA-04	JAM-006 & JAM-003/003A	No reduction in CSOs	Abandoned due to no CSO benefits
B-1f	Real time control of existing private building retention facilities	JAM-006 & JAM-003/ 003A	Limited reduction in CSOs	Abandoned due to limited CSO benefits
B-1g	Installation of underflow baffles for floatables control at Regulators JA-03 and JA-14	JAM-006 & JAM-003/ 003A	No reduction in CSOs and an increase in HGL	Abandoned due to HGL impacts
B-2a	Modification of upstream sewers to optimize flows between Regulators JA-03 and JA-14	JAM-003/ 003A	No reduction in CSOs and an increase in HGLs	Abandoned due to HGL impacts
B-2c	Redirect HBPS force main from West Interceptor to Jamaica WWTP	JAM-003/ 003A	Reduction in CSO, but an increase in HGL in the East Interceptor	Abandoned due to HGL impacts

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Table 8-4. Jamaica WWTP Collection System Optimization Alternatives

Alternative ID	Description	Impacted Outfalls	Observations	Status
B-2d	Construction of a parallel interceptor from Regulators JA-03 and JA-14, along Nassau Expressway to the Jamaica WWTP	JAM-003/ 003A	Reduction in CSO, but an increase in HGL in both the East and West Interceptors	Not constructible due to conflicts at crossings of other utilities
B-2d1	Construction of a parallel interceptor from Regulators JA-03 and JA-14, along Nassau Expressway to the Jamaica WWTP with a 50 MGD pumping station	JAM-003/003A	Reduces CSO with no increase in the HGL of both the East and West Interceptors	Retain for further consideration

Alternative B-2d1: Construct Parallel Sewer from Regulators JA-03 and JA-14 to 50 MGD Pumping Station at Jamaica WWTP

This alternative involves the following elements (Figure 8-5):

- Two new diversion chambers with tide gates constructed on the existing JAM-003 and JAM-003A outfalls downstream of the existing regulators.
- Approximately 150 LF of gravity conveyance piping from the new diversion structure to a launch shaft for the microtunnel.
- Approximately 3,200 LF of 96” gravity sewer to convey flow along Nassau Expressway to the head end of the Jamaica WWTP.
- Manholes at regular intervals along the sewer route based on drive lengths, curvature of the sewer required and crossing of the Nassau Expressway.
- Construction of a new screening and grit chamber and 50 MGD dewatering pumping station and associated force main to convey flows from the microtunnel to the influent distribution box of the primary settling tanks at the Jamaica WWTP.

The diversion chambers, diversion sewers, and the launch shaft would be sited on a city-owned lot subject to a long term lease with the Port Authority of NY and NJ (PANYNJ). The PANYNJ currently uses this property as a parking lot for JFK Airport. Negotiations to revise the long-term lease of this property, even for the period of construction, would likely be difficult and may not be achievable. The 50 MGD pumping station would be sited on vacant land, which is under DEP jurisdiction and part of the Jamaica WWTP.

Under this alternative, dry-weather flow would continue to the Jamaica WWTP via Regulators JA-03 and JA-14 to the West Interceptor. Under wet-weather conditions, overflow at Outfalls JAM-003 and JAM-003A would be diverted to the new parallel sewer and to the pumping station. Modeling results project a 32 percent reduction in CSO overflow volume to Bergen Basin. As a result, this alternative will be carried forward as a retained alternative for further evaluation.

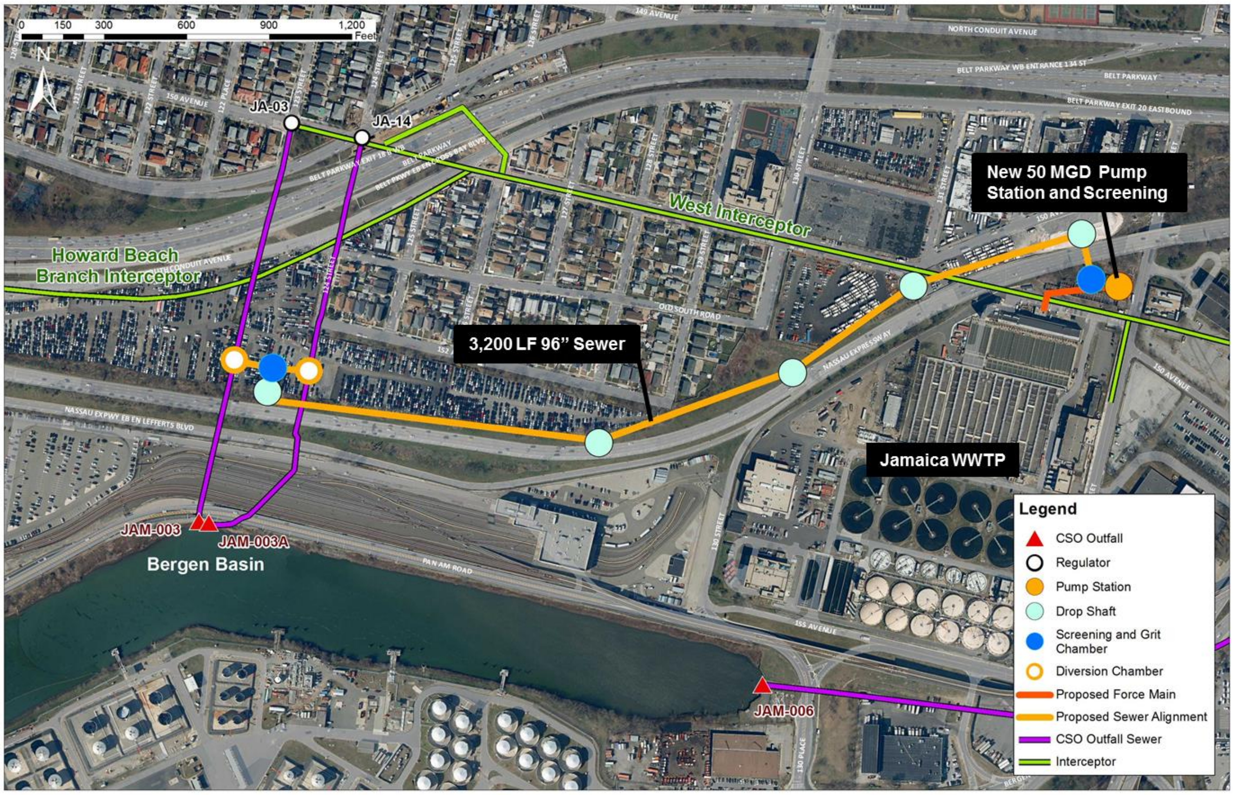

Figure 8-5. Layout of Proposed Parallel Sewer to West Interceptor and Dewatering Pumping Station

The benefits, cost, and challenges associated with this alternative are as follows:

Benefits

- Captures and conveys CSO from JAM-003/003A to the Jamaica WWTP for treatment
- Isolates CSO (by use of a pumping station) to reduce impacts to the West Interceptor

Cost

- The estimated NPW Cost for this control measure is $690M.
- Details of the estimate are presented in Section 8.4.

Challenges

- Limited improvement in Bergen Basin WQ attainment
- Property acquisition and permitting

Other system optimization alternatives evaluated under this LTCP: Implementation of real time control was evaluated for improved management of wet-weather flows from privately owned stormwater retention facilities. Model runs were performed to simulate real time control of privately owned stormwater retention systems to more effectively manage the timing of stormwater runoff to the collection sewer system. While some capture benefits were observed, the practicality of regionally implementing these systems on a large number of privately owned systems is a concern. Property easements or other property rights would need to be developed with private property owners to allow the City to install these systems, as well as outline future responsibilities for operation and maintenance of these systems. “Fail-safe” measures would also need to be incorporated into the designs to eliminate the liability for sewer backups as a result of power outages or system malfunction. Considering the various complexities and risks of operating and maintaining these systems, real time control was not retained for further evaluation for this LTCP.

The benefits and challenges of installing underflow baffles in existing regulator chambers to control floatables were evaluated. As-built plans of the regulators were reviewed to determine the elevations of the weir crests and develop preliminary layouts of the baffles for simulation using the collection system model. Model runs indicated that the baffles would cause increases in the HGL of the sewers upstream of the regulators during higher intensity storm events, thereby increasing the risk of flooding. As a result, floatables baffles were not retained for further evaluation.

26th Ward Wastewater Treatment Plant Collection System

Alternatives for system optimization within the 26th Ward WWTP sewershed are described below and summarized in Table 8-5. As indicated in Table 8-5, none of the optimization alternatives were carried forward for further evaluation due to either adverse HGL impacts, limited or no CSO reduction benefits, and/or high cost-to-benefit ratio.

Regulator Improvements to the collection system within the 26th Ward WWTP sewershed were not recommended in the Jamaica Bay WWFP, and as a result, they have been revisited under this LTCP to determine whether additional wet-weather flow can be diverted to the WWTP. The results for each alternative evaluated and recommendations are summarized in Table 8-5. Fixed weir modifications were analyzed to reduce overflows to Spring Creek, Hendrix Creek, and Fresh Creek, but preliminary modeling results indicated an elevated hydraulic grade and risk of flooding, resulting in rejection of this alternative. Bending weir alternatives were also evaluated and abandoned for the same reasons.

Pumping Station Modifications recommended in the Jamaica Bay WWFP were limited to replacement of existing emergency pumps at the 26th Ward WWTP to facilitate improved flow distribution to the primary settling tanks. While there are several pumping stations and ejectors throughout the 26th Ward WWTP combined sewer area, flow is regulated downstream of the pumping station force main connections at the trunk sewer connection to the interceptor sewer. Any CSO captured as a result of upgrading the capacity of these pumping stations could overflow at the downstream regulators. To effectively capture the additional wet-weather flow from these pumping stations, capacity improvements would need to be made to the trunk sewers, regulators, and interceptor sewers. As a result, this alternative was not further considered.

Parallel Interceptors/Sewers: Construction of major near-surface sewers would have significant constructability and construction impacts due to the size of the streets, level of traffic and density of existing utilities. As a result, the sewer would need to be constructed using trenchless technologies at sufficient depth to clear the obstructions along the route of the tunnel. A pumping station would also be needed at the downstream end of the sewer to convey the flow to the 26th Ward WWTP. CSO tunnels will be considered in lieu of parallel sewers.

Other system optimization alternatives that were evaluated in this LTCP included implementing real time control to manage discharges from private stormwater retention facilities and installation of underflow baffles within existing regulators for floatables control. Model runs produced similar responses to those observed in the Jamaica WWTP collection system. As a result, these alternatives were eliminated from further consideration.

Table 8-5. 26th Ward Collection System Optimization Alternatives

Waterbody	Alternative ID	Description	Impacted Outfalls	Observations	Status
Hendrix Creek	HC-1	Modification of fixed weir at Regulator 26W-01	26W-003 & 26W-004	Slight reduction in CSOs but an increase in HGL	Abandoned due to HGL impacts
Hendrix Creek	HC-2	Construction of parallel interceptor/sewer along either Flatlands Avenue or Vandalia Avenue to divert CSO from Regulator 26W-01 to Spring Creek AWWTP	26W-003 & 26W-004	Limited reduction in CSO with an increase in HGL in the East Interceptor	Abandoned due to high cost-to-benefit ratio
Fresh Creek	FC-1a	Modification of fixed weir at Regulator 26W-02 and 26W-02A	26W-003 & 26W-004	Reduction of CSOs at 26W-003 but increased CSOs at 26W-004, resulting in a net increase in CSOs	Abandoned due to increase in CSO
Fresh Creek	FC-1b	Modification of fixed weir at Regulator 26W-02	26W-003 & 26W-004	Reduction of CSOs at 26W-003 but increased CSOs at 26W-004, resulting in a net increase in CSOs	Abandoned due to increase in CSO
Spring Creek, Hendrix Creek & Fresh Creek	26W-1	Real time control of existing private building retention facilities	26W-002, 26W-003, 26W-004 & 26W-005	Limited reduction in CSOs	Abandoned due to limited CSO benefits
Hendrix Creek & Fresh Creek	26W-2	Installation of underflow baffles for floatables control at Regulators 26W-01 & 26W-02	26W-002, 26W-003 & 26W-004	No reduction in CSOs and an increase in HGL	Abandoned due to HGL impacts and no CSO benefits

8.2.a.3 Waterbody Specific Alternatives

The Jamaica Bay and Tributaries LTCP addresses CSO impacts to six tributaries, in addition to Jamaica Bay. As presented in Section 6, annual and recreational season (May 1st through October 31st) attainment of the Existing WQ Criteria for fecal coliform was less than 95 percent at the head ends of Thurston Basin, Bergen Basin, and Fresh Creek under baseline conditions. In contrast, 100 percent attainment is achieved at all of the stations within Spring Creek, Hendrix Creek, Paerdegat Basin and Jamaica Bay (during the recreational season and on an annual basis). Attainment levels of greater than 95 percent were also projected at the confluence of each waterbody with Jamaica Bay. In consideration of the wide range of attainment, the level of CSO control and appropriate technologies will be waterbody specific. As a result, the discussion of the evaluation of CSO control alternatives has been organized by the waterbodies they are targeted to improve.

Bergen Basin Alternatives

Bergen Basin is located in Jamaica, Queens, to the immediate west of JFK Airport and south of the Jamaica WWTP. The Bergen Basin watershed is approximately 10,300 acres in area, of which approximately 2,900 acres is combined drainage area, 5,600 acres is MS4 drainage area, 1,200 acres is separated sewershed and 600 acres is airport drainage area. Small quantities of direct drainage also exist along the banks of the basin. CSO and stormwater flow is discharged to this basin by 3 CSOs and 26 storm outfalls. CSO Outfalls JAM-003, JAM-003A and JAM-006 are the three biggest outfalls, measuring 8' x 9', double barrel (DBL) 13' x 9', and triple barrel (TBL) 19' x 9', respectively. Under baseline conditions, the model predicted JAM-003 and 003A to discharge to 230 MGY of CSO to Bergen Basin; while JAM-006 contributes 2 MGY of CSO, 2,837 MGY of stormwater, and 5,470 MGY of WWTP effluent. Preliminary modeling also indicated that the primary driving factor for bacterial loading and, consequently water quality impacts, was the significant volume of storm flows entering the waterbody. However, this project is intended to focus on reducing CSOs to the waterbodies of Jamaica Bay; low cost alternatives which provide limited water quality improvements by reduction of these CSOs may fall on the cost-benefit curve and should be evaluated. Thus, each element of the Alternatives Toolbox has been considered and evaluated.

A review of existing land uses near the discharge of Outfalls JAM-003, JAM-003A and JAM-006 was performed for the purposes of identifying potential sites for new treatment/storage facilities. A 1.5 acre city-owned vacant parcel was identified (see Figure 8-6) near the north end of the Jamaica WWTP, where a building had been demolished. An additional city-owned property was identified along the north edge of the Nassau Expressway which is currently utilized by the New York City Department of Sanitation for parking of fleet vehicles. Other potential parcels for construction include city-owned properties that are leased by the PANYNJ; these properties are subject to a longer team lease and are used for airport long term parking and car rental. Highway medians and right-of-way are also identified.

The city-owned properties, median strips and the right-of-way along the northern side of the Nassau Expressway provide sufficient space for construction of sewers, tunnels or pumping stations for conveyance of CSO to the Jamaica WWTP, but are not of sufficient size to accommodate satellite treatment or off-line storage tanks. While the long term parking lots are of sufficient size to accommodate most technologies, the lease arrangements and current uses supporting airport operations may prevent them from being considered for technologies that would have impacts to these properties during construction and/or operation of the completed facilities. Property requirements will be considered in assessing the viability of each of the technologies evaluated.

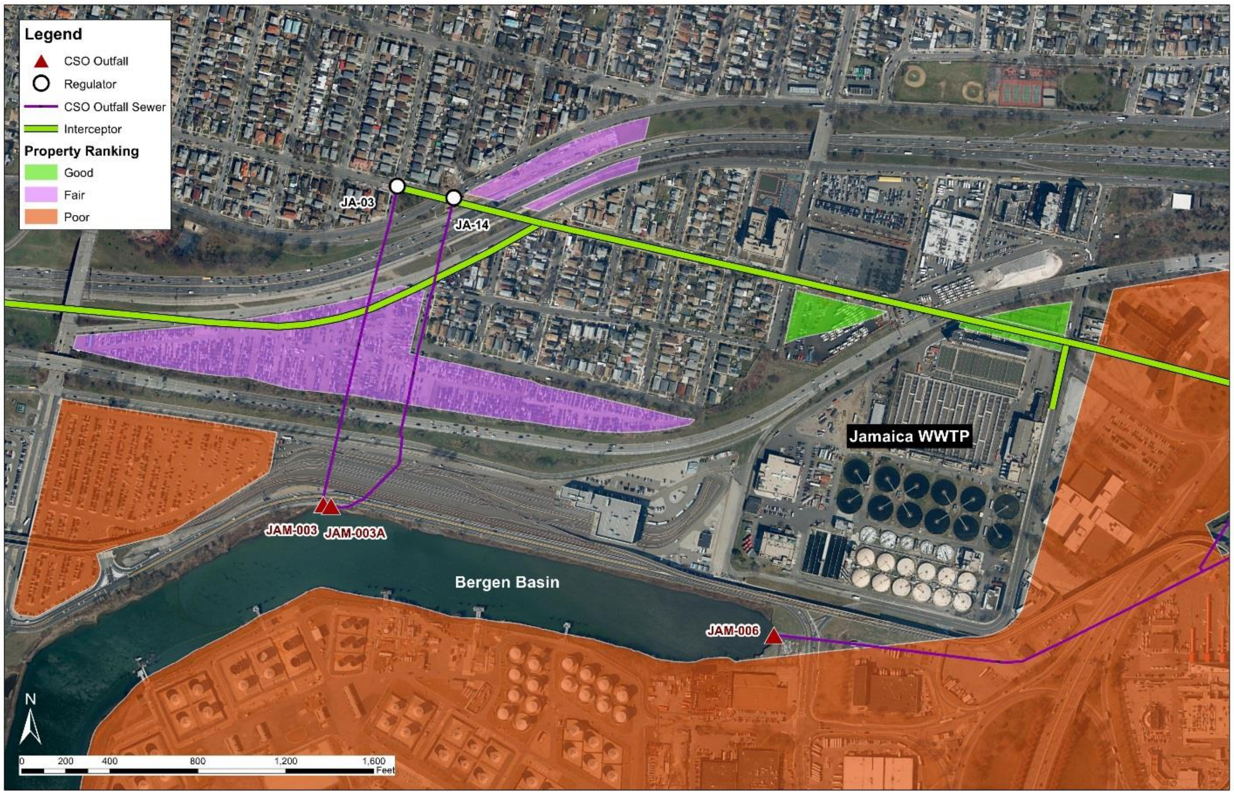

Figure 8-6. Potential Properties near Bergen Basin CSO Outfalls

CSO Relocation: This concept involves conveying overflows by gravity from one receiving water to another receiving water that would either be less sensitive or provide greater dilution/assimilation. Diversion of the outfall to Jamaica Bay, which has more stringent water quality standards for the promotion of primary contact recreation, is contrary to the intended uses of the Bay and is not recommended for further consideration.

A number of potential CSO Relocation alternatives were identified that involved shifting of overflows between tributaries without increasing discharges directly to Jamaica Bay. These alternatives were initially evaluated, but none were determined to provide significant opportunity to warrant pursuing further. Gravity Flow Tipping to Other Watersheds and Flow Tipping with Conduit/Tunnel and Pumping options evaluated include the following:

Gravity Flow Tipping was implemented in the Jamaica Bay WWFP for Bergen Basin at Regulator JA-02. Installation of an electro-hydraulic actuator enabled flow tipping from the Bergen Basin watershed to the Spring Creek watershed during wet-weather events, reducing overflows to Bergen Basin and maximizing capacity utilization of the Spring Creek AWWTP. The connection of the HBPS force main to the East Interceptor was identified as a potential flow constriction. To reduce wet-weather flow to the pumping station, the East Interceptor and overflows to Bergen Basin, Alternative B-2e was proposed to redirect dry-weather flow from Regulator JA-02 to the 26th Ward WWTP via the existing CSO outfall sewer from JA-02. A new regulator would be required to divert flow from this CSO line to the existing Vandalia Avenue Interceptor. However, on further analysis it was determined that the new sewer could not be constructed to match the crown of the Vandalia Avenue Interceptor sewer, resulting in a risk of sewer surcharge and settling of solids in the new sewer during peak flow conditions. As a result, this alternative was eliminated from further evaluation.

Flow Tipping with Conduit/Tunnel and Pumping. This control measure would be similar to gravity flow tipping, but the conveyance of flow to another receiving water would require pumping. Diversion of dry and wet-weather flow was evaluated across the boundary between the subcatchments of Outfalls JAM003/003A and 26W-002/004, which discharge to Bergen Basin and the Hendrix Creek, respectively. Each of the following alternatives evaluated the diversion of flow from the HBPS from the Jamaica WWTP sewer system to the collection system serving the 26th Ward WWTP.

Alternative B-2e: Abandon the HBPS and Construct a Gravity Sewer to the 26th Ward WWTP

InfoWorks CS™ (IW) Modeling indicates that during wet-weather events, flows from the HBPS displace flows from Regulators JA-03 and JA-14 in the West Interceptor, resulting in flooding and increased CSO discharge to Bergen Basin. Alternative B-2e evaluates abandonment of the HBPS and redirection of its flows to the 26th Ward WWTP sewershed via a new gravity sewer (Figure 8-7). The new sewer would convey both dry- and wet-weather flow. A pumping station would be required to continuously convey the diverted flow from the tunneled conveyance to the WWTP. The pumping station would be sited, based on the final alignment, in one of three identified city-owned parcels, The shortest tunnel (Alt. B-2e1) could terminate at the Spring Creek AWWTP and pump to the Vandalia Avenue Interceptor near Regulator 26W-03. A second route alternative (B-2e2) could be terminated at the intersection of Flatlands Avenue and Vandalia Avenue with pumping to the Vandalia Avenue Interceptor or the head of the WWTP. The longest route could terminate at a pumping station to be located at the south end of the WWTP site with a force main constructed to dewater the tunnel to the head of the WWTP. Modeling for Alternative B-2e2, a 14,700 LF, 13 foot diameter tunnel to a pumping station at the intersection of Flatlands and Vandalia Avenues, resulted in a projected 12 percent CSO average annual overflow volume (AAOV) reduction at Bergen Basin.

Construction would largely involve trenchless methods to reduce impacts to sensitive transportation infrastructure and residential housing by utilizing a tunnel boring machine. Each of the three tunnel routes was evaluated to determine the alignment with minimal impacts to existing utilities. All of the proposed routes follow median space along the Shore Parkway from the existing HBPS to the new pumping station sites.

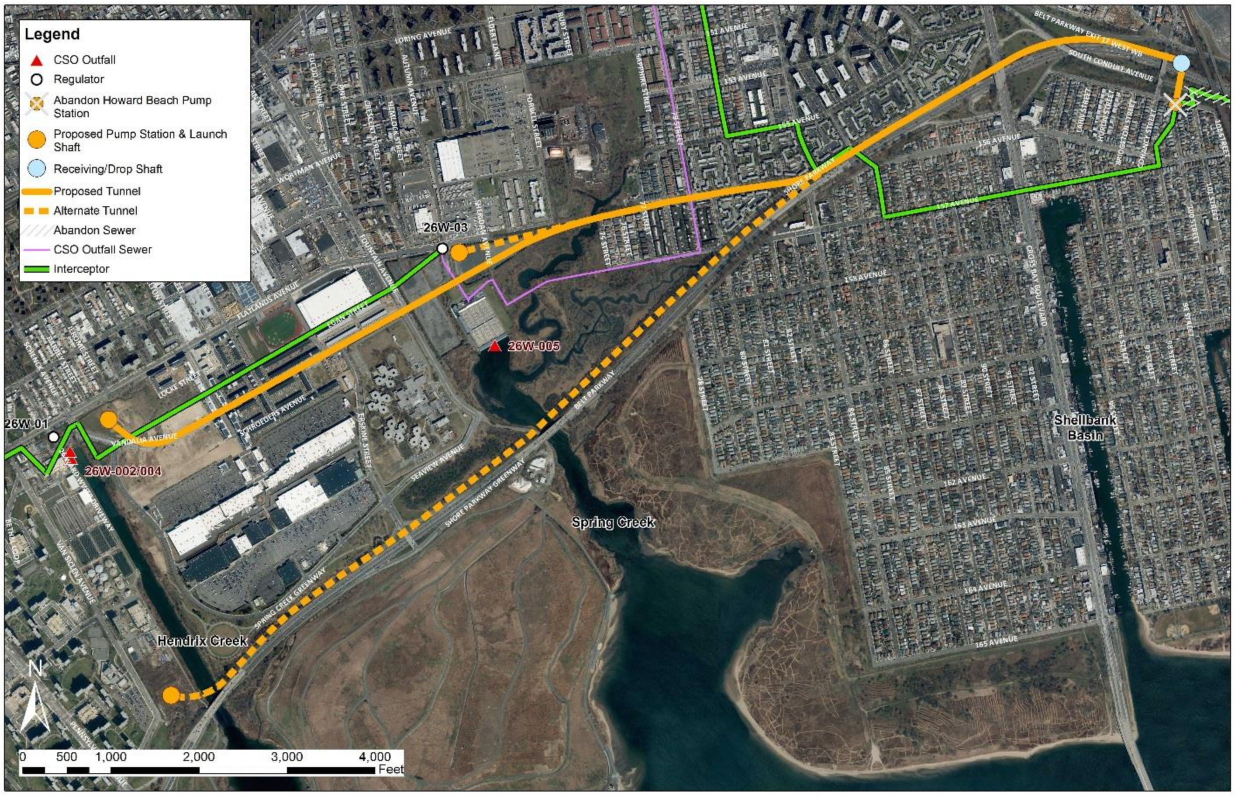

Figure 8-7. Layout of Proposed Gravity Sewer to 26th Ward WWTP

The benefits, cost, and challenges associated with this alternative are as follows:

<u>Benefits</u>

- Utilizes available capacity at the 26th Ward WWTP to provide additional wet-weather capacity at the Jamaica WWTP
- The final tunnel size can be further adjusted during design to help address drainage issues in Howard Beach in addition to controlling CSO discharges

<u>Cost</u>

- The estimated NPW for this control measure is $961M.

<u>Challenges</u>

- High cost to CSO volume capture
- Limited improvement in Bergen Basin water quality attainment
- Property acquisitions and permitting
- Crossing of pile supported drainage culverts and highway infrastructure

In consideration of the high cost to implement this alternative in relation to the relatively small reduction in CSO discharged to Bergen Basin annually, this alternative was eliminated from further consideration.

Alternative B-2f: Combination of Alternatives B-2d and B-2e

Alternative B-2f consists of a combination of Alternatives B-2d Bergen Basin Parallel Interceptor and Alternative B-2e Abandon HBPS and the construction of a gravity sewer to 26th Ward WWTP. This alternative, as illustrated in Figure 8-8, includes a 3,200 LF 13 foot diameter parallel interceptor from Outfalls JAM-003 and JAM-003A to the Jamaica WWTP and abandonment of the HBPS by construction of a 14,700 LF, 13 foot diameter gravity sewer to a pumping station located at the intersection of Vandalia and Flatlands Avenues. Modeling of Alternative B-2f2 projects a 34 percent CSO AAOV reduction at Bergen Basin.

Figure 8-8. Layout for Proposed Parallel Interceptor to Jamaica WWTP and Gravity Sewer to 26th Ward WWTP

The benefits, cost and challenges associated with this alternative are as follows:

Benefits

- Utilizes available capacity at the 26th Ward WWTP to provide additional wet-weather capacity at the Jamaica WWTP
- The final tunnel size can be further adjusted during design to help address drainage issues in Howard Beach in addition to controlling CSO discharges

Cost

- The estimated NPW for this control measure is $1,651M.

Challenges

- High cost to CSO volume capture
- Limited improvement in Bergen Basin water quality attainment
- Property acquisition and permitting
- Crossing of pile supported drainage culverts and highway infrastructure

In consideration of the high cost to implement this alternative in relation to the relatively small reduction in CSO discharged to Bergen Basin annually, this alternative was eliminated from further consideration.

Alternative B-2g: Abandon HBPS and Construct CSO Storage Tunnel to 26th Ward WWTP

Alternative B-2g, as shown in Figure 8-9, includes all the elements from Alternative B-2e. Additionally, this alternative proposes an extension of the gravity sewer along the Belt Parkway to divert Outfalls JAM-003 and JAM-003A to capture CSO discharging to Bergen Basin. During dry-weather this tunnel would convey flows diverted from the HBPS only. During storm events, the tunnel would convey wet-weather flows from the HBPS as well as CSO from Regulators JA-03 and JA-14.

IW modeling of the 19,500 LF tunnel indicated that to reduce CSO volumes by 25, 50, 75 and 100 percent at Bergen Basin, 12 foot, 21 foot, 30 foot and 45 foot diameter tunnels would be required respectively. However, for Bergen Basin, the gap analysis showed that even with 100% CSO removal, Existing WQ Criteria for fecal coliform would not be achieved. Thus, due to this high cost-to-benefit ratio, this alternative has been eliminated from further evaluation.

Figure 8-9. Layout for Proposed CSO Tunnel to 26th Ward WWTP

The benefits, cost, and challenges associated with this alternative are as follows:

<u>Benefits</u>

- Utilizes available capacity at the 26th Ward WWTP to provide additional wet-weather capacity at the Jamaica WWTP
- The final tunnel size can be further adjusted during design to help address drainage issues in Howard Beach in addition to controlling CSO discharges
- Provides storage capacity for equalization of peak flows to the 26th Ward WWTP

<u>Cost</u>

- The estimated NPW for this control measure varies by level of control as follows:
  - 25% CSO control: $1,195M
  - 50% CSO control: $1,573M
  - 75% CSO control: $2,287M
  - 100% CSO control: $4,006M

Challenges

- High cost to CSO volume capture
- Limited improvement in Bergen Basin water quality attainment
- Property acquisitions and permitting

Water Quality/Ecological Enhancements: The control measures under the category of Water Quality/Ecological Enhancements are not CSO reduction measures but, rather, focus on enhancing water quality through other approaches. Environmental dredging has been recommended under certain other New York City CSO LTCPs to remove organics and other sediment deposits that can create odors when exposed during low tide. Wetlands Restoration, and bioextraction through ribbed mussel habitat creation can be considered to enhance aquatic and wildlife habitats, manage stormwater runoff, and reduce pathogens and other contaminants.

Wetlands and Bioextractors: Due to the risk of tidal wetlands attracting birds to waterways adjacent to the airport and the potential hazards associated to aircraft, tidal wetland restoration has been eliminated from further consideration for Bergen Basin and has not been included in Alternative B-13, Additional GI and Environmental Improvements. Bioextractors, such as ribbed mussels, can provide water quality benefits through the continuous filtration of contaminants and nutrients from the waters in which they reside. Recent studies indicate that ribbed mussels can filter pathogens of various sizes at rates of 25-100 percent, varying with water temperature and mussel density. In order to provide estimates of the reduction in bacteria concentrations due to the influence of filtration by ribbed mussels that could be included in a LTCP, a simplified and conservative approach was applied. Based on the review of literature referenced in Section 10, low end estimates of filtration could support a 10 percent reduction in bacteria where ribbed mussels would be installed. Model runs were completed using Recommended Plan conditions, and then a 10 percent reduction of model-calculated concentrations in the ambient waters was applied as part of post-processing the model output. The literature indicates that the application of a 10 percent reduction could be a conservatively low level of filtration, given that the ribbed mussels would filter the bacteria continuously during dry- and wet-weather. However, a proper design and deployment of ribbed mussels could provide a higher level of bacteria reduction.

Ribbed mussels provide continuous filtering of the waterbody to remove pollutants and enhance native habitat. As shown in Figure 8-10, Alternative B-13 includes 4 acres of ribbed mussel beds to be created within Bergen Basin. The final locations and configuration of the ribbed mussel beds would be refined during the implementation phase. The WQ model was run (See Appendix D for a memo detailing the modeling approach) to assess the impact of adding the ribbed mussels to the other components of Alternative B-13, Additional GI and Environmental Improvements. Under 2008 typical year rainfall conditions, model predictions indicate that implementation of ribbed mussels improves attainment of Existing WQ Criteria for fecal coliform at the head of the Bergen Basin by 5 percent on an annual basis and during the recreation season (May 1st through October 31st). That improvement would be on top of the improvement in attainment associated with the additional GI component. In contrast, the gap analysis indicated that 100% CSO control would improve fecal coliform attainment by 6 percent on an annual basis and 3 percent during the recreation season. The level of attainment resulting from the ribbed mussels can be attributed to the continuous filtration of the water column through dry- and wet-weather conditions, while CSO control is limited to larger wet-weather events when CSOs are activated (33 times/year for JAM-003A, 17 times/year for JAM-003 and 14 times/year for JAM-006). As the ribbed mussels and tidal wetlands provide low cost water quality and ecological benefits that address impacts of

CSO and stormwater discharges in addition to naturally occurring sources of pathogens and other contaminants, this alternative will be retained for further consideration.

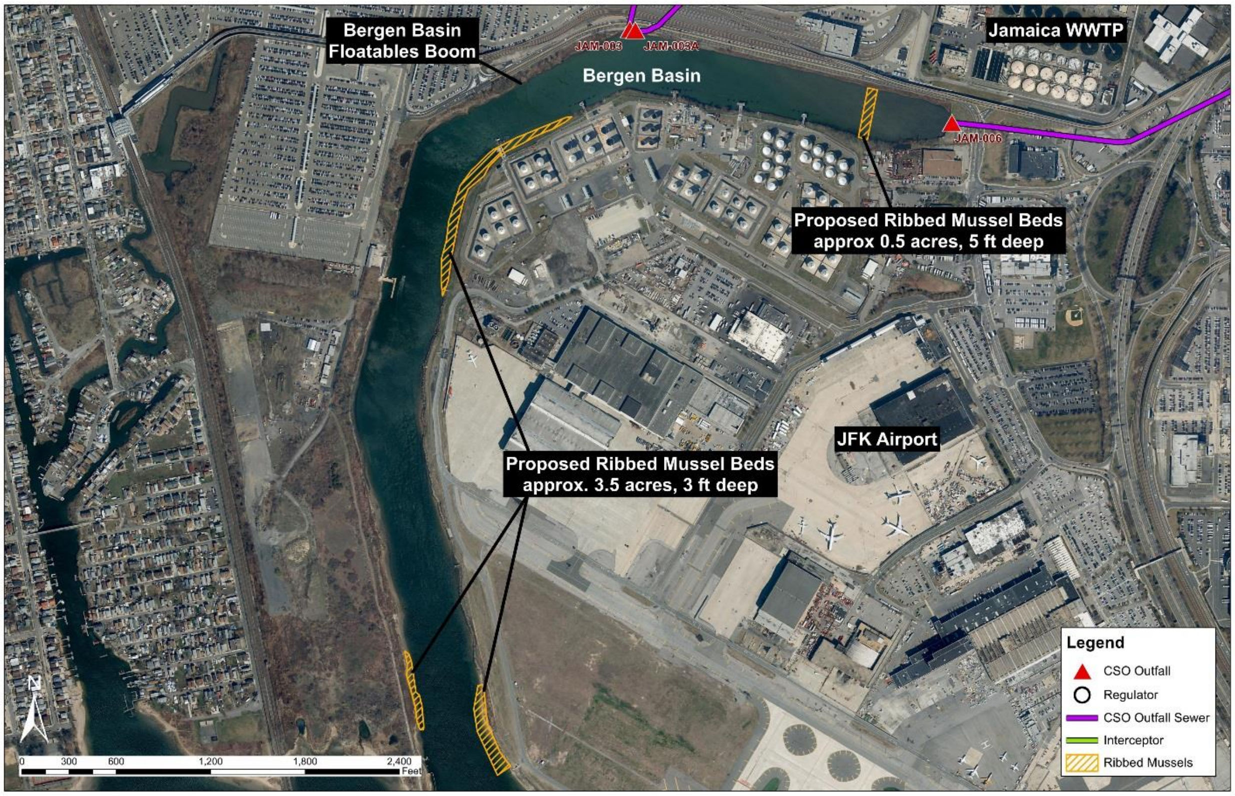

Figure 8-10. Ribbed Mussel Installation in Bergen Basin

Environmental Dredging: Based upon NOAA navigation charts and field visits during low tide, mounds of sediment were observed during low tide at the head end of Bergen Basin. In consideration of documented odor complaints in the area of Bergen Basin, notwithstanding the recent upgrades to the Jamaica WWTP odor control systems, dredging of exposed sediment at Outfall JAM-006 would be performed. An estimate of 50,000 CY of dredged material was developed based upon the dredging limits shown in Figure 8-11. Dredging depths, final grading of the stream bottom and restorative measures would need to be coordinated with the ribbed mussel bed design and PANYNJ airport operations. While this alternative provides no reduction in CSO discharge, it does address ancillary issues of CSO discharges through the removal of odor causing sediments, as well as aesthetic benefits of stream bottom restoration. Environmental dredging has been included in Alternative B-13 and retained for further consideration.

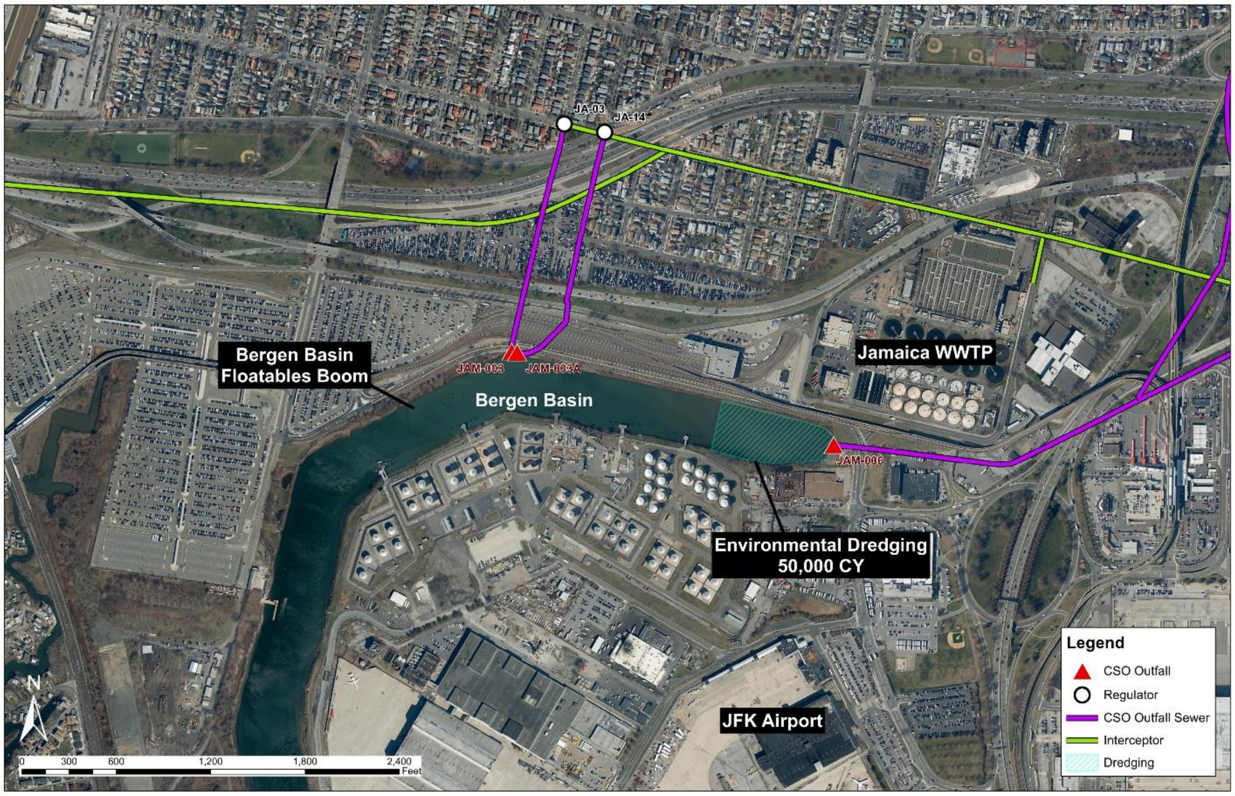

Figure 8-11. Environmental Dredging of Bergen Basin

Treatment/Storage Alternatives: A number of the control measures considered for Bergen Basin fall under the dual category of treatment and storage. These control measures include in-line or in-system storage, off-line tanks and deep tunnel storage. Treatment refers to disinfection in either CSO outfalls or at Retention Treatment Basins (RTBs). A discussion of the treatment and storage alternatives evaluated for Bergen Basin follows.

<u>Evaluation of Re-purposing or Upgrading of Existing Infrastructure for Treatment/Storage</u>

Initial evaluations focused on optimizing the performance of existing infrastructure to capture and/or treat CSO discharges. *In-System storage* is limited due to the lack of existing infrastructure large enough to accommodate sufficient volumes to make the alternatives cost effective. Storage in the CSO outfalls was not considered feasible due to the relatively short length of the outfalls, and the volume of stormwater that also discharges through the outfalls downstream of the regulators.

An alternative was evaluated utilizing in-line storage within the East and West Interceptors, with designated pumping stations at the treatment plant for each interceptor, however, modeling indicated that HGLs in the West Interceptor would be raised increasing the risk of flooding along contributing trunk and collector sewers. As a result, In-System Storage was eliminated from further evaluation for this waterbody.

WWTP Upgrades were determined to be infeasible for the Jamaica WWTP due to limited available space for installing additional primary settling tanks and expansion of disinfection facilities. In addition, IW modeling indicated that WWTP capacity upgrades would negligibly reduce CSO discharges to Bergen

Basin without providing storage capacity to equalize peak wet-weather flow. This alternative was eliminated from further evaluation for the Jamaica WWTP.

Outfall Disinfection was determined to be non-viable for Bergen Basin due to the lack of available contact time within the two largest outfall sewers. The outfall for JAM-003 is a 1,500 foot long single barrel 9' x 8' sewer, and the outfall for JAM-003A is a 1,500 foot long double barrel 13.5' x 9' sewer. While disinfection and dechlorination facilities (if needed) could both be sited along the outfall, the contact time cannot be achieved at the peak flow rates predicted by the model for many storm events. As these sewers are tidally influenced, new tide gates would need to be installed at the discharge end of the outfall sewers. In addition, a siphon exists under the Belt Parkway, as well as several storm sewer connections, further impacting the hydraulic complexity of designing and effectively operating disinfection facilities along this outfall. In consideration of the site characteristic and associated design and operational complexities, this alternative has been eliminated from further evaluation for Bergen Basin.

Evaluation of New Treatment/Storage Facilities

Treatment/Storage Alternatives require dewatering of stored CSO volumes after wet-weather events. Table 8-6 provides a summary of the total storage volume and the associated dewatering rate assuming a 24-hour dewatering period for storage facilities providing 25, 50, 75 and 100 percent levels of CSO Control for Outfalls JAM-003 and JAM-003A.

Table 8-6. Storage and Dewatering System Capacity for Storage Alternatives for Outfalls JAM-003 and JAM-003A

Level of Control	Storage Volume (MG)	Dewatering PS Capacity(1) (MGD)
25%	4	4
50%	8	10
75%	19	20
100%	45	50

Note:

(1) Assumes pump-back of stored CSO within a 24 hour period with peak flow limited to 1.5xDDWF.

During wet-weather conditions, the Jamaica WWTP's SDPES permit requires the WWTP to treat up to 1.5xDDWF (150 MGD) through all treatment processes and up to 2xDDWF through preliminary, primary and disinfection processes. In sizing CSO storage tanks and tunnels for the Jamaica CSO LTCP, it was assumed that dewatering would only be performed when peak flows were less than 150 MGD, so that all captured CSO would receive full treatment. Flow logic was built into the model to adjust the dewatering pumping station discharge rate to convey the difference between 1.5xDDWF and the incoming flow from the interceptor system. For example, if the flow entering the Jamaica WWTP from the East and West Interceptors totaled 120 MGD, the dewatering pumping station could pump up to 30 MGD. If the incoming flow was 100 MGD, the pump rate would increase to 50 MGD. In the case of back-to-back storm events, the tunnel dewatering pumps would shut off when peak flows exceeded 150 MGD.

RTB and storage concepts evaluated for control of CSO from JAM-003 and JAM-003A included a conveyance conduit with an RTB and CSO storage tunnels. Further description and discussion relating to these alternatives follows.

Retention Treatment Basins: As discussed earlier and illustrated in Figure 8-6, a number of viable sites for the installation of new treatment or storage facilities were identified in the vicinity of Bergen Basin. A 1.5 acre city-owned vacant parcel was identified near the north end of the Jamaica WWTP, where a building had been demolished. Other potential parcels for construction included city-owned properties leased by PANYNJ for long term parking and car rental.

The only parcels large enough to accommodate RTBs were the long term parking and car rental leased by PANYNJ. Figure 8-12 illustrates the plan view for the proposed RTB sited on this parcel, for 25, 50, 75 and 100 percent levels of CSO control. The challenges associated with siting this facility include significant loss of JFK parking spaces over a five to six year construction period as well as property acquisition/access challenges while providing minimal water quality benefits to Bergen Basin. As a result, this alternative has been eliminated from further evaluation under this LTCP.

Storage tanks require a larger footprint than RTBs, resulting in a greater impact to the long term parking and car rental parcel. Thus, this alternative has also been eliminated from further evaluation under this LTCP.

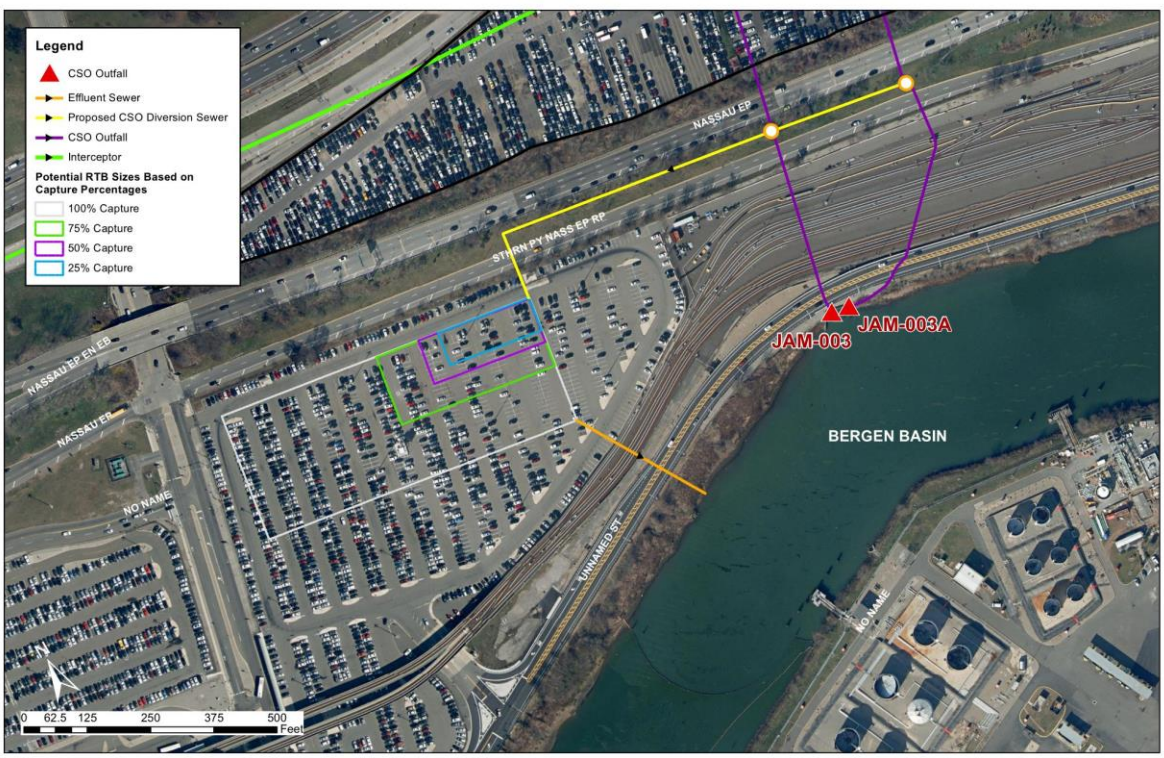

Figure 8-12. Layout for Proposed Retention Treatment Basin

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Alternative B-2c1: Extend HBPS Discharge to a RTB at Jamaica WWTP

This alternative, shown in Figure 8-13, includes the elements of Alternative B-2c: Abandonment of the force main connection of the HBPS to the West Interceptor, and redirection of this force main to the head end of the Jamaica WWTP. A new 50 MGD RTB sited at the head end of the Jamaica WWTP would receive flow and discharge its effluent to the chlorine contact tanks at the treatment plant.

This alternative removes the flow constriction at the West Interceptor, preventing backups at Regulators JA-03 and JA-14 during wet-weather events, reducing the HGL of the West Interceptor and thereby reducing CSOs to Bergen Basin. IW modeling projects a 13 percent CSO reduction at Bergen Basin, which is small in consideration of the cost to implement this alternative.

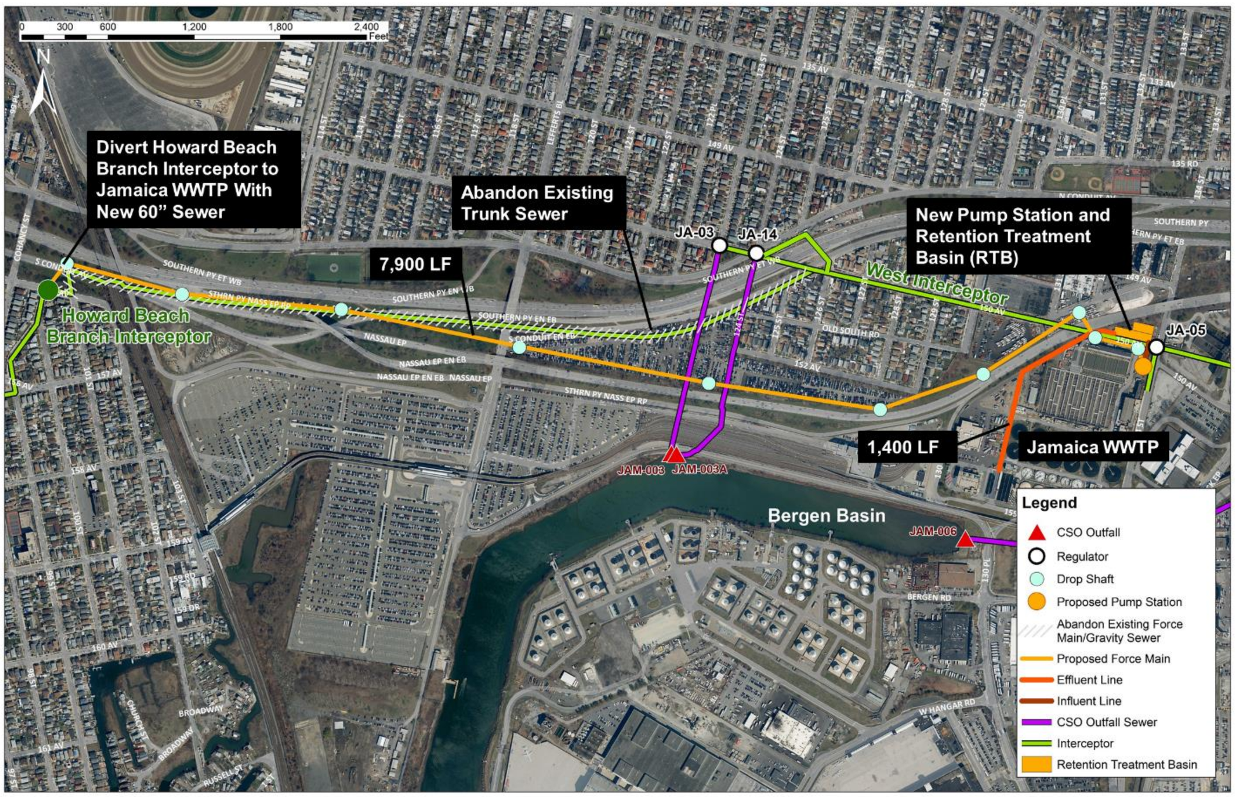

Figure 8-13. Layout for Diversion of the HBPS Discharge to a RTB at the Jamaica WWTP

The benefits, cost, and challenges associated with this alternative are as follows:

Benefits

- Provides additional capacity in West Interceptor for conveyance of JAM-003/003A CSO to the Jamaica WWTP
- The final sewer size could be further adjusted in conjunction with HBPS upgrades during final design to help address drainage issues in Howard Beach in addition to controlling CSO discharges

Cost

- The estimated NPW for this control measure is $985 M.

Challenges

- High cost to CSO volume capture
- Requires continuous pumping to address dry and wet-weather flow conveyed by the diverted trunk sewer
- Limited improvement in Bergen Basin water quality attainment
- Property acquisition and permitting
- Limited space for construction of RTB and pumping station
- Highway and West Interceptor crossings
- Construction of RTB effluent sewer to chlorine contact tank

Alternative B-2d2: Construct a Parallel Sewer From Regulators JA-03 and JA-14 to a 50 MGD RTB at the Jamaica WWTP

Alternative B-2d2 includes the components of Alternative B-2d with a new 50 MGD RTB sited at the head end of the Jamaica WWTP. The RTB would receive flow and discharge its effluent to the chlorine contact tanks at the treatment plant, as shown in Figure 8-14. Under this alternative, dry-weather flow would continue to the Jamaica WWTP via Regulators JA-03 and JA-14 and the West Interceptor. Under wet-weather conditions, overflow at Outfalls JAM-003 and JAM-003A would be diverted to the new parallel sewer and to the RTB. Modeling results project a 63 percent reduction in CSO overflow volumes to Bergen Basin.

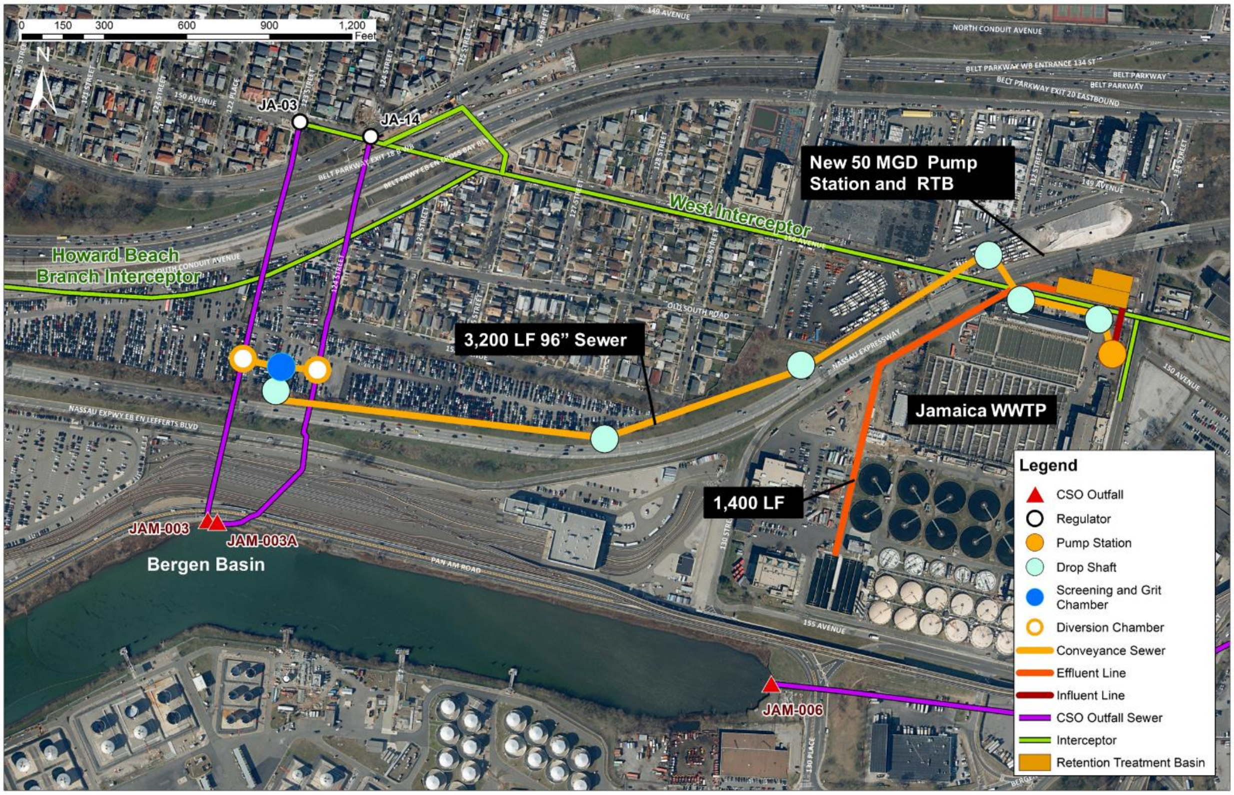

Figure 8-14. Layout for the Diversion of JAM-003/003A to a RTB at Jamaica WWTP

The benefits, cost, and challenges associated with this alternative are as follows:

Benefits

- Captures and conveys CSO from JAM-003/003A to a RTB
- Isolates CSO to reduce HGL impacts to the East and West Interceptors
- Mechanical components are located at the Jamaica WWTP to facilitate O&M
- Staff familiar with RTB Operations and Maintenance

Cost

- The estimated NPW for this control measure is $882M.

Challenges

- Limited improvement in Bergen Basin water quality attainment
- Property acquisition and permitting
- Tight site for construction of facilities
- Potential for sewer conflicts on WWTP site
- Highway and West Interceptor crossings

- Construction of RTB effluent sewer to chlorine contact tank

As a result of the high cost to water quality benefit ratio, this alternative has been eliminated from further evaluation.

CSO Storage Tunnels: As a result of the limited availability of suitable sites for traditional storage and satellite treatment technologies within the Bergen Basin sewershed, tunnel alternatives were developed further. Unlike traditional tanks, tunnels:

1. Can provide for both conveyance and storage of CSO;
2. Require less permanent above-ground property per equivalent unit of storage volume;
3. Minimize surface construction impacts;
4. Reduce construction related groundwater pumping and treatment costs; and
5. Reduce the volume of near-surface spoil material to be treated, handled, and transported for disposal during construction.

These benefits make tunnel storage more practical for highly developed sewersheds such as Bergen Basin.

Alternative B-6: CSO Storage Tunnel From Outfalls JAM-003 and JAM-003A With a Dewatering Pumping Station at the Jamaica WWTP

Tunnel construction would involve the boring of a linear storage conduit underground using a tunnel boring machine. Shafts would be installed during construction for the connection of CSO diversion pipes and O&M access. A tunnel dewatering pumping station (TDPS) would also be included at the downstream end of the tunnel with pumped discharges being conveyed to the Jamaica WWTP for treatment after wet-weather events. A mechanical ventilation system would be provided with an activated carbon odor control system. Additional passive odor control systems and/or backdraft dampers would be provided at the drop shafts.

As shown in Figure 8-15, two diversion chambers, a screening/grit chamber and a receiving/drop shaft would be sited along Outfalls JAM-003 and JAM-003A, causing temporary disturbances to PANYNJ facilities. Two gravity sewers would convey flows from these diversion chambers through the screening and grit chamber to the storage tunnel. The 3,200 LF tunnel would generally follow the northern edge of the Nassau Expressway until crossing it at the head end of the Jamaica WWTP. A launch shaft, screening chamber and 50 MGD TDPS would be sited at the head end of the WWTP.

This system would remain inactive during dry-weather, only seeing flows during wet-weather events, when the hydraulic capacity of the West Interceptor is exceeded and the weirs at Regulators JA-03 and JA-14 are overtopped. Flows would then be diverted to this tunnel, which would retain these CSOs until the wet-weather event has receded and the Jamaica WWTP could handle the CSO pump back.

Modeling determined that a 21 foot diameter single barrel 8 MG tunnel would be required for 50 percent capture, a 32 foot diameter single barrel 19 MG tunnel would be required for 75 percent capture and a 49 foot diameter 2,200 LF double barrel and 1,200 LF single barrel 91 MG tunnel would be required for 100% CSO capture.

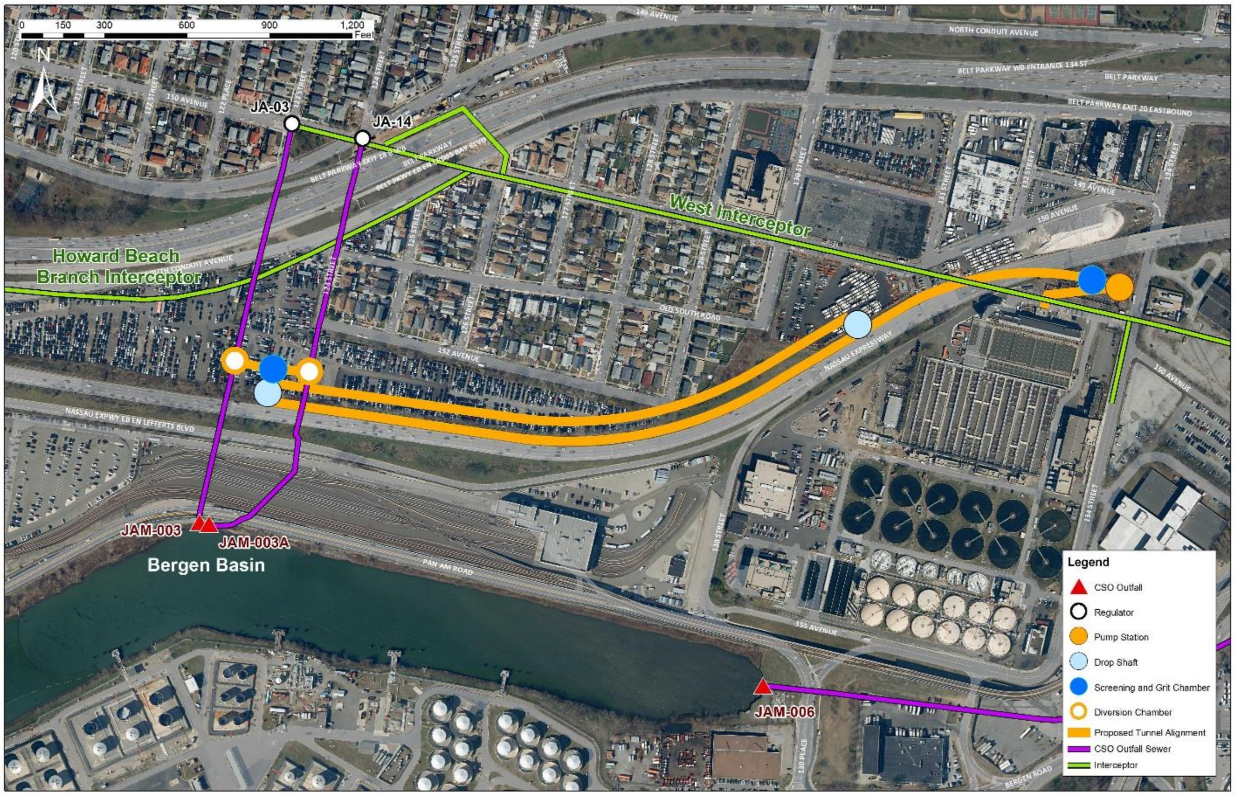

Figure 8-15: Layout of CSO Storage Tunnel and 50 MGD Dewatering Pumping Station at Jamaica WWTP

The benefits, cost, and challenges associated with this alternative are as follows:

<u>Benefits</u>

- Can provide high level of CSO capture and treatment
- Provides storage and conveyance for control of wet-weather peak flows from Regulators JA-03 and JA-14

<u>Cost</u>

- The estimated NPW for this control measure varies by level of control is as follows:
  - 50% CSO control: $736M
  - 75% CSO control: $896M
  - 100% CSO control: $1,755

  Details of the cost estimates are presented in Section 8.4.

<u>Challenges</u>

- Limited improvement in Bergen Basin water quality attainment

- Temporary relocation of parking and businesses during construction
- Crossings of the Nassau Expressway and the West Interceptor
- The 100% CSO control tunnel is near the limit of current TBM technology and may not be constructible

As previously stated, preliminary Gap Analysis showed that the water quality benefits from reducing CSOs in Bergen Basin are insignificant compared to the water quality impacts associated with storm and WWTP effluent flows. Thus, due to a high cost-to-benefit ratio, this alternative has been eliminated from further evaluations.

8.2.b Other Future Green Infrastructure (Bergen and Thurston Basins)

Jamaica Bay and its tributaries are priority watersheds for DEP's GI Program, which seeks to saturate priority watersheds with GI based on the specific opportunities each watershed presents. DEP plans to construct approximately 877 greened acres of GI by 2030, including ROW practices, public property retrofits, and compliance with stormwater connection regulations on private property within the Jamaica and 26th Ward WWTP sewersheds. As discussed in Section 5, DEP projects that baseline GI should result in a CSO volume reduction to Jamaica Bay and its tributaries of approximately 202 MGY, based on 2008 typical year rainfall conditions. This projected GI has been included as part of the baseline model projections, and is thus not categorized as an LTCP alternative.

Note that the Alternative B-13 and T-12 will enable DEP to build GI in the combined sewer area within Thurston Basin (See Figure 5-2), which has been assumed in the GI baseline. However, if the Recommended Plan is not approved, DEP will not pursue this limited area of expanded GI given its distance and isolation from other GI baseline assets which would lead to disproportionately high maintenance costs for GI in the area depicted in Figure 5-2.

For the purpose of this LTCP, "Other Future Green Infrastructure" is defined as GI alternatives that are in addition to those implemented under previous facility plans and those included in the baseline conditions. Under Alternative B-13 and T-12, an additional 15 MGY CSO reduction is projected due to the increased capacity in the interceptors in CSO portion of system. GI will also provide additional co-benefits, such as property value appreciation, carbon sequestration, air quality improvements, urban heat island reduction, and habitat creation in addition to reductions in CSO and stormwater pathogen loads. Thus, this alternative will be retained for further evaluation.

8.2.c Hybrid Green/Grey Alternatives (Bergen Basin)

Hybrid green/grey alternatives are those that combine traditional grey control measures with GI control measures, to achieve the benefits of both. However, as discussed above, the SEQ Storm Sewer Build-out Program is ongoing and will significantly impact the drainage patterns throughout the collections system tributary to the Jamaica WWTP. Therefore, no controls in this category are proposed for the Jamaica Bay and Tributaries LTCP.

8.2.d Retained Alternatives (Bergen Basin)

The goal of the previous evaluations was the development of a list of retained control measures for Outfalls JAM-003, JAM-003A and JAM-006 to Bergen Basin. These control measures, whether individually or in combination, formed the basis of basin-wide alternatives that DEP assessed using the more rigorous cost-performance and cost-attainment analyses. That list is presented in Table 8-7. 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 the CSO storage tunnels and the Additional GI and Environmental Improvements. Measures for additional and/or improved floatables control are addressed within the retained alternatives.

Table 8-7. Summary of Bergen Basin Specific Alternatives

Waterbody	Alternative ID	Description	Impacted Outfalls	Observations	Recommendations
Bergen Basin	B-2b	In-line storage within the East and West Interceptors along with designated pumping stations at the Jamaica WWTP	JAM-003 & JAM-003A	Limited reduction in CSOs and an increase in HGL in the West Interceptor	Abandoned due to HGL impacts
Bergen Basin	B-2c1	Redirect the HBPS force main to a new RTB located at the Jamaica WWTP	JAM-003 & JAM-003A	Slight reduction in CSO with limited Water Quality Benefits	Abandoned due to high cost-to-benefit ratio
Bergen Basin	B-2d2	Construction of a parallel sewer to convey CSO from JA-03 and JA-14 to a new 50 MGD RTB at the Jamaica WWTP	JAM-003 & JAM-003A	Significant reduction in CSO but with limited Water Quality Benefits	Abandoned due to high cost-to-benefit ratio
Bergen Basin	B-2e	Abandon HBPS and construct a new gravity sewer and dewatering pumping station at 26th Ward WWTP	JAM-003 & JAM-003A	Slight reduction in CSO with limited Water Quality Benefits	Abandoned due to high cost-to-benefit ratio
Bergen Basin	B-2f	Abandon HBPS, construction of a new gravity sewer, dewatering pumping station at 26th Ward WWTP and construction of a new parallel sewer from JA-03 and JA-14 to the Jamaica WWTP	JAM-003 & JAM-003A	Significant reduction in CSO but with limited Water Quality Benefits	Abandoned due to high cost-to-benefit ratio
Bergen Basin	B-2g	Abandon HBPS, construction of a new CSO Storage Tunnel from Outfalls JAM-003 & JAM-003A with a dewatering pumping station at 26th Ward WWTP. Diverts flow from HBPS Drainage Area.	JAM-003 & JAM-003A	Significant reduction in CSO but with limited Water Quality Benefits	Abandoned due to high cost-to-benefit ratio

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Table 8-7. Summary of Bergen Basin Specific Alternatives

Waterbody	Alternative ID	Description	Impacted Outfalls	Observations	Recommendations
Bergen Basin	B-2h	Diversion of all flow from Regulator JA-02 to 26th Ward WWTP Sewer Service Area	JAM-003 & JAM-003A	This alternative was not modeled. Insufficient grade differential to construct new sewer.	Abandoned. Not constructible.
Bergen Basin	B-3	Outfall disinfection of CSO Outfalls JAM-003 and JAM-003A	JAM-003 & JAM-003A	Insufficient contact time and tidal impacts	Abandoned due to insufficient contact time
Bergen Basin	B-4	Construction of a CSO storage tank to receive flow from Outfalls JAM-003 and JAM-003A with a dewatering pumping station and force main to return flows to the system after the wet-weather event has receded	JAM-003 & JAM-003A	Significant reduction in CSO but with limited Water Quality Benefits	Abandoned due to high cost-to-benefit ratio and significant impacts to JFK Airport facilities due to a large footprint
Bergen Basin	B-6	Construction of a CSO storage tunnel from Outfalls JAM-003 and JAM-003A with a dewatering pumping station at Jamaica WWTP	JAM-003 & JAM-003A	Significant reduction in CSO but with limited Water Quality Benefits. Equalizes peaks and provides operational benefits during wet-weather	Retain. Provides CSO conveyance, storage, and treatment at WWTP.
Bergen Basin	B-7	Construction of a RTB at the Port Authority leased Parking Lot to receive flows from Outfalls JAM-003 and JAM-003A	JAM-003 & JAM-003A	Limited Water Quality Benefits	Abandoned due to high cost-to-benefit ratio and significant impacts to JFK Airport facilities
Bergen Basin	B-10	Construction of a new regulator along Outfall JAM-006 to divert CSO and stormwater to Jamaica WWTP	JAM-006	Limited CSO reduction and Water Quality Benefits	Abandoned due to tidal flows seen in outfall sewer as well as HGL impacts to the interceptors
Bergen Basin	B-11	Construction of a new regulator along Outfall JAM-006 to divert CSO and stormwater to Jamaica WWTP, and construction of a CSO storage tunnel from Outfalls JAM-003	JAM-003, JAM-003A & JAM-006	Significant reduction in CSO but with limited Water Quality Benefits and an increase in HGLs in the East and West	Abandoned due to high cost-to-benefit ratio and increased HGL impacts

Table 8-7. Summary of Bergen Basin Specific Alternatives

Waterbody	Alternative ID	Description	Impacted Outfalls	Observations	Recommendations
		and JAM-003A with a dewatering pumping station at Jamaica WWTP		Interceptor	
Bergen and Thurston Basin	B-12	Jamaica WWTP capacity upgrade	JAM-003, JAM-003A & JAM-006	No CSO reduction	Abandoned due to lack of available space for installation of new primary tank and due to lack of CSO reduction
Bergen and Thurston Basin	B-13	Additional GI and Environmental Improvements	JAM-003, JAM-003A & JAM-006	Low CSO reduction, but provides SW reduction. Dredging removes odor causing sediments. Ribbed mussels provide filtration of tide cycles and CSO/SW discharges.	Retain. Low cost-to-benefit ratio. Co-benefits.

Thurston Basin Alternatives

Thurston Basin is located in Jamaica, Queens to the immediate east of JFK Airport. It receives runoff from approximately a 9,220 acre drainage area, out of which approximately 1,170 acres is combined drainage area, 6,870 acres is separated sewershed and 970 acres is airport drainage area. About 210 acres of direct drainage also exist along the banks of the basin. CSO and stormwater is discharged to this basin by two CSO and seven storm outfalls. CSO Outfalls JAM-005 and JAM-007 are the two biggest outfalls, measuring quadruple barrel (QBL) 16' x 8' and QBL 17' x 6', respectively.

Based on 2040 projected flows, with all proposed Jamaica Bay WWFP projects constructed, the model projects discharges to Thurston Basin in the amount of 213 MGY of CSO and 1,226 MGY of stormwater. Baseline loading, as summarized in Table 6-4, indicates that pathogen and BOD loading from stormwater sources ranges from 2.5 to 3 times the load of CSOs. This is reflected in the gap analyses, which indicates that 100% CSO control fails to achieve attainment of pathogen and DO WQ Criteria for Thurston Basin. In consideration of these findings, the cost-to-benefit ratio of CSO control is expected to be very high. As a result, it will be desirable to consider technologies and approaches that reduce stormwater contributions to both the combined and separate portions of the collection system.

A review of existing land uses near the discharge of Outfalls JAM-005 and JAM-007 was performed for the purposes of identifying potential sites for new treatment/storage facilities. Figure 8-16 illustrates the location of the sites in relation to the CSO outfalls and Thurston Basin. The most suitable locations identified were a 15 acre privately owned parking lot on Rockaway Boulevard and a number of small vacant city-owned lots near 148 Avenue, which total less than an acre. Other viable parcels for construction include a few privately owned vacant lots near 148 Avenue. However, wetlands cover sizable portions of these lots thereby limiting their use. While the outfalls pass through Idlewild Park, park alienation relating to construction of above-grade facilities would likely be an issue.

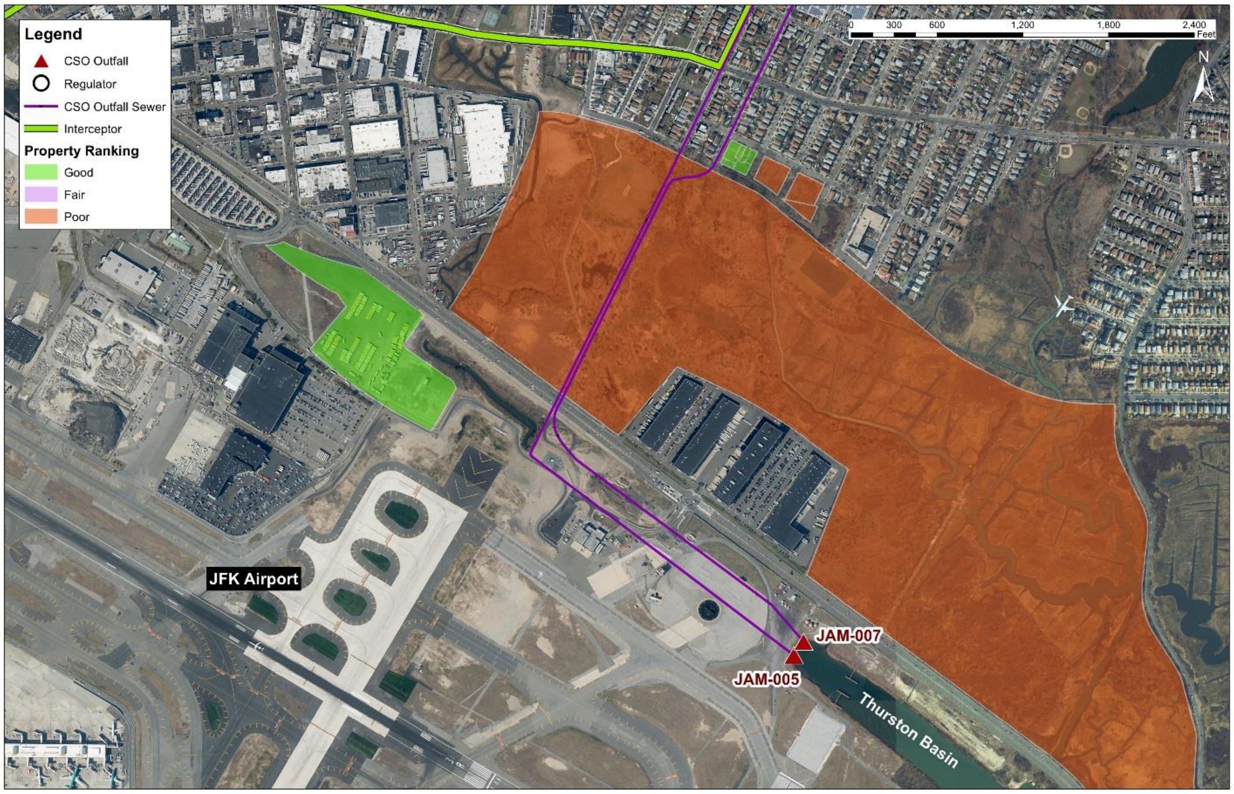

Figure 8-16. Potential Properties near Thurston Basin CSO Outfalls

CSO Relocation: This concept involves conveying overflows by gravity from one receiving water to another receiving water, where the second receiving water would either be less sensitive or provide greater dilution/assimilation than the one from which the CSO is being diverted. Neither Gravity Flow Tipping nor Flow Tipping with Conduit/Tunnel and Pumping were recommended in the WWFP for Thurston Basin. Based on preliminary water quality modeling, Bergen Basin was determined to be just as sensitive, if not more so, than Thurston Basin. In addition, diversion of the outfall to Jamaica Bay, which has more stringent water quality standards for the promotion of primary contact recreation, is contrary to the intended uses of the Bay. As a result, these alternatives have not been pursued further under the LTCP.

Water Quality/Ecological Enhancements: The control measures under the category of Water Quality/Ecological Enhancements are not CSO reduction measures but, rather, focus on enhancing the water quality through other approaches.

Environmental Dredging: Based upon NOAA navigation charts and field observations, sediment deposition does not appear to be an issue in this waterbody. In addition, a review of historical complaint records does not indicate an issue with odors in the area. As a result, this technology will not be retained for further consideration.

Wetlands and Bioextractors: Due to the risk of tidal wetlands attracting birds adjacent to the airport and the potential hazards to aircraft, tidal wetland restoration has been eliminated from further consideration for Thurston Basin and has not been included in Alternative T-12, Additional GI, and Environmental Improvements. Ribbed mussels provide continuous filtering of the waterbody to remove pollutants and enhance native habitat. Alternative T-12 includes 3 acres of ribbed mussel beds to be created within Thurston Basin as shown in Figure 8-17. As this alternative provides low cost water quality benefits that address impacts of CSO and stormwater discharges, in addition to naturally occurring sources of pathogens and other contaminants, Alternative T-12 will be retained for further consideration.

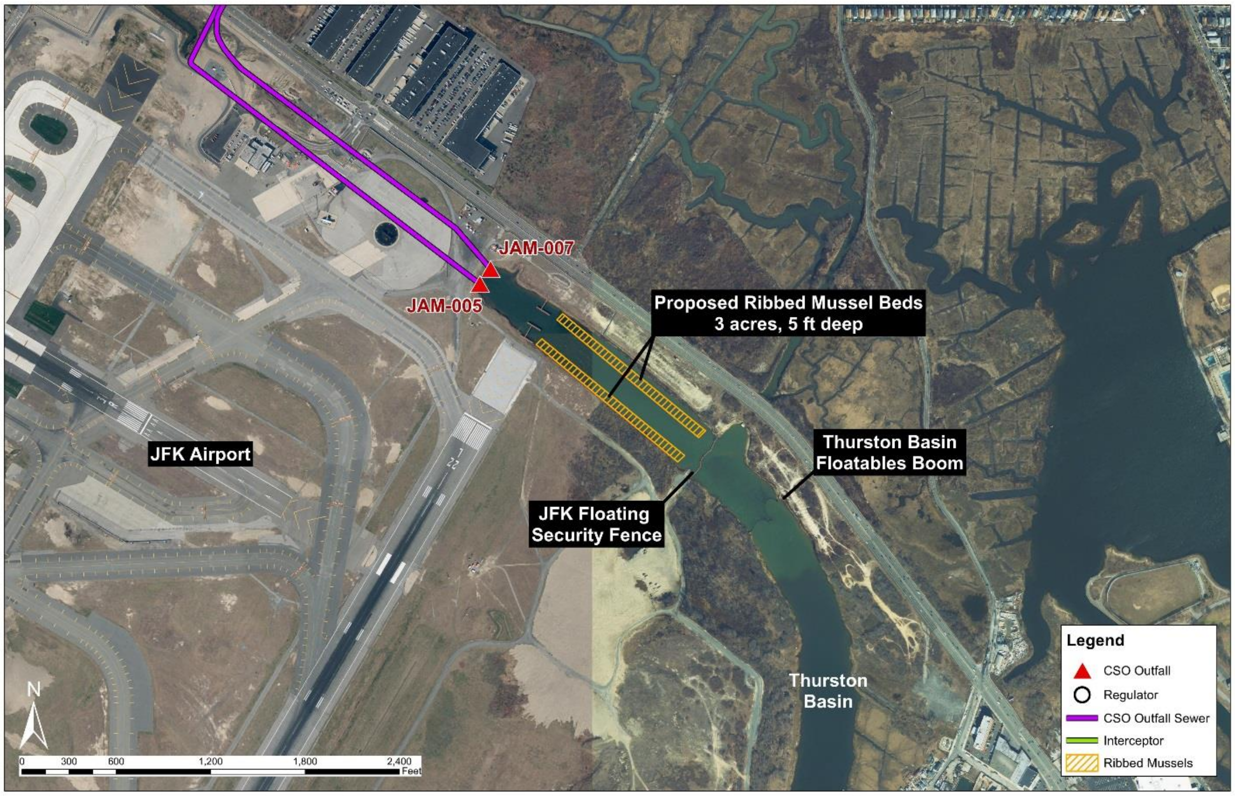

Figure 8-17. Ribbed Mussel Installation in Thurston Basin

WWTP Upgrades were determined to be infeasible for the Jamaica WWTP due to limited available space for installing additional primary settling tanks and expansion of disinfection facilities. In addition, IW modeling indicated that WWTP capacity upgrades would negligibly reduce CSO discharges to Bergen Basin unless storage capacity is provided to equalize peak wet-weather flow. As a result, this alternative was eliminated from further evaluation for the Jamaica WWTP.

Treatment/Storage Alternatives: A number of the control measures considered for Thurston Basin fall under the categories of treatment and storage. These control measures include in-line or in-system storage, off-line tanks and deep tunnel storage. Treatment refers to disinfection in either CSO outfalls or at RTBs. A discussion of the treatment/storage alternatives evaluated follows.

Evaluation of Re-purposing or Upgrading of Existing Infrastructure for Treatment/Storage

In-system Storage: Initial alternatives evaluations focused on maximizing the performance of existing infrastructure to capture and/or treat CSO discharges. CSO JAM-005 consists of a 4,750 LF QBL 17' x 6' box culvert, while JAM-007 is a 4,500 LF DBL 16' x 8' box culvert. While the size of these sewers appears to offer opportunities for in-system storage, the outfalls are heavily influenced by tidal inflow. During field investigations and performance of the sampling program, tidal influence was observed within the outfall at points north of the Belt Parkway, significantly reducing the available volume for CSO control. As a result, in-line storage was eliminated from further consideration.

Outfall disinfection has been recommended in prior LTCPs where the outfall length provides the necessary contact time to kill bacteria and remove residual chlorine. To accommodate a wide range of flow conditions, the outfalls are often retrofitted to prevent tidal inflow, manage contact time, provide chemical mixing or address other process needs. Outfall disinfection was assessed for Thurston Basin as Alternative T-3.

Alternative T-3: Outfall Disinfection of CSO and Stormwater in CSOs JAM-005 and JAM-007

A desktop analysis of outfall disinfection opportunities was performed to determine the feasibility of utilizing the length and in-line capacity of CSOs JAM-005 and JAM-007. The concept for this alternative, as shown in Figure 8-18, includes the installation of a sodium hypochlorite feed system with introduction of disinfectant to the outfalls barrels near 148 Avenue. The chlorination building would be constructed within a vacant lot located at the intersection of 148 Avenue and 226th Street. An above-ground dechlorination facility would be sited near the outfall discharge point in Idlewild Park. The dechlorination feed line would be located along the outfall to provide enough contact time to control the residual chlorine before the flows are discharged to Thurston Basin. To address the tidal impacts, a tide gate chamber would be installed with tide gates on all eight of the sewer barrels.

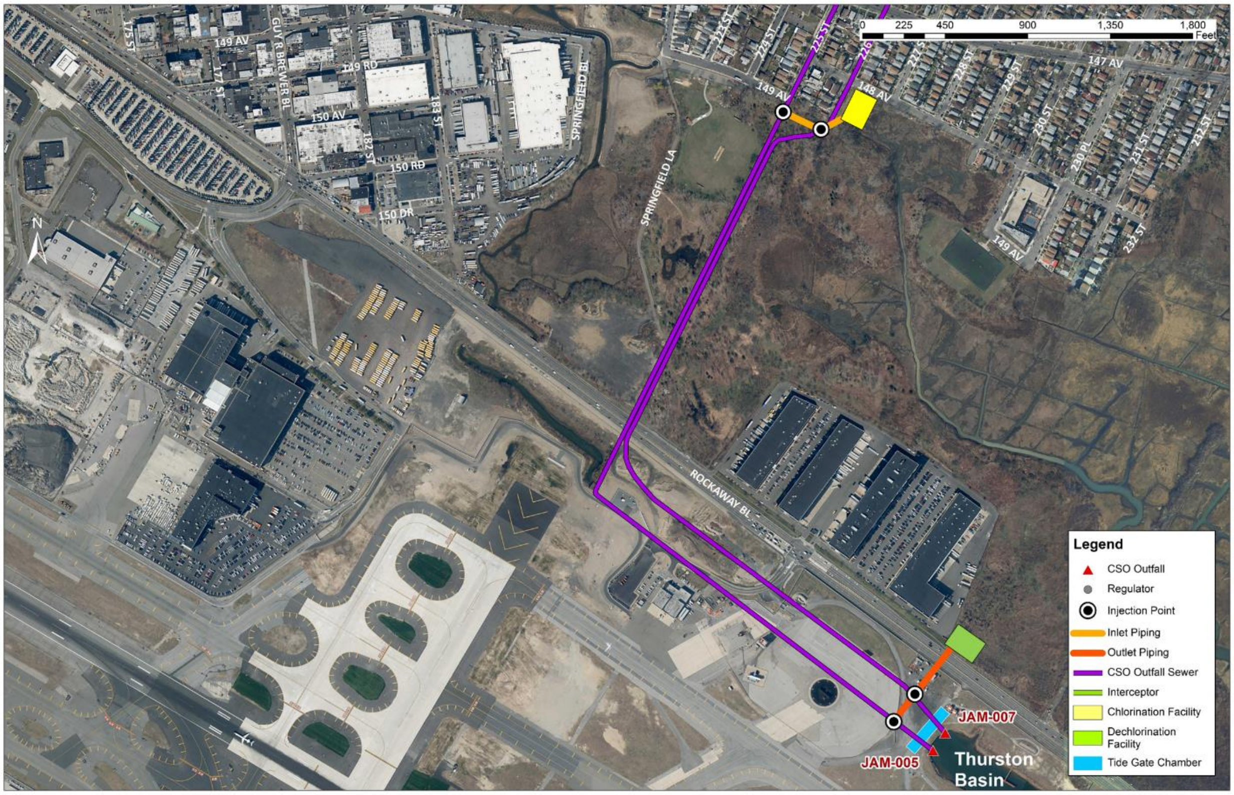

Figure 8-18. Layout for Outfall Disinfection of CSOs JAM-005/007

The benefits, cost and challenges associated with this alternative are as follows:

Benefits

- Disinfects both CSO and stormwater in JAM-005 and JAM-007
- Low cost pathogen control

Cost

- The estimated NPW Cost for this control measure is $25 M.

Challenges

- Property acquisitions and permitting
- Potential impacts to parkland
- Tidal influence
- Control of total residual chlorine
- Additional storm sewer and open stream connections exist along the outfall downstream of the hypochlorite feed point
- Transition from dual barrel sewers to quadruple barrels

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- Process control challenges associated with flow in multiple barrels, and the streamflow/stormwater connections downstream of the disinfectant dosing location.
- Access for operation and maintenance
- Community opposition
- Potential impacts to shellfish restoration projects in Head of Bay and Thurston Basin

There are numerous siting and operational challenges to overcome for the successful installation and operation of disinfection facilities along Outfalls JAM-005 and JAM-007. While the chlorination building could be sited in a vacant lot, permitting for impacts to wetlands and buffers would be needed for the chemical feed piping, and an access road for installation and periodic maintenance of mixers or other equipment located along the outfall. The dechlorination facilities would need to be sited in Idlewild Park, which would likely require State legislation, or within a secure area of the airport property, which would require agreement from the PANYNJ. The transition of the outfalls from dual barrel to quadruple barrel configurations, the introduction of additional stormwater and surface streams at points along the outfall and the impacts of tidal action create highly variable operating conditions that will make it extremely difficult to achieve the required bacteria kills and satisfy total residual chlorine limits that would be included in a future SPDES permit for this facility. These challenges create potentially unmanageable challenges and risks, some of which are beyond the control of DEP or the City, that eliminate this alternative from further consideration.

Based on technical discussions with DEC, DEP conducted further review of these challenges. This further review, documented in a technical memorandum attached hereto as Appendix E, supports the above-conclusions. Therefore, DEP is not recommending this technology for further consideration.

Evaluation of New Treatment/Storage Facilities

CSO Storage Tank and Tunnel alternatives require dewatering of stored CSO volumes as wet-weather events subside and WWTP capacity becomes available. Table 8-8 provides a summary of the total storage volume and the associated dewatering rate assuming a 24-hour dewatering period for storage facilities providing 25, 50, 75, and 100 percent levels of CSO control for Outfalls JAM-005 and JAM-007.

Table 8-8. Storage and Dewatering System Capacity for Storage Tunnel Alternatives for Outfalls JAM-005 and JAM-007

Level of Control	Storage Volume (MG)	Dewatering PS Capacity(1) (MGD)
25%	4	5
50%	9	10
75%	29	30
100%	91	100

Note:
(1) Assumes pump-back of stored CSO within a 24 hour period with peak flow limited to 1.5xDDWF.

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During wet-weather conditions, and in accordance with the WWTP SPDES permit, the Jamaica WWTP can treat up to 1.5xDDWF (150 MGD) through all treatment processes and up to 2xDDWF through preliminary, primary and disinfection processes. In sizing CSO storage tunnels for the Jamaica CSO LTCP, it was assumed that tunnel dewatering would only be performed when peak flows were less than 150 MGD, so that all captured CSO would receive full treatment. Flow logic was built into the model to adjust the dewatering pumping station discharge rate to the difference between 1.5xDDWF and the incoming flow from the interceptor system. For example, if the flow entering the Jamaica WWTP from the East and West Interceptors totaled 120 MGD, the dewatering pumping station could pump up to 30 MGD. If the incoming flow was 100 MGD, the pump rate would increase to 50 MGD. In the case of back-to-back storm events, the tunnel dewatering pumps would shut off when peak flows exceeded 150 MGD.

As mentioned earlier and illustrated in Figure 8-16, a number of viable sites for the installation of new treatment or storage facilities were identified in the vicinity of Thurston Basin. The most suitable locations identified were a privately owned parcel on Rockaway Boulevard and a number of small city-owned lots near 148 Avenue, which amount to less than an acre and are currently un-utilized. Siting of facilities at Idlewild Park would require park alienation. Acquisition of the private site would be difficult and would be accomplished either through negotiation or eminent domain.

In consideration of the limited availability of vacant or undeveloped properties*, CSO Storage Tanks* were determined to be non-viable. Properties of sufficient size to accommodate a storage tank are limited to PANYNJ or Idlewild Park. In addition, portions of the park and smaller private properties were found to fall within JFK Airport flight patterns, resulting in severe height restrictions for buildings and construction equipment. In consideration of the site constraints and a high cost-to-benefit ratio, this alternative has been eliminated from further evaluation.

Though *Retention Treatment Basins* require a smaller footprint than *CSO Storage Tanks*, they are also subject to the same site constraints and limitations. Because of this, the alternative has been eliminated from further evaluation.

Alternative T-6: CSO Storage Tunnel from Outfalls JAM-005 and JAM-007 to the Jamaica WWTP

As a result of the limited availability of suitable sites for traditional storage and treatment technologies within the Thurston Basin watershed, tunnel alternatives were developed further (Figure 8-19) Unlike traditional tanks, tunnels:

1. Can provide for both conveyance and storage of CSO;
2. Require less permanent above-ground property per equivalent unit of storage volume;
3. Minimize surface construction impacts;
4. Reduce construction related groundwater pumping and treatment costs; and
5. Reduce the volume of near-surface spoil material to be treated, handled, and transported for disposal during construction.

Tunnel construction would involve the boring of a linear storage conduit using a tunnel boring machine. Shafts would be installed along the tunnel route for connection of the CSO diversion sewers and O&M access. A TDPS would also be included at the downstream end of the tunnel with pumped discharges conveyed to the Jamaica WWTP for treatment when influent flow from the interceptors drops below 1.5xDDWF. A mechanical ventilation system would be provided with an activated carbon odor control system. Additional passive odor control systems and/or backdraft dampers would be provided at the drop shafts.

Diversion chambers, a screening/grit chamber and a receiving/drop shaft would be sited along Outfalls JAM-005 and JAM-007, at the city-owned vacant lands identified. Two gravity sewers would convey flows from these diversion chambers through the screening and grit chamber to the storage tunnel. The 15,200 LF tunnel would generally follow the southern edge of Rockaway Boulevard and the Nassau Expressway until it reaches the Jamaica WWTP. A launch shaft, screening/grit chamber and 50 MGD dewatering pumping station would be sited in a vacant lot located at the north end of the WWTP.

This system would remain inactive during dry-weather, only seeing flows during wet-weather events, when the hydraulic grade has topped the weirs at Regulators JA-06, JA-07, and JA-08. Flows would then be diverted to this tunnel, which would retain these CSOs until the wet-weather event has receded and capacity is available at the Jamaica WWTP to dewater the tunnel.

Modeling for the CSO tunnel determined that a 10 foot diameter 9 MG tunnel would be required for 50 percent capture, an 18 foot diameter 29 MG tunnel would be required for 75 percent capture and a 28 foot diameter 70 MG tunnel would be required for 100% CSO capture. The difference between the two smallest capture alternatives is minimal due to the fact that the tunnel diameter for the 25 percent and 50 percent capture are essentially dominated by the sanitary flow, while the sizing of the higher percent capture tunnels are driven by more intense longer duration rainfall events that contribute large volumes of stormwater.

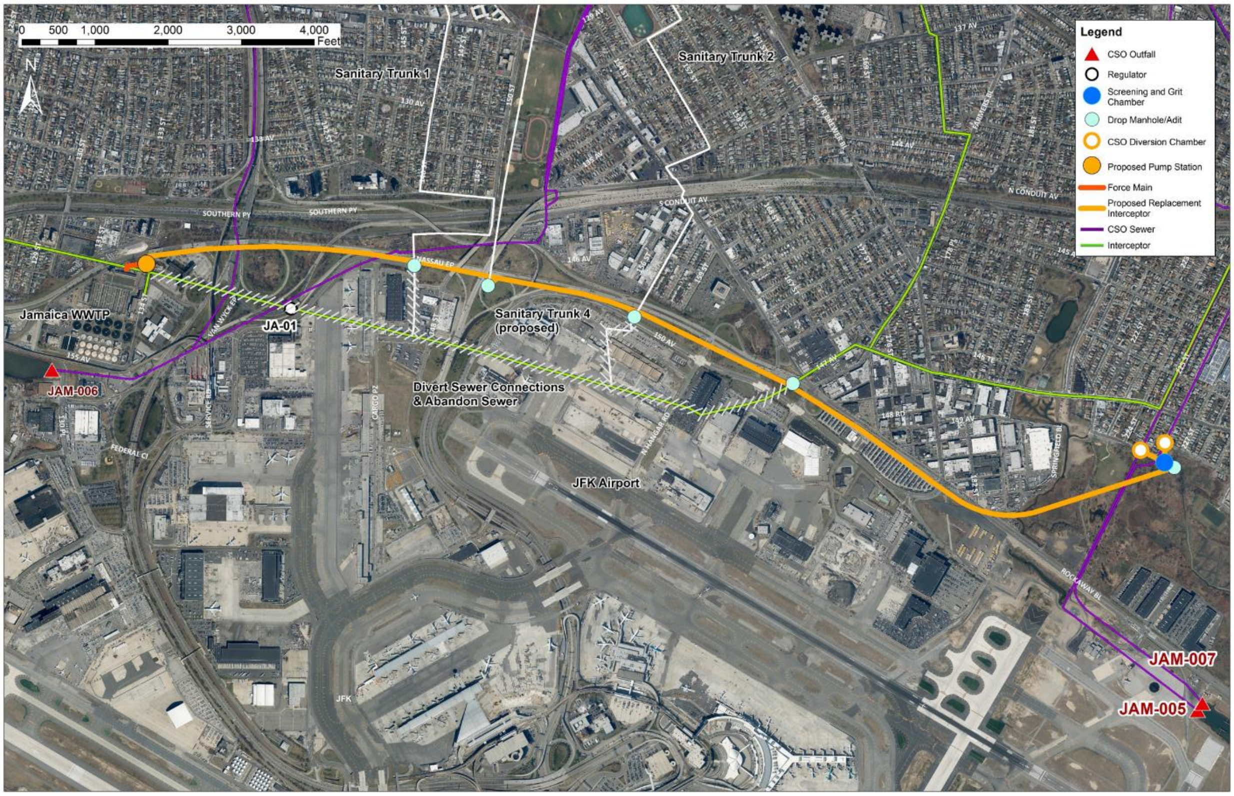

Figure 8-19. Layout for Proposed CSO Tunnel From JAM-005/007 to Jamaica WWTP

The benefits, cost, and challenges associated with this alternative are as follows:

<u>Benefits</u>

- Diverts CSO from JAM-005 and JAM-007 to the Jamaica WWTP for treatment
- Provides equalization of peak wet-weather flows and allows for flexibility in WWTP operations

<u>Cost</u>

- The estimated NPW for this control measure varies by level of control as follows:
  - 50% CSO control: $721M
  - 75% CSO control: $1,020M
  - 100% CSO control: $1,637M

  Details of the estimates for each level of CSO control are presented in Section 8.4.

<u>Challenges</u>

- Limited improvement in Thurston Basin water quality attainment
- Property acquisitions and permitting

- Neighborhood impacts associated with diversion chamber construction
- Highway ramp crossings

The gap analysis showed that the water quality benefits from 100% CSO capture for Thurston Basin results in a four percent increase in fecal coliform attainment annually and a two percent improvement during the recreational season (May 1st through October 31st) for 2008 typical year rainfall conditions. Despite the limited water quality benefits, Alternative T-6 isolates the captured CSO from the East and West Interceptor and does not impact the hydraulic grade line of the existing trunk and collector sewers. As a result, this alternative has been retained for further evaluation.

8.2.e Other Future Green Infrastructure (Thurston Basin)

See Section 8.2b.

8.2.f Hybrid Green/Grey Alternatives (Thurston Basin)

Hybrid green/grey alternatives are those that combine traditional grey control measures with GI control measures, to achieve the benefits of both. However, as discussed above, the SEQ Storm Sewer Build-out Program is ongoing and will significantly impact the drainage patterns throughout the collections system tributary to the Jamaica WWTP. Therefore, no controls in this category are proposed for the Jamaica Bay and Tributaries LTCP.

8.2.g Retained Alternatives (Thurston Basin)

The goal of the previous evaluations was the development of a list of retained control measures for Outfalls JAM-005 and JAM-007 to Thurston Basin. These control measures, whether individually or in combination, formed the basis of basin-wide alternatives that DEP assessed using the more rigorous cost-performance and cost-attainment analyses. That list is presented in Table 8-9. 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 the CSO storage tunnels and the Additional GI and Environmental Improvements. Measures for additional and/or improved floatables control are addressed within the retained alternatives.

Table 8-9. Summary of Thurston Basin Specific Alternatives

Waterbody	Alternative ID	Description	Impacted Outfalls	Observations	Status
Thurston Basin	T-3	Construction of disinfection and dechlorination facilities along Outfalls JAM-005 and JAM-007	JAM-005/007	Limited water quality benefits, operational complexity, public opposition	Abandoned due to operational concerns and site accessibility concerns
Thurston Basin	T-4a & 4b	Construction of a CSO storage tank at vacant lots south of 148 Ave or at Idlewild Park with a dewatering pumping station and force main to the East Interceptor	JAM-005/007	Significant reduction in CSO but limited water quality benefits, limited property available	Abandoned due to high cost-to-benefit ratio and impacts to wetlands

Table 8-9. Summary of Thurston Basin Specific Alternatives

Waterbody	Alternative ID	Description	Impacted Outfalls	Observations	Status
Thurston Basin	T-4c	Construction of a CSO storage tank at private parking lot south of Rockaway Boulevard with a dewatering pumping station and force main to the East Interceptor	JAM-005/007	Significant reduction in CSO but with limited water quality benefits	Abandoned due to high cost-to-benefit ratio
Thurston Basin	T-6	Construction of a CSO storage tunnel/replacement interceptor from Outfalls JAM-005 and JAM-007 with a dewatering pumping station at the Jamaica WWTP	JAM-005/007	Significant reduction in CSO but with limited water quality benefits. Equalizes peaks and provides operational benefits during wet-weather.	Retain. Provides CSO conveyance, storage, and treatment at WWTP.
Thurston Basin	T-7a & 7b	Construction of an RTB at vacant lots south of 148 Ave or at Idlewild Park with an effluent sewer back to Outfalls JAM-005 and JAM-007	JAM-005/007	Limited availability of property and water quality benefits, park alienation	Abandoned due to high cost-to-benefit ratio and impacts to wetlands
Thurston Basin	T-7c	Construction of an RTB at vacant lots south of Rockaway Blvd with an effluent sewer back to Outfalls JAM-005 and JAM-007	JAM-005/007	Limited water quality benefits, effluent return line through PANYNJ	Abandoned due to high cost-to-benefit ratio and impacts to JFK facilities
Thurston Basin	T-9	Springfield/Laurelton area high level storm sewer build-out	JAM-005/007	Storm sewer capacity not available	Abandoned because project cannot meet LTCP schedule
Thurston Basin	T-10	In-line storage	JAM-005/007	Limited reduction in CSO. Limited water quality benefits.	Abandoned due to HGL impacts in the East and West Interceptor
Thurston Basin	T-11	Construction of wetlands to treat stormwater	JAM-005/007	Grade issues for discharge of outfall, wetland impacts, park alienation	Abandoned. Cannot daylight outfall in wetland.
Thurston Basin	T-12	Additional GI and Environmental Improvements	JAM-005/007	Limited water quality benefits, reduced SW volume, improved habitat, low cost	Retain. Low cost-to-benefit ratio. Co-benefits.

Spring Creek Alternatives

Spring Creek straddles the boundary of Brooklyn and Queens and is located immediately south of the Spring Creek AWWTP. It receives discharges from approximately a 4,250 acre drainage area, of which approximately 3,300 acres is combined drainage area and 600 acres is separated sewershed. About 300 acres of direct drainage exists along the banks of the basin. Flows enter this basin through 1 CSO, 1 MS4 and 6 other storm outfalls. CSO Outfall 26W-005 is the tank overflow which has 72 tide gates measuring 7'-6" x 2'-5" each. Based on 2040 projected flows, with all proposed WWFP projects constructed, the model predicted discharges to Spring Creek to amount to 310 MGY of CSO and 44 MGY of storm flow. Water quality modeling indicates that Existing WQ Criteria for fecal coliform and DO are attained under baseline conditions. In addition, attainment of Proposed *Enterococci* WQ Criteria* (GM<35%) is achieved during the recreational season (May 1st through October 31st). However, the Proposed *Enterococci* WQ Criteria* (STV<130%) is not attained at the head end of Spring Creek.

Water Quality/Ecological Enhancements: The control measures under the category of Water Quality/Ecological Enhancements are not CSO reduction measures but, rather, focus on enhancing the water quality through other approaches.

Environmental Dredging: Based upon NOAA navigation charts and field observations, sediment deposition does not appear to be an issue in this waterbody. In addition, a review of historical complaint records does not indicate an issue with odors in the area. As a result, this technology will not be retained for further consideration.

Wetlands and Bioextractors: As Spring Creek is in attainment with Existing WQ Criteria for fecal coliform and Proposed *Enterococci* WQ Criteria* (GM<35 cfu/100mL) under baseline conditions, ribbed mussels will not be retained for further consideration. However, preliminary field investigations indicate that approximately 13 acres of tidal wetlands could be restored along the shoreline of Spring Creek. As implementation of tidal wetlands will help to build upon the water quality improvements associated with the implementation of the WWFP recommendations through enhancement of fish and wildlife habitats, promote filtering of direct drainage and other co-benefits, tidal wetland restoration will be retained for further consideration.

Since the only source of CSO into this waterbody is the overflow from the Spring Creek AWWTP, only *Treatment* alternatives for modifications to this existing facility were considered.

Evaluation of Re-purposing or Upgrading of Existing Infrastructure for Retention/Treatment

The Jamaica Bay WWFP recommended upgrades to the Spring Creek AWWTP consisting of floatables control, high rate settling and in-line CSO storage. Thus, alternatives evaluations in the LTCP focused on outfall disinfection only. DEP is currently conducting a CSO chlorination study at this facility in order to optimize sodium hypochlorite dosage needed to achieve a two-log kill (99 percent bacteria reduction), to minimize residuals to near non-detect and to avoid the need for dechlorination.

Under baseline conditions, the Spring Creek AWWTP discharges seven times annually with a total AAOV of 310 MGY under 2008 typical year rainfall conditions. Of the seven overflow events annually, four of those events occur during the recreational season (May 1st through October 31st). Despite the infrequent overflow, operators would need to activate the chlorination process for the majority of storm events to

*Proposed *Enterococci* WQ Criteria, if adopted as proposed, would only apply to coastal Class SB and SA waters.

avoid the risk of discharging untreated effluent from the tank. As a result, large volumes of chemicals would be applied to the flow entering the tank without any concomitant benefit.

A review of the gap analysis indicates that Existing WQ Criteria and Proposed *Enterococci* WQ Criteria* (GM<35 cfu/100mL) are attained in Spring Creek with no appreciable improvement in attainment (one percent annually and two percent during the recreation season) with 100% CSO control. In consideration of the limited water quality benefit, this alternative was eliminated from further consideration.

8.2.h Retained Alternatives (Spring Creek)

The goal of the previous evaluations was the development of a list of retained control measures for Outfall 26W-005 to Spring Creek. These control measures, whether individually or in combination, formed the basis of basin-wide alternatives that DEP assessed using the more rigorous cost-performance and cost-attainment analyses. That list is presented in Table 8-10. The reasons for excluding the non-retained control measures from further consideration are also noted in the table. As shown, the retained control measures were limited to Environmental Improvements.

Table 8-10. Summary of Spring Creek Specific Alternatives

Waterbody	Alternative ID	Description	Impacted Outfalls	Modeling Results	Status
Spring Creek	SC-3	Construction of disinfection and dechlorination facilities (if needed) at the Spring Creek AWWTP	26W-005	Limited water quality benefits, community opposition, concerns with operational effectiveness	Abandoned. Negligible water quality benefit.
Spring Creek	SC-4	Environmental Improvements	All CSO and SW Outfalls	Builds upon past WWFP projects. Enhances fish and wildlife habitat and other co-benefits.	Retain for further evaluation.

Hendrix Creek Alternatives

Hendrix Creek is located in Brooklyn, to the immediate East of the 26th WWTP. It receives discharges from approximately a 450 acre drainage area, out of which approximately 250 acres is combined drainage area, 100 acres is MS4 drainage area and 100 acres is separately sewered. Small quantities of direct drainage also exist along the banks of the basin. Flows discharge to this basin through one WWTP effluent outfall, one WWTP plant bypass sewer, one CSO, two MS4 and 21 other storm outfalls. CSO Outfalls 26W-002, 26W-004 and 26W-001 are the three biggest outfalls, measuring QBL 11' x 7.5', QBL 11' x 7.5' and 10' x 6', respectively. Based on 2040 projected flows, with all proposed WWFP projects constructed, the model predicted discharges to Hendrix Creek to amount to 104 MGY of CSO and 112 MGY of storm flow, in addition to the 19,622 MGY of WWTP effluent flows.

Under baseline conditions, water quality modeling projects that this waterbody is in attainment of Existing WQ Criteria for fecal coliform over a typical year. Attainment of Proposed *Enterococci* WQ Criteria* (GM<35 cfu/100mL) is also achieved during the recreational season (May 1st through October 31st). However, Existing WQ Criteria for DO (Class I) and the Proposed *Enterococci* WQ Criteria* (STV<130%)

*Proposed *Enterococci* WQ Criteria, if adopted as proposed, would only apply to coastal Class SB and SA waters.

would not be achieved for the 95 percent attainment metric. The gap analysis indicates that attainment can be improved by one percent from 90 percent under baseline conditions to 91 percent with 100% CSO control. Considering the limited benefit of 100% CSO control, cost-to-benefit ratios for CSO control are expected to be high.

A review of existing land uses near the discharge of Outfall 26W-004 was performed for the purposes of identifying potential sites for new retention/treatment facilities. As indicated in Figure 8-20, the most suitable location identified was an 18 acre, partially vacant lot at the southern end of the 26th Ward WWTP, under the jurisdiction of DEP. Other viable parcels for construction included two acre and 40 acre lots under the jurisdiction of the New York City Department of Parks and Recreation, and a two acre lot under the jurisdiction of the New York City Department of General Services, all on the east side of the Creek, across from the WWTP.

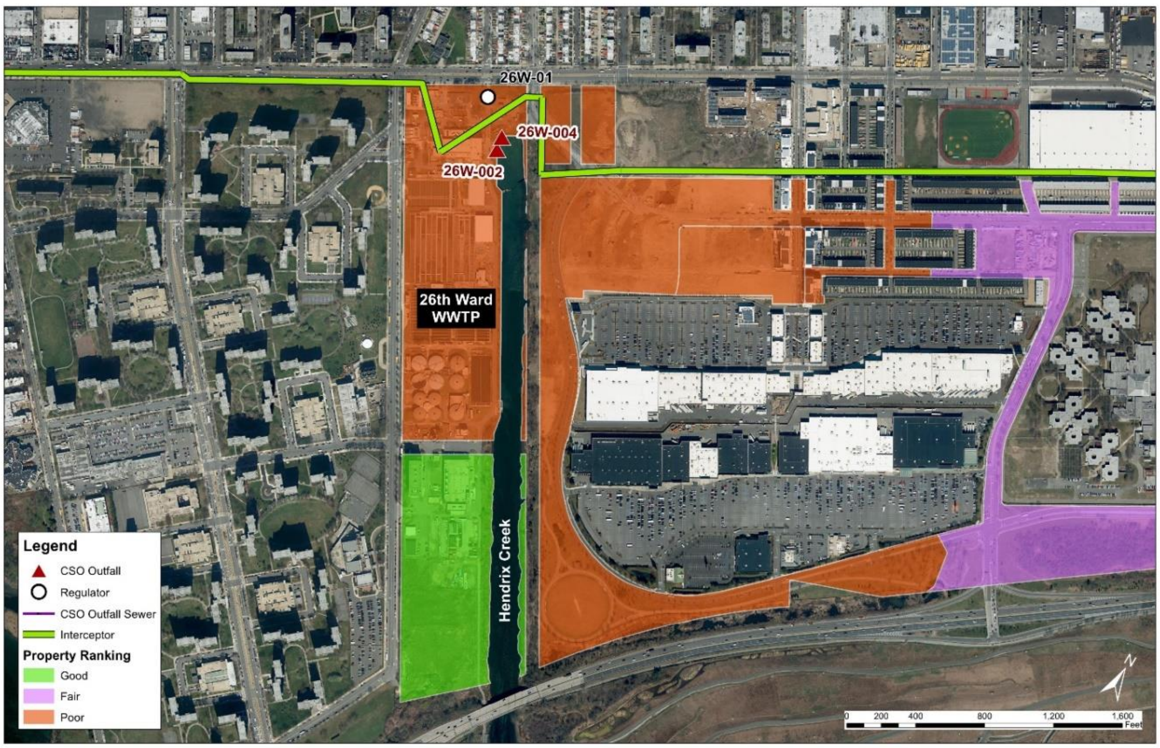

Figure 8-20. Potential Properties near Hendrix Creek CSO Outfalls

CSO Relocation: This concept involves conveying overflows by gravity from one receiving water to another, where the second receiving water would either be less sensitive or provide greater dilution/assimilation than the one from which the CSO is being diverted. Neither *Gravity Flow Tipping* nor *Flow Tipping with Conduit/Tunnel and Pumping* were recommended in the WWFP for Hendrix Creek. Based on modeling, Fresh Creek and Spring Creek were both determined to be just as sensitive, if not more so, than Hendrix Creek. In addition, diversion of the outfall to Jamaica Bay, which has more stringent water quality standards for the promotion of primary contact recreation, is contrary to the intended uses of the Bay. As a result, these alternatives will not be evaluated further under the LTCP.

Water Quality/Ecological Enhancements: The control measures under the category of Water Quality/Ecological Enhancements are not CSO reduction measures but, rather, focus on enhancing the water quality through other approaches.

Environmental Dredging: Based upon NOAA navigation charts and field observations, sediment deposition does not appear to be an issue in this waterbody. As a review of historical complaint records does not indicate an issue with odors in the area, this technology will not be retained for further consideration.

Wetlands and Bioextractors: As Hendrix Creek attains Existing WQ Criteria for fecal coliform and Proposed *Enterococci* WQ Criteria* (GM<35 cfu/100mL) under baseline conditions, ribbed mussels will not be retained for further consideration. However, preliminary field investigations indicate that approximately three acres of tidal wetlands could be restored along the shoreline of Hendrix Creek. As implementation of tidal wetlands will help to build upon the water quality improvements associated with the implementation of the Jamaica Bay WWFP recommendations through enhancement of fish and wildlife habitats, promoting filtering of direct drainage and other co-benefits, tidal wetland restoration will be retained for further consideration.

WWTP Upgrades: Model runs were performed to simulate a 20 percent increase in treatment capacity at the 26th Ward WWTP. IW modeling indicated that WWTP capacity upgrades would negligibly reduce CSO discharges unless storage capacity is provided to equalize peak wet-weather flow. As a result, this alternative was eliminated from further evaluation for the 26th Ward WWTP.

Retention / Treatment: A number of the control measures considered for Hendrix Creek fall under the dual category of treatment and retention/storage. These control measures include in-line or in-system storage, off-line tanks and deep tunnel storage. Treatment refers to disinfection in either CSO outfalls or at RTBs. A discussion of the retention/treatment alternatives evaluated follows.

Evaluation of Re-purposing or Upgrading of Existing Infrastructure for Retention/Treatment

Initial evaluations focused on maximizing the performance of existing infrastructure to capture and/or treat CSO discharges. *In-system storage* is problematic due to the lack of existing infrastructure large enough to accommodate such volumes; though the sewer to Outfall 26W-004 is a large quad barrel, 11' x 7.5', it has a short run of only about 250 LF between the regulator and the outfall, which does not provide sufficient CSO storage capacity to reduce the frequency of volume of discharge. In addition, optimization alternatives evaluated for the collection system tributary to 26th Ward WWTP indicate hydraulic grade line impacts increasing the risk of flooding. As a result, *In-system storage* has been eliminated from further consideration.

Outfall disinfection was determined to be non-viable for Hendrix Creek due to the lack of available contact time within the CSO outfall sewer. The outfall for 26W-004 is only 250 feet long providing insufficient contact time. Thus, this alternative has been eliminated from further evaluation for Hendrix Creek.

*Proposed *Enterococci* WQ Criteria, if adopted as proposed, would only apply to coastal Class SB and SA waters.

Evaluation of New Retention/Treatment Facilities

As mentioned earlier and illustrated in Figure 8-20, a number of viable sites for the installation of new treatment or storage facilities were identified in the vicinity of Hendrix Creek. The most suitable location identified was an 18 acre partially vacant lot at the southern end of the 26th Ward WWTP, under DEP's jurisdiction. Other viable parcels for construction included a two acre and 40 acre lots under the jurisdiction of New York City Department of Parks and Recreation, and a two acre lot under the jurisdiction of the New York City Department of General Services, all on the east side of the Creek, across from the WWTP. However, unless all facilities are constructed below grade, park alienation concerns would eliminate the New York City Department of Parks and Recreation properties from further consideration.

Based on the identified properties, *CSO Storage Tanks* could be sited at the southern end of the WWTP or at the head end of Hendrix Creek, with minimal impacts to existing utilities or above-grade infrastructure. A diversion chamber would be required along the sewer to Outfall 26W-004 to convey wet-weather flow to the tank. Influent flow would be screened of large solids and floatable material. Following each storm event, the tank would be dewatered and cleaned and prepared for the next event. Flushing gates, tipping buckets, nozzle systems and/or high pressure hoses would be provided to facilitate cleaning of the tank bottom. Flushed grit and solids would be conveyed in a channel to a wet well containing dewatering pumps for pump down of the facilities to the Vandalia Avenue Interceptor for conveyance to the 26th Ward WWTP. Due to its proximity to residential and commercial properties, odor control facilities using activated carbon would be provided. Due to a very high cost-to-benefit ratio, this alternative has been eliminated from further evaluation.

Retention Treatment Basins could be sited in similar locations at similar cost to the tank alternative, without providing any additional water quality benefits. Thus, due to a very high cost-to-benefit ratio, this alternative has been eliminated from further evaluation.

The *CSO Storage Tunnel* alternative described below requires dewatering of stored CSO volumes after wet-weather events occur. Table 8-11 provides a summary of the total storage volume and the associated dewatering rate assuming a 24-hour dewatering period for storage facilities providing 25, 50, 75, and 100 percent levels of CSO Control for Hendrix Creek.

Table 8-11. Storage and Dewatering System Capacity for Storage Alternatives for Hendrix Creek

Level of Control	Storage Volume (MG)	Dewatering PS Capacity(1) (MGD)
25%	2	5
50%	4	5
75%	8	10
100%	18	15

Note:
(1) Assumes pump-back of stored CSO within a 24 hour period.

Alternative HC-6: CSO Storage Tunnel from Outfall 26W-004 with a Dewatering Pumping Station at Spring Creek AWWTP

As a result of the limited availability of suitable sites for traditional storage and satellite treatment technologies within the Hendrix Creek sewershed, tunnel alternatives were developed further. As illustrated in Figure 8-21, tunnel construction would involve the boring of a linear storage conduit under Flatlands or Vandalia Avenues. Shafts would be installed during construction for the connection of CSO diversion pipes and O&M access. A tunnel dewatering pumping station (TDPS) would also be included at the downstream end of the tunnel with pumped discharges being conveyed to the Spring Creek AWWTP for treatment after wet-weather events. A mechanical ventilation system would be provided with an activated carbon odor control system. Additional passive odor control systems and/or backdraft dampers would be provided at the drop shafts.

A diversion chamber, a screening/grit chamber and a receiving/drop shaft would be sited along Outfall 26W-004, causing temporary disturbances to the 26th Ward WWTP lot. A gravity sewer would convey flows from this diversion chamber through the screening and grit chamber to the storage tunnel. Two alignments of the 5,000 LF tunnel were evaluated – one following Flatlands Avenue (Alternative HC-6a) and the other following Vandalia Avenue (Alternative HC-6b), both of which convey flow to the head end of the Spring Creek AWWTP. A launch shaft, screening chamber and 50 MGD TDPS would be sited at the head end of the AWWTP.

This system would remain inactive during dry-weather, only seeing flows during wet-weather events, when the hydraulic capacity of the interceptor is exceeded and the weir at Regulators 26W-01 is overtopped. Flows would then be diverted to this tunnel, which would retain these CSOs until the wet-weather event has receded and the Spring Creek AWWTP could handle the CSO pump back.

Modeling determined that a 7 foot diameter single barrel 1.5 MG tunnel would be required for 25 percent capture of CSOs, a 11 foot diameter single barrel 3.4 MG tunnel would be required for 50 percent capture, a 17 foot diameter single barrel 7.7 MG tunnel would be required for 75 percent capture and a 25 foot diameter single barrel 18 MG tunnel would be required for 100% CSO capture.

Figure 8-21. Layout of CSO Storage Tunnel and 50 MGD Dewatering Pumping Station at the Spring Creek AWWTP

The benefits, cost, and challenges associated with this alternative are as follows:

<u>Benefits</u>

- Can provide high level of CSO capture and treatment
- Provides storage and conveyance for control of wet-weather peak flows from Regulator 26W-01

<u>Cost</u>

- The estimated NPW for this control measure varies by level of control as follows:
  - 25% CSO control: $716M
  - 50% CSO control: $747M
  - 75% CSO control: $758M
  - 100% CSO control: $868M

<u>Challenges</u>

- Limited improvement in Hendrix Creek water quality attainment

- Site constraints for construction of diversion chamber and tunnel receiving shaft at head of 26th Ward WWTP
- Park alienation for construction of dewatering pumping station near Spring Creek AWWTP

As previously stated, the preliminary Gap Analysis showed that water quality benefits from reducing CSOs in Hendrix Creek were minimal even with 100% CSO capture. Thus, due to a high cost-to-benefit ratio, this alternative has been eliminated from further evaluations.

8.2.i Retained Alternatives (Hendrix Creek)

The goal of the previous evaluations was the development of a list of retained control measures for Outfall 26W-004 to Hendrix Creek. These control measures, whether individually or in combination, formed the basis of basin-wide alternatives that DEP assessed using the more rigorous cost-performance and cost-attainment analyses. That list is presented in Table 8-12. The reasons for excluding the non-retained control measures from further consideration are also noted in the table. As shown, the retained control measures were limited to Environmental Improvements.

Table 8-12. Summary of Hendrix Creek Specific Alternatives

Waterbody	Alternative ID	Description	Impacted Outfalls	Observations	Status
Hendrix Creek	HC-3	Construction of disinfection and dechlorination facilities (if needed) at CSO outfall	26W-004	Insufficient contact time to enable significant reduction in bacteria loading	Abandoned due to insufficient contact time
Hendrix Creek	HC-4	Construction of a CSO storage tank at vacant lot south of 26th Ward WWTP with a dewatering pumping station and force main to the head end of the WWTP	26W-004	Significant reduction in CSO but with limited Water Quality Benefits	Abandoned due to high cost-to-benefit ratio
Hendrix Creek	HC-6	Construction of a CSO Storage Tunnel from 26W-004 to the Spring Creek AWWTP	26W-004	Significant reduction in CSO but with limited Water Quality Benefits	Abandoned due to high cost-to-benefit ratio
Hendrix Creek	HC-7	Construction of a RTB at the south end of 26th Ward WWTP	26W-004	Significant reduction in CSO bacteria loadings but with limited Water Quality Benefits	Abandoned due to high cost-to-benefit ratio
Hendrix Creek	HC-8	Environmental Improvements	All CSO and SW Outfalls	Builds upon past WWFP projects. Enhances fish and wildlife habitat and other co-benefits.	Retain for further evaluation

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Fresh Creek Alternatives

Fresh Creek is located in Brooklyn, to the West of the 26th WWTP. The combined collection system receives stormwater runoff from approximately a 4,250 acre drainage area, out of which approximately 3,300 acres is combined drainage area, 50 acres is MS4 drainage area, 600 acres is separately sewered and 300 acres is direct drainage to the basin. Wet-weather flow is discharged to Fresh Creek through one CSO, four MS4 and 14 other storm outfalls. Outfall 26W-003 is the biggest sewer, measuring QBL 15' x 10'. Based on 2040 projected flows, with all proposed WWFP projects constructed, the model predicted discharges to Fresh Creek to amount to 300 MGY of CSO and 520 MGY of storm flow. Water quality analysis showed that this waterbody achieves dissolved oxygen attainment for the 2008 typical year rainfall. While fecal coliform attainment for Existing WQ Criteria is not achieved, attainment of the Proposed *Enterococci* WQ Criteria* (GM<35 cfu/100mL) are met for the recreational season (May 1st through October 31st). Attainment of the Proposed *Enterococci* WQ Criteria* (STV<130 cfu/100mL), however, is not achieved. A review of the gap analysis indicates that annual attainment for fecal coliform can be improved from 86 percent to 91 percent and recreational season attainment can be improved from 93 percent to 98 percent with 100% CSO control.

A review of existing land uses near the discharge of Outfall 26W-003 was performed for the purposes of identifying potential sites for new retention/treatment facilities. Figure 8-22 indicates that the only suitable location identified was a privately owned parcel at the head end of Fresh Creek. Based on field inspection in the winter of 2017, it is believed that the site is being developed. Properties to the north are under the jurisdiction of the NYC Department of Parks and Recreation and the New York City Housing Authority. Due to the lack of vacant city-owned property, acquisition of private properties would need to be considered to accommodate additional CSO controls.

*Proposed *Enterococci* WQ Criteria, if adopted as proposed, would only apply to coastal Class SB and SA waters.

Figure 8-22. Potential Properties near Fresh Creek CSO Outfalls

CSO Relocation: This concept involves conveying overflows by gravity from one receiving water to another receiving water, where the second receiving water would either be less sensitive or provide greater dilution/assimilation than the one from which the CSO is being diverted. Neither *Gravity Flow Tipping* nor *Flow Tipping with Conduit/Tunnel and Pumping* were recommended in the WWFP for Fresh Creek. Based on water quality modeling, Hendrix Creek and Paerdegat Basin were both determined to attain Existing WQ Criteria for fecal coliform just above the 95 percent metric. Diversion of additional CSO to these waterbodies would impact attainment within these waterbodies. In addition, diversion of the outfall to Jamaica Bay, which has more stringent water quality standards for the promotion of primary contact recreation, is contrary to the intended uses of the Bay. As a result, *CSO Relocation* has been eliminated from further consideration under this LTCP.

Water Quality/Ecological Enhancements: The control measures under the category of Water Quality/Ecological Enhancements are not CSO reduction measures but, rather, focus on enhancing the water quality through other approaches.

Environmental Dredging: Based upon NOAA navigation charts and field observations, sediment deposition does not appear to be an issue in Fresh Creek. In addition, a review of historical complaint records does not indicate an issue with odors in the area. As a result, this technology will not be retained for further consideration.

Wetlands and Bioextractors: While under baseline conditions, Fresh Creek does not attain Existing WQ Criteria for fecal coliform, Proposed *Enterococci* WQ Criteria* (GM<35 cfu/100mL) are achieved. As a result, ribbed mussels will not be retained for further consideration. However, preliminary field investigations indicate that approximately 14 acres of tidal wetlands could be restored along the shoreline of Fresh Creek. As implementation of tidal wetlands will help to build upon the water quality improvements associated with the implementation of the Jamaica Bay WWFP recommendations through enhancement of fish and wildlife habitats, promoting filtering of direct drainage and other co-benefits, tidal wetland restoration will be retained for further consideration.

WWTP Upgrades: Model runs were performed to simulate a 20 percent increase in treatment capacity at the 26th Ward WWTP. IW modeling indicated that WWTP capacity upgrades would negligibly reduce CSO discharges unless storage capacity is provided to equalize peak wet-weather flow. As a result, this alternative was eliminated from further evaluation for the 26th Ward WWTP.

Retention / Treatment: A number of the control measures considered for Fresh Creek fall under the dual category of treatment and retention/storage. These control measures include in-line or in-system storage, off-line tanks and deep tunnel storage. Treatment refers to disinfection in either CSO outfalls or at RTBs. A discussion of the retention/treatment alternatives evaluated follows.

Evaluation of Re-purposing or Upgrading of Existing Infrastructure for Retention/Treatment

Initial evaluations focused on maximizing the performance of existing infrastructure to capture and/or treat CSO discharges. *In-System storage* is problematic due to the lack of existing infrastructure large enough to accommodate such volumes; though the sewer to Outfall 26W-003 is a large QBL15' x 10', it has a short run of only about 350 LF between regulator and outfall, which does not provide sufficient CSO storage capacity to reduce the frequency of volume of discharge. In addition, optimization alternatives evaluated for the collection system tributary to 26th Ward WWTP indicate hydraulic grade line impacts increasing the risk of flooding. As a result, *In-system storage* has been eliminated from further consideration.

Outfall disinfection was determined to be non-viable for Fresh Creek due to the lack of available contact time within the CSO outfall sewer. The outfall for 26W-003 is only 350 feet long providing insufficient contact time within the outfall sewer. As a result, *In-system storage* has been eliminated from further consideration.

Evaluation of New Retention/Treatment Facilities

As mentioned earlier and illustrated in Figure 8-22, no vacant city-owned properties were identified in the vicinity of Fresh Creek and DEP would thus have to consider acquisition of private property. Acquisition of any private sites is challenging and would require either negotiated acquisition or the use of eminent domain.

IW modeling performed to estimate the size of *CSO Storage tanks* for 25, 50, 75 and 100 percent CSO control indicated that at least 1.1 acres would be required to accommodate a tank and related facilities. While Retention Treatment Basins typically require a smaller footprint, a RTB sized for 25 percent CSO control was estimated to require 0.5 acres. Due to the unavailability of properties of sufficient size to accommodate a tank or RTB in close proximity to Fresh Creek, *CSO Storage Tanks and RTBs* were eliminated from further consideration.

*Proposed *Enterococci* WQ Criteria, if adopted as proposed, would only apply to coastal Class SB and SA waters.

The *CSO Storage Tunnel* alternative described below requires dewatering of stored CSO volumes after wet-weather events occur. Table 8-13 provides a summary of the total storage volume and the associated dewatering rate assuming a 24-hour dewatering period for storage facilities providing 25, 50, 75, and 100 percent levels of CSO Control for Outfall 26W-003.

Table 8-13. Storage and Dewatering System Capacity for Storage Alternatives for Outfall 26W-003

Level of Control	Storage Volume (MG)	Dewatering PS Capacity(1) (MGD)
25%	6	10
50%	15	15
75%	28	30
100%	53	50

Note:
(1) Assumes pump-back of stored CSO within a 24 hour period.

<u>**Alternative FC-6: CSO Storage Tunnel from Outfall 26W-003 with a Dewatering Pumping Station at 26th Ward WWTP**</u>

As a result of the limited availability of suitable sites for traditional storage and satellite treatment technologies within the Fresh Creek sewershed, tunnel alternatives were developed further. Tunnel construction, as shown in Figure 8-23, would involve the boring of a linear storage conduit along Flatlands Avenue. Shafts would be installed during construction for the connection of CSO diversion pipes and O&M access. A TDPS would also be included at the downstream end of the tunnel with pumped discharges being conveyed to the 26th Ward WWTP for treatment after wet-weather events. Mechanical ventilation would be provided with an activated carbon odor control system. Additional passive odor control systems and/or backdraft dampers would be provided at the drop shafts.

A diversion chamber, a screening/grit chamber and a receiving/drop shaft would be sited along Outfall 26W-003. A gravity sewer would convey flows from this diversion chamber through the screening and grit chamber to the storage tunnel. The alignment generally follows Flatlands Ave for approximately 3,500 LF and conveys flow to the head end of the 26th Ward WWTP. A launch shaft, screening chamber and 50 MGD TDPS would be sited at the head end of the WWTP.

This system would remain inactive during dry-weather, only seeing flows during wet-weather events, when the hydraulic capacity of the interceptor is exceeded and the weir at Regulators 26W-02 is overtopped. Flows would then be diverted to this tunnel, which would retain these CSOs until the wet-weather event has receded and the WWTP could handle the CSO pump back.

Modeling determined that a 16 foot diameter single barrel 6 MG tunnel would be required for 25 percent capture of CSOs, a 27 foot diameter single barrel 15 MG tunnel would be required for 50 percent capture, a 39 foot diameter single barrel 31 MG tunnel would be required for 75 percent capture and a 51 foot diameter single barrel 54 MG tunnel would be required for 100% CSO capture.

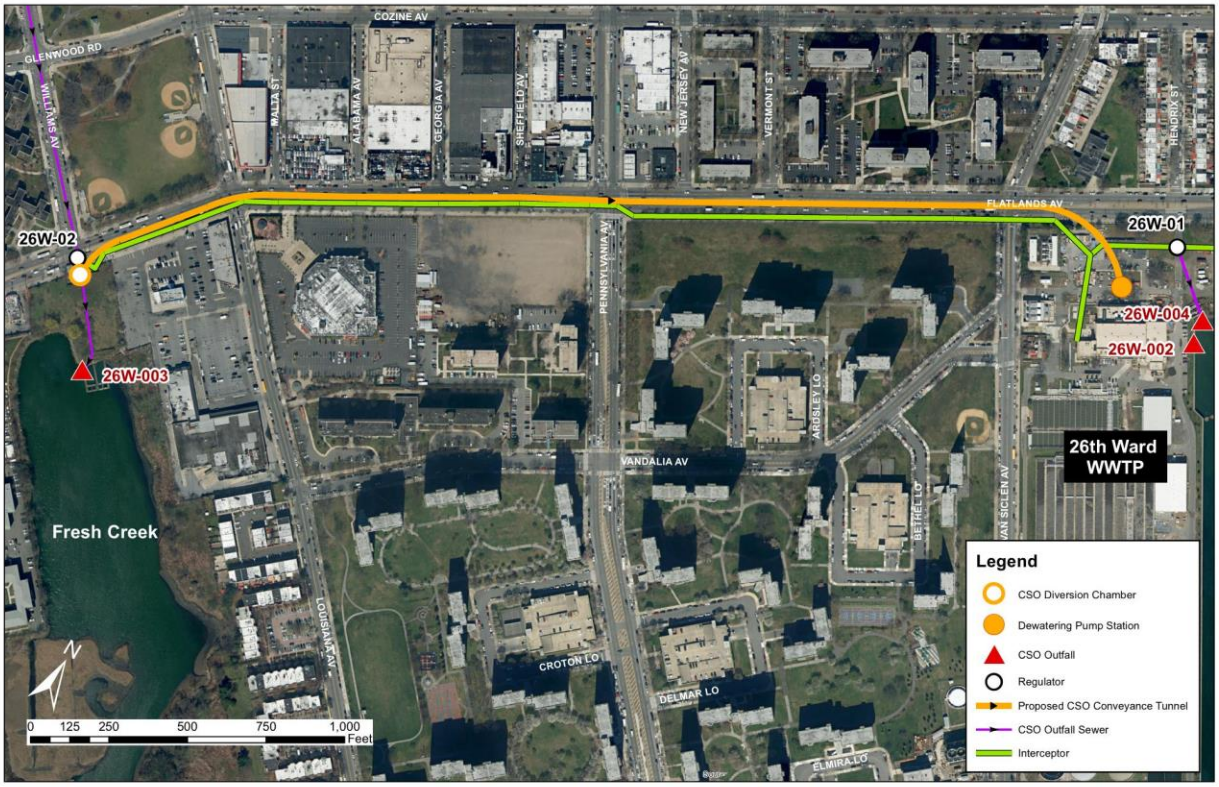

Figure 8-23. Layout of CSO Storage Tunnel and Dewatering Pumping Station at the 26th Ward WWTP

The benefits, cost and challenges associated with this alternative are as follows:

Benefits

- Can provide high level of CSO capture and treatment
- Provides storage and conveyance for control of wet-weather peak flows from Regulator 26W-02

Cost

- The estimated NPW for this control measure varies by level of control as follows:
  - 25% CSO control: $738M
  - 50% CSO control: $840M
  - 75% CSO control: $1,067M
  - 100% CSO control: $1,471M

Challenges

- Limited improvement in Fresh Creek water quality attainment
- Limited space at the head of the WWTP to accommodate the dewatering pumping station

- The 100% CSO control tunnel is near the limit of current TBM technology and may not be constructible

As previously stated, preliminary Gap Analysis showed that water quality benefits from reducing CSOs in Fresh Creek were limited even with 100% CSO capture. Thus, due to a high cost-to-benefit ratio, this alternative has been eliminated from further evaluations.

8.2.j Retained Alternatives (Fresh Creek)

The goal of the previous evaluations was the development of a list of retained control measures for Outfall 26W-003 to Fresh Creek. These control measures, whether individually or in combination, formed the basis of basin-wide alternatives that DEP assessed using the more rigorous cost-performance and cost-attainment analyses. That list is presented in Table 8-14. 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 Environmental Improvements.

Table 8-14. Summary of Fresh Creek Specific Alternatives

Waterbody	Alternative ID	Description	Impacted Outfalls	Observations	Status
Fresh Creek	FC-6	Construction of a CSO Storage Tunnel from 26W-003 to the 26th Ward WWTP	26W-003	Significant reduction in CSO but with limited Water Quality Benefits	Abandoned due to high cost-to-benefit ratio
Fresh Creek	FC-8	Environmental Improvements	All CSO and SW Outfalls	Builds upon past WWFP projects. Enhances fish and wildlife habitat and other co-benefits.	Retain for further evaluation

Paerdegat Basin Alternatives

The head end of Paerdegat Basin is located, near the intersection of Ralph and Flatlands Avenues in Brooklyn. The waterbody receives discharges from approximately a 5,950 acre drainage area, of which approximately 5,200 acres is combined drainage area, 300 acres is MS4 drainage area and 200 acres is separated sewershed. In addition, about 250 acres of direct drainage passes along the ground surface and down the stream banks to Paerdegat Basin. Flow is discharged to this waterway through the Paerdegat Basin CSO Retention Facility overflow, three CSO, five MS4 and nine other storm outfalls. CSO Outfalls CI-004, CI-005 and CI-006 are the three largest of these outfalls, measuring DBL 12' x 9', DBL 10' x 9' and DBL 7', respectively.

Based on 2040 projected flows, with all proposed WWFP projects constructed, the model predicted discharges to Paerdegat Basin to amount to 591 MGY of CSO and 351 MGY of storm flow. Continuous 10-year water quality modeling indicates that Existing WQ Criteria for fecal coliform and dissolved oxygen are achieved under baseline conditions. In addition, attainment of Proposed *Enterococci* WQ Criteria* (GM<35 cfu/100mL) is achieved during the recreational season (May 1st through October 31st). The Proposed *Enterococci* WQ Criteria* (STV<130 cfu/100mL) is not attained.

*Proposed *Enterococci* WQ Criteria, if adopted as proposed, would only apply to coastal Class SB and SA waters.

Water Quality/Ecological Enhancements: The control measures under the category of Water Quality/Ecological Enhancements are not CSO reduction measures but, rather, focus on enhancing the water quality through other approaches.

Environmental Dredging: Based upon NOAA navigation charts and field observations, sediment deposition does not appear to be an issue in this waterbody. In addition, a review of historical complaint records does not indicate an issue with odors in the area. As a result, this technology will not be retained for further consideration.

Wetlands and Bioextractors: As Paerdegat Basin is in attainment with Existing WQ Criteria for fecal coliform and Proposed *Enterococci* WQ Criteria* (GM<35 cfu/100mL) under baseline conditions, ribbed mussels will not be retained for further consideration. However, preliminary field investigations indicate that approximately four acres of tidal wetlands could be restored along the shoreline of Paerdegat Basin. As implementation of tidal wetlands will help to build upon the water quality improvements associated with the implementation of the Jamaica Bay WWFP recommendations through enhancement of fish and wildlife habitats, promote filtering of direct drainage and other co-benefits, tidal wetland restoration was retained for further consideration.

Since the majority of the CSO into this waterbody is the overflow from the Paerdegat CSO Retention Facility, only *Treatment* alternatives for modifications to this facility were considered.

Evaluation of Re-purposing or Upgrading of Existing Infrastructure for Retention/Treatment

The Paerdegat Basin CSO Facility already provides floatables control and CSO storage, in tanks and the influent sewers. Thus, initial evaluations in the LTCP focused on outfall disinfection only.

Under baseline conditions, the Paerdegat Basin CSO Retention Facility discharges 12 times annually with a total AAOV of 591 MGY under 2008 typical year rainfall conditions. Of the 12 overflow events annually, eight of those events occur during the recreational season (May 1st through October 31st). Despite the infrequent overflow, operators would need to activate the chlorination process for the majority of storm events to avoid the risk of discharging undisinfected effluent from the tank. As a result, large volumes of disinfection chemicals would be applied to the flow entering the tank without any concomitant benefit.

A review of the gap analysis indicates that Existing WQ Criteria for fecal coliform and Proposed *Enterococci* WQ Criteria* (GM<35 cfu/100mL) are attained in Paerdegat Basin; analysis of a modeled 100% CSO control provided limited improvement in attainment (three percent annually and five percent during the recreation season). In consideration of the limited water quality benefit, this alternative was eliminated from further consideration.

*Proposed *Enterococci* WQ Criteria, if adopted as proposed, would only apply to coastal Class SB and SA waters.

8.2.k Retained Alternatives (Paerdegat Basin)

The goal of the previous evaluations was the development of a list of retained control measures for the Paerdegat CSO Retention Facility overflow and Outfalls CI-004, CI-005 and CI-006. These control measures, whether individually or in combination, formed the basis of basin-wide alternatives that DEP assessed using the more rigorous cost-performance and cost-attainment analyses. That list is presented in Table 8-15. 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 Environmental Improvements.

Table 8-15. Summary of Paerdegat Basin Specific Alternatives

Waterbody	Alternative ID	Description	Impacted Outfalls	Observations	Status
Paerdegat Basin	PB-3	Construction of disinfection and dechlorination facilities (if needed) at the Paerdegat Basin CSO Retention Facility	Tank Overflow Outfall	Limited water quality benefits, community opposition, concerns with operational effectiveness	Abandoned. Limited water quality benefit.
Paerdegat Basin	PB-4	Environmental Improvements	All CSO and SW Outfalls	Builds upon past WWFP projects. Enhances fish and wildlife habitat and other co-benefits.	Retain for further evaluation

<u>Jamaica Bay Alternatives</u>

Jamaica Bay receives discharges from an approximately 66,269 acre drainage area, of which approximately 15,287 acres is combined sewer area, 13,396 acres is MS4 drainage area, 10,643 acres is separated sewershed and about 22,934 acres is direct drainage. Stormwater is discharged to the Bay via 109 MS4 and 26 other storm outfalls.

Based on 2040 projected flows, with all proposed WWFP projects constructed, the model indicates that no CSO discharges occur under 2008 typical year rainfall conditions from the six Rockaway CSOs. Model predicted stormwater discharges to Jamaica Bay amount to 6,645 MGY of storm flow. Water quality modeling indicates that Existing WQ Criteria for fecal coliform and DO (Class SB) are achieved under baseline conditions. In addition, attainment of Proposed *Enterococci* WQ Criteria* (GM<35 cfu/100mL) is achieved during the recreational season (May 1st through October 31st). While the Proposed *Enterococci* WQ Criteria* (STV<130 cfu/100mL) is attained at most stations within the Bay, a station located near the confluence of Bergen Basin falls below 95 percent.

Wetlands and Bioextractors: As Jamaica Bay is in attainment with Existing WQ Criteria for fecal coliform and Proposed *Enterococci* WQ Criteria* (GM<35 cfu/100mL) under baseline conditions, ribbed mussels will not be retained for further consideration. However, preliminary field investigations indicate that approximately 16 acres of tidal wetlands could be restored in addition to current USACE funded projects. Tidal wetlands would be restored throughout the Bay including the Northern Channel, Inner Bay, and Rockaway Shore. As implementation of tidal wetlands will help to build upon the water quality improvements associated with the implementation of the Jamaica Bay WWFP recommendations through enhancement of fish and wildlife habitats, promoting filtering of direct drainage and other co-benefits, tidal wetland restoration will be retained for further consideration.

*Proposed *Enterococci* WQ Criteria, if adopted as proposed, would only apply to coastal Class SB and SA waters.

8.2.l Retained Alternatives (Jamaica Bay)

The goal of the previous evaluations was the development of a list of retained control measures for Jamaica Bay. These control measures, whether individually or in combination, formed the basis of basin-wide alternatives that DEP assessed using the more rigorous cost-performance and cost-attainment analyses. That list is presented in Table 8-16. The reasons for excluding the non-retained control measures from further consideration are also noted in the table. As shown, the retained control measure is Environmental Improvements.

Table 8-16. Summary of Jamaica Bay Specific Alternatives

Waterbody	Alternative ID	Description	Impacted Outfalls	Observations	Status
Jamaica Bay	JB-1	Environmental Improvements	All CSO and SW Outfalls	Builds upon past WWFP projects. Enhances fish and wildlife habitat and other co-benefits.	Retain for further evaluation

Regional Planning Alternatives

In addition to developing alternatives for each waterbody individually, this LTCP also considers implementing alternatives which span across multiple basins to provide consolidation of flows for storage and treatment.

Three regional tunnel alternatives were evaluated for capture CSO from each of the existing active CSO outfalls for conveyance to existing treatment facilities. The regional CSO storage tunnels require dewatering of stored CSO volumes after wet-weather events and can utilize available capacities at the Jamaica, 26th Ward and Coney Island WWTPs. Table 8-17 provides a summary of the total storage volume and the respective TDPS capacities assuming a 48-hour dewatering period for facilities providing 100 percent levels of CSO control for the Jamaica WWTP only (Thurston and Bergen Basins), Jamaica and 26th Ward WWTPs (Thurston Basin, Bergen Basin, Spring Creek, Hendrix Creek and Fresh Creek) and Jamaica, 26th Ward and Coney Island WWTPs (all Jamaica Bay tributaries).

Table 8-17. Storage and Dewatering System Capacity for Regional Tunnel Storage Alternatives

Level of Control	Storage Volume (MG)	Dewatering PS Capacity$^{(1)}$ (MGD)
RP-1A: Jamaica only	133	75
RP-1B: Jamaica and 26th Ward	288	75, 75
RP-1C: Jamaica, 26th Ward and Coney Island	482	75, 75, 75

Note:
(1) Assumes pump-back of stored CSO within a 48 hour period with peak WWTP flow limited to 2xDDWF.

Alternative RP-1a: Jamaica WWTP CSO Tunnel

This alternative would involve the following elements (Figure 8-24):

- Four new diversion chambers with tide gates constructed on the existing JAM-003, JAM-003A, JAM-005 and JAM-007 outfalls downstream of the existing regulators.
- Approximately 150 LF of gravity conveyance piping from the diversion structures in Bergen Basin to a launch shaft for the CSO tunnel.
- Approximately 700 LF of gravity conveyance piping from the diversion structures in Thurston Basin to a launch shaft for the CSO tunnel.
- Approximately 18,250 LF of 35 foot diameter tunnel to convey flow along Nassau Expressway to the head end of the Jamaica WWTP.
- Construction of a new screening and grit chamber and 75 MGD dewatering pumping station and associated force main to convey flows from the CSO tunnel to the influent distribution box of the primary settling tanks at the Jamaica WWTP.

The diversion chambers, diversion sewers and the launch shaft for Outfalls JAM-003 and JAM-003A would be sited on a city-owned lot currently leased to the PANYNJ, and utilized as a parking lot for JFK Airport. Similar structures for Outfalls JAM-005 and JAM-007 would be sited on city-owned vacant property, which may have some wetland impacts. The 75 MGD pumping station would be sited on vacant land, which is DEP owned and part of the Jamaica WWTP.

Under this alternative, dry-weather flow would continue to the Jamaica WWTP via the interceptors. Under wet-weather conditions, overflow at Outfalls JAM-003, JAM-003A, JAM-005 and JAM-007 would be diverted to the new CSO tunnel and to the pumping station. Modeling results project a 30 percent reduction in CSO overflow volumes regionally. As a result, DEP retained this alternative for further evaluation.

Figure 8-24. Layout of Proposed CSO Tunnel and Dewatering Pumping Station

The benefits, costs, and challenges associated with this alternative are as follows:

<u>Benefits</u>

- Captures and conveys CSO from JAM-003/003A/005/007 to the Jamaica WWTP for treatment
- Isolates CSO (by use of a pumping station) to reduce impacts to the East and West Interceptors

<u>Cost</u>

- The estimated NPW Cost for this control measure is $2,901.
- Details of the estimate are presented in Section 8.4.

<u>Challenges</u>

- Limited improvement in Bergen Basin and Thurston Basin water quality attainment
- Property acquisition and permitting
- Parkland alienation and wetland impacts in Thurston Basin
- Protection of highway ramps and infrastructure

<u>Alternative RP-1b: Jamaica/26th Ward WWTP CSO Tunnel</u>

This alternative would include the following elements (Figure 8-25):

- All elements from Alternative RP-1a.
- Three new diversion chambers with tide gates constructed on the existing 26W-003, 26W-004 and 26W-005 outfalls downstream of the existing regulators.
- Gravity conveyance piping from the diversion structures to a launch/receiving shaft for the CSO tunnel.
- In addition to the 18,250 LF of 35 foot tunnel from Alternative RP-1a, approximately 23,000 LF of 35 foot diameter tunnel to convey flow along Shore Parkway and Flatlands Avenue to the head end of the 26th Ward WWTP.
- Construction of a new screening and grit chamber and 75 MGD dewatering pumping station and associated force main to convey flows from the CSO tunnel to the influent distribution box of the primary settling tanks at the 26th Ward WWTP.

The diversion chambers, diversion sewers and the launch shaft for Outfall 26W-003 would be sited on privately owned property. For Outfall 26W-004, such structures would be sited on property under DEP's jurisdiction, which is part of the 26th Ward WWTP. Similar structures for Outfall 26W-005 would be sited on city-owned vacant property, which is currently a part of the Spring Creek AWWTP. The 75 MGD pumping station would be sited on vacant land, which is currently under the jurisdiction of the New York City Department of Parks and Recreation or New York City Department of General Services.

Under this alternative, dry-weather flow would continue to the Jamaica and 26th Ward WWTPs via the interceptors. Under wet-weather conditions, overflow at Outfalls JAM-003, JAM-003A, JAM-005, JAM-007, 26W-003, 26W-004 and 26W-005 would be diverted to the new CSO tunnel and to the pumping station. Modeling results project a 70 percent reduction in CSO overflow volumes regionally. As a result, DEP retained this alternative for further evaluation.

Figure 8-25. Layout of Proposed CSO Tunnel and Dewatering Pumping Stations

The benefits, costs, and challenges associated with this alternative are as follows:

Benefits

- Captures and conveys CSO from JAM-003/003A/005/007 and 26W-003/004/005 to the Jamaica WWTP and 26th Ward WWTP for treatment
- Isolates CSO (by use of a pumping station) to reduce impacts to the interceptors

Cost

- The estimated NPW Cost for this control measure is $6,219.
- Details of the estimate are presented in Section 8.4.

Challenges

- Limited improvement in Bergen Basin and Thurston Basin water quality attainments
- Property acquisition and permitting
- Parkland alienation and wetland impacts
- Site constraints for construction of dewatering pumping station at head of 26th Ward WWTP
- Construction of diversion chambers along outfalls

<u>Alternative RP-1c: North Shore CSO Storage Tunnel</u>

This alternative would involve the following elements (Figure 8-26):

- All elements from Alternative RP-1b.
- Three new diversion chambers with tide gates constructed on the existing CI-004, CI-005 and CI-006 outfalls downstream of the existing regulators.
- Gravity conveyance piping from the diversion structures to a launch/receiving shaft for the CSO tunnel.
- In addition to the 41,300 LF of 35 foot diameter tunnel from Alternative RP-1b, approximately 26,500 LF of 35 foot diameter tunnel to convey flow along Ralph Avenue, Avenue T and Knapp Street to the head end of the Coney Island WWTP.
- Construction of a new screening and grit chamber and 75 MGD dewatering pumping station and associated force main to convey flows from the CSO tunnel to the influent distribution box of the primary settling tanks at the 26th Ward WWTP.

Under this alternative, dry-weather flow would continue to the Jamaica, 26th Ward, and Coney Island WWTPs via the interceptors. Under wet-weather conditions, overflow at Outfalls JAM-003, JAM-003A, JAM-005, JAM-007, 26W-003, 26W-004, 26W-005, CI-004, CI-005, and CI-006 would be diverted to the new CSO tunnel and to the pumping station. Modeling results project a 100 percent reduction in CSO overflow volumes regionally. As a result, DEP retained this alternative for further evaluation.

Figure 8-26. Layout of Proposed CSO Tunnel and Dewatering Pumping Stations

The benefits, costs, and challenges associated with this alternative are as follows:

Benefits

- Captures and conveys CSO from JAM-003/003A/005/007, 26W-003/004/005 and CI-004/005/006 to the Jamaica WWTP, 26th Ward WWTP and Coney Island WWTP for treatment
- Isolates CSO (by use of a pumping station) to reduce impacts to the interceptors

Cost

- The estimated NPW Cost for this control measure is $9,851M.
- Details of the estimate are presented in Section 8.4.

Challenges

- Limited improvement in Bergen Basin and Thurston Basin water quality attainments
- Property acquisition and permitting
- Parkland alienation and wetland impacts

8.2.m Other Future Green Infrastructure (Regional Alternatives)

Jamaica Bay and its tributaries are priority watersheds for DEP's GI Program, which seeks to saturate priority watersheds with GI based on the specific opportunities each watershed presents. DEP plans to construct approximately 877 greened acres of GI by 2030, including ROW practices, public property retrofits, and compliance with stormwater connection regulations on private property within the Jamaica and 26th Ward WWTP sewersheds. As discussed in Section 5, DEP projects that baseline GI should result in a CSO volume reduction to Jamaica Bay and its tributaries of approximately 202 MGY, based on 2008 typical year rainfall conditions. This projected GI has been included as part of the baseline model projections, and is thus not categorized as an LTCP alternative.

Note that the Alternative B-13 and T-12 will enable DEP to build GI in the combined sewer area within Thurston Basin (See Figure 5-2), which has been assumed in the GI baseline. However, without the alignment with the GI expansion DEP will not be able to build in this area due to its distance from the other GI baseline assets and maintenance will be costly and impractical.

For the purpose of this LTCP, "Other Future Green Infrastructure" is defined as GI alternatives that are in addition to those implemented under previous facility plans and those included in the baseline conditions. Under Alternative B-13 and T-12, an additional 15 MGY reduction in CSO volume is projected due to the increased capacity in the interceptors in CSO portion of system. As GI will provide additional co-benefits, such as property value appreciation, carbon sequestration, air quality improvements, urban heat island reduction, and habitat creation in addition to reductions in CSO and stormwater pathogen loads, this alternative will be retained for further evaluation.

8.2.n Hybrid Green/Grey Alternatives

Hybrid green/grey alternatives are those that combine traditional grey control measures with GI control measures, to achieve the benefits of both. However, as discussed above, the SEQ Storm Sewer Build-out

Program is ongoing and will significantly impact the drainage patterns throughout the collections system tributary to the Jamaica WWTP. Therefore, no controls in this category are proposed for the Jamaica Bay and Tributaries LTCP.

8.2.o Retained Alternatives

The goal of the previous evaluations was the development of a list of retained control measures for CSOs to Jamaica Bay and its tributaries. These control measures, whether individually or in combination, formed the basis of the basin-wide alternatives that DEP assessed using the more rigorous cost-performance and cost-attainment analyses. That list is presented in Table 8-18. The reasons for excluding the non-retained control measures from further consideration are also identified in the table.

Table 8-18. Summary of Next Level of Control Measure Screening

Control Measure	Category	Drainage Area	Retained for Further Analysis?	Remarks
Additional GI	Source Control	Jamaica WWTP	YES	Additional sites in separately sewered areas were identified.
		26th Ward WWTP	NO	Additional sites were not identified.
High Level Storm Sewers	Source Control	Jamaica WWTP	NO	Recommended and in construction under the WWFP and SEQ SSBP. Was not evaluated further under the LTCP.
		26th Ward WWTP	NO	Recommended and in construction under the WWFP. Was not evaluated further under the LTCP.
Fixed Weir Modifications	System Optimization	Jamaica WWTP	NO	Increases HGL and provides minimal CSO reduction benefit
		26th Ward WWTP		
Bending Weirs/Control Gates	System Optimization	Jamaica WWTP	NO	Recommended and implemented under the WWFP. Increases HGL and provides minimal CSO reduction benefit.
		26th Ward WWTP	NO	Increases HGL and provides minimal CSO reduction benefit
Parallel Interceptor Sewer	System Optimization	Jamaica WWTP	YES	Alternative B-2d2 evaluated a sewer paralleling the West Interceptor to a designated pumping station at the WWTP. Other alternatives increased the collection system HGL.

Table 8-18. Summary of Next Level of Control Measure Screening

Control Measure	Category	Drainage Area	Retained for Further Analysis?	Remarks
		26th Ward WWTP	NO	Increases HGL within collection system
Pumping Station Modifications	System Optimization	Jamaica WWTP	NO	Recommended in the WWFP leading to the installation of a new pumping station for Meadowmere and Warnerville; No other sensitive pumping stations were identified for modification under the LTCP.
		26th Ward WWTP	NO	Recommended for the influent pumps at the 26th Ward WWTP under the WWFP. No other sensitive pumping stations were identified for modification under the LTCP.
Gravity Flow Tipping to Other Watersheds	CSO Relocation	Thurston Basin	NO	No opportunity for flow tipping due to sensitivity of adjacent waterbodies
		Bergen Basin	NO	Recommended and implemented to divert CSO from Regulator JA-04 to the Spring Creek AWWTP under the WWFP. No additional opportunities were identified under the LTCP.
		Spring Creek	NO	No opportunity for flow tipping due to sensitivity of adjacent waterbodies
		Hendrix Creek		
		Fresh Creek		
		Paerdegat Basin		
Flow Tipping with Conduit/Tunnel and Pumping	CSO Relocation	All Tributaries	NO	No opportunity for flow tipping due to sensitivity of adjacent waterbodies
Floatables Control	Water Quality / Ecological Enhancement	All Tributaries	NO	Existing controls have been very effective. Additional control provides no CSO reduction benefit with increased HGL.
Environmental Dredging	Water Quality/ Ecological Enhancement	Thurston Basin	NO	No odor complaints
		Bergen Basin	YES	Retained. Addresses odor complaints.
		Spring Creek	NO	No odor complaints
		Hendrix Creek	NO	Recommended and completed under the WWFP

Table 8-18. Summary of Next Level of Control Measure Screening

Control Measure	Category	Drainage Area	Retained for Further Analysis?	Remarks
		Fresh Creek	NO	No odor complaints
		Paerdegat Basin	NO	No odor complaints
Mechanical Aeration	Water Quality/ Ecological Enhancement	All Tributaries	NO	In-stream aeration was recommended and implemented at Shellbank Basin under the WWFP. This technology was not considered further under this LTCP.
Wetlands and Bioextractors	Water Quality/ Ecological Enhancement	Thurston Basin	YES	Opportunities for tidal wetland restoration and ribbed mussel habitat creation were identified
		Bergen Basin		
		Spring Creek		
		Hendrix Creek		
		Fresh Creek		
		Paerdegat Basin		
Outfall Disinfection	Treatment: Satellite	Thurston Basin	NO	Siting and operability challenges
		Bergen Basin	NO	Insufficient outfall length to provide the required contact time
		Spring Creek		
		Hendrix Creek		
		Fresh Creek		
		Paerdegat Basin		
Retention/Treatment Basins	Treatment: Satellite	All Tributaries	NO	Insufficient land available
In-System Storage (Outfalls)	Storage	All Tributaries	NO	Increases HGL within collection system while providing limited level of CSO control
Off-line Storage (Shafts)	Storage	All Tributaries	NO	Limited capacity would require multiple shafts. Limited number of existing facilities from which to judge performance/ operational issues.
Off-line Storage (Tanks)	Storage	All Tributaries	NO	Insufficient land available.
Off-line Storage (Tunnels)	Storage	All Tributaries	YES	Tunnels were retained for Alternatives B-6, T-6, RP-1a, RP-1b and RP-1c

As shown, the retained control measures include the CSO storage tunnels, additional GI, environmental dredging, tidal wetland restoration and bioextractors (ribbed mussels). Measures for additional and/or improved floatables control are also addressed within the retained alternatives.

8.3 CSO Reductions and Water Quality Impact of Retained Alternatives

To evaluate effects on the loadings and water quality impacts, DEP analyzed the retained alternatives listed in Table 8-19 using both the Jamaica Bay-26th Ward watershed (IW) and receiving water quality (JEMWQM) models. Evaluations of levels of CSO control for each alternative are presented below. In all cases, the predicted reductions shown are relative to the baseline conditions using 2008 JFK typical year rainfall as described in Section 6. The baseline assumptions were described in detail in Section 6 and assume that the grey infrastructure projects from the Jamaica Bay WWFP have been implemented, along with the GI projected implementation identified in Section 5.

The 11 retained alternatives shown in Table 8-19 were then analyzed on the basis of their cost-effectiveness in reducing loads and improving water quality. These more advanced analyses are described in Sections 8.3, 8.4 and 8.5.

Table 8-19. Retained Alternatives with New Sequential Numbering

Alternative	Description
Thurston Basin Alternatives	
1. CSO Tunnel from JAM-005/007 to Jamaica WWTP (50% Capture)	15,200 LF, 10-foot diameter CSO tunnel (9 MG) from JAM-005/007 to Jamaica WWTP
2. CSO Tunnel from JAM-005/007 to Jamaica WWTP (75% Capture)	15,200 LF, 18-foot diameter CSO tunnel (29 MG) from JAM-005/007 to Jamaica WWTP
3. CSO Tunnel from JAM-005/007 to Jamaica WWTP (100% Capture)	15,200 LF, 28-foot diameter CSO tunnel (91 MG) from JAM-005/007 to Jamaica WWTP
Bergen Basin Alternatives	
4. CSO Conveyance from JAM-003/003A to Jamaica WWTP	3,200 LF, 8-foot diameter sewer from Outfalls JAM-003/003A to a 50 MGD pumping station at the Jamaica WWTP
5. CSO Tunnel from JAM--03/003A to Jamaica WWTP (50% Capture)	3,200 LF, 21-foot diameter CSO tunnel (8 MG) from JAM-003/003A to Jamaica WWTP

Table 8-19. Retained Alternatives with New Sequential Numbering

Alternative	Description
6. CSO Tunnel from JAM-003/003A to Jamaica WWTP (75% Capture)	3,200 LF, 32-foot diameter CSO tunnel (19 MG) from JAM-003/003A to Jamaica WWTP
7. CSO Tunnel from JAM-003/003A to Jamaica WWTP (100% Capture)	5,400 LF, 49-foot diameter CSO tunnel (45 MG) from JAM-003/003A to Jamaica WWTP
Regional Alternatives	
8. Jamaica WWTP CSO Tunnel (30% Regional Capture)	18,500 LF, 35-foot diameter CSO tunnel (133 MG) from JAM-003/003A to JAM-005/007 with Dewatering Pumping Station at Jamaica WWTP
9. Jamaica/26W WWTP CSO Tunnel (70% Regional Capture)	40,100 LF, 35-foot diameter CSO tunnel (288 MG) from JAM-005/007 (Thurston Basin) to 26W-003 (Fresh Creek) with Dewatering Pumping Stations at Jamaica WWTP and 26th Ward WWTP
10. North Shore CSO Storage Tunnel (100% Regional Capture)	67,000 LF, 35-foot diameter CSO tunnel (482 MG) from JAM-005/007 (Thurston Basin) to the Coney Island WWTP with Dewatering Pumping Stations at Jamaica, 26th Ward and Coney Island WWTPs
11. Additional GI and Environmental Improvements	*Thurston Basin* • Green Infrastructure – 147 greened acres • Ribbed Mussels – 3 Acres *Bergen Basin* • Environmental Dredging – 50,000 cubic yards • Green Infrastructure – 232 greened acres • Ribbed Mussels – 4 acres *Spring Creek* • Tidal Wetlands Restoration – 13 acres *Hendrix Creek* • Tidal Wetlands Restoration – 3 acres *Fresh Creek* • Tidal Wetlands Restoration – 14 acres Paerdegat Basin • Tidal Wetlands Restoration – 4 acres Jamaica Bay • Tidal Wetlands Restoration – 16 acres

8.3.a CSO Volume and Bacteria Loading Reductions of Basin-Wide Retained Alternatives

Table 8-20 summarizes the projected performance of the retained Jamaica Bay alternatives in terms of CSO volume, fecal coliform and *Enterococci* load reduction. The bacteria loading reductions shown in Table 8-20 were computed on an annual basis. These data are plotted on Figure 8-27 through 8-29.

Table 8-20. Jamaica Bay Retained Alternatives Summary (2008 Typical Year)

Alternative[1]	Untreated CSO Volume (MGY) [2,6]	Frequency of Overflow[3,6]	Untreated CSO Volume Reduction (%)	Fecal Coliform Reduction (%)[4]	*Enterococci* Reduction (%)[4]
Thurston Basin					
Baseline Conditions	626 (213)	73 (25)	-	-	-
1. CSO Tunnel from JAM-005/007 to Jamaica WWTP (50% Capture)	313 (146)	11 (6)	50 (32)	32	32
2. CSO Tunnel from JAM-005/007 to Jamaica WWTP (75% Capture)	155 (85)	10 (2)	75 (60)	60	60
3. CSO Tunnel from JAM-005/007 to Jamaica WWTP (100% Capture)	0	0	100	100	100
Bergen Basin					
Baseline Conditions	338	33	-	-	-
4. 96"CSO Conveyance from JAM-003/003A to Jamaica WWTP	230	16	32	32	32
5. CSO Tunnel from JAM-003/003A to Jamaica WWTP (50% Capture)	169	11	50	50	50
6. CSO Tunnel from JAM-003/003A to Jamaica WWTP (75% Capture)	85	7	75	75	75
7. CSO Tunnel from JAM-003/003A to Jamaica WWTP (100% Capture)	0	0	100	100	100
Regional Alternatives					
Baseline Conditions	2,271 (1,858)	73 (33)	-	-	-
8. Jamaica WWTP CSO Tunnel (30% Regional Capture)	1,590	30	30	30	30
9. Jamaica/26W WWTP CSO Tunnel (70% Regional Capture)	681	12	68	68	68
10. North Shore CSO Storage Tunnel (100% Regional Capture)	0	0	100	100	100

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Table 8-20. Jamaica Bay Retained Alternatives Summary (2008 Typical Year)

Alternative[(1)]	Untreated CSO Volume (MGY) [(2,6)]	Frequency of Overflow[(3,6)]	Untreated CSO Volume Reduction (%)	Fecal Coliform Reduction (%)[(4)]	*Enterococci* Reduction (%)[(4)]
11. Additional GI and Environmental Improvements	2,256 (1,843)	73 (33)	1	10[(5)]	10[(5)]

Notes:

(1) Retained alternatives include waterbody-specific control where water quality attainment is not currently achieved under baseline conditions.

(2) Based upon 2008 typical year rainfall conditions. Rockaway CSOs do not overflow..

(3) Frequency of overflow includes remaining CSO discharges to Jamaica Bay tributaries that are not captured or receive primary treatment.

(4) Bacteria reduction is computed on an annual basis.

(5) Fecal coliform and *Enterococci* load reductions shown are based on CSO and SW volume reductions associated with Alternative 11. An additional 10 percent reduction in the in-receiving water concentrations within Thurston and Bergen Basins has been assumed to account for the ribbed mussels installed within those basins.

(6) Stormwater connections contribute flow to JAM-005/007 downstream of the regulator weirs in Thurston Basin. As a result, the diversion chambers would direct CSO and stormwater to the tunnel during wet-weather events. The statistics represent the CSO volume and stormwater volume at the point the flow is diverted to the tunnel. Flows in parentheses identify the model predicted CSO volumes overtopping the regulator weirs.

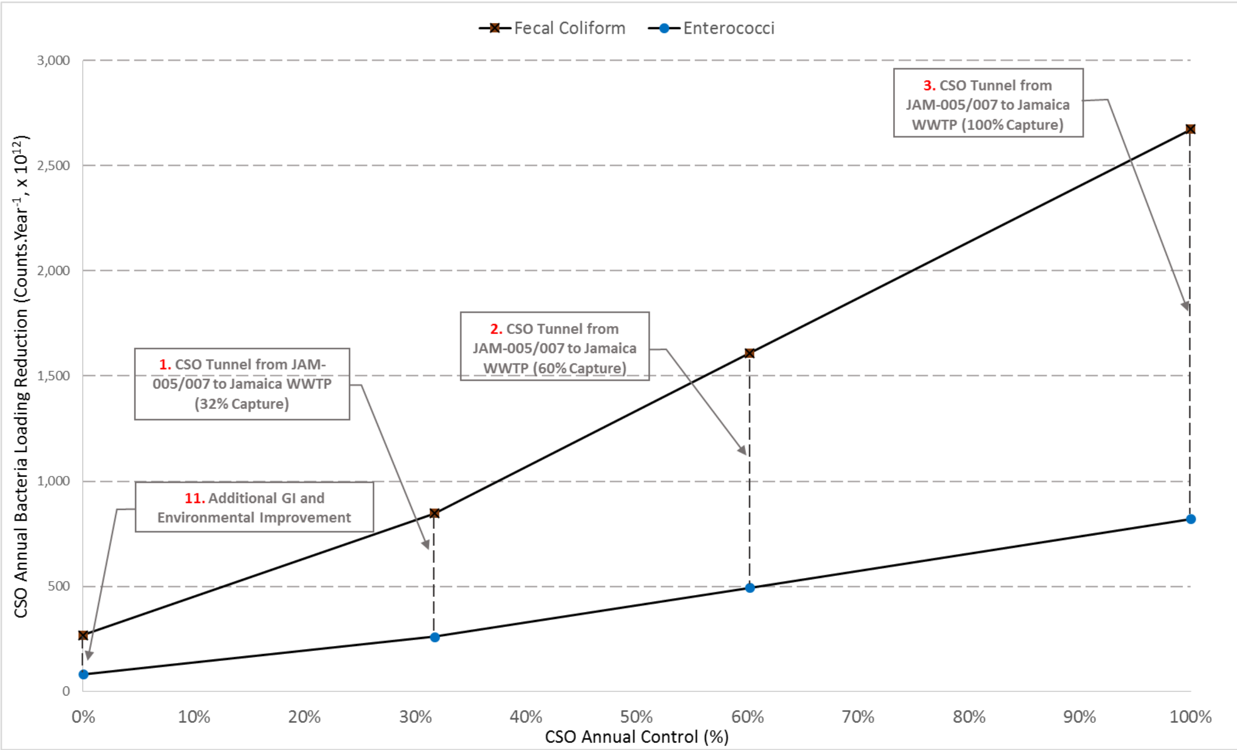


Figure 8-27. Untreated CSO Volume Reductions (as Percent CSO Annual Control) vs. Annual CSO Bacteria Loading Reduction (2008 Typical Year) for Thurston Basin

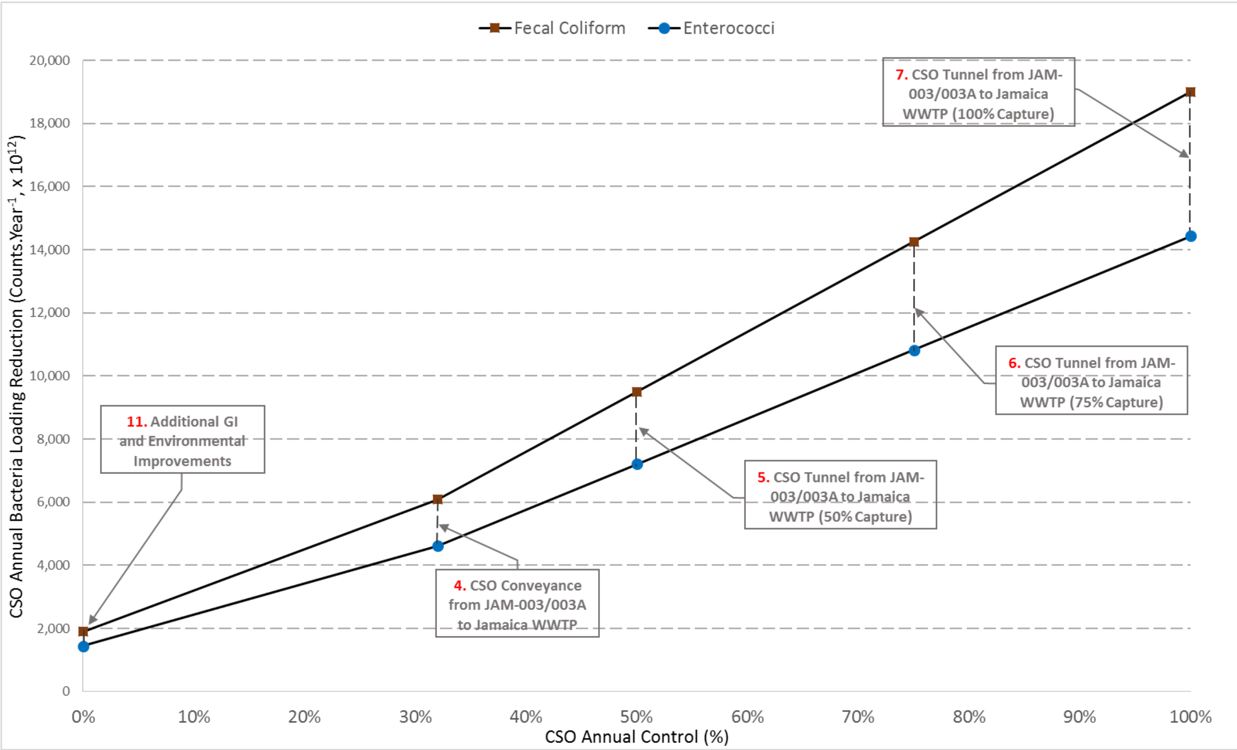


Figure 8-28. Untreated CSO Volume Reductions (as Percent CSO Annual Control) vs. Annual CSO Bacteria Loading Reduction (2008 Typical Year) for Bergen Basin

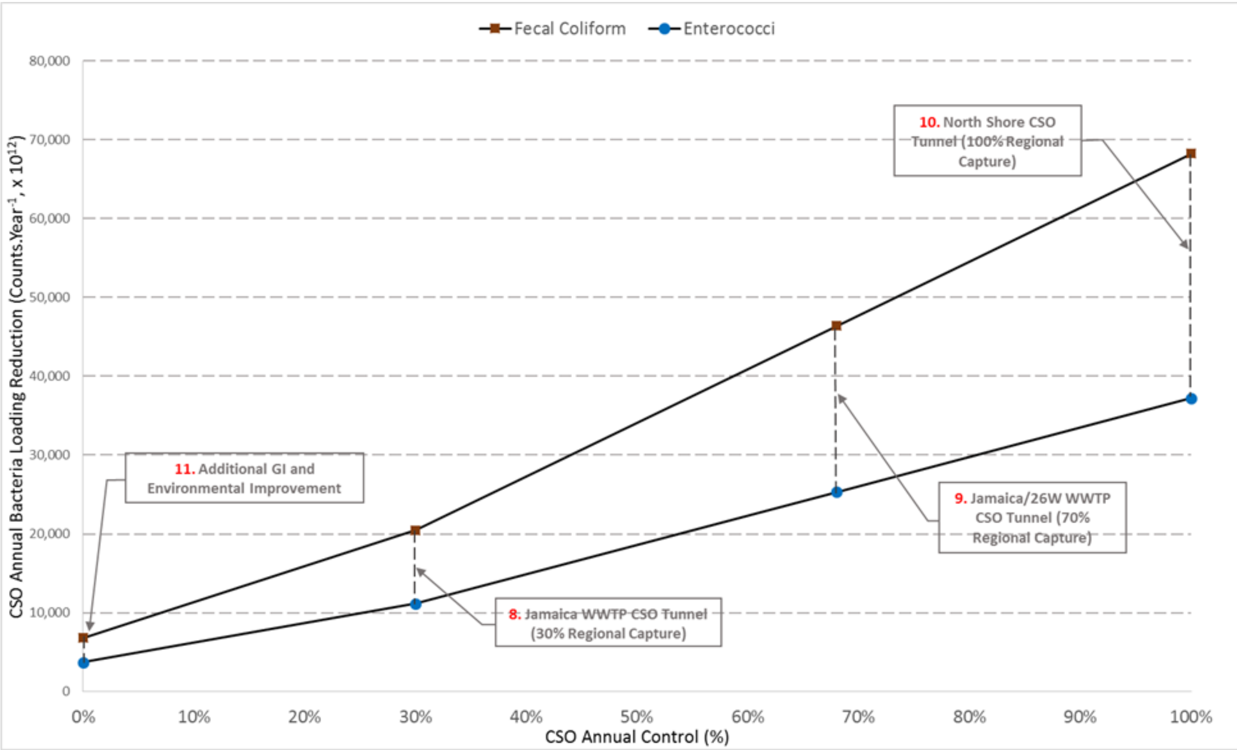


Figure 8-29. Untreated CSO Volume Reductions (as Percent CSO Annual Control) vs. Annual CSO Bacteria Loading Reduction (2008 Typical Year) for Jamaica Bay and its Tributaries

Because the retained alternatives for Jamaica Bay and its tributaries primarily provide volume reduction and not treatment, the predicted bacteria loading reductions of the alternatives are very closely aligned with their projected CSO volume reductions. However, Alternative 11 includes stormwater reductions associated with the green infrastructure and ribbed mussels that provide additional pathogen load reductions beyond the reduction in CSO loading.

8.3.b Water Quality Impacts within Jamaica Bay

Due to the geographic location of Jamaica Bay relative to the other tributary branches, the analysis of water quality impacts to the waterbody was segmented accordingly below:

Water Quality of Jamaica Bay

Jamaica Bay is a Class SB waterbody. Based on the analysis presented in Section 6.0, and supported by the 10-year JEMWQM runs, historic and recent water quality monitoring, along with baseline condition modeling, all locations assessed within the waterbody are currently in attainment with the Existing WQ Criteria for fecal coliform and DO (Class SB) and Proposed *Enterococci* WQ Criteria* (GM<35 cfu/100mL).

*Proposed *Enterococci* WQ Criteria, if adopted as proposed, would only apply to coastal Class SB and SA waters.

CSO Reductions and Water Quality of Tributaries to Jamaica Bay

Tributaries to Jamaica Bay are all classified as Class I waterbodies. Based on the analysis presented in Section 6.0, and supported by the 10-year JEMWQM runs, historic and recent water quality monitoring, along with baseline condition modeling, locations within Bergen Basin, Thurston Basin and Fresh Creek waterbodies do not meet the Class I criterion for fecal coliform, with annual and recreational season (May 1st through October 31st) attainments less than 95 percent at the head ends of these basins.

The 10-year baseline condition scenario was rerun with the CSO loadings to Jamaica Bay tributaries removed. This projection represents the maximum possible reduction of CSO loads to the tributaries of Jamaica Bay and is referred to as the 100% CSO control scenario. All other conditions from the baseline projection remain unchanged in the 100% CSO control scenario. On an annual basis, the head ends of Fresh Creek, Bergen Basin, and Thurston Basin do not achieve 95 percent attainment of the criterion even with 100% CSO control. This is also the case for the recreational period (May 1st through October 31st) with the exception of the head end of Fresh Creek, which improves from 93 to 98 percent attainment. This analysis indicates that CSO controls cannot completely close the gap between attainment and non-attainment of the fecal coliform water quality criterion for Bergen and Thurston Basins.

Based on 2008 typical year rainfall conditions, the upstream ends of Bergen Basin, Thurston Basin, and Hendrix Creek are not in attainment with the Class I criterion for DO under baseline conditions. With 100% CSO control, the upstream ends of Bergen and Thurston Basins would still not be in attainment for DO, while the DO attainment in the upstream end of Hendricks Creek would increase from 94 to 95 percent. This analysis indicates that CSO controls cannot close the gap between attainment and non-attainment of the Class I DO water quality criterion for Bergen and Thurston Basins.

8.4 Cost Estimates for 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 4 percent. As the majority of the alternatives consist of tunnels, a 100-year life cycle was used in computing the NPW. Design, construction management, and land acquisition costs are not included in the cost estimates. All costs are in June 2018 dollars and are considered Level 5 cost estimates by AACE International with an accuracy of -50 percent to +100 percent.

8.4.a Alternative 1 – 50 Percent Control CSO Tunnel from JAM-005/007 to Jamaica WWTP

The costs for Alternative 1 include planning-level estimates for the construction of a deep tunnel for 50 percent CSO Control for Outfalls JAM-005 and JAM-007, and reflect the description provided in Section 8.2. Site acquisition costs are not included. The total cost, expressed as NPW, for Alternative 1 is $699M, as shown in Table 8-21.

Table 8-21. Costs for Thurston Basin Alternative 1

Item	June 2018 Cost ($ Million)
Probable Bid Cost	665
Annual O&M Cost	1
Net Present Worth	699

8.4.b Alternative 2 – 75 Percent Control CSO Tunnel from JAM-005/007 to Jamaica WWTP

The costs for Alternative 2 include planning-level estimates for the construction of a deep tunnel for 75 percent CSO Control for Outfalls JAM-005 and JAM-007, and reflect the description provided in Section 8.2. Site acquisition costs are not included. The total cost, expressed as NPW, for Alternative 2 is $1,020M, as shown in Table 8-22.

Table 8-22. Costs for Thurston Basin Alternative 2

Item	June 2018 Cost ($ Million)
Probable Bid Cost	939
Annual O&M Cost	2
Net Present Worth	1,020

8.4.c Alternative 3 – 100 Percent Control CSO Tunnel from JAM-005/007 to Jamaica WWTP

The costs for Alternative 3 include planning-level estimates for the construction of a deep tunnel for 100% CSO Control for Outfalls JAM-005 and JAM-007, and reflect the description provided in Section 8.2. Site acquisition costs are not included. The total cost, expressed as NPW, for Alternative 3 is $1, 637M, as shown in Table 8-23.

Table 8-23. Costs for Thurston Basin Alternative 3

Item	June 2018 Cost ($ Million)
Probable Bid Cost	1,509
Annual O&M Cost	3
Net Present Worth	1,637

8.4.d Alternative 4 – CSO Conveyance from JAM-003/003A to Jamaica WWTP

The costs for Alternative 4 include planning-level estimates for the construction of a microtunneled CSO conveyance for Outfalls JAM-003 and JAM-003A, and reflect the description provided in Section 8.2. Site acquisition costs are not included. The total cost, expressed as NPW, for Alternative 4 is $690M, as shown in Table 8-24.

Table 8-24. Costs for Bergen Basin Alternative 4

Item	June 2018 Cost ($ Million)
Probable Bid Cost	633
Annual O&M Cost	1
Net Present Worth	690

8.4.e Alternative 5 – 50 Percent Control CSO Tunnel from JAM-003/003A to Jamaica WWTP

The costs for Alternative 5 include planning-level estimates for the construction of a deep tunnel for 50 percent CSO Control for Outfalls JAM-003 and JAM-003A, and reflect the description provided in Section 8.2. Site acquisition costs are not included. The total cost, expressed as NPW, for Alternative 5 is $736M, as shown in Table 8-25.

Table 8-25. Costs for Bergen Basin Alternative 5

Item	June 2018 Cost ($ Million)
Probable Bid Cost	676
Annual O&M Cost	2
Net Present Worth	736

8.4.f Alternative 6 – 75 Percent Control CSO Tunnel from JAM-003/003A to Jamaica WWTP

The costs for Alternative 6 include planning-level estimates for the construction of a deep tunnel for 75 percent CSO Control for Outfalls JAM-003 and JAM-003A, and reflect the description provided in Section 8.2. Site acquisition costs are not included. The total cost, expressed as NPW, for Alternative 6 is $895M, as shown in Table 8-26.

Table 8-26. Costs for Bergen Basin Alternative 6

Item	June 2018 Cost ($ Million)
Probable Bid Cost	818
Annual O&M Cost	2
Net Present Worth	895

8.4.g Alternative 7 – 100 Percent Control CSO Tunnel from JAM-003/003A to Jamaica WWTP

The costs for Alternative 7 include planning-level estimates for the construction of a deep tunnel for 100% CSO Control for Outfalls JAM-003 and JAM-003A, and reflect the description provided in Section 8.2. Site acquisition costs are not included. The total cost, expressed as NPW, for Alternative 7 is $1,755M, as shown in Table 8-27.

Table 8-27. Costs for Basin-Wide Alternative 7

Item	June 2018 Cost ($ Million)
Probable Bid Cost	1,636
Annual O&M Cost	3
Net Present Worth	1,755

8.4.h Alternative 8 – 30 Percent Control CSO Tunnel from JAM-003, JAM-003A, JAM-005 and JAM-007 to Jamaica WWTP

The costs for Alternative 8 include planning-level estimates for the construction of a deep tunnel for Outfalls JAM-003, JAM-003A, JAM-005, and JAM-007, and reflect the description provided in Section 8.2. The alternative provides 30 percent control of all CSO discharges to Jamaica Bay and its tributaries. Site acquisition costs are not included. The total cost, expressed as NPW, for Alternative 8 is $2,901M, as shown in Table 8-28.

Table 8-28. Costs for Basin-Wide Alternative 8

Item	June 2018 Cost ($ Million)
Probable Bid Cost	2,740
Annual O&M Cost	4
Net Present Worth	2,901

8.4.i Alternative 9 – 70 Percent Control CSO Tunnel from JAM-003/003A, JAM-005/007 and 26W-003/004/005 to Jamaica WWTP and 26th Ward WWTP

The costs for Alternative 9 include planning-level estimates for the construction of a deep tunnel for Outfalls JAM-003, JAM-003A, JAM-005, JAM-007, 26W-003, 26W-004 and 26W-005, and reflect the description provided in Section 8.2. The alternative provides 70 percent control of all CSO discharges to Jamaica Bay and its tributaries. Site acquisition costs are not included. The total cost, expressed as NPW, for Alternative 9 is $6,219, as shown in Table 8-29.

Table 8-29. Costs for Basin-Wide Alternative 9

Item	June 2018 Cost ($ Million)
Probable Bid Cost	5,831
Annual O&M Cost	11
Net Present Worth	6,219

8.4.j Alternative 10 – 100% Control CSO Tunnel from JAM-003/003A, JAM-005/007, 26W-003/004/005 and CI-003/004/005 to Jamaica WWTP, 26 Ward WWTP and Coney Island WWTP

The costs for Alternative 10 include planning-level estimates for the construction of a deep tunnel for Outfalls JAM-003, JAM-003A, JAM-005, JAM-007, 26W-003, 26W-004, 26W-005, CI-003, CI-004 and CI-005, and reflect the description provided in Section 8.2. The alternative provides 100 percent control of all CSO discharges to Jamaica Bay and its tributaries. Site acquisition costs are not included. The total cost, expressed as NPW, for Alternative 9 is $9,851 M, as shown in Table 8-30.

Table 8-30. Costs for Basin-Wide Alternative 10

Item	June 2018 Cost ($ Million)
Probable Bid Cost	9,102
Annual O&M Cost	23
Net Present Worth	9,851

8.4.k Alternative 11 – Additional GI and Environmental Improvements

The costs for Alternative 11 include planning-level estimates for the expansion of the Green Infrastructure Program within the separately sewered areas of the Bergen Basin and Thurston Basin watersheds. Additionally, this alternative also recommends wetlands restoration and creation of ribbed mussel colonies in the Jamaica Bay tributaries. The total cost, expressed as NPW, for Alternative 11 is $401M, as shown in Table 8-31.

Table 8-31. Costs for Basin-Wide Alternative 11

Item	June 2018 Cost ($ Million)
Probable Bid Cost	310
Annual O&M Cost	2
Net Present Worth	401

The cost estimates of these retained alternatives are summarized below in Table 8-32 and are then used in the development of the cost-performance and cost-attainment plots presented in Section 8.5.

Table 8-32. Cost of Retained Alternatives

Alternative	PBC(1) ($ Million)	Annual O&M Cost ($/Yr Million)	Total Net Present Worth ($ Million) (2)
Thurston Basin Alternatives			
1. CSO Tunnel from JAM-005/007 to Jamaica WWTP (50% Capture)	665	1	722
2. CSO Tunnel from JAM-005/007 to Jamaica WWTP (75% Capture)	939	2	1,020
3. CSO Tunnel from JAM-005/007 to Jamaica WWTP (100% Capture)	1,509	3	1,637
Bergen Basin Alternatives			
4. CSO Conveyance from JAM-003/003A to Jamaica WWTP	633	1	690
5. CSO Tunnel from JAM-003/003A to Jamaica WWTP (50% Capture)	676	2	736
6. CSO Tunnel from JAM-003/003A to Jamaica WWTP (75% Capture)	818	2	896
7. CSO Tunnel from JAM-003/003A to Jamaica WWTP (100% Capture)	1,635	3	1,755
Regional Alternatives			
8. Jamaica WWTP CSO Tunnel (30% Regional Capture)	2,740	4	2,901
9. Jamaica/26W WWTP CSO Tunnel (70% Regional Capture)	5,831	11	6,219
10. North Shore CSO Storage Tunnel (100% Regional Capture)	9,102	23	9,851
11. Recommended Plan	310	2	401

Notes:
(1) The Probable Bid Cost (PBC) for the construction contract based on June 2018 dollars.
(2) The Net Present Worth is based upon a 100-year service life, and is calculated by multiplying the annual O&M cost by a present worth factor of 24.505 and adding this value to the PBC.

8.5 Cost-Attainment 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 WQ criteria. Those retained alternatives that did not show incremental gains in performance (shown in red in the figures) were not included in the development of the best-fit curve.

8.5.a Cost-Performance Curves

Cost-performance curves were developed by plotting the costs of the retained alternatives against their predicted level of CSO control. For the purposes of this section, CSO control is defined as the degree or rate of bacteria reduction through volumetric capture. Both the cost-performance and subsequent cost-attainment analyses focus on bacteria loadings and bacteria WQ criteria.

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.

DEP also evaluated the level of bacteria loadings reductions to the receiving waters. Figure 8-30 shows the percent reductions on a volumetric basis achieved by each alternative, whereas Figure 8-31 illustrates the CSO events remaining upon implementation of each alternative. Bacteria load reduction plots are presented in Figure 8-32 (*Enterococci*) and Figure 8-33 (fecal coliform). These curves plot the cost of the alternatives against their associated projected annual CSO *Enterococci* and fecal coliform loading reductions, respectively. The primary vertical axis shows percent CSO bacteria loading reductions. The secondary vertical axis shows the corresponding total bacteria loading reductions, as a percentage, when loadings from other non-CSO sources of bacteria are included.

The evaluation of the retained alternatives focused on cost-effective reduction of the frequency of CSO discharge, in addition to CSO volume and pathogen load reductions, to address current impacts to waterbody uses and issues raised by the public.

8.5.b 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 and Proposed *Enterococci* WQ Criteria* as modeled using JEMWQM with 2008 typical year rainfall. The cost-performance plots shown in Figure 8-30 through Figure 8-33 indicate that most of the retained alternatives represent incremental gains in marginal performance. Those retained alternatives that did not show incremental gains in marginal performance on the cost-performance curves are not included in the cost-attainment curves as they were deemed not to be cost-effective relative to other alternatives.

In addition to the bacteria Primary Contact WQ Criteria, the cost-attainment analysis considered Proposed *Enterococci* WQ Criteria*. As was noted in Section 2.0, the Proposed *Enterococci* WQ Criteria*, if adopted as proposed, do not apply to the tributaries of Jamaica Bay, which are not coastal recreation waters and do not have primary contact recreation as a designated use. However, as requested by DEC, DEP assessed compliance with those proposed criteria for all waters considered in this LTCP including the tributaries. The resultant curves for the Existing WQ Criteria for fecal coliform and Proposed *Enterococci* WQ Criteria* and relevant criteria are presented as Figure 8-34 through Figure 8-43 for ten locations (Stations BB5 through BB8, TBH1, TBH3, and TB9 through TB12,) within Bergen Basin and Thurston Basin.

Based on the continuous 10- year water quality model simulations for this LTCP, annual or seasonal attainment of the Existing WQ Criteria or Primary Contact WQ Criteria for fecal coliform under baseline conditions are not satisfied 100 percent of the time near the head end of Bergen and Thurston Basins.

Based on 10-year model runs with no CSO loadings, it was determined that the head ends of Fresh Creek, Bergen Basin, and Thurston Basin do not achieve 95 percent attainment of the Existing WQ Criteria for fecal coliform even with a 100% CSO control scenario. This is also the case for the recreational period with the exception of the head end of Fresh Creek, which improves from 93 to 98 percent attainment. This analysis indicates that CSO controls cannot completely close the gap between attainment and non-attainment of the fecal coliform water quality criterion for Bergen and Thurston Basins.

*Proposed *Enterococci* WQ Criteria, if adopted as proposed, would only apply to coastal Class SB and SA waters.

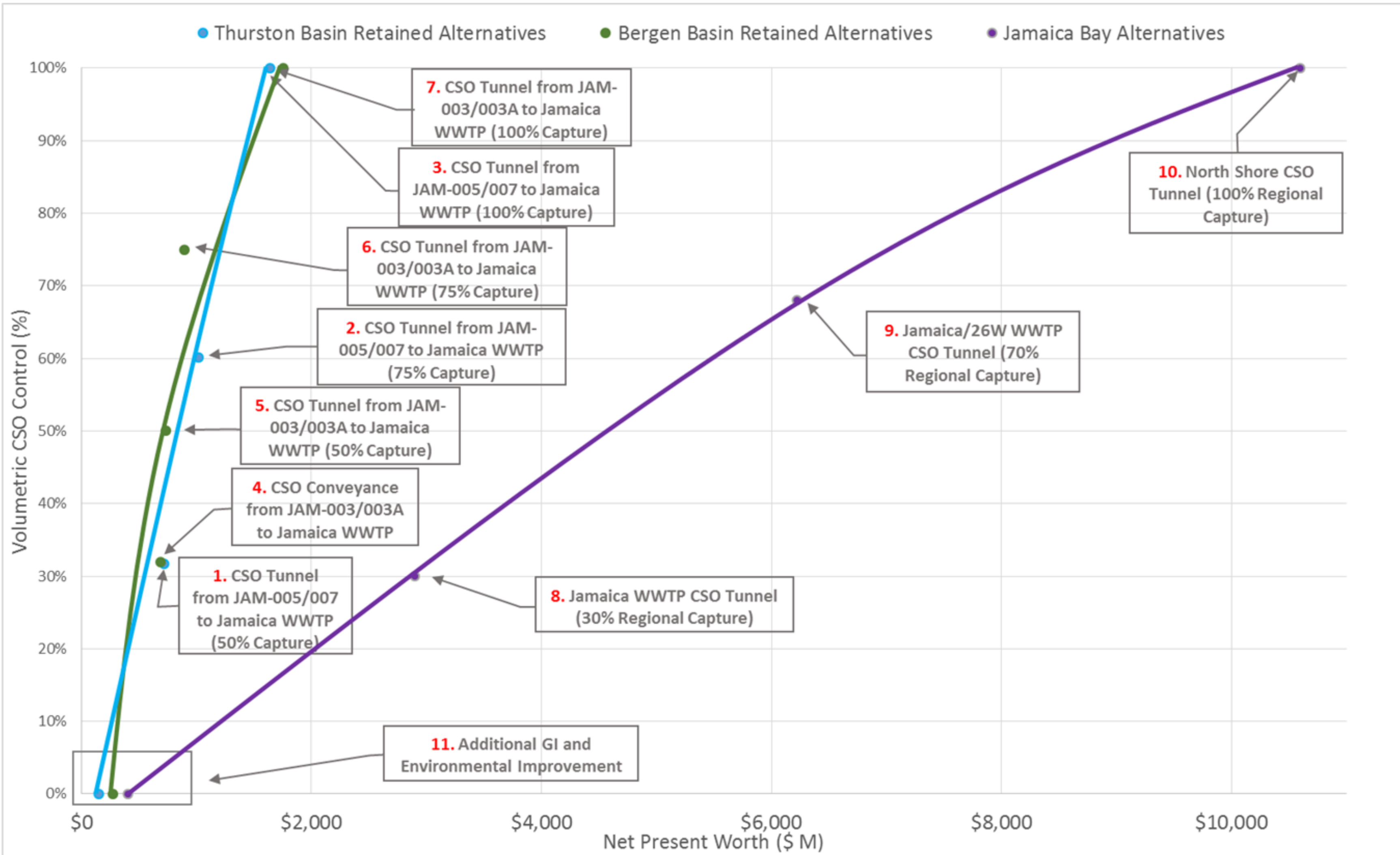


Figure 8-30. Cost vs. CSO Control (2008 Typical Year)

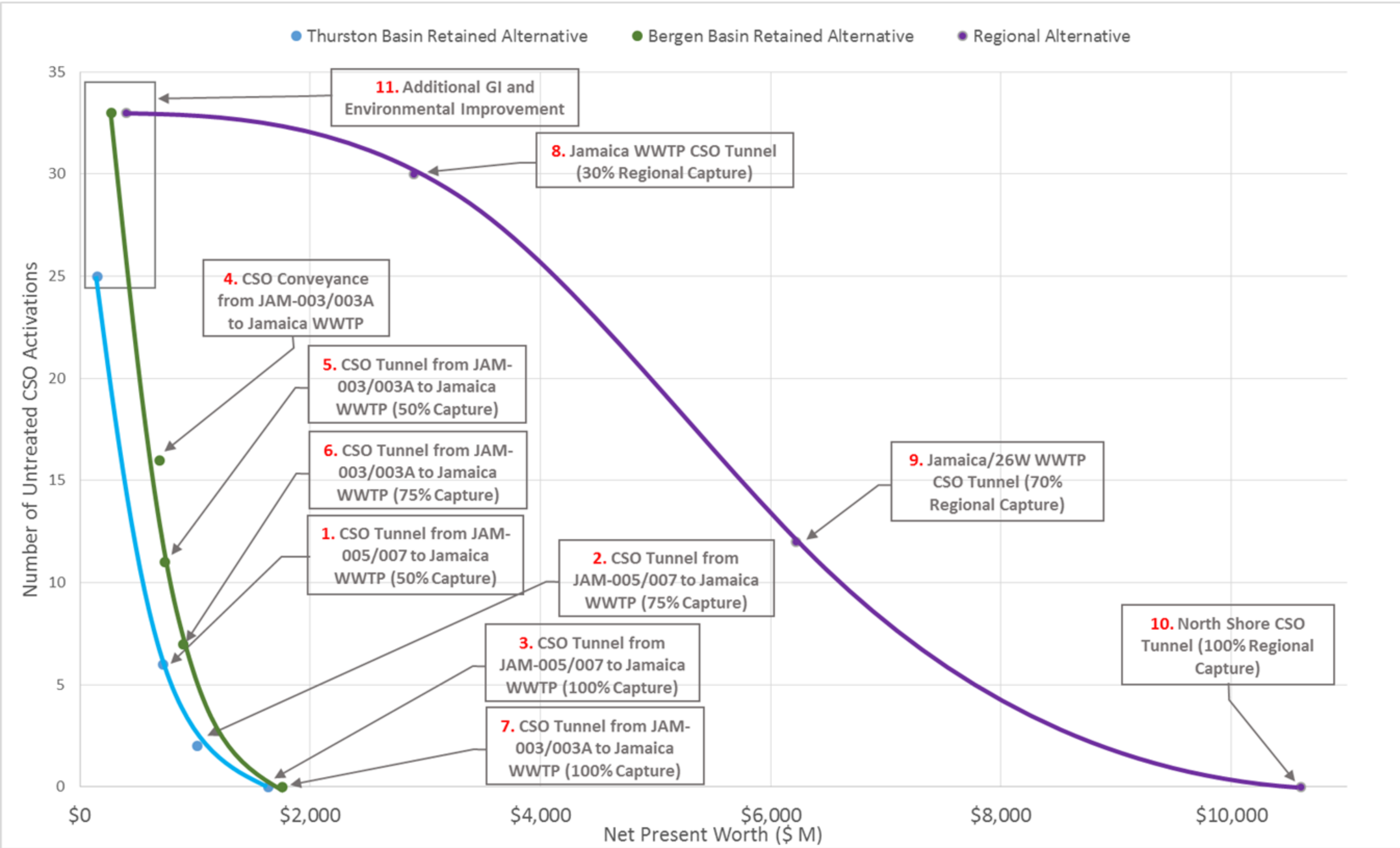


Figure 8-31. Cost vs. Remaining CSO Events (2008 Typical Year)

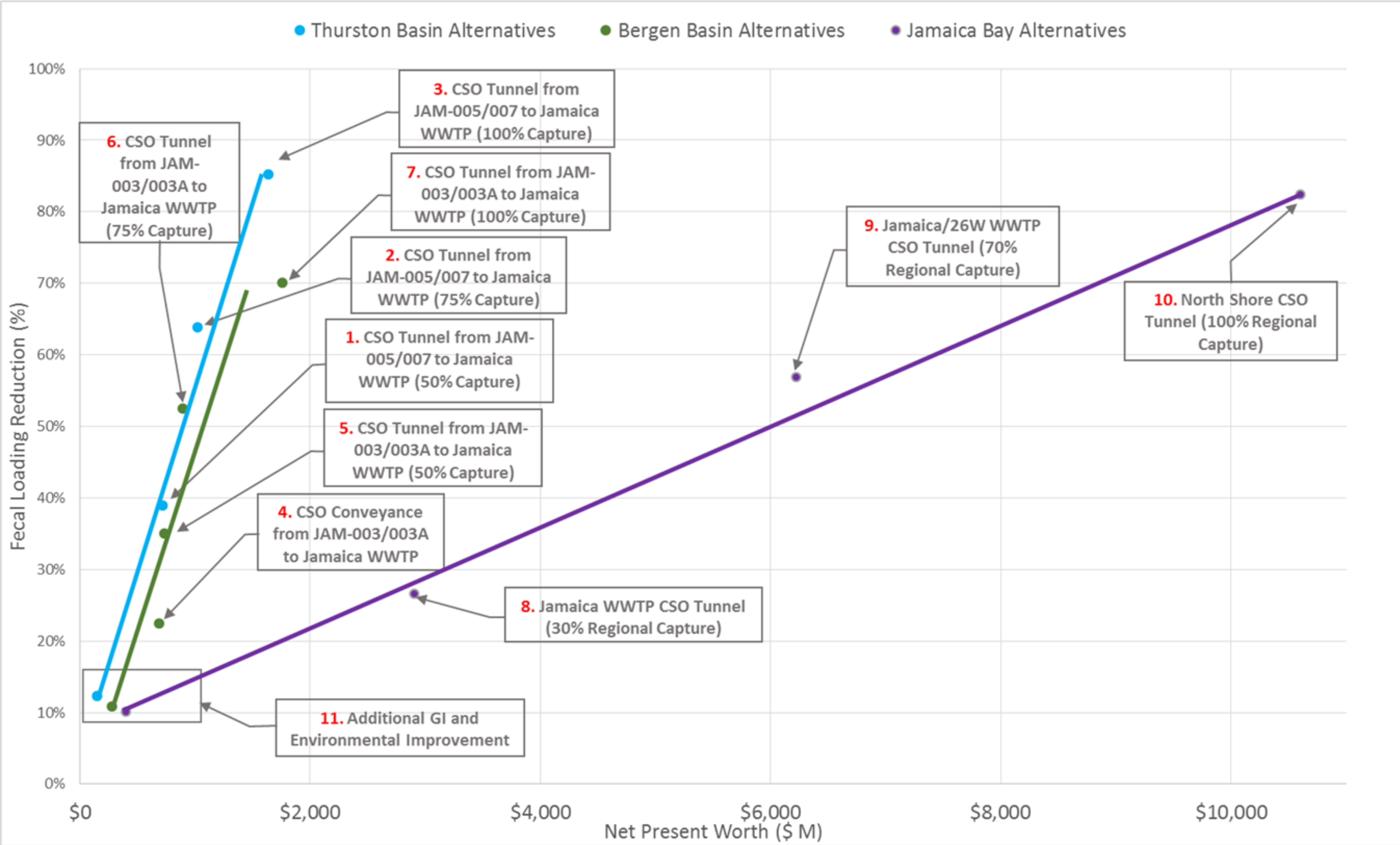


Figure 8-32. Cost vs. *Enterococci* Loading Reduction (2008 Typical Year)

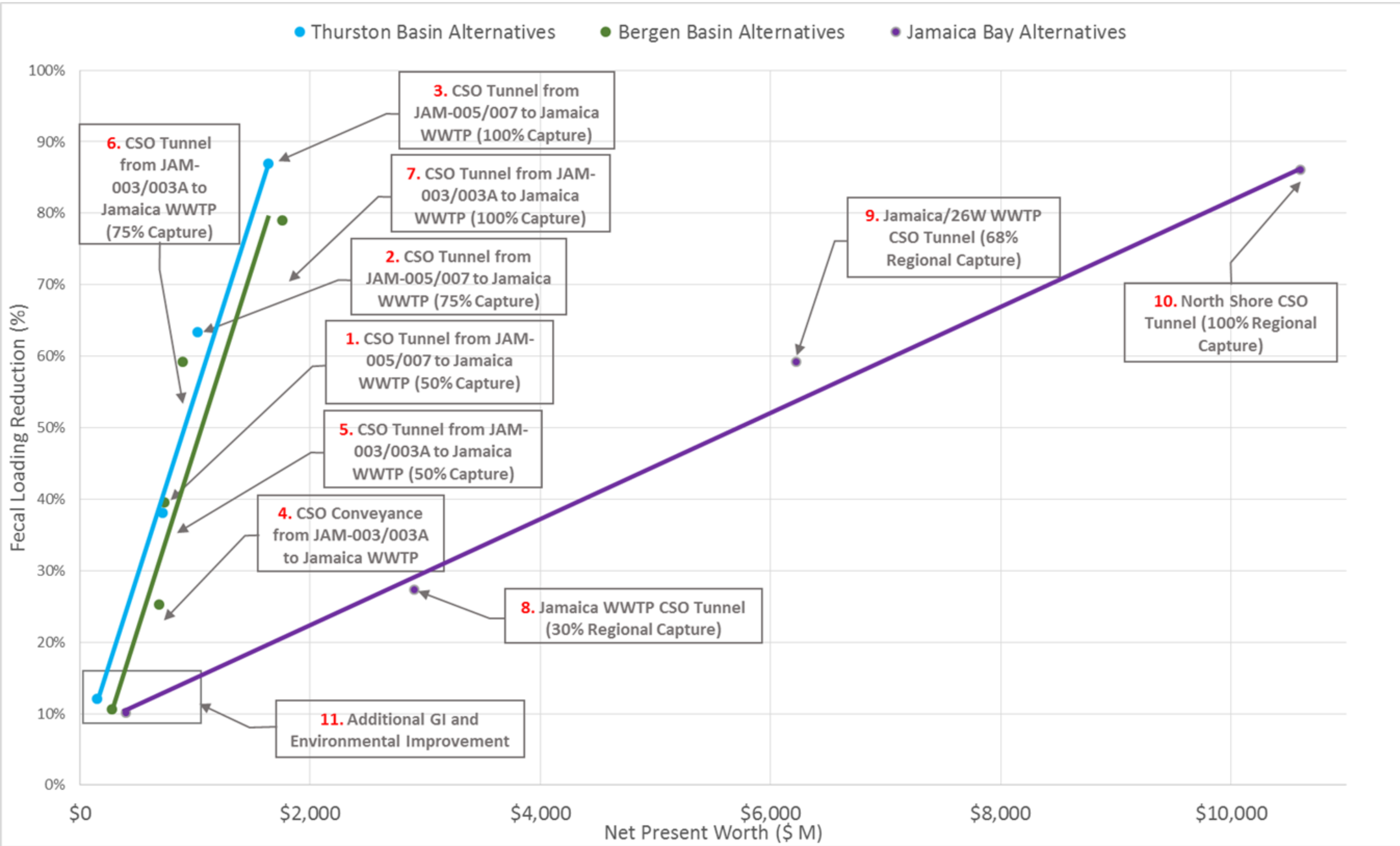


Figure 8-33. Cost vs. Fecal Coliform Loading Reduction (2008 Typical Year)

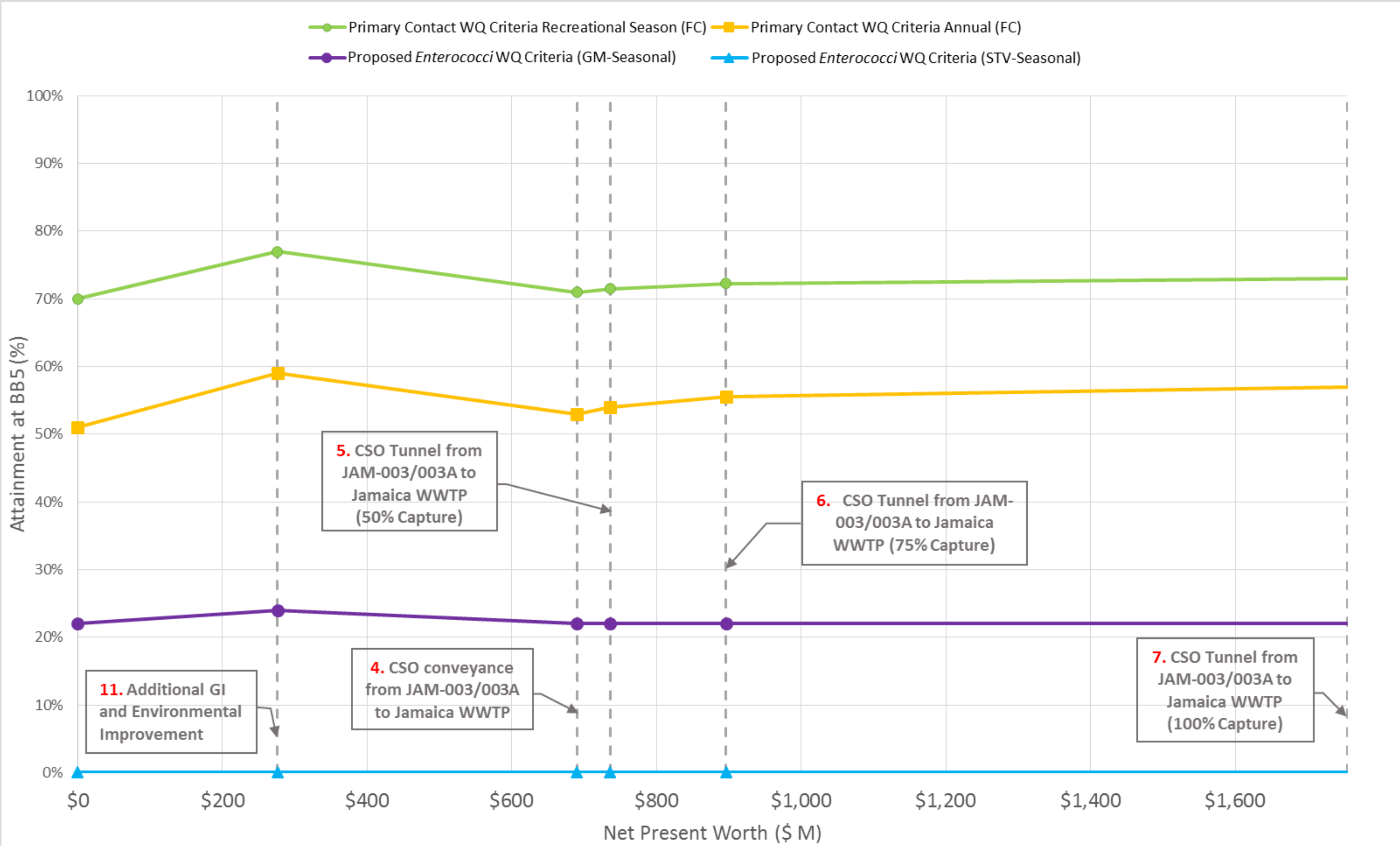


Figure 8-34. Cost vs. Bacteria Attainment at Station BB5 (2008 Typical Year)

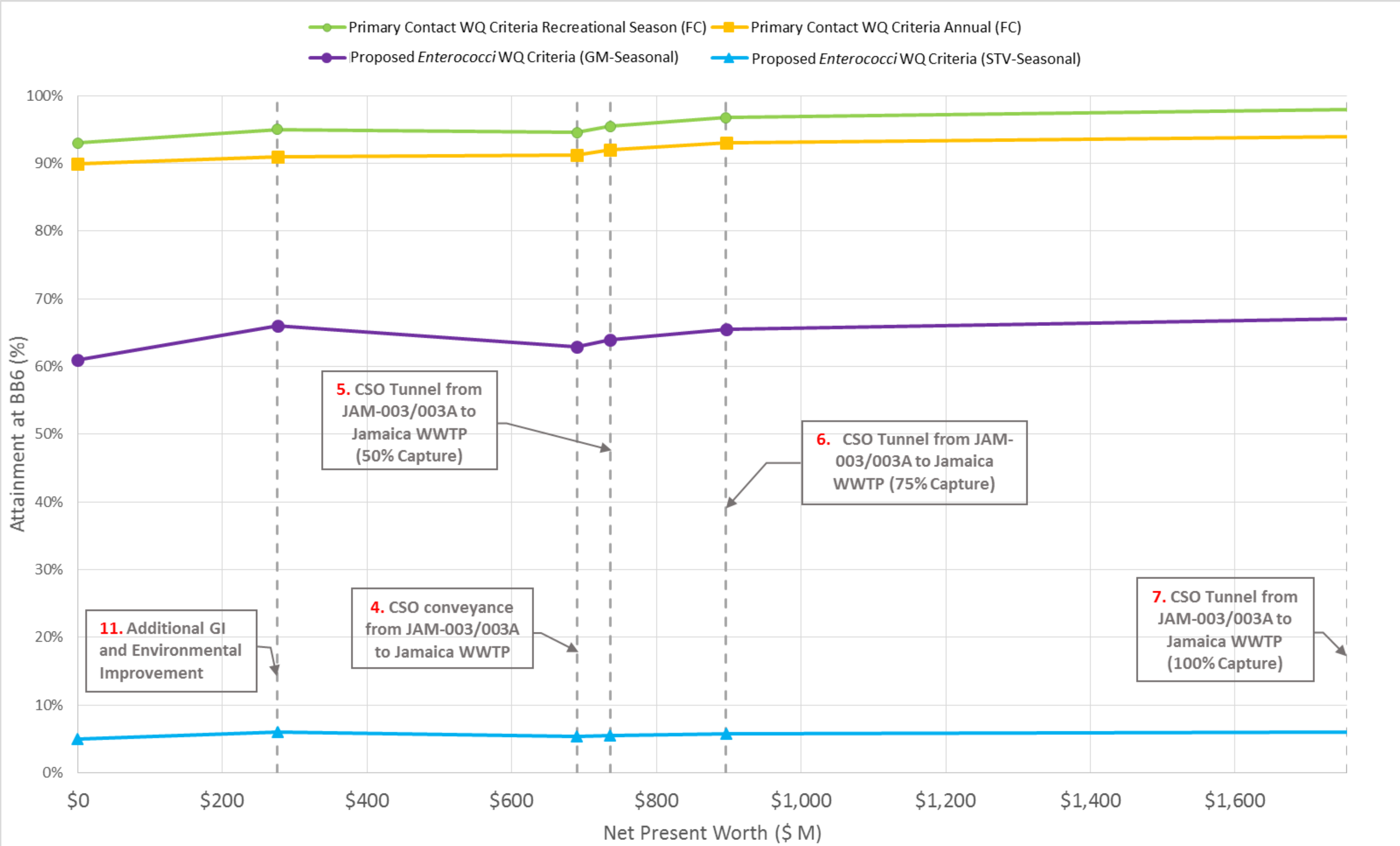


Figure 8-35. Cost vs. Bacteria Attainment at Station BB6 (2008 Typical Year)

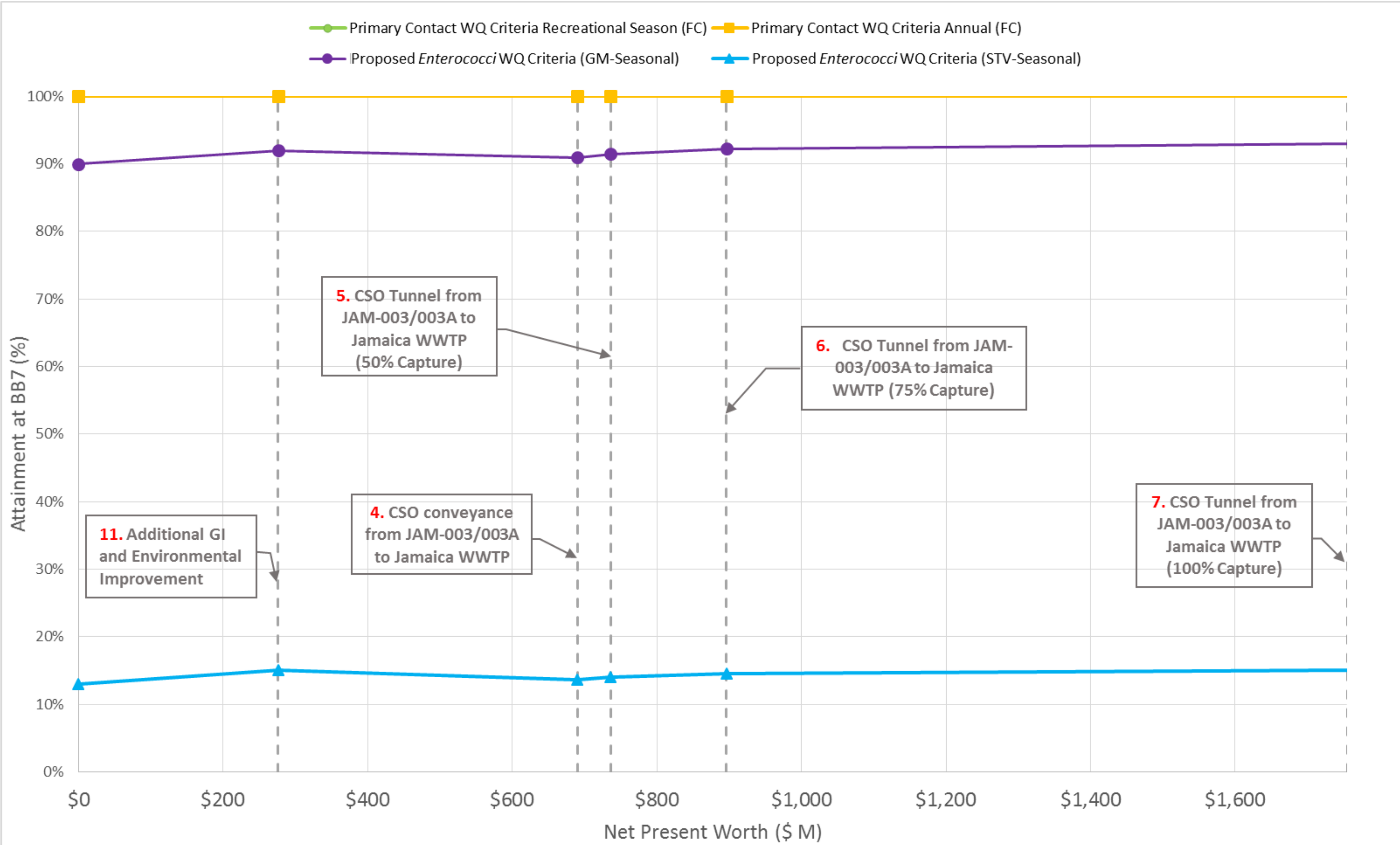


Figure 8-36. Cost vs. Bacteria Attainment at Station BB7 (2008 Typical Year)

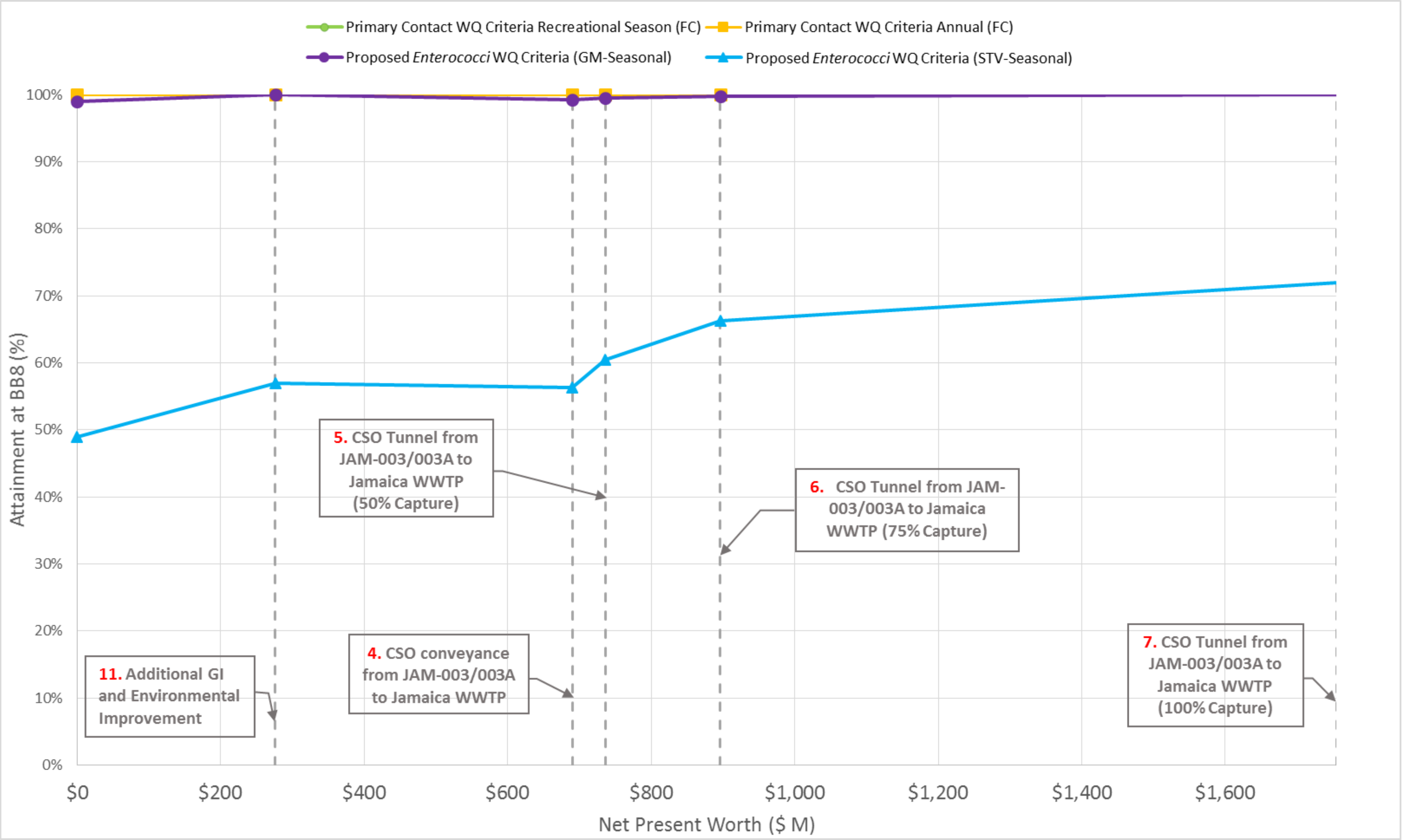


Figure 8-37. Cost vs. Bacteria Attainment at Station BB8 (2008 Typical Year)

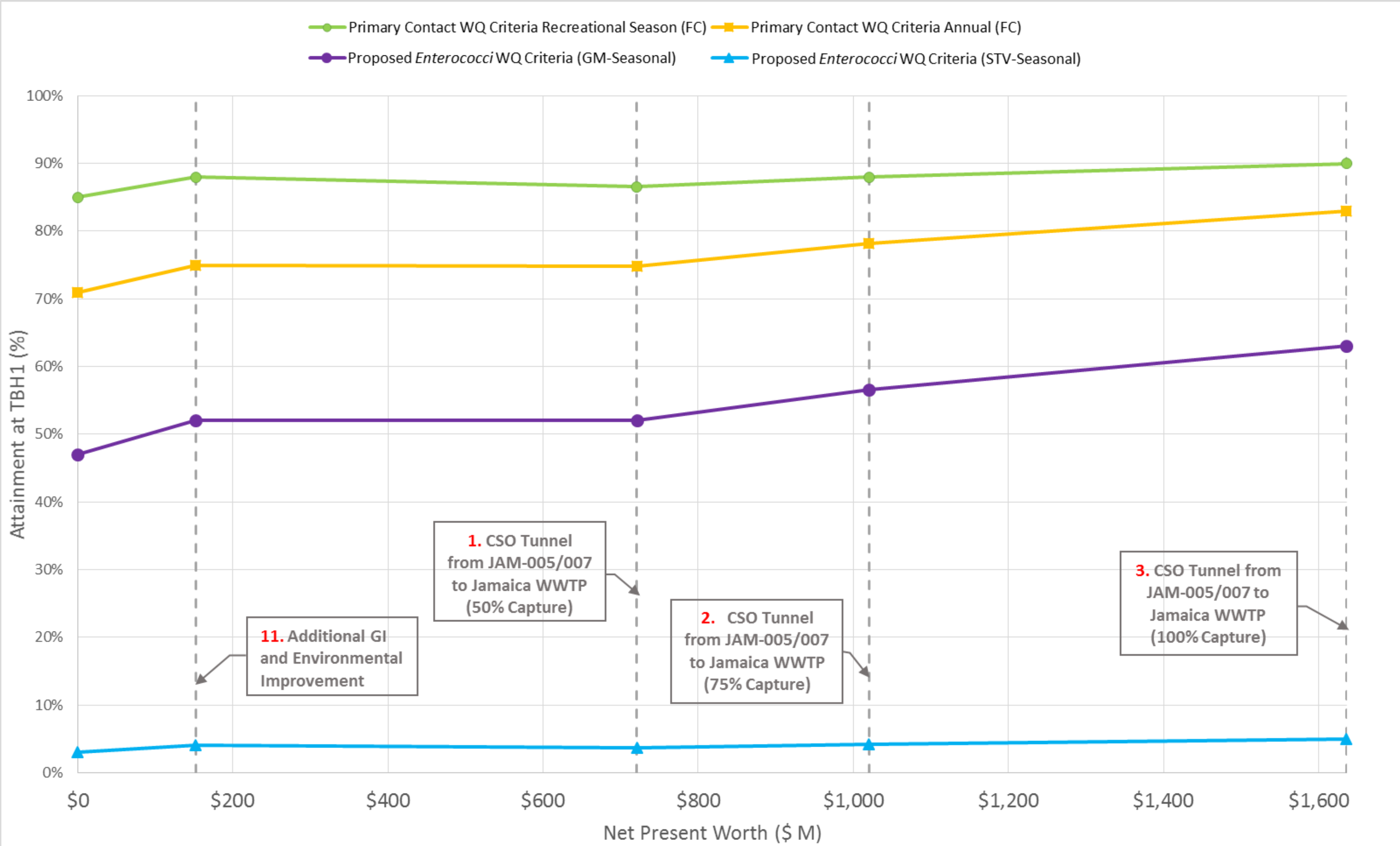


Figure 8-38. Cost vs. Bacteria Attainment at Station TBH1 (2008 Typical Year)

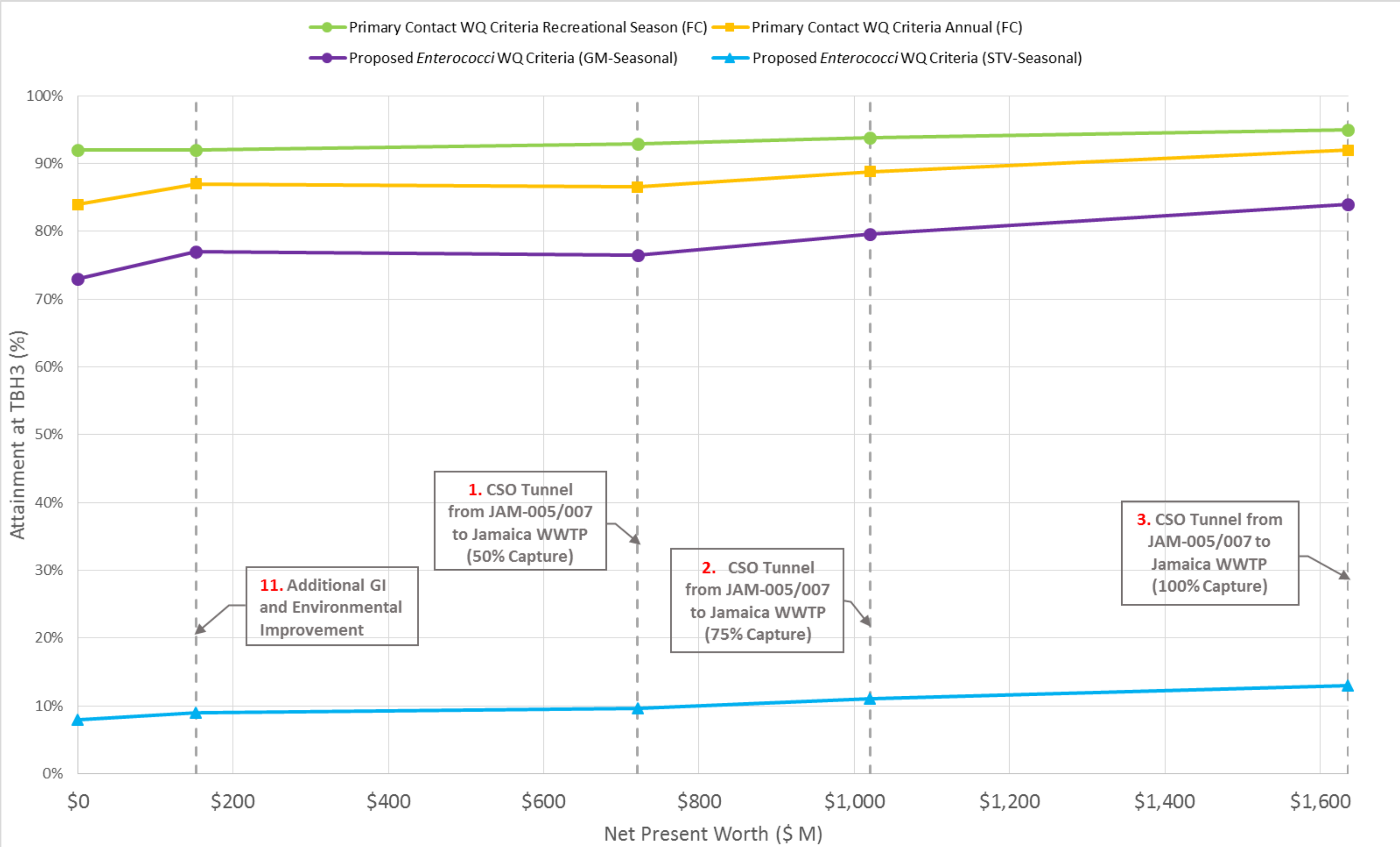


Figure 8-39. Cost vs. Bacteria Attainment at Station TBH3 (2008 Typical Year)

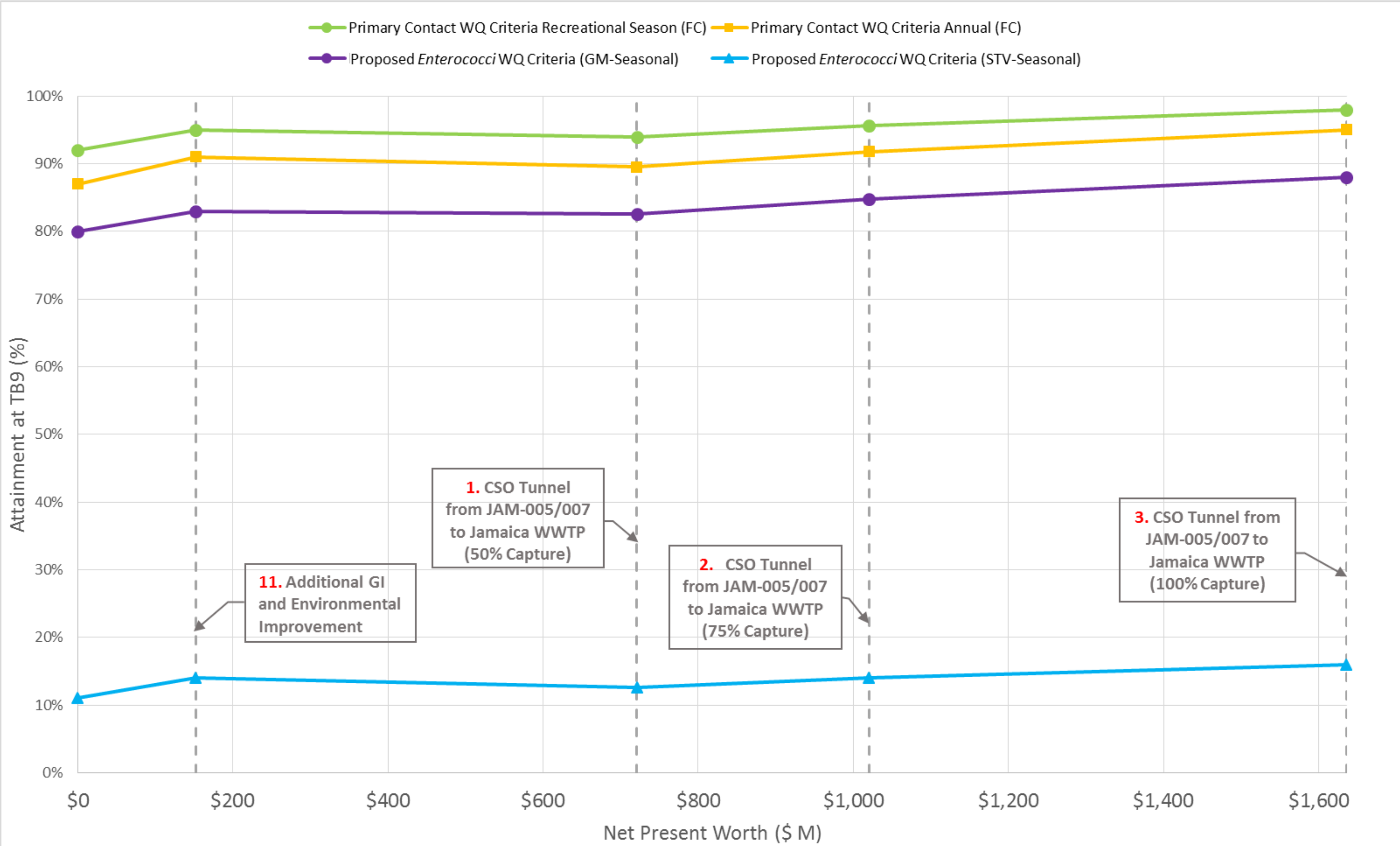


Figure 8-40. Cost vs. Bacteria Attainment at Station TB9 (2008 Typical Year)

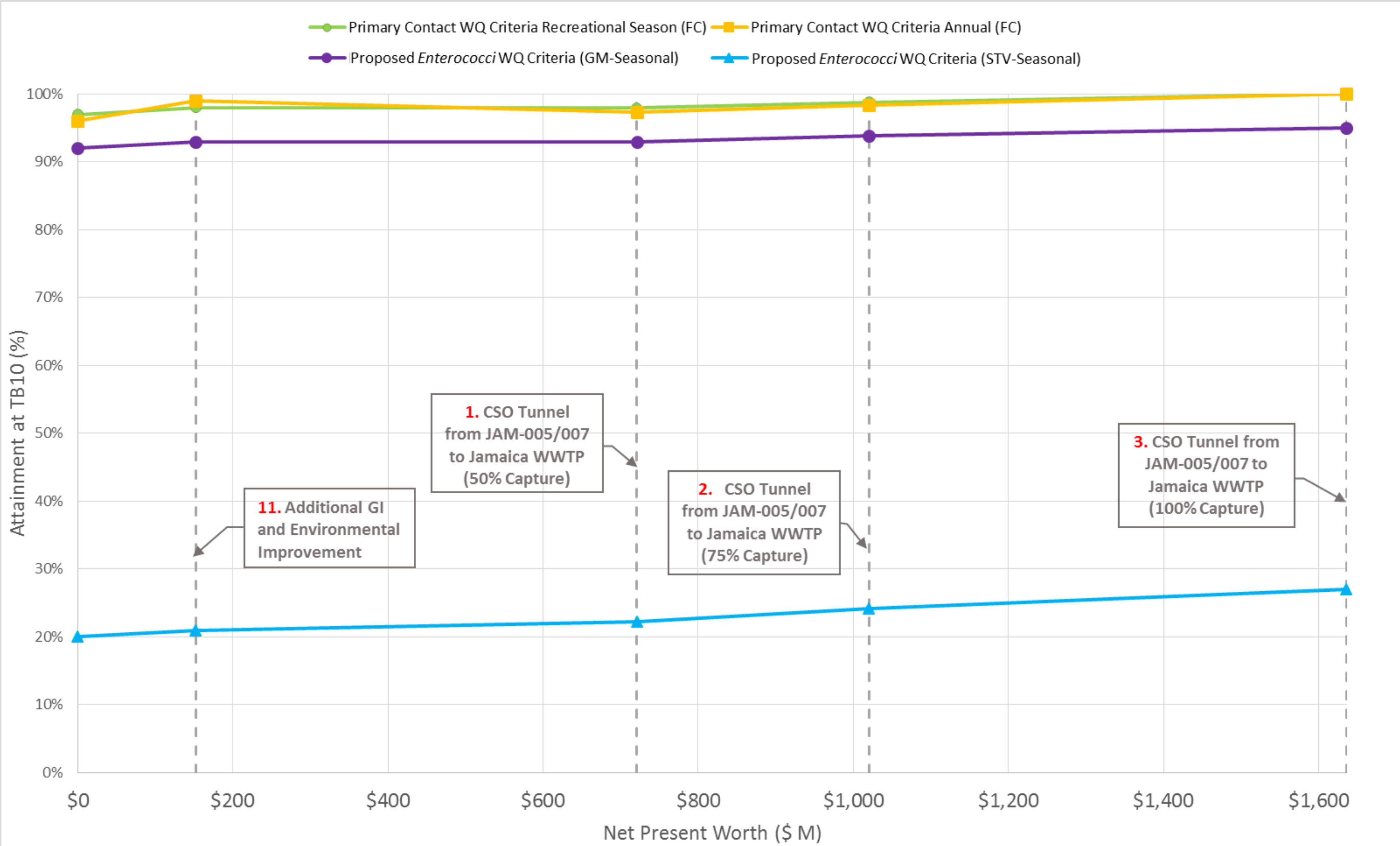


Figure 8-41. Cost vs. Bacteria Attainment at Station TB10 (2008 Typical Year)

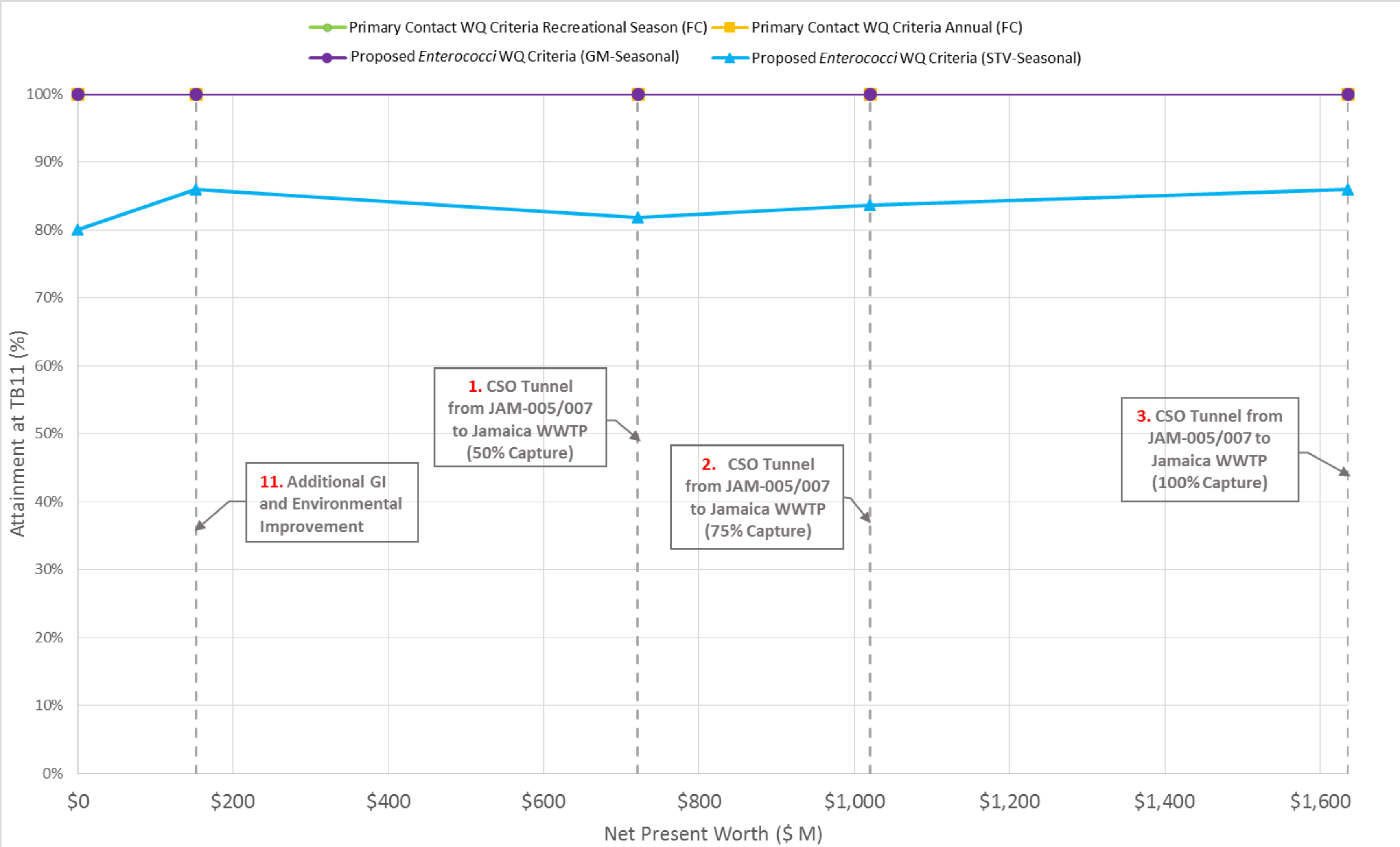


Figure 8-42. Cost vs. Bacteria Attainment at Station TB11 (2008 Typical Year)

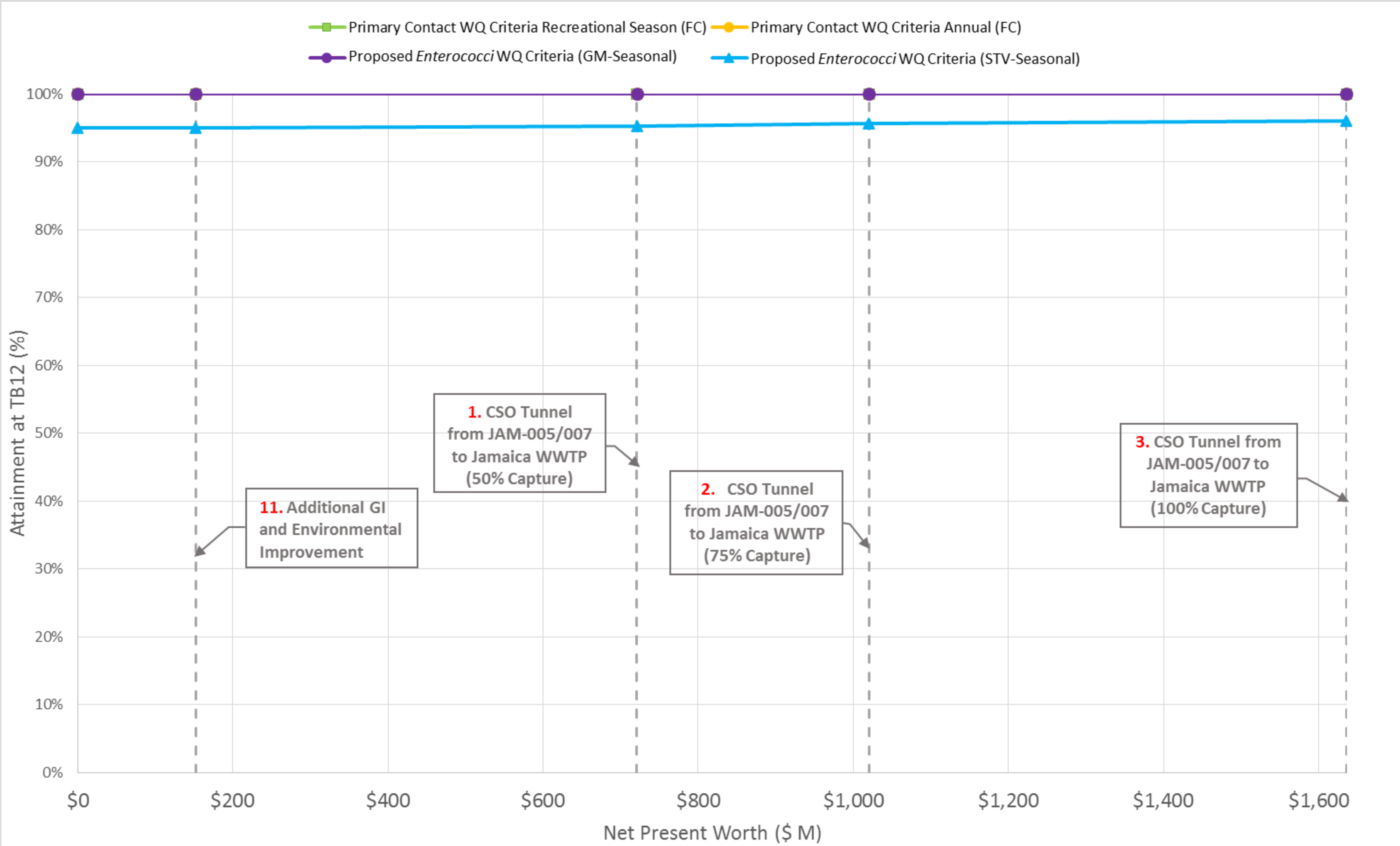


Figure 8-43. Cost vs. Bacteria Attainment at Station TB12 (2008 Typical Year)

8.5.c Conclusion on Recommended Plan

The alternatives were reviewed for cost-effectiveness, ability to meet Existing WQ Criteria and Proposed *Enterococci* WQ Criteria*, public comments and operations. 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 4 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 June 2018 dollars and are considered Level 5 cost estimates by Association for the Advancement of Cost Engineering (AACE) International with an accuracy of -50 to +100 percent.

The selection of the recommended plan is based on multiple considerations including public input, environmental and water quality benefits, and cost. The traditional KOC analysis for cost versus attainment indicates that the Recommended Plan (Alternative 11 – Additional GI and Environmental Improvements) is the most cost-effective approach for CSO control in Bergen and Thurston Basins. This alternative includes expansion of GI to include an additional 379 greened acres in the Bergen and Thurston Basin tributary areas beyond the baseline levels of GI, seven acres of ribbed mussel colony creation distributed between Bergen and Thurston Basins, 50,000 CY of environmental dredging in Bergen Basin, and 50 acres of wetland restoration, distributed among Spring Creek, Hendrix Creek, Fresh Creek, Paerdegat Basin and Jamaica Bay. Evaluations indicated that the expansion of the GI program in separately sewered areas would help capture stormwater for smaller storms, reducing bacterial loading to Bergen and Thurston Basins. These GI assets would generally be sited in the public right-of-way with minimal impact to private properties. Additionally, wetland restoration and ribbed mussel colony creation along the banks of the tributary basins would provide in-stream concentration reductions of bacteria, improving attainment. Wetland restoration would also enhance wildlife habitat along the shoreline. Environmental dredging in Bergen Basin will improve aesthetics and reduce odors. The specific dimensions and configurations of the ribbed mussel beds, limits of environmental dredging, areas identified for restoration of tidal wetlands and details of the GI to be implemented will be finalized during the design phase.

The Additional GI and Environmental Improvements alternative is projected to result in attainment of the Existing WQ Criteria for fecal coliform in the areas of Jamaica Bay and its tributaries that are accessible to the public. The only area that would not achieve attainment of the Existing WQ Criteria for fecal coliform would be the upstream ends of Thurston and Bergen Basins. Public access to those areas is prohibited due to JFK Airport security, and in the case of Thurston Basin, a chain link fence across the waterbody further restricts access. In addition, the gap analysis for Jamaica Bay's tributaries presented in Section 6 indicated that even with a modeled 100% CSO reduction, Existing WQ Criteria for fecal coliform and DO would not be met at the head end of Thurston and Bergen Basins.

While DEP identified grey infrastructure alternatives for Bergen and Thurston Basins that would provide greater reduction in annual CSO volume than the Additional GI and Environmental Improvements alternative, those grey alternatives carried significantly higher costs, would not significantly improve the attainment of WQ criteria, and would not provide the range of ancillary benefits that would be provided by the Additional GI and Environmental Improvements alternative. To further support the evaluation of alternatives, DEP conducted a Triple-Bottom-Line evaluation of the 50 percent control storage tunnel grey alternatives for Bergen and Thurston Basins versus the Additional GI and Environmental Improvements alternative, where the ancillary benefits of the Additional GI and Environmental Improvements alternative were monetized. The Triple-Bottom-Line evaluation is presented below.

*Proposed *Enterococci* WQ Criteria, if adopted as proposed, would only apply to coastal Class SB and SA waters.

Triple-Bottom-Line Benefits

In addition to closing the gap in attainment of Existing WQ Criteria for Jamaica Bay and its tributaries, the Additional GI and Environmental Improvements alternative provides economic, social, and environmental benefits that supplement prior grey infrastructure improvements. A Triple-Bottom-Line analysis was performed to estimate the monetary value of environmental and social benefits and aggregate them alongside the traditional financial bottom line estimates for the project. The Triple-Bottom-Line analysis is based on estimated magnitude of benefits and an equivalent monetary value per unit benefit, which may be derived by calculation of obtained from a representative reference. Although the CSO Policy does not require a Triple-Bottom-Line analysis, or the attainment of such co-benefits, they are worth noting.

Table 8-33 summarizes and quantifies the Triple-Bottom-Line benefits that DEP anticipates will be realized through the implementation of GI, performance of environmental dredging, creation of ribbed mussel colonies, and restoration of tidal wetlands. Co-benefits that were monetized are listed below with their basis of valuation:

- Appreciation of property value – associated with improved curb appeal and drainage improvements and based on one property for each GI practice appreciating by 3 percent from a median property value in Jamaica Bay drainage area of $458,600. The value of 3 percent is the median from the potential range indicated by NYC DEP's Green Infrastructure Co-Benefits Calculator.

- Carbon sequestration – based on carbon sequestration into plant per square foot of wetland and GI area, as detailed by NYC DEP's Water Energy Nexus tool. Carbon offsets are monetized according to NYC Local Law 6 of 2016.

- Air quality improvements – based on NO_2 and PM2.5 removal by urban GI, as detailed by NYC DEP's Green Infrastructure Co-Benefits Calculator. Reductions were monetized using the Autocase TBL-CBA software, developed by Impact Infrastructure.

- Heat island reduction – based on grey area replaced by vegetated area. Reductions were monetized using the Autocase TBL-CBA software, developed by Impact Infrastructure.

Other Triple-Bottom-Line benefits that were not monetized include aesthetic improvements associated with installation of GI and tidal wetland restoration, as well as the reduction of odors associated with exposed organics during low tide.

The benefits provided by the Additional GI and Environmental Improvements alternative achieve many of the ecosystem goals outlined in Plan OneNYC, including expansion of GI, reduction of pollution from stormwater runoff, expansion in tree planting, increase in terrestrial species, and habitat improvements for aquatic species.

The Triple-Bottom-Line of the Additional GI and Environmental Improvements alternative was evaluated over a 100 year service life and the benefits were monetized to estimate the life cycle costs and to determine the economic benefits to the community. Property value appreciation was estimated at $83M. The value of environmental benefits such as air quality improvement, carbon footprint reduction, habitat creation, and urban heat island reduction was estimated at $2M. The $85M in Triple-Bottom-Line benefits was found to be almost equal to the $91M in operation and maintenance costs over the 100 year life cycle. In comparison, the 50 percent Capture Tunnel for Bergen and Thurston Basins grey alternative provided none of the environmental or economic benefits of the Additional GI and Environmental Improvements alternative. Although the grey alternative had a higher reduction in annual CSO volume, it provided no co-benefits such as improvement in stormwater volume, and would not provide the 24/7 continuous filtering of the water in Bergen and Thurston Basins that would be provided with the ribbed mussel habitat.

Table 8-33. Triple-Bottom-Line Comparison

Triple-Bottom-Line Benefits	Additional GI and Environmental Improvements	50% Capture Tunnel for Bergen and Thurston Basins
Water Quality Benefits		
Reduction in CSO Volume (MG)	15	493
Reduction in Stormwater Volume (MG)	234	0
Volume of Water Filtered by Ribbed Mussels (MG)	8,354	0
Environmental Benefits		
Lifetime Carbon Footprint Reduction (MT)	12,806(1)	-31,894(1)
Air Quality (NO_2 Removal) (lbs/yr)	664	0
Air Quality PM_{25} Removal) (lbs/yr)	46	0
Ecosystem Habitat Creation (acres)	72	0
Heat Island Reduction (acres)	10	0
Economic Benefit ($ Millions)		
Probable Bid Cost	-$310	-$1,293
Lifetime O&M and Replacement Cost	-$91	-$124
Valuation of Environmental Benefit	+$2	-$1.2
Property Value Appreciation	+$83	0
Total Net Present Cost	**-$317**	**-$1,418**

Note:

(1) Positive value indicates reduction in carbon footprint versus baseline; negative value indicates increase in carbon footprint versus baseline.

As shown in the cost/attainment figures above, the percent attainment of WQ criteria at the stations in Bergen and Thurston Basins for the Additional GI and Environmental Improvements alternative would be either slightly higher or about the same as the 50 percent capture grey alternative. Since the Additional GI and Environmental Improvements alternative would provide equal or slightly higher WQ criteria attainment at a significantly lower cost than the 50 percent capture grey alternative, and would provide extensive ancillary environmental benefits that the 50 percent capture grey alternative would not provide, Alternative 11 "Additional GI and Environmental Improvements" was identified as the Recommended Plan for Jamaica Bay and its tributaries.

Water Quality Benefits

Figure 8-44 identifies each of the water quality monitoring stations evaluated within Jamaica Bay and its tributaries. The water quality modeling results associated with this Recommended Plan for Jamaica Bay and its tributaries are shown in Table 8-34 and Table 8-35. Table 8-34 provides the calculated annual and recreational season (May 1st through October 31st) attainment of the Existing WQ Criteria for fecal coliform and Table 8-35 presents the recreational season attainment of the Proposed *Enterococci* WQ Criteria*. The results presented in Table 8-34 and Table 8-35 are based on the 10-year simulation.

As indicated in Table 8-34, the Recommended Plan will achieve attainment of the Existing WQ Criteria for fecal coliform annually and during the recreational season (May 1st through October 31st) for most waterbodies, with the exception of Thurston Basin (TBH1, TBH3), Bergen Basin (BB5, BB6), and Fresh Creek (FC1). However, the impacted stations in Bergen Basin and Thurston Basin are prohibited to access by the public by JFK Airport security. In Thurston Basin, access is also prohibited by a floating chain link fence across the waterbody. At Stations TBH3, BB6, and FC1, attainment during the recreational season is 92 percent or better, falling just short of the 95 percent metric. In addition, the gap analysis presented in Section 6 demonstrated that the upstream ends of Thurston Basin, Bergen Basin, and Fresh Creek would not be in attainment with the Existing WQ Criteria for fecal coliform even with 100% CSO control.

As indicated in Table 8-35, the Proposed *Enterococci* WQ Criteria* (rolling 90-day GM <35 cfu/100mL) are met for most waterbodies, except for Thurston and Bergen Basins. However, the stations where attainment falls short of the 95 percent goal are in areas that are prohibited to public access. Attainment of the 90th percentile STV of <130 cfu/100mL ranges between 0 and 100 percent with the lowest levels of attainment occurring at the head ends of Thurston Basin, Bergen Basin, Fresh Creek and Hendrix Creek. Attainment of the STV standard ranges between 55 and 100 percent within Jamaica Bay and at the confluence of each tributary with the Bay.

*Proposed *Enterococci* WQ Criteria, if adopted as proposed, would only apply to coastal Class SB and SA waters.

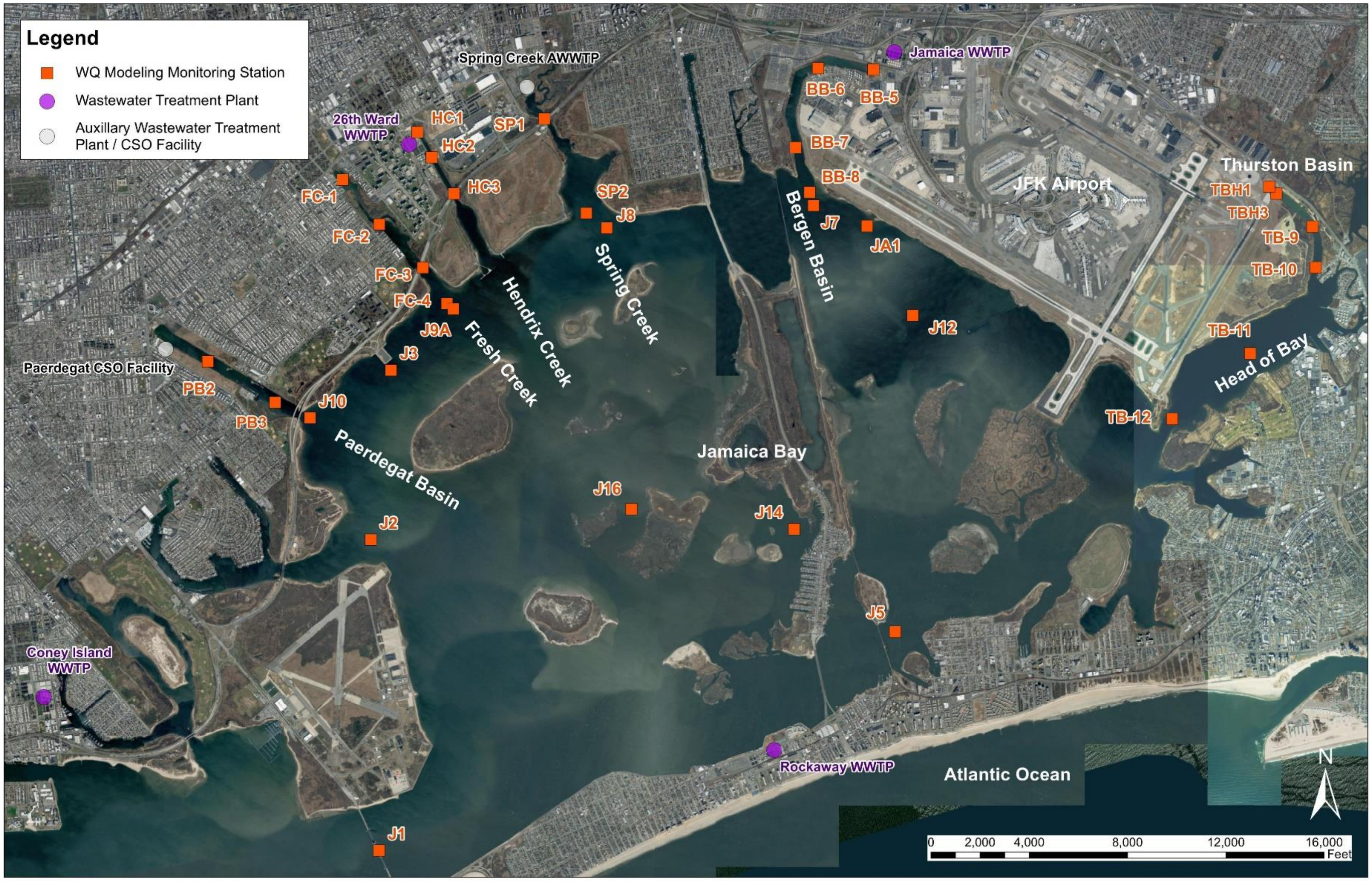


Figure 8-44. LTCP2 Water Quality Monitoring Stations in Jamaica Bay and its Tributaries

Table 8-34. Model Calculated Recommended Plan Fecal Coliform Percent Attainment of Existing WQ Criteria and Primary Contact WQ Criteria

Station	10-Year Percent Attainment (GM<200 cfu/100mL)[3]	
	Annual	Recreational Season[2]
Thurston Basin		
TBH1[1]	75	88
TBH3[1]	87	92
TB9[1]	91	95
TB10[1]	99	98
TB11	100	100
TB12	100	100
Bergen Basin		
BB5[1]	59	77
BB6[1]	91	95
BB7[1]	100	100
BB8	100	100
Spring Creek		
SP1	100	100
SP2	100	100
Hendrix Creek		
HC1	98	97
HC2	100	100
HC3	100	100
Fresh Creek		
FC1	86	93
FC2	96	98
FC3	100	100
FC4	100	100
Paerdegat Basin		
PB1	97	95
PB2	100	100
Jamaica Bay (Northern Shore)		
J10	100	100
J3	100	100
J9a	100	100
J8	100	100
J7	100	100
JA1	100	100

Table 8-34. Model Calculated Recommended Plan Fecal Coliform Percent Attainment of Existing WQ Criteria and Primary Contact WQ Criteria

Station	10-Year Percent Attainment (GM<200 cfu/100mL)(3)	
	Annual	Recreational Season(2)
Jamaica Bay (Inner Bay)		
J2	100	100
J12	100	100
J14	100	100
J16	100	100
Jamaica Bay (Rockaway Shore)		
J1	100	100
J5	100	100

Notes:
(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.
(2) The recreational season is from May 1st through October. 31st.
(3) As described in Section 8.2, the ribbed mussels proposed for Bergen and Thurston Basins were assumed to provide an additional 10 percent reduction in in-water bacteria concentrations in Bergen and Thurston Basins. The attainment values in this table take into account that 10-percent reduction in concentration. Without the 10 percent reduction associated with the ribbed mussels, the percent attainment in Bergen and Thurston Basins would be in the range of 1 to 5 percent lower, depending on the station.

Table 8-35. Model Calculated Recommended Plan *Enterococci* Percent Attainment of Proposed *Enterococci* WQ Criteria*

Station	10-Year Recreational Season(2) Percent Attainment(3)(4)	
	90-day Rolling GM <35 cfu/100mL	90th Percentile STV <130 cfu/100mL
Thurston Basin		
TBH1(1)	61	0
TBH3(1)	89	1
TB9(1)	92	3
TB10(1)	100	11
TB11	100	95
TB12	100	99
Bergen Basin		
BB5(1)	19	0
BB6(1)	78	0
BB7(1)	100	3
BB8	100	58

*Proposed *Enterococci* WQ Criteria, if adopted as proposed, would only apply to coastal Class SB and SA waters.

Table 8-35. Model Calculated Recommended Plan *Enterococ*ci Percent Attainment of Proposed *Enterococci* WQ Criteria*

Station	10-Year Recreational Season(2) Percent Attainment(3)(4)	
	90-day Rolling GM <35 cfu/100mL	90th Percentile STV <130 cfu/100mL
Spring Creek		
SP1	100	84
SP2	100	100
Hendrix Creek		
HC1	100	16
HC2	100	23
HC3	100	72
Fresh Creek		
FC1	100	4
FC2	100	5
FC3	100	34
FC4	100	100
Paerdegat Basin		
PB1	100	12
PB2	100	67
Jamaica Bay (Northern Shore)		
J10	100	99
J3	100	100
J9a	100	100
J8	100	100
J7	100	55
JA1	100	95
Jamaica Bay (Inner Bay)		
J2	100	100
J12	100	100
J14	100	100
J16	100	100
Jamaica Bay (Rockaway Shore)		
J1	100	100
J5	100	100

Notes:

(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.

(2) The recreational season is from May 1st through October. 31st.

(3) The Proposed *Enterococci* WQ Criteria*, if adopted as proposed, would not apply to non-coastal Class I waters, including the tributaries of Jamaica Bay.

(4) As described in Section 8.2, the ribbed mussels proposed for Bergen and Thurston Basins were assumed to provide an additional 10 percent reduction in in-water bacteria concentrations in Bergen and Thurston Basins. The attainment values in this table take into account that 10-percent reduction in concentration. Without the 10 percent reduction associated with the ribbed mussels, the percent attainment of the 90-day Rolling GM criterion in Bergen and Thurston Basins would be in the range of 1 to 5 percent lower, depending on the station.

*Proposed *Enterococci* WQ Criteria, if adopted as proposed, would only apply to coastal Class SB and SA waters.

The average annual attainment of DO criteria for the Recommended Plan based on the water quality model simulation is presented in Table 8-36 for 2008 typical year rainfall conditions (the LTCP framework does not evaluate DO attainment under a 10-year simulation). The average annual attainment is calculated by averaging the calculated attainment in each of 10 modeled depth layers, comprising the entire water column. When assessing the water column in its entirety, attainment of the DO criterion is very high, with the exception of the head ends of Bergen Basin, Thurston Basin, and Hendrix Creek. All other monitoring station locations that were assessed have a water column annual attainment of 95 percent or greater for 2008 typical year rainfall conditions.

Table 8-36. Model Calculated Recommended Plan DO Attainment – Existing WQ Criteria (2008 Typical Year)

Annual Attainment (%) (Entire Water Column)				
Tributaries – Class I		Jamaica Bay - Class SB		
Station	Instantaneous (>=4.0 mg/L)	Station	Instantaneous (>=3.0 mg/L)	Daily Ave. (>=4.8 mg/L)
Thurston Basin		**Jamaica Bay (Northern Shore)**		
TBH1(1)	90	J10	100	100
TBH3(1)	90	J3	100	100
TB9(1)	92	J9a	100	100
TB10(1)	92	J8	100	100
TB11	97	J7	100	100
TB12	99	JA1	100	99
Bergen Basin		**Jamaica Bay (Inner Bay)**		
BB5(1)	89	J2	100	100
BB6(1)	95	J12	100	100
BB7(1)	99	J14	100	100
BB8	100	J16	100	100
Spring Creek		**Jamaica Bay (Rockaway Shore)**		
SP1	99	J1	100	100
SP2	100	J5	100	100
Hendrix Creek				
HC1	94			
HC2	98			
HC3	100			
Fresh Creek				
FC1	99			
FC2	100			
FC3	100			
FC4	100			
Paerdegat Basin				
PB2	99			
PB3	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.

The key components of the Recommended Plan include:

- Thurston Basin
  - 147 greened acres of GI Expansion
  - 3 acres of Ribbed Mussel Colony Creation
- Bergen Basin
  - 232 greened acres of GI Expansion
  - 50,000 CY Environmental Dredging
  - 4 acres of Ribbed Mussel Colony Creation
- Spring Creek
  - 13 acres of Tidal Wetland Restoration
- Hendrix Creek
  - 3 acres of Tidal Wetland Restoration
- Fresh Creek
  - 14 acres of Tidal Wetland Restoration
- Paerdegat Basin
  - 4 acres of Tidal Wetland Restoration
- Jamaica Bay
  - 16 acres of Tidal Wetland Restoration

DEP will identify the specific locations and layouts of the proposed projects in each of the tributaries during subsequent planning and design phases. The implementation of these elements has a NPW of approximately $401M, reflecting $91M of O&M for a 100-year service life.

The proposed schedule for the implementation of the Recommended Plan is presented in Section 9.2.

8.6 Use Attainability Analysis

The CSO Order requires that a UAA be included in a 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, even with the implementation of the Recommended Plan, Bergen Basin, Thurston Basin, and Fresh Creek are not projected to fully meet Existing WQ Criteria for fecal coliform and Bergen Basin, Thurston Basin, and Hendrix Creek are not projected to fully attain the Existing WQ Criteria for DO (Class I). Thus, a UAA has been included in this LTCP.

8.6.a 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 water quality requirements. This may either be the Existing WQ Criteria (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 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 water quality requirements. In this case, if a higher level of control is not feasible, the UAA must justify the shortcoming using at least one of the six criteria (see Section 8.6 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 Tables 8-34 and 8-36, upon implementation of the LTCP Recommended Plan, the fecal coliform and DO criteria for the Class I waters of the tributaries to Jamaica Bay are not projected to be achieved on a recreational season (May 1st through October 31st) basis. The non-attainment is predominantly due to stormwater, direct drainage and other urban sources of pathogens to these waterbodies. As indicated in Table 6-7 of Section 6.3, the criteria would not be attained even with a 100% CSO control scenario, thus supporting the influence that non-CSO sources have on the ability to achieve attainment of WQ criteria.

8.6.b 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 WQS for Jamaica Bay and Class I WQS for the tributaries, as fulfillment of the CWA's fishable/swimmable goal.

Based on the 10-year continuous simulations, as presented in Table 8-34, the Recommended Plan would result in attainment of the Existing WQ Criteria for fecal coliform during the recreational season (May 1st through October 31st) for Jamaica Bay and Existing WQ Criteria for fecal coliform for Spring Creek, Hendrix Creek and Paerdegat Basin. However, Existing WQ Criteria for fecal coliform for Thurston Basin, Bergen Basin, and Fresh Creek would not be achieved. As indicated in Table 8-36, the Existing WQ Criteria for DO (Class SB) would be met for Jamaica Bay on an annual average basis. In addition, the Existing WQ Criteria for DO (Class I) would be met for all tributaries except for Thurston Basin, Bergen Basin, and Hendrix Creek.

As discussed in Section 6, 100% CSO control does not result in attainment of the Existing WQ Criteria for fecal coliform or DO for these tributaries. Thus, CSO loads are not the controlling factor for bacteria or DO concentrations and CSO controls will not substantially improve WQ criteria attainment. This finding is not unexpected as the DO and bacteria concentrations in the Jamaica Bay Tributaries are influenced by many non-CSO factors including stormwater loads, tidal flushing, and the nitrogen discharged from WWTPs (DO impact, only).

8.6.c Assessment of Highest Attainable Use

The CSO Order Goal Statement stipulates that, in situations where the proposed alternatives presented in 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 some of the Jamaica Bay Tributaries are not projected to fully attain the Class I fecal coliform or DO criteria on an annual basis, a UAA is required under the CSO Order. Table 8-37 summarizes the compliance with Existing, Primary Contact, and Proposed *Enterococci* WQ Criteria* for the Recommended Plan. The UAA is included as Appendix C.

*Proposed *Enterococci* WQ Criteria, if adopted as proposed, would only apply to coastal Class SB and SA waters.

Table 8-37. Recommended Plan Compliance with Bacteria WQ Criteria

Waterbody	Location	Fecal Coliform Annual Attainment (1)	Fecal Coliform Recreational Attainment (2)	Proposed Enterococcus 90-Day GM (3)	Proposed Enterococcus 90-Day STV (4)	Dissolved Oxygen Annual Attainment (5)
Thurston Basin	Head End(9)	✗	✗	N/A	N/A	✗
	Mid Point(9)	✗	✓	N/A	N/A	✗
	Mouth	✓	✓	N/A	N/A	✓
Bergen Basin	Head End(9)	✗	✗	N/A	N/A	✗
	Mid Point(9)	✗	✓	N/A	N/A	✓
	Mouth	✓	✓	N/A	N/A	✓
Hendrix Creek	Head End	✓	✓	N/A	N/A	✗ (6)
	Mid Point	✓	✓	N/A	N/A	✓
	Mouth	✓	✓	N/A	N/A	✓
Fresh Creek	Head End	✗ (7)	✗ (7)	N/A	N/A	✓
	Mid Point	✓	✓	N/A	N/A	✓
	Mouth	✓	✓	N/A	N/A	✓
Paerdegat Basin	Head End	✓	✓	N/A	N/A	✓
	Mid Point	✓	✓	N/A	N/A	✓
	Mouth	✓	✓	N/A	N/A	✓
Jamaica Bay (Grassy Bay)	Northern	✓	✓	✓	✗ (8)	✓
	Southern	✓	✓	✓	✓	✓
Jamaica Bay (North Channel)	Entire	✓	✓	✓	✓	✓
Jamaica Bay (Beach Channel)	Entire	✓	✓	✓	✓	✓
Jamaica Bay (Island Channel)	Entire	✓	✓	✓	✓	✓
Jamaica Bay (Rockaway Inlet)	Entire	✓	✓	✓	✓	✓

Notes:

✓ indicates that attainment is projected to occur ≥ 95% of the time
✗ indicates that attainment is projected to occur < 95% of the time

(1) Fecal coliform annual attainment is based on a monthly geometric mean of ≤200 cfu/100 mL.
(2) Fecal coliform recreational attainment is based on a monthly geometric mean of ≤200 cfu/100 mL from May 1 thru Oct 31.
(3) The proposed 90-day *Enterococcus* GM attainment is based on DEC proposed 90-day *Enterococcus* standard of ≤35 cfu/100 mL for coastal recreational waters during recreational season (May 1 thru Oct 31).
(4) The proposed 90-day *Enterococcus* STV attainment is based on the DEC proposed 90-day *Enterococcus* standard that required 90% of the values to be ≤ 130 cfu/100 mL during the recreational season (May 1 thru Oct 31).
(5) The DO standard in the tributaries is never less than 4 mg/L and in Jamaica Bay is never less than 3 mg/L and a allows for duration-based excursions between 3 and 4.8 mg/L.
(6) The projected attainment at the very head end of Fresh Creek is about 86% and 93% for annual and recreational attainment, respectively.
(7) The projected dissolved oxygen attainment in the head end of Hendrix Creek is 94%.
(8) Only a small area of Grassy Bay just outside of Bergen Basin is projected not to attain the proposed 90-day *Enterococcus* STV that required 90% of values to be less ≤ 130 cfu/100 mL.
(9) Unauthorized access to these portions of Bergen and Thurston Basins is prohibited by JFK Airport security.

8.7 Water Quality Goals

Based on the analyses of Jamaica Bay, its tributaries and the WQ criteria associated with the designated uses, the following conclusions can be drawn:

8.7.a Existing Water Quality

Jamaica Bay, excluding the tributaries, is classified as suitable for primary and secondary contact recreation and fishing. Numerous public access points that facilitate primary and secondary contact activities within Jamaica Bay exist at federal, State, and City parklands. Approximately 66 percent of the publicly accessible parkland is within the GNRA. The bulk of the remaining waterfront access is provided by the New York City Department of Parks and Recreation operated parks and open space areas and includes four kayak/canoe launch sites. Only one public boat launch ramp is located within Jamaica Bay, adjacent to the Rockaway WWTP.

Under baseline conditions, Spring Creek and Paerdegat Basin are in attainment with the bacteria and DO criteria associated with their current classification (Class I), while Thurston Basin, Bergen Basin, Fresh Creek, and Hendrix Creek are not. Jamaica Bay, itself, is in attainment with the bacteria and DO criteria associated with its current classification (Class SB).

8.7.b Primary Contact Water Quality Criteria

As presented in Section 8.5, this LTCP incorporates assessments for attainment with primary contact WQS, as the Existing WQ Criteria for fecal coliform are the same as the Primary Contact WQS. DEP assessed attainment both spatially and temporally using the 2008 typical year rainfall and a 10-year simulation for bacteria. For the Recommended Plan, projected bacteria levels show that Jamaica Bay and its tributaries (with the exception of the stations at the head ends of Thurston Basin, Bergen Basin, and Fresh Creek) will meet the Existing WQ Criteria for fecal coliform during the recreational season (May 1st through October 31st). The same is true for the Primary Contact WQ Criteria for bacteria. The stations near the head ends of Thurston and Bergen Basins (TBH1 and BB5) are not projected to achieve attainment of the Existing WQ Criteria for fecal coliform during the recreational season even with 100% CSO control. These stations, however, are prohibited from public access. The stations within these waterbodies that are accessible to the public (TB11 and BB8) achieve both annual and recreational season attainment for the fecal coliform criteria. These stations also achieve attainment for the Proposed *Enterococci* WQ Criteria* (GM<35 cfu/100mL) although this proposed criteria is not applicable to Class I waters. While Fresh Creek does not achieve 95 percent annual or recreational season attainment of Existing WQ Criteria for fecal coliform under baseline conditions, Fresh Creek does achieve the Proposed *Enterococci* WQ Criteria* (GM<35 cfu/100mL) although this proposed criteria is not applicable to Class I waters.

8.7.c Proposed *Enterococci* WQ Criteria*

DEP is committed to improving water quality in Jamaica Bay and its tributaries. Toward that end, DEP has identified instruments that will allow DEP to continue to improve water quality in the system over time. Wet-weather advisories based on time to recovery analysis are recommended for consideration while advancing towards the numerical criteria established, or others under consideration by DEC, including Proposed *Enterococci* WQ Criteria*.

*Proposed *Enterococci* WQ Criteria, if adopted as proposed, would only apply to coastal Class SB and SA waters.

8.7.d Time to Recovery

Although Jamaica Bay and the accessible areas in the tributaries could be protective of primary contact use during the recreational season (May 1st through October 31st), they will not be capable of supporting primary contact 100 percent of the time. Even with anticipated reductions in CSO and stormwater volumes resulting from the Recommended Plan, the waterbodies cannot support primary contact during, and, for a certain period of time, following rainfall events. Toward the goal of maximizing the amount of time that Jamaica Bay and its tributaries can achieve water quality levels to support primary contact, DEP has performed an analysis to assess the amount of time following the end of a rainfall event required for Jamaica Bay and its tributaries to recover and return to fecal coliform concentrations less than 1,000 cfu/100mL. This concentration represents the maximum that the New York City Department of Health and Mental Hygiene (DOHMH) considers safe for primary contact.

The analyses consisted of examining the water quality model-calculated bacteria concentrations in Jamaica Bay and its tributaries for recreational periods (May 1st through October 31st) abstracted from 10 years of model simulations. The time to return (or "time to recovery") to a fecal coliform concentration of 1,000 cfu/100mL for each water quality station within the waterbody was then calculated for each storm within the various size categories. The median time after the end of rainfall was then calculated for each rainfall category. Table 8-38 presents the results of these analyses for Jamaica Bay and its tributaries, for the storms that fell within the range of 1.0 to 1.5 inches of rainfall. Approximately 90 percent of the storms are 1.5-inches or less on an average annual basis. As described in Section 8, results presented for the Recommended Plan for the 10-year model simulations were interpolated from available results for the alternatives that included the 0 and 50 percent CSO control tunnels for Bergen and Thurston Basins. As indicated in Table 8-38, the median duration of time within which pathogen concentrations are expected to be higher than 1,000 cfu/100mL varies by location within Jamaica Bay and each of its tributaries. For the Recommended Plan, the median times to recovery are below 24 hours at all of the water quality stations for the storm sizes up to 1.5 inches except for Stations TBH1, TBH2, and TB9 in Thurston Basin, BB5 and BB6 in Bergen Basin and FC1 in Fresh Creek. The median times to recovery at those stations ranged from 32 to 43 hours. For storms greater than 1.5 inches, the median times to recovery are well above 24 hours at all stations located near the head end of each tributary, except for Hendrix Creek (22 hours). All stations within Jamaica Bay have median times to recovery well below 24 hours.

Table 8-38. Time to Recovery – Recommended Plan

Station	Time to Recovery (hours) Fecal Coliform Threshold (1,000 cfu/100mL)(1)
Thurston Basin	
TBH1(2)	38
TBH3(2)	35
TB9(2)	30
TB10(2)	16
TB11	0
TB12	0
Bergen Basin	
BB5(2)	40

Table 8-38. Time to Recovery – Recommended Plan

Station	Time to Recovery (hours) Fecal Coliform Threshold (1,000 cfu/100mL)(1)
BB6(2)	33
BB7(2)	18
BB8	6
Spring Creek	
SP1	6
SP2	0
Hendrix Creek	
HC1	19
HC2	18
HC3	10
Fresh Creek	
FC1	35
FC2	24
FC3	9
FC4	1
Paerdegat Basin	
PB1	19
PB2	6
Jamaica Bay (Northern Shore)	
J10	3
J3	0
J9a	0
J8	0
J7	6
JA1	1
Jamaica Bay (Inner Bay)	
J2	0
J12	0
J14	0
J16	0
Jamaica Bay (Rockaway Shore)	
J1	0
J5	0

Notes:

(1) Median values for storms in the 1.0 to 1.5-inch range, for the 10-year recreational periods.

(2) Monitoring station is located in a portion of the waterbody where unauthorized access is prohibited by JFK Airport security and/or a physical barrier.

8.8 Recommended LTCP Elements to Meet Water Quality Goals

Water quality in Jamaica Bay will be improved with the Recommended Plan and other actions identified herein.

The actions identified in this LTCP include in the following waterbodies:

- Thurston Basin
  - 147 greened acres of GI Expansion
  - 3 acres of Ribbed Mussel Colony Creation

- Bergen Basin
  - 232 greened acres of GI Expansion
  - 50,000 CY Environmental Dredging
  - 4 acres of Ribbed Mussel Colony Creation

- Spring Creek
  - 13 acres of Tidal Wetland Restoration

- Hendrix Creek
  - 3 acres of Tidal Wetland Restoration

- Fresh Creek
  - 14 acres of Tidal Wetland Restoration

- Paerdegat Basin
  - 4 acres of Tidal Wetland Restoration

- Jamaica Bay
  - 16 acres of Tidal Wetland Restoration

Furthermore, the Recommended Plan will result in an additional 15 MGY reduction in CSO volume due to the increased capacity in the interceptors in the CSO portion of system.

DEP is committed to improving water quality in these waterbodies, 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 citizens of NYC.

9.0 LONG TERM CSO CONTROL PLAN IMPLEMENTATION

The evaluations performed for this LTCP concluded that under baseline conditions, Jamaica Bay is in attainment with existing Class SB WQ Criteria for fecal coliform bacteria and DO. Among the tributaries to Jamaica Bay, the existing Class I WQ Criteria for fecal coliform bacteria are projected to be attained, except in the most upstream reaches of Thurston Basin, Bergen Basin, and Fresh Creek. Paerdegat Basin, Fresh Creek, and Spring Creek are in attainment with existing Class I WQ Criteria for DO; however, the upstream reaches of Hendrix Creek, Bergen, and Thurston Basins are not in attainment with the Class I WQ Criteria for DO. Even with 100% CSO control, the upstream reaches of Thurston and Bergen Basins are not projected to be in attainment with the Class I WQ Criteria for fecal coliform and DO. As detailed in Section 8.5, the selection of the preferred alternative is based on multiple considerations including public input, environmental benefits, water quality improvements, and cost effectiveness. In addition to the traditional cost-performance curves, a triple-bottom-line analysis was performed to quantify the co-benefits of the Recommended Plan in comparison to other alternatives.

Water quality in Jamaica Bay and its tributaries will be improved through the implementation of the following:

(1) Constructed and currently planned improvements including those recommended in the Jamaica Bay WWFP;

(2) Constructed and planned GI projects in combined sewer areas; and

(3) The Recommended Plan for the Jamaica Bay and Tributaries LTCP, which includes the following projects:

- GI expansion in Bergen and Thurston Basins;
- 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.

The analyses developed herein indicate that the Recommended Plan will achieve attainment of the Existing WQ Criteria for bacteria annually and during the recreational season (May 1st through October 31st) for Jamaica Bay and its tributaries, with the exception of the upstream reaches of Thurston Basin, Bergen Basin and Fresh Creek. However, in the upstream reaches of Thurston and Bergen Basins, unauthorized access is prohibited by JFK International Airport security, and in the case of Thurston Basin, access is further restricted by a chain-link fence spans the waterway.

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 effectiveness of the currently operational CSO controls.

NYC is developing a program to further address stormwater discharges as part of its MS4 permit. This program, along with the actions identified in this LTCP, may further improve water quality in Jamaica Bay and its tributaries.

DEP will also continue to monitor the water quality of Jamaica Bay and its tributaries 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 Jamaica, 26th Ward, Coney Island, and Rockaway WWTP SPDES permits.

9.2 Implementation Schedule

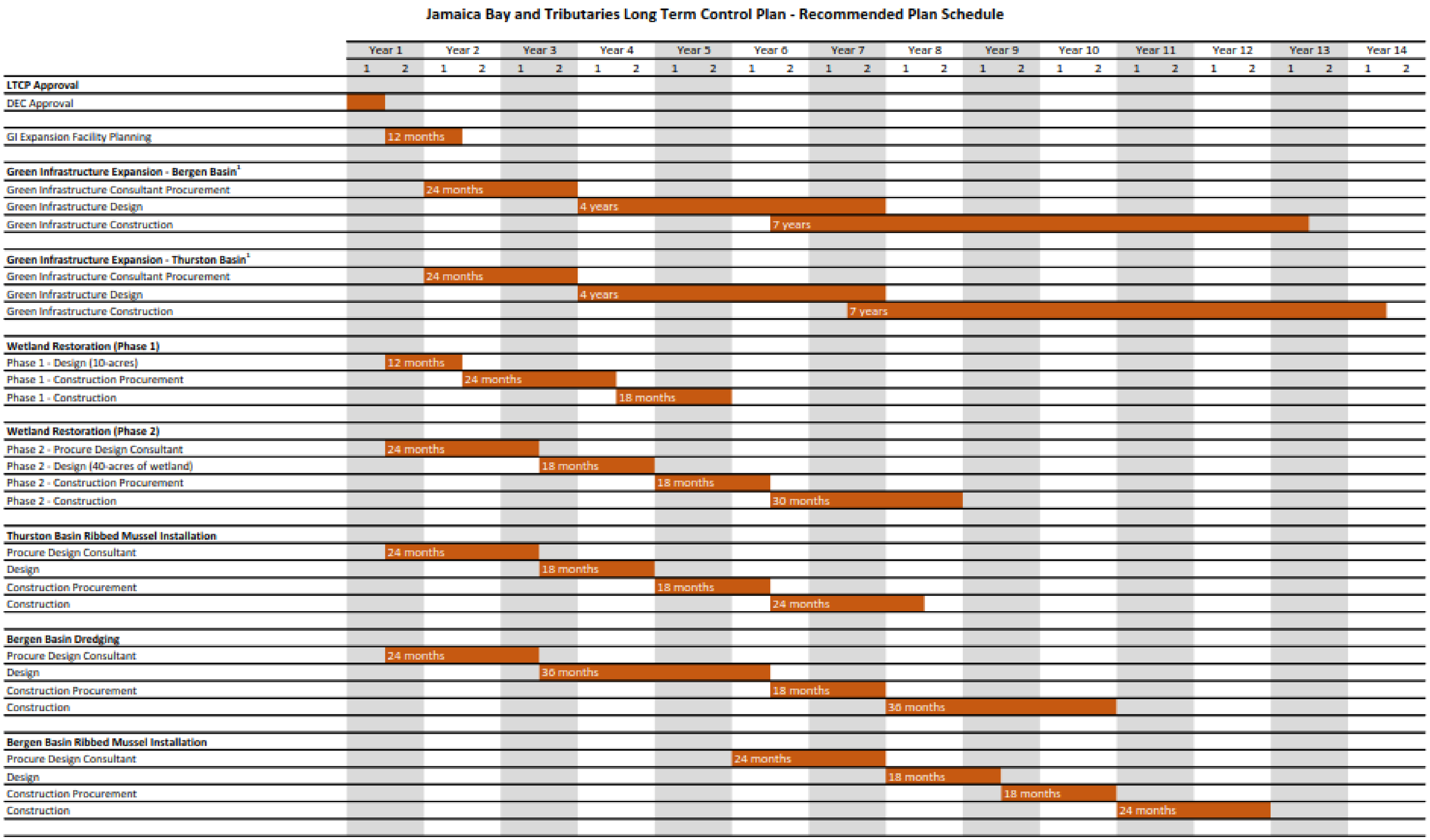
The implementation schedules for the elements of the Jamaica Bay and Tributaries LTCP Recommended Plan are presented in Figure 9-1. The schedule presents the estimated duration of time needed to conduct facility planning, procure design consultants, perform the engineering design, advertise and bid the 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.

9.3 Operational Plan/O&M

DEP is committed to effectively incorporating Jamaica Bay and Tributaries LTCP components into the grey and green improvement projects currently built and planned for Jamaica Bay and its tributaries. Program specific O&M plans will be developed for the proposed GI expansion, environmental dredging, wetland creation, and ribbed mussel colony creation.

9.4 Projected Water Quality Improvements

As described in Section 8.4, the elements of the Recommended Plan will reduce CSO and stormwater bacteria loadings to Bergen and Thurston Basins through additional GI implementation, will further improve water quality in Bergen and Thurston Basins through ribbed mussel colony creation, and will improve shoreline habitat through tidal wetland restoration in Jamaica Bay and multiple tributaries. As described in the triple-bottom-line evaluation in Section 8.5, the Recommended Plan will provide benefits beyond water quality improvement to the project area, including air quality improvement, carbon footprint reduction, habitat creation, heat island reduction, and anticipated property value improvement.



Notes:

1. Green Infrastructure Expansion schedule is subject to change due to coordination with Southeast Queens sewer and flooding mitigation work, which could delay design and/or construction of some sites or areas.

Figure 9-1. Jamaica Bay and Tributaries LTCP – Recommended Plan Schedule

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 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 Policy

The Jamaica Bay and Tributaries 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 preferred alternative 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. A triple-bottom-line analysis was conducted to determine the co-benefits that would be realized through the implementation of additional GI and eco-restoration work including environmental dredging, installation of ribbed mussel colonies, and restoration of tidal wetlands. These co-benefits include appreciation of property values, carbon sequestration, air quality improvements, heat island reduction, and habitat creation. Further, the Recommended Plan achieves many of the ecosystem goals outlined in Mayor DeBlasio's OneNYC Plan, including expansion of GI, reduction of pollution from stormwater runoff, expansion of tree planting, increase in terrestrial species, and habitat improvements for aquatic species.

Table 9-1 presents the projected attainment of existing Class SB Criteria for bacteria for Jamaica Bay and Class I for its tributaries for baseline conditions and the Recommended Plan based on a 10-year simulation. Also presented in Table 9-1 is the projected attainment of the Proposed *Enterococci* WQ Criteria* for Jamaica Bay and its tributaries. It should be noted that the Proposed *Enterococci* WQ Criteria* would not apply to non-coastal waters and thus does not include the Jamaica Bay tributaries. However, DEP's assessment for the highest attainable use evaluated both the Proposed *Enterococci* WQ Criteria* and fecal coliform criteria for primary contact recreation. Table 9-2 presents the projected attainment of Existing Class SB Criteria for DO for Jamaica Bay and Class I for its tributaries for baseline conditions and the Recommended Plan based on a 2008 typical year simulation.

As indicated in Table 9-2, Jamaica Bay is projected to be in attainment with existing Class SB WQ Criteria for fecal coliform bacteria. Among the tributaries to Jamaica Bay, the existing Class I WQ Criteria for fecal coliform bacteria are projected to be attained under the Recommended Plan except in the most upstream reaches of Thurston Basin, Bergen Basin, and Fresh Creek. In the upstream reaches of Thurston and Bergen Basins, unauthorized access is prohibited by JFK International Airport security, and in the case of Thurston Basin, access is further restricted by a chain-link fence that spans the waterway. Modeling indicated that even with 100% CSO control, the upstream reaches of Thurston and Bergen Basins would not be in attainment with the Class I criterion for bacteria. Attainment with the 90-day GM Proposed *Enterococci* WQ Criteria* follow a similar trend, except that Fresh Creek is projected to be in attainment with the Recommended Plan. Attainment of the 90-day STV Proposed *Enterococci* WQ Criteria* falls short in all waterbodies except for Jamaica Bay Inner Bay and Rockaway Shore.

*Proposed *Enterococci* WQ Criteria, if adopted as proposed, would only apply to coastal Class SB and SA waters.

Table 9-1. Projected Attainment for Baseline Conditions and the Recommended Plan – Existing and Proposed WQ Criteria* for Bacteria

Station	Baseline(2)				Recommended Plan(2)			
	Fecal Coliform		*Enterococcus*(4)		Fecal Coliform		*Enterococcus*(4)	
	Annual Monthly GM <200 cfu/100mL	Rec. Season(3) Monthly GM <200 cfu/100mL	90-day Running GM <35 cfu/100mL	90-day Running 90th Percentile STV <130 cfu/100mL	Annual Monthly GM <200 cfu/100mL	Rec. Season(3) Monthly GM <200 cfu/100mL	90-day Running GM <35 cfu/100mL	90-day Running 90th Percentile STV <130 cfu/100mL
Thurston Basin								
TBH1(1)	71	85	60	0	75	88	61	0
TBH3(1)	84	92	88	1	87	92	89	1
TB9(1)	87	92	92	3	91	95	92	3
TB10(1)	96	97	100	11	99	98	100	11
TB11	100	100	100	95	100	100	100	95
TB12	100	100	100	99	100	100	100	99
Bergen Basin								
BB5(1)	51	57	17	0	59	77	19	0
BB6(1)	90	94	78	0	91	95	78	0
BB7(1)	100	100	100	6	100	100	100	3
BB8	100	100	100	86	100	100	100	58
Spring Creek								
SP1	99	98	100	95	100	100	100	84
SP2	100	100	100	100	100	100	100	100
Hendrix Creek								
HC1	98	97	100	34	98	97	100	16
HC2	100	100	100	42	100	100	100	23
HC3	100	100	100	100	100	100	100	72

*Proposed *Enterococci* WQ Criteria, if adopted as proposed, would only apply to coastal Class SB and SA waters.

Table 9-1. Projected Attainment for Baseline Conditions and the Recommended Plan – Existing and Proposed WQ Criteria* for Bacteria

Station	Baseline[2]				Recommended Plan[2]			
	Fecal Coliform		*Enterococcus*[4]		Fecal Coliform		*Enterococcus*[4]	
	Annual Monthly GM <200 cfu/100mL	Rec. Season[3] Monthly GM <200 cfu/100mL	90-day Running GM <35 cfu/100mL	90-day Running 90th Percentile STV <130 cfu/100mL	Annual Monthly GM <200 cfu/100mL	Rec. Season[3] Monthly GM <200 cfu/100mL	90-day Running GM <35 cfu/100mL	90-day Running 90th Percentile STV <130 cfu/100mL
Fresh Creek								
FC1	86	93	100	9	86	93	100	4
FC2	96	98	100	10	96	98	100	5
FC3	100	100	100	51	100	100	100	34
FC4	100	100	100	100	100	100	100	100
Paerdegat Basin								
PB1	97	95	100	27	97	95	100	12
PB2	100	100	100	99	100	100	100	67
Jamaica Bay (Northern Shore)								
J10	100	100	100	100	100	100	100	99
J3	100	100	100	100	100	100	100	100
J9a	100	100	100	100	100	100	100	100
J8	100	100	100	100	100	100	100	100
J7	100	100	100	86	100	100	100	55
JA1	100	100	100	100	100	100	100	95
Jamaica Bay (Inner Bay)								
J2	100	100	100	100	100	100	100	100
J12	100	100	100	100	100	100	100	100
J14	100	100	100	100	100	100	100	100
J16	100	100	100	100	100	100	100	100

*Proposed *Enterococci* WQ Criteria, if adopted as proposed, would only apply to coastal Class SB and SA waters.

Table 9-1. Projected Attainment for Baseline Conditions and the Recommended Plan – Existing and Proposed WQ Criteria* for Bacteria

Station	Baseline(2)				Recommended Plan(2)			
	Fecal Coliform		*Enterococcus*(4)		Fecal Coliform		*Enterococcus*(4)	
	Annual Monthly GM <200 cfu/100mL	Rec. Season(3) Monthly GM <200 cfu/100mL	90-day Running GM <35 cfu/100mL	90-day Running 90th Percentile STV <130 cfu/100mL	Annual Monthly GM <200 cfu/100mL	Rec. Season(3) Monthly GM <200 cfu/100mL	90-day Running GM <35 cfu/100mL	90-day Running 90th Percentile STV <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) Monitoring station is located in a portion of the waterbody where unauthorized access is prohibited by signage installed by JFK Airport security and/or a physical barrier.
(2) Based on 10-Year simulation.
(3) The recreational season is from May 1st through October 31st.
(4) Attainment with Proposed *Enterococci* WQ* Criteria during the Primary Contact Recreational Season (May 1st through October 31st). These criteria, if adopted as proposed, will not apply to the tributaries to Jamaica Bay. Refer to Section 2 of the LTCP for further description of the Proposed *Enterococci WQ* Criteria*.

*Proposed *Enterococci* WQ Criteria, if adopted as proposed, would only apply to coastal Class SB and SA waters.

Table 9-2. Projected Attainment for Baseline Conditions and the Recommended Plan – Existing and Proposed WQ Criteria* for DO

Station	Dissolved Oxygen[2]					
	Baseline			Recommended Plan		
	Class I (>=4.0 mg/L)	Class SB Acute (>=3.0 mg/L)	Class SB Chronic (>=4.8 mg/L)	Class I (>=4.0 mg/L)	Class SB Acute (>=3.0 mg/L)	Class SB Chronic (>=4.8 mg/L)
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						
PB1	100	-	-	100	-	-
PB2	100	-	-	100	-	-

*Proposed *Enterococci* WQ Criteria, if adopted as proposed, would only apply to coastal Class SB and SA waters.

Table 9-2. Projected Attainment for Baseline Conditions and the Recommended Plan – Existing and Proposed WQ Criteria* for DO

Station	Dissolved Oxygen(2)					
	Baseline			Recommended Plan		
	Class I (>=4.0 mg/L)	Class SB Acute (>=3.0 mg/L)	Class SB Chronic (>=4.8 mg/L)	Class I (>=4.0 mg/L)	Class SB Acute (>=3.0 mg/L)	Class SB Chronic (>=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	99	-	100	99
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) Monitoring station is located in a portion of the waterbody where unauthorized access is prohibited by signage by airport security and/or a physical barrier.
(2) Average annual attainment based on 2008 typical year simulation.

As indicated in Figure 9-2, Jamaica Bay will be in attainment with existing Class SB WQ Criteria for DO, and Paerdegat Basin, Fresh Creek, and Spring Creek will be in attainment with existing Class I WQ Criteria for DO. However, the upstream ends of Hendrix Creek, Bergen, and Thurston Basins will not be in attainment with the Class I WQ Criteria for DO under the Recommended Plan.

9.6.a Affordability and Financial Capability Introduction

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." EPA's financial capability 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).

*Proposed *Enterococci* WQ Criteria, if adopted as proposed, would only apply to coastal Class SB and SA waters.

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. EPA's 1997 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" clarifying the flexibility within their CSO guidance. Although EPA did not modify the metrics established in the 1997 guidance, the 2014 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 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 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.

This section begins to explore affordability and financial capability concerns as outlined in the 1997 and 2001 guidance documents and the 2014 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. This affordability and financial capability section will be refined in each LTCP as project costs are further developed, and to reflect the latest available socioeconomic metrics.

9.6.b Residential Indicator (RI)

As discussed above, the first economic test from EPA's 1997 CSO 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 Fiscal Year (FY) 2019 rates, to consumption rates by household type, as shown in Table 9-3.

Table 9-3. 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]	663	**1.08**	1,080	**1.76**
Multi-family[3]	431	**0.70**	702	**1.14**
Average Household Consumption[4]	543	**0.89**	885	**1.44**
MCP[5]	631	**1.03**	1,029	**1.68**

Notes:
1. Latest MHI data is $58,856 based on 2019 ACS data, estimated MHI adjusted to 2018 is $61,334.
2. Based on 80,000 gallons/year consumption and Fiscal Year (FY) 2019 Rates.
3. Based on 52,000 gallons/year consumption and FY2019 Rates.
4. Based on average consumption across all metered residential units of 65,534 gallons/year and FY2019 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 9-3, the RI for wastewater costs varies between 0.70 percent of MHI to 1.08 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 1.14 percent to 1.76 percent of MHI.

Based on this initial screen, current wastewater costs pose a low to mid-range economic impact according to the EPA's 1997 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 638,000 households in NYC (about 21 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.c Financial Capability Indicators (FCI)

The second phase of the 1997 CSO guidance develops the Permittee FCI, 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 FCI scores imply weaker economic conditions and thus an increased likelihood that additional controls would cause substantial economic impact.

Table 9-4 summarizes the FCI scoring as presented in the 1997 CSO guidance. NYC's FCI score based on this test is presented in Table 9-5 and is further described below.

Table 9-4. 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 9-5. NYC Financial Capability Indicator Score

Financial Capability Metric	Actual Value	Score
Debt Indicators		
Bond rating (G.O. bonds)	AA (S&P) AA (Fitch) Aa2 (Moody's)	Strong/3
Bond rating (Revenue bonds)	AAA (S&P) AA (Fitch) Aa2 (Moody's)	
Overall net debt as percentage of FMPV	3.6%	Mid-range/2
G.O. Debt	$37.9B	
Market value	$1,064.2B	
Socioeconomic Indicators		
Unemployment rate (2017 annual average)	0.2% above the national average	Mid-range/2
NYC unemployment rate	4.6%	
United States unemployment rate	4.4%	
MHI as percentage of national average	101.9%	Mid-range/2
Financial Management Indicators		
Property tax revenues as percentage of FMPV	2.4%	Mid-range/2
Property tax revenue collection rate	98.3%	Strong/3
Permittee Indicators Score		2.3

Notes:
Debt and Market Value Information as of April 24, 2018.
G.O. Debt and market value from 2017 CAFR.

9.6.c.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.c.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 FY2017, NYC had more than $37.9B in outstanding G.O. debt, and the FMPV within NYC was $1,064.2B. This results in a ratio of outstanding debt to FMPV of 3.6 percent and a "mid-range" rating for this indicator. If $24.4B of MWFA revenue bonds that support the system are included, net debt as a percentage of FMPV increases to 5.9 percent, which results in a "weak" rating for this indicator. Furthermore, if NYC's $46.8B of additional debt that is related to other services and infrastructure is also included, the ratio further increases to 10.3 percent.

9.6.c.3 Unemployment Rate

For the unemployment benchmark, the 2017 annual average unemployment rate for NYC was compared to that for the U.S. NYC's 2017 unemployment rate of 4.6 percent is 0.2 percentage points higher than the national average of 4.4 percent (U.S. Bureau of Labor Statistics). Based on 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 significantly 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.

9.6.c.4 Median Household Income (MHI)

The MHI benchmark compares the community's MHI to the national average. Using American Community Survey (ACS) 2016 single-year estimates, NYC's MHI is $58,856 and the nation's MHI is $57,617. Thus, NYC's MHI is approximately 102 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.c.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 FY2017, NYC had billed $25.8B in real property taxes against a $1,064.2B 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 FY2017, system revenues ($3.8B) would increase the ratio to 2.8 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.c.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 FY2017 NYC Property Tax Annual Report indicates NYC's total property tax levy was $25.8B, of which 98.7 percent was collected, resulting in a "strong" 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.d 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 9-6), to evaluate the level of financial burden the current CWA program costs may impose on NYC. Based on a RI score of 0.89 percent (using average household consumption), and a FCI score of 2.3, NYC's Financial Capability Matrix score is "Low Burden." The score falls in the "Medium Burden" category when considering the higher RI scores of 1.08 percent and 1.03 percent for single-family and multi-family conservation plan households, respectively.

Table 9-6. 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.e Socioeconomic Considerations in the New York City Context

As encouraged by EPA's financial capability assessment guidance, 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.e.1 Income Levels

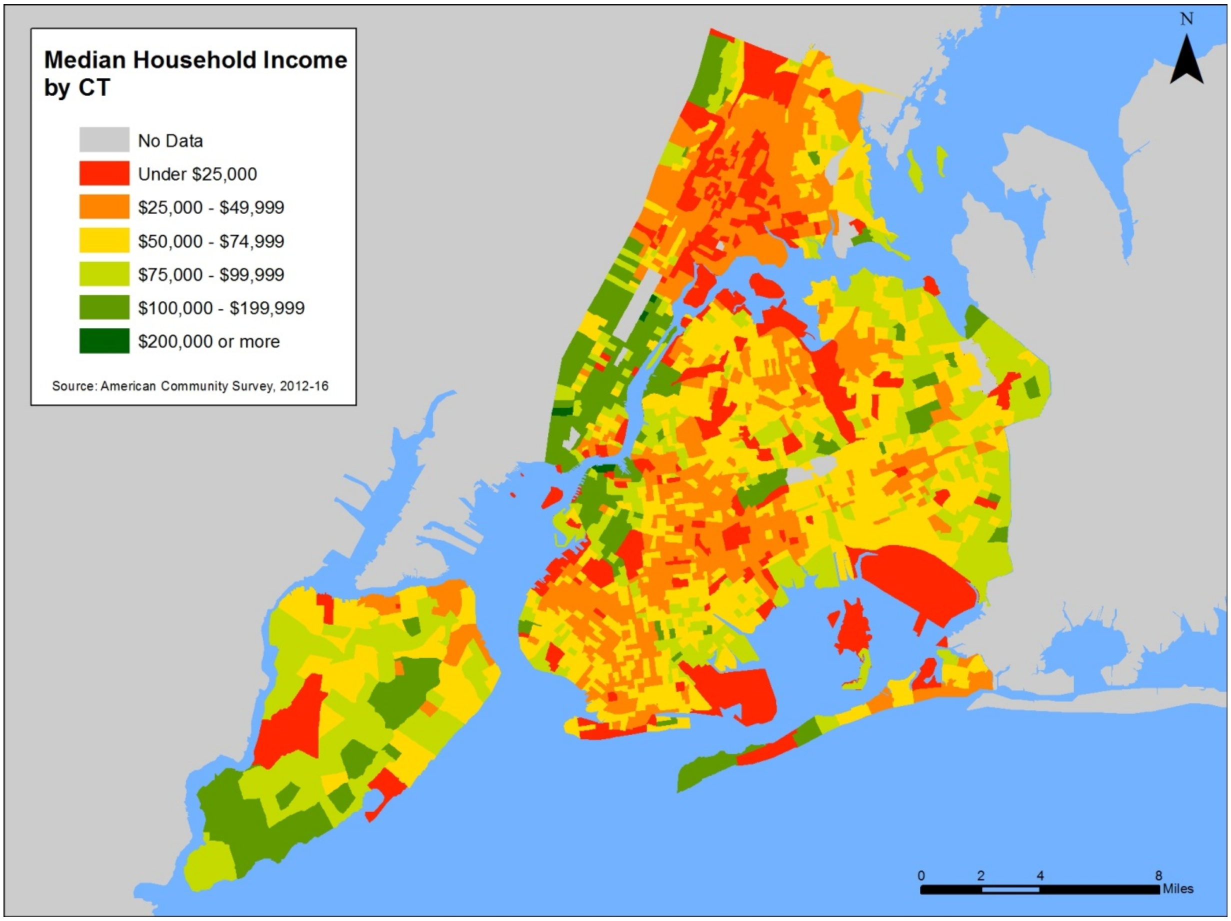
In 2016, the latest year for which Census data is available, the MHI in NYC was $58,856. As shown in Table 9-7, across the NYC boroughs, MHI ranged from $37,525 in the Bronx to $77,559 in Manhattan. Figure 9-2 shows that income levels also vary considerably across NYC neighborhoods, and there are several areas in NYC with high concentrations of low-income households.

Table 9-7. Median Household Income

Location	2016 (MHI)
United States	$57,617
New York City	$58,856
Bronx	$37,525
Brooklyn	$55,150
Manhattan	$77,559
Queens	$62,207
Staten Island	$77,197

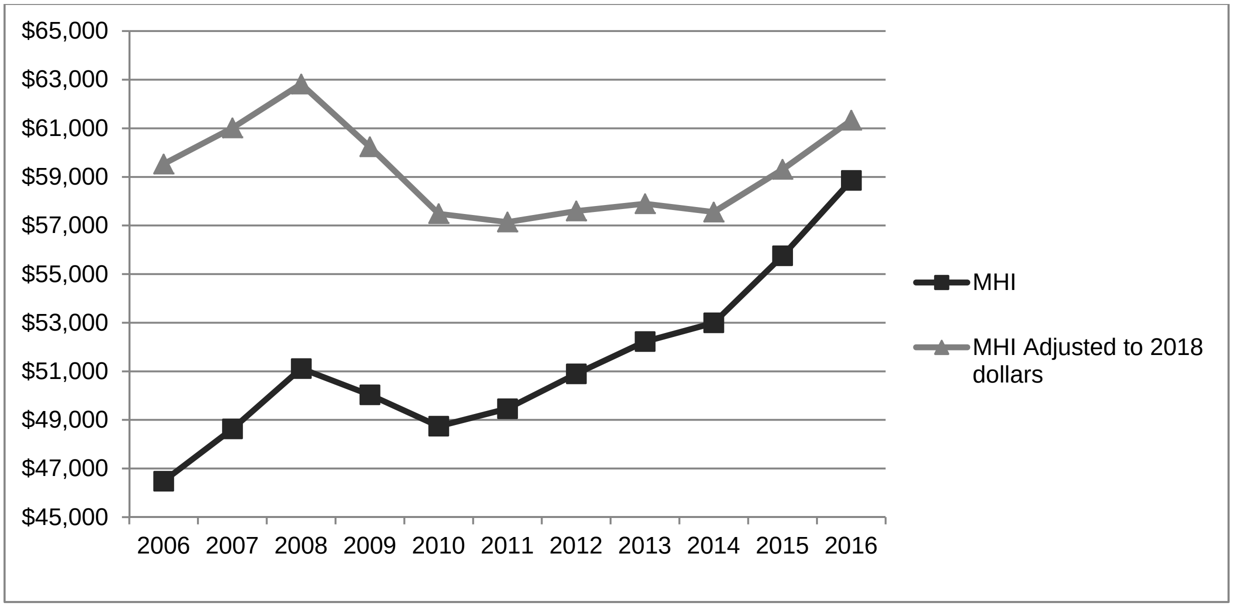
Source: U.S. Census Bureau 2016 ACS 1-Year Estimates.

As shown in Figure 9-3, 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 (2018 dollars) using the Bureau of Labor Statistics Consumer Price Index, MHI in NYC in 2016 was still 2.4 percent below MHI in 2008 (see Figure 9-2).



Source: U.S. Census Bureau 2012-2016 ACS 5-Year Estimates.

Figure 9-2. Median Household Income by Census Tract



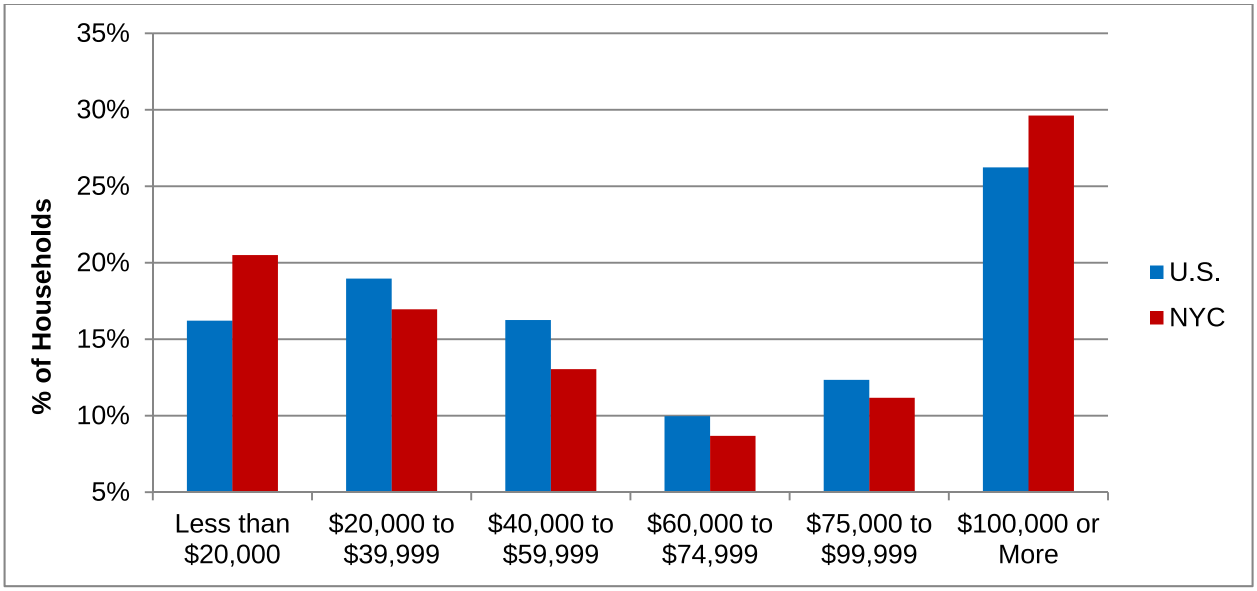
Source: U.S. Census Bureau 2006 through 2016 ACS 1-Year Estimates, Bureau of Labor Statistics Consumer Price Index.

Figure 9-3. NYC Median Household Income Over Time

9.6.e.2 Income Distribution

NYC currently ranks as one of the most unequal cities in the United States (U.S.) 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 9-4, 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 7.7 percent less in NYC than in the United States.

As shown in Table 9-8, the income level that defines the upper end of the Lowest Quintile (i.e., the lowest 20 percent of income earners) in NYC is $19,440, compared to $23,638 nationally. This further demonstrates that NYC has a particularly vulnerable, and sizable, lower income population. Table 9-9 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 FY2019 rates. As shown in this table, households in the Lowest Quintile have a wastewater RI of approximately 2.68 percent, which easily exceeds EPA's "High Financial Impact" threshold of 2.0 percent, and the combined water and wastewater RI is approximately 4.37 percent.



Source: U.S. Census Bureau 2016 ACS 1-Year Estimates.

Figure 9-4. Income Distribution for NYC and U.S.

Table 9-8. Household Income Quintile Upper Limits in New York City and the United States (2016 Dollars)

Quintile	New York City	United States
20th Percentile	$19,440	$23,638
40th Percentile	$42,794	$45,325
60th Percentile	$76,283	$72,384
80th Percentile	$130,683	$116,614
95th Percentile	$250,000+	$219,851

Source: U.S. Census Bureau 2016 ACS 1-Year Estimates.

Table 9-9. Average Household Consumption Residential Indicator (RI) for Different Income Levels using FY2019 Rates

Income Level	Wastewater RI(1)	Water and Wastewater RI(1)
Lowest 20 Percent Upper Limit	2.68%	4.37%
Lowest 40 Percent Upper Limit	1.22%	1.98%
MHI	0.89%	1.44%

Note:

(1) RI calculated by dividing average household consumption annual wastewater bill ($543 using FY2019 rates) and wastewater and water bill ($885 using FY2019 rates) by income level values adjusted to 2018 dollars.

9.6.e.3 Poverty Rates

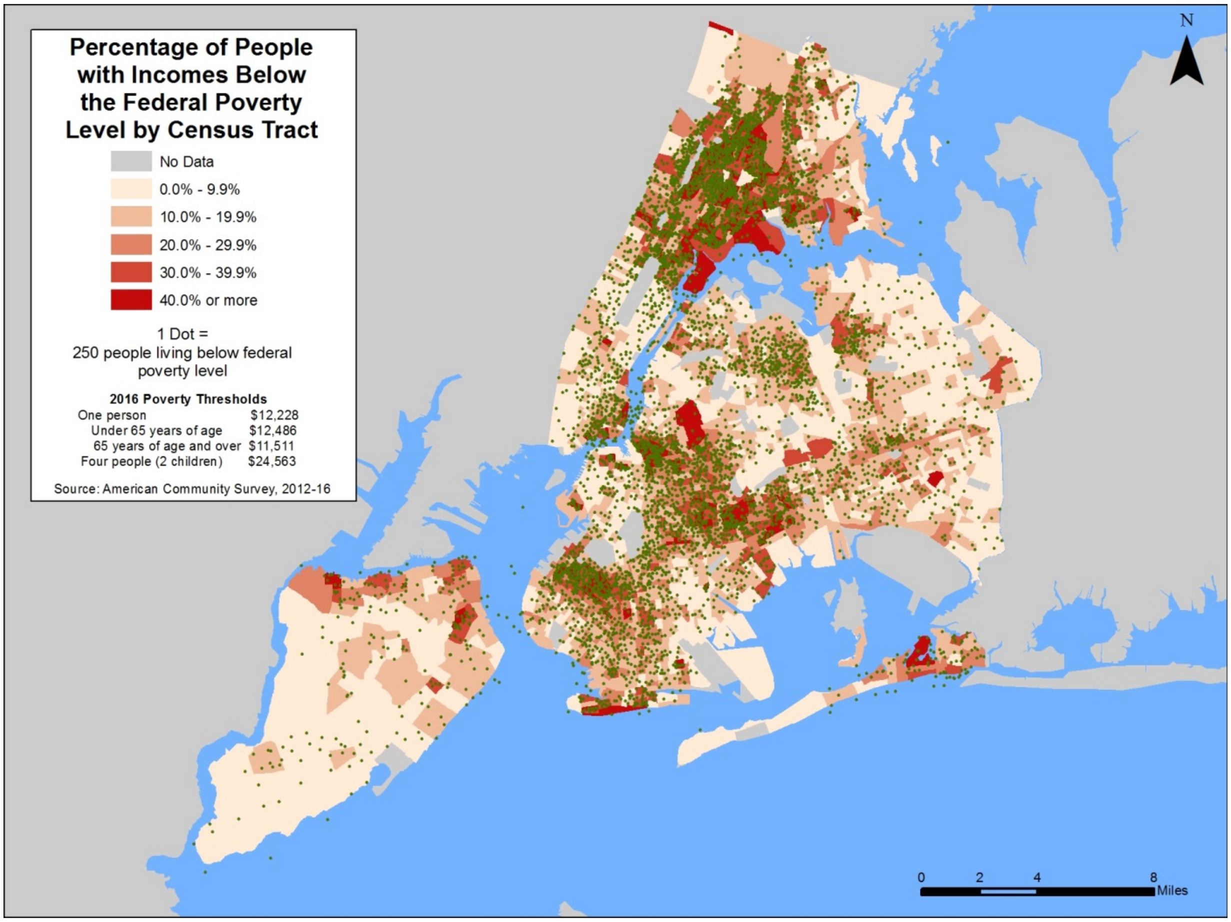
Based on the latest available Census data, 18.9 percent of NYC residents (almost 1.6 million people, which, for reference, is greater than the entire population of Philadelphia) are living below the federal poverty level. This is significantly higher than the national poverty rate of 14.0 percent, despite similar MHI levels for NYC and the U.S. as a whole. As shown in Table 9-10, across the NYC boroughs, poverty rates vary from 13.2 percent in Staten Island and Queens to 28.7 percent in the Bronx.

Table 9-10. NYC Poverty Rates

Location	Percentage of Residents Living Below the Federal Poverty Level
United States	14.0%
New York City	18.9%
Bronx	28.7
Brooklyn	20.6%
Manhattan	17.3%
Queens	13.2%
Staten Island	13.2%

Source: U.S. Census Bureau 2016 ACS 1-Year Estimates.

Figure 9-5 shows that poverty rates also vary across neighborhoods, with several areas in NYC having a relatively high concentration of people living below the federal poverty level. Each green dot 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.

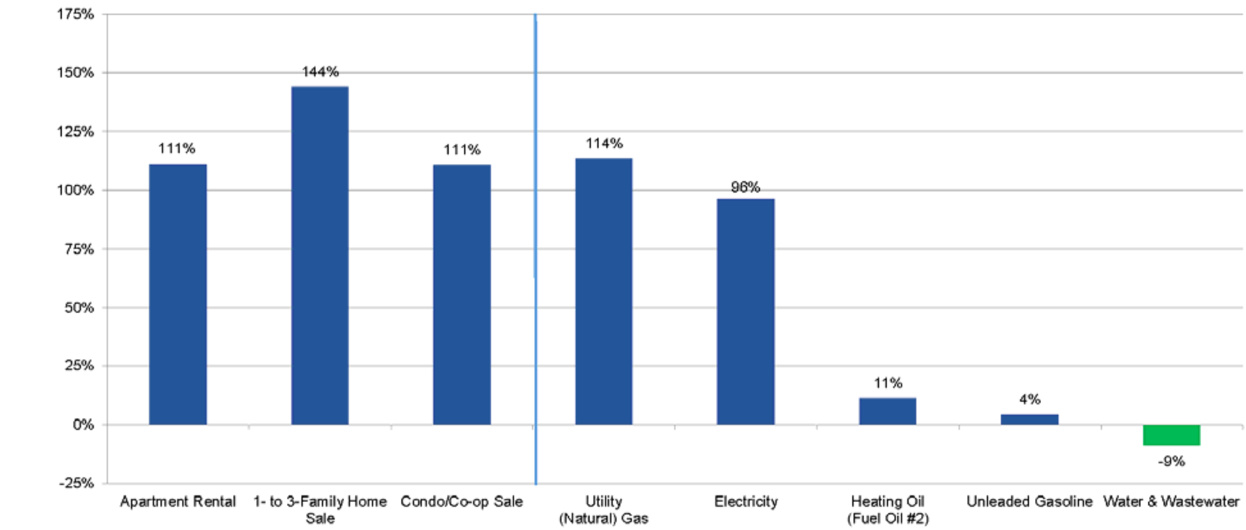


Source: U.S. Census Bureau 2012-2016 ACS 5-Year Estimates

Figure 9-5. Poverty Clusters and Rates in NYC

9.6.e.4 Cost of Living and Housing Burden

NYC residents face relatively high costs for nondiscretionary items (e.g., housing, utilities) compared to individuals living almost anywhere else in the nation, as shown in Figure 9-6. While water costs are slightly less than the average for other major United States cities, the housing burden is significantly higher.



	(average monthly rent)	*(median per sale)*	*(median per sale)*	*(average per year)*	*(average per year; 6,000 kwh)*	*(average per gallon)*	*(average per gallon)*	*(average per year; 80,000 gallons)*
NYC	$2,460	$620,000	$500,000	$1,290	$1,603	$3.01	$2.57	$1,055
U.S. Cities	$1,166	$254,000	$237,200	$604	$816	$2.70	$2.46	$1,156

Source: Apartment List (apartment rental); The Real Estate Board of New York and National Association of Realtors (condo/co-op and 1-3 family home sale); Consolidated Edison and U.S. Bureau of Labor Statistics "BLS" (electricity); National Grid and American Gas Association (natural gas); New York State Energy Research and Development Authority and U.S. BLS (heating oil); U.S. BLS (gasoline); NYC FY 2018 Water and Wastewater Rate Report (water & wastewater)

Figure 9-6. 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 2016, NYC's Cost of Living Index (COLI)[1] was 167, or 67 percent higher than the average cost of living of other cities. When adjusted for cost of living, the purchasing power of a MHI of $61,334 is reduced to $36,727 in NYC (2018 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 0.89 to 1.48 for wastewater and 1.44 to 2.41 for water and wastewater. Table 9-11 displays the RI adjusted for 2018 dollars and cost of living in NYC.

[1] The Council for Community and Economic Research (C2ER)'s Cost of Living Index (COLI) measures how urban areas compare in the 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.

Table 9-11. 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)	1.08	1.81	1.76	2.94
Multi-family(3)	0.70	1.17	1.14	1.91
Average Household Consumption(4)	0.89	1.48	1.44	2.41
MCP(5)	1.03	1.72	1.68	2.80

Notes:

(1) Latest MHI data is $58,856 based on 2016 ACS data. Estimated MHI adjusted to 2018 is $61,334. Adjusting 2018 MHI for cost of living, MHI is $36,727.
(2) Based on 80,000 gallons/year consumption and FY2019 Rates.
(3) Based on 52,000 gallons/year consumption and FY2019 Rates.
(4) Based on average consumption across all metered residential units of 65,534 gallons/year and FY2019 Rates.
(5) Multi-family Conservation Plan is a flat fee per unit for customers who will implement certain conservation measures.

Approximately 68 percent of all households in NYC are renter-occupied, compared to about 37 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, EPA's 1997 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 2016 ACS Census data shows approximately 17 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 180,000 households) spent more than 50 percent. This compares to 14 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 35 percent of households in NYC versus 23 percent of households nationally spent more than 30 percent of their income on housing costs.

New York City Housing Authority (NYCHA) is responsible for 177,634 affordable housing units, which accounts for 9 percent of the total renter households in NYC. NYCHA paid approximately $184M for water and wastewater in FY2017. This total represents approximately 5.7 percent of NYCHA's $3.24B 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 EPA 1997 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, total tax burden, and long-term debt. 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 below with respect to historical and future commitments.

9.6.f 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, three 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 WWTPs. 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 WWTPs, DEP also has four CSO storage facilities. In 2010, DEP launched a 20-year, $1.5B GI program with additional investments through private partnerships. A summary of historical spending is presented in Table 9-12, and additional details on the identified projects and programs are provided in the following sections.

Table 9-12. Historical DEP Spending Summary

Spending Category	Major Project or Program
Wastewater Mandated Programs	CSO Abatement and Stormwater Management Programs
	Biological Nitrogen Removal
	Wastewater Treatment Plan Upgrades
Drinking Water Mandated Programs	Croton Watershed - Croton Water Treatment Plant
	Catskill/Delaware Watershed - Filtration Avoidance Determination
	Catskill/Delaware Watershed - UV Disinfection Facility
State of Good Repair Projects	Multiple investments related to maintenance and repair of assets and infrastructure

9.6.f.1 Historical Capital and Operations and Maintenance Spending

As shown in Figure 9-7, from FY2008 through FY2017, 40.1 percent of DEP's capital spending was for wastewater and water mandates. Figure 9-8 identifies associated historical wastewater and water operating expenses from FY2007 through FY2016, 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.

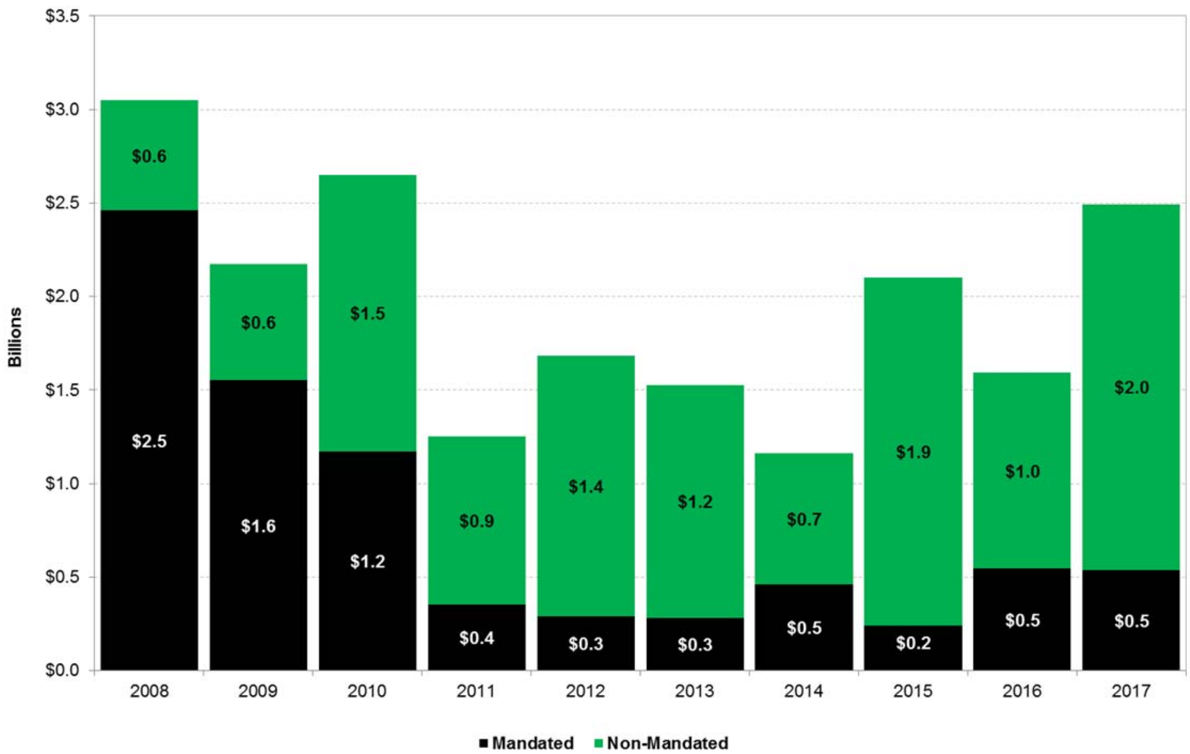


Figure 9-7. Historical Capital Commitments

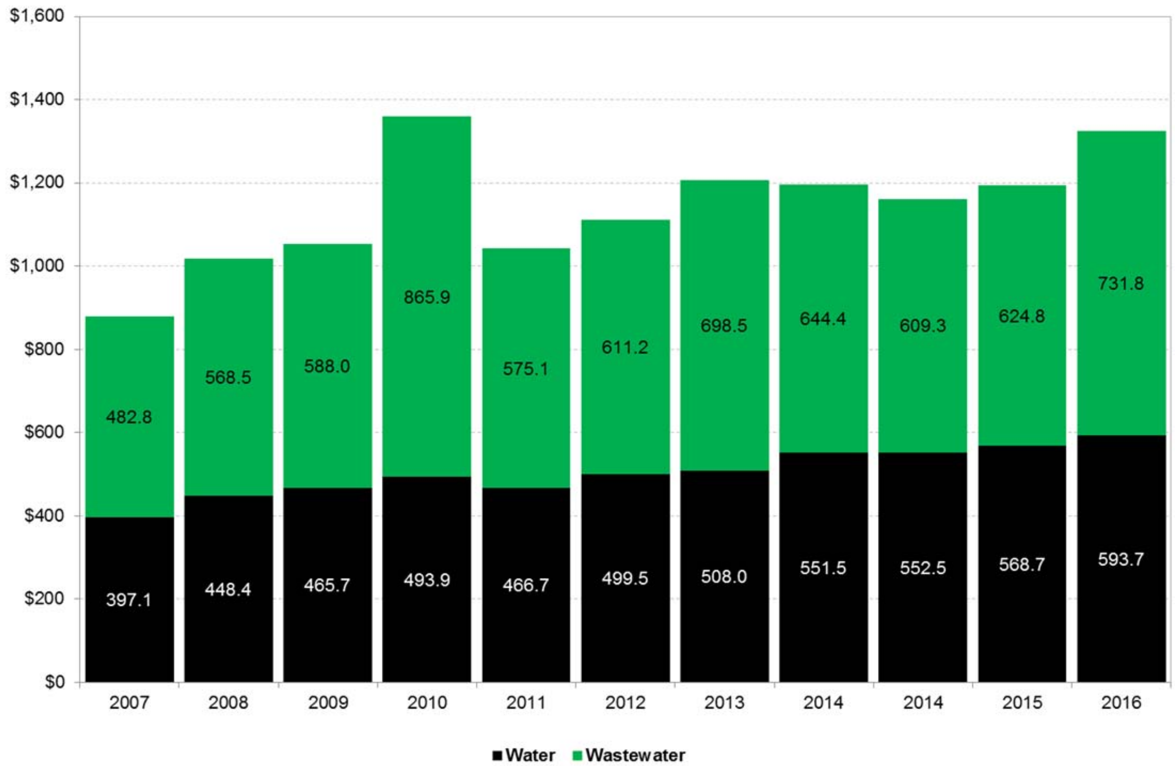


Figure 9-8. Historical Operating Expenses

9.6.f.2 Wastewater Mandated Programs

DEP is subjected to 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 does 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 floatables and debris that enters the combined wastewater system from being discharged, dredging of CSO sediments that contribute to low DO and poor aesthetic conditions, and other water quality based enhancements to enable attainment of the WQS. These initiatives impact both the capital investments that DEP must make, and the agency's O&M expenses. Historical and existing commitments are estimated to cost $4.2B ($2.7B in Waterbody Watershed Facility Plans and $1.5B for the GI program) DEP expects that additional investments in stormwater controls will be required, as they will be for other NYC agencies, pursuant to MS4 requirements.

- Biological Nitrogen Removal

  In 2006, NYC entered into a Consent Judgment with DEC, which required DEP to upgrade five WWTPs to reduce nitrogen discharges. Pursuant to a modification and amendment to the Consent Judgment in 2011, DEP agreed to upgrade three additional WWTPs and to install additional nitrogen controls at one of the WWTPs included in the original Consent Judgment. To-date, DEP has completed nitrogen upgrades at 6 WWTPs and expects to complete work on the remaining 2 WWTPs in 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 $91M in the 10-year capital plan), as well as O&M expenses (chemicals alone in FY2017 cost $10M).

- Wastewater Treatment Plant Upgrades

  The Newtown Creek WWTP 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 WWTP met the effluent discharge requirements of the CWA, bringing all 14 WWTPs into compliance with the secondary treatment requirements.

9.6.f.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 on the Croton Water Treatment Plant began in late 2004, and the facility began operating in 2015. To-date, DEP has spent roughly $3.3B in capital costs. Since commencement of operations, DEP is also now incurring annual expenses for labor, power, chemicals, and other costs associated with plant O&M. For FY2017, O&M costs were about $16M.

- Catskill/Delaware Watershed - Filtration Avoidance Determination

  Since 1993, DEP has been operating under a series of Filtration Avoidance Determinations (FADs), which allow NYC to avoid filtering surface water from the Catskill and Delaware systems. In 2007, EPA issued a new FAD (2007 FAD), which requires NYC to take certain actions over a ten-year period to protect the Catskill and Delaware water supplies. In 2014, the NYSDOH issued mid-term revisions to the 2007 FAD. In December 2017, NYSDOH issued another

10- year FAD. DEP has committed about $1.7B to-date and anticipates that expenditures for the current FAD will amount to $1B.

- 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 Cryptosporidium 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. FY2017 O&M costs were $23M, including taxes.

9.6.f.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.

9.6.f.5 Initiatives to Reduce Operational Expenditures

To mitigate rate increases, DEP has diligently managed operating expenses and has undertaken an agency-wide program to review and reduce costs and to improve the efficiency of the agency's operations. DEP has already implemented changes through this program that resulted in a financial benefit of approximately $98.2M in FY2016.

9.6.g History of DEP Water and Sewer Rates

9.6.g.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 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 9-9, increases in capital expenditures have resulted in increased debt. Expenditures and total debt are projected to increase over the next several years.

For FY2019, most customers will be charged a proposed uniform water rate of $0.52 per 100 gallons of water. Wastewater charges are levied at 159 percent of water charges ($0.83 per 100 gallons). A small percentage of properties are billed a flat rate. Under the 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).

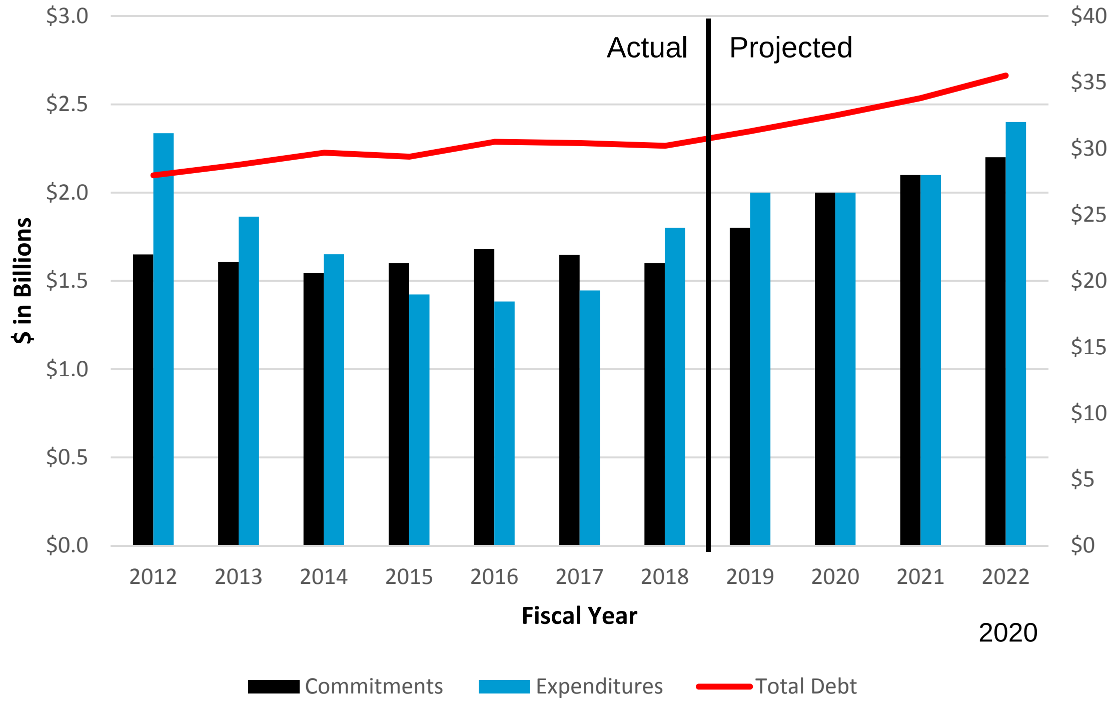


Figure 9-9. Past Costs and Total Debt

9.6.g.2 Historical Rate Increases to meet Cost of Service

Figure 9-10 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 FY2019, water and sewer rates have risen 200 percent, or approximately 107 percent when adjusted for inflation. This is despite the fact that DEP has diligently reduced operating costs and improved the efficiency of the agency's operations.

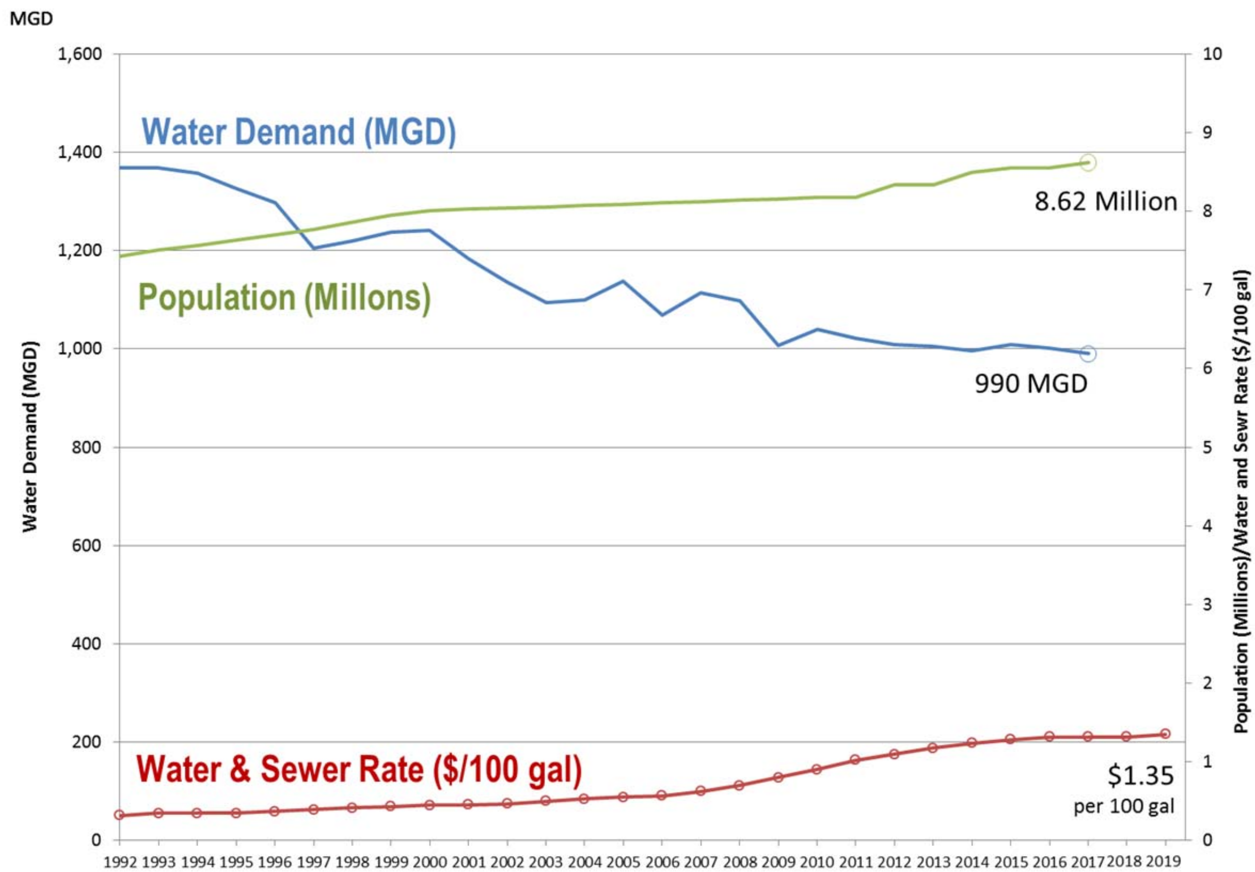


Figure 9-10. Population, Consumption Demand, and Water and Sewer Rates Over Time

9.6.g.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 recently 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 new 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.g.4 Future System Investment

Over the next decade, the percentage of mandated project costs already identified in the Capital Improvement Plan (CIP) is anticipated to decrease, but DEP will be funding critical state of good repair projects and other projects needed to maintain NYC's infrastructure to deliver clean water and treat wastewater. Accordingly, as of April 2018, DEP's capital budget for FY2019 through FY2028 is $16.3B. This budget includes projected capital commitments averaging $1.6B per year through FY2028, which is similar to the average spending from FY2008 through FY2017 shown in Figure 9-7 above. In addition, DEP anticipates that there will be additional mandated investments related to compliance with the City's MS4 SPDES permit, recent modifications to DEP's in-city WWTP SPDES permits and potential future modifications related to the Proposed *Enterococci* WQ Criteria*, Superfund remediation, and the Total Residual Chlorine (TRC) Order. It is also possible that DEP will be required to construct a cover for Hillview Reservoir, as well as 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. Additional details for a summary of anticipated future mandated and non-mandated projects and programs is presented in Table **9-13**, and additional details on the identified projects and programs are provided in the following sections.

Table 9-13. Potential Future DEP Spending Summary

Spending Category	Major Project or Program
Wastewater	Municipal Separate Storm Sewer System (MS4) Permit Compliance
	WWTP SPDES Permit Compliance
	Total Residual Chlorine (TRC) Consent Order
	Superfund Remediation
	Climate Resiliency
	Energy Projects at Wastewater Treatment Plants
	Southeast Queens Flood Mitigation Plan
Water	Hillview Reservoir Cover
	Water for the Future
	Gilboa Dam Rehabilitation
	Kensico Eastview Connection 2
	Activation of City Tunnel No. 3 Brooklyn/Queens
	Ashokan Century Program

*Proposed *Enterococci* WQ Criteria, if adopted as proposed, would only apply to coastal Class SB and SA waters.

9.6.g.5 Potential or Unbudgeted Wastewater Regulations

- Municipal Separate Storm Sewer System (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 is required to coordinate efforts with other NYC agencies and to develop a stormwater management program plan for NYC to facilitate compliance with the permit. This plan includes the necessary legal authority to implement and enforce the stormwater management program, and will develop enforcement and tracking measures and provide adequate resources to comply with the MS4 permit. Some of the stormwater control measures identified through this plan may result in increased costs to DEP, and those costs will be more clearly defined upon completion of the plan. The permit also requires NYC to conduct fiscal analysis of the capital and O&M expenditures necessary to meet the requirements of this permit, including any required development, implementation and enforcement activities, within three years of the effective permit date.

  The full MS4 permit compliance costs are yet to be estimated. The future compliance costs will be shared by other NYC agencies that are responsible for managing stormwater. The projected cost for stormwater and CSO programs in other major urban areas such as Philadelphia and Washington, D.C. are $2.4B and $2.6B, respectively. According to preliminary estimates completed by Washington District Department of Environment, the MS4 cost could be $7B (green build-out scenario) or as high as $10B (traditional infrastructure) to meet the TMDLs. In FY2016, Philadelphia's FY16 Stormwater Management Program budget was $99.5M (MS4 Permit Annual Report, 2016). Washington D.C. reported total MS4 expenditures of $11.7M in 2016 and a budget of $26.7M for FY17 (MS4 Permit Annual Report, 2017).

  Existing data for estimating future NYC MS4 compliance costs is limited. Based on estimates from other cities, stormwater retrofit costs are estimated between $25,000 and $35,000 per impervious acre on the low end, to between $100,000 and $150,000 on the high end. Costs would vary based on the type and level of control selected. For the purposes of this analysis, a stormwater retrofit cost of $35,000 per impervious acre was assumed, which results in estimated MS4 compliance costs of about $2B for NYC.

- WWTP SPDES Permit Compliance

  On November 1, 2015, newly modified SPDES permits for DEP's 14 WWTPs went into effect. These modifications to the SPDES permits may have significant monetary impacts to DEP and include the following requirements:

  - New effluent ammonia limits at many WWTPs, which may require upgrades at the North River, 26th Ward, and Jamaica WWTPs.

  - Monthly sampling for free cyanide with results submitted in report form to DEC. After review, DEC may reopen the permits to add a limit or action level for free cyanide.

- Beginning three years from the effective date of the Permit (11/01/2018), maintain and implement an Asset Management Plan (AMP) covering DEP's WWTPs, pumping stations, and CSO control facilities to prioritize the rehabilitation and replacement of capital assets that comprise the AMP Treatment System.

- Develop, implement, and maintain a Mercury Minimization Program (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.

- The Proposed *Enterococci* WQ Criteria* may result in additional compliance costs for the WWTPs once a water quality based effluent limit is identified.

- The CSO BMP section of the SPDES permit has been revised as follows:

  - Additional requirements related to DEP's CSOs to maximize flow were added to the permit as a new Additional CSO BMP Special Condition section, as required pursuant to the CSO BMP Order. The SPDES Additional CSO Special Conditions include monitoring of any CSOs from specified regulators, reporting requirements for bypasses, and providing notification of equipment out-of-service at the WWTPs during rain events. DEP to assess compliance with requirements to "Maximize Flow to the WWTP" using CSO data from key regulators and to identify options for reducing or eliminating CSOs that occur prior to the WWTP achieving twice design flow. A schedule for reasonable and cost-effective options that can be completed within two years must be submitted to DEC for review and approval. Other projects that cannot be completed within two years shall be considered as part of the LTCP process. The costs for compliance for this new permit requirement have not yet been determined, but DEP expects this program will require the expenditure of additional capital and expense dollars.

- Total Residual Chlorine (TRC) Consent Order

  As part of the TRC Consent Order effective October 8, 2015, DEP is required to construct alternate disinfection at six WWTPs. In addition, DEP is developing TRC Facility Plans for the WWTPs that require further upgrades to disinfection to comply with the TRC WQ based effluent limit.

- Superfund Remediation

  Two major Superfund sites in NYC may affect DEP's Long Term Control Plans, and are at different stages of investigation. The Gowanus Canal Remedial Investigation/Feasibility Study (RI/FS) is complete, and remedial design work will take place in the next three to five years. Completion of the Newtown Creek RI/FS is anticipated approximately 2021 with issuance of a Record of Decision (ROD) projected by the end of 2023.

*Proposed *Enterococci* WQ Criteria, if adopted as proposed, would only apply to coastal Class SB and SA waters.

DEP's ongoing costs for these projects are estimated to total approximately $50-60M for the next ten years, excluding design or construction costs. EPA's selected remedy for the Gowanus Canal requires that NYC build two combined sewage overflow retention tanks. Potential Superfund costs for the two Gowanus Canal retention tanks total approximately $825M. For Newtown Creek, the City does not believe that CSO discharges are a significant source of hazardous substances to Newtown Creek. However, the CSO control alternative selected in the Newtown Creek LTCP would address any CSO discharge controls that EPA may require as a result of the Superfund process for Newtown Creek.

- 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 has since been increased to $1.9B.

9.6.g.6 Potential, Unbudgeted Drinking Water Regulation

- Hillview Reservoir Cover

  LT2 also mandates that water from uncovered storage facilities, including DEP's Hillview Reservoir, be treated, or that the reservoir be covered. DEP has entered into an Administrative Order with the NYSDOH and an Administrative Order with EPA, both of which mandate NYC to begin work on a reservoir cover by the end of January 2017. In August 2011, EPA announced that it would review LT2 and its requirement to cover uncovered finished storage reservoirs such as Hillview. DEP has spent significant funds analyzing water quality, engineering options, and other matters relating to the Hillview Reservoir. Potential costs affiliated with construction are estimated to be $1.6B. DEP submitted a request to EPA in April 2013 for suspension of the January 2017 milestone. This request was made to avoid use of limited resources for a contract that may be rescheduled or eliminated pending the outcome of the LT2 review. On January 11, 2017, EPA issued its determination that it was not going to include the LT2 as one of the regulations for revision, and that the requirement to cover uncovered finished storage reservoirs would remain. DEP and EPA are in discussions concerning next steps.

9.6.g.7 Other: State of Good Repair Projects and Sustainability/Resiliency Initiatives

Wastewater Projects

- 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 wastewater treatment plants 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 treatment facilities. 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 wastewater treatment plants. 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 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 WWTPs

In April 2015, NYC launched One New York: The Plan for a Strong and Just City (OneNYC), which calls for reducing NYC's greenhouse gas (GHG) emissions by 80 percent below 2005 levels by 2050. 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 off-site 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 22 percent reduction in GHG emissions at DEP from 2006 to 2017. DEP has approximately $344M allocated in its CIP 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. A 12 megawatt cogeneration and electrification system estimated at $271M is currently in design for the North River WWTP and is estimated to be in operation in winter 2020. DEP has completed energy audits that identified close to 150 energy conservation measures at the in-city WWTPs having the potential to reduce GHG emissions by over 160,000 metric tons of carbon dioxide equivalent at an approximate cost of $140M. DEP is in the process of developing an agency-wide Energy Plan to determine the most economically, operationally, and technologically feasible and innovative pathways forward to achieve the OneNYC goals.

Water Projects

- 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 a toilet replacement program, replacing municipal fixtures, and providing demand management assistance to the wholesale customers located north of NYC. Construction of the shafts for the bypass tunnel is underway, and the project will culminate with the connection of the bypass tunnel in 2022. The cost for this project is estimated to be approximately $1.6B.

- Gilboa Dam

  DEP is currently investing in a major rehabilitation project of the Gilboa Dam at Schoharie Reservoir. Reconstruction of the dam is the largest public works project in Schoharie County, and one of the largest in the entire Catskills. The rehabilitation costs for Gilboa Dam is approximately $458M.

- 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. The cost for this project is estimated at approximately $1.28B.

- 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. The project is scheduled for completion in the 2020s. When activated, 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 multiyear program is estimated to cost $742M.

9.6.h 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 53 percent of households could pay two percent or more of their income for wastewater services. The information in this section will be refined in future LTCP waterbody submittals.

9.6.h.1 Estimated Costs for Waterbody CSO Preferred Alternative

As discussed in Section 8.8, the selection of the Recommended Plan for the Jamaica Bay and Tributaries LTCP includes additional GI, shoreline wetland restoration, environmental dredging, and ecological restoration. The estimated costs (in April 2018 dollars) for the Recommended Plan are: NPW of $401M, PBC of $310M, and annual O&M of $2M. The escalated design and construction costs for the LTCP Recommended Plan are estimated to be $579M.

9.6.h.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 CSOs and to meet applicable WQS at that time. As part of the CSO Order between DEC and DEP, these grey infrastructure projects were integrated in the Order with specific project design and construction milestones. Additionally, in the Order DEP committed to a $1.5B 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 will advance pursuant to the CSO Order schedule and any subsequent amendments. Overall anticipated CSO program costs for NYC will be unknown until each LTCP is developed and approved. Capital costs for the LTCP preferred alternatives that have been identified to-date are presented in Table 9-14, and resulting CSO volume reductions and treated/disinfected CSO volumes are presented in Table 9-15. Costs and CSO volume reductions for waterbodies where a LTCP has not yet been prepared will be identified in future LTCP waterbody submittals. The LTCP preferred alternatives for these waterbodies could be a mix of treatment and storage options. Approximately $1.9B of LTCP project costs are committed in the current CIP (FY2019-2028). The remainder of LTCP costs will be committed beyond FY2028.

9.6.h.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 current CIP (FY2019-2028) and applying estimated future DEP investments from 2029 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 2028, In addition, a conceptual $5.7B in LTCP spending through 2045 was applied, a portion of which is included in the current CIP. This potential $5.7B in LTCP spending is in addition to the $4.2B 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 $9.9B. When accounting only for the $5.0B for LTCPs that have been submitted or approved, this total commitment is $9.2B (see Table 9-16). The cost estimates presented will evolve over the next year and will be updated when the Citywide LTCP is completed.

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 @ CSO Retention Facility	$8	$12
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 WWTP + Floatables Control	$46	New Regulator and Floatables Control at HP-011 + Hydraulic Relief at Outfalls HP-007/-009	$110	$185
Coney Island Creek	Avenue V PS Expansion + Wet Weather Force Main	$197	No Additional Projects	$0	$0
Citywide/Open Waters	Bowery Bay Headworks + Port Richmond Throttling Facility + Tallman Island Conveyance + Outer Harbor CSO Regulator Improvements	$196	TBD	TBD	TBD
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	$1,616
Flushing Creek	CSO Retention Facility + Vortex Facilities	$363	Floatables Control (Baffles) at Diversion Chamber 3 (Outfall TI-010) and Regulator TI-09 (Outfall TI-011)	$56	$92
Gowanus Canal	Gowanus PS Reconstruction + Flushing Tunnel	$198	8 MG Tank at RH-034 and 4 MG Tank at OH-007	$670	$932
Hutchinson River	Hunts Point WWTP Headworks	$3	Diversion Structure with Floatables Control at HP-024	$90	$167
Jamaica Bay and Tributaries	Sewer Improvements in 26W + 26W HLSS + Hendrix Creek Canal Dredging + Shellbank Destratification + Spring Creek AWWTP Upgrade + 26 Ward Wet Weather Improvements	$652	Additional GI, Shoreline Wetland Restoration, Environmental Dredging, and Ecological Restoration	$310	$579
Newtown Creek	Floatables Control + Bending Weirs + Plant Expansion + Instream Aeration	$262	26 MGD BAPS Expansion and 39 MG Deep Tunnel	$647	$1,422
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	$0
Green Infrastructure Program(4)	Citywide GI Program	$1,500			
Total Cost		***$4,203***		***$2,720***	***$5,005***

Notes:

(1) Costs reported in this column reflect current estimated construction costs only (i.e., probable bid cost).
(2) Costs reported in this column reflect total project costs (including design, construction management, and construction costs) escalated out to midpoint of construction. Projected O&M costs are not included.
(3) LTCP Program costs for Bergen, Thurston, and Paerdegat Basins are included in the Jamaica Bay and Tributaries cost.
(4) GI Program costs are not part of the LTCP Program costs.

Table 9-15. Overall Estimated Citywide CSO Reductions

Waterbody	Waterbody Watershed Facility Plan				LTCP CSO Program[4]				
	Pre-WWFP CSO Volume (MGY)[1]	Baseline LTCP CSO Volume (MGY)[2]	CSO Reduction (MGY)	CSO Volume Reduction (%)	Baseline LTCP CSO Volume (MGY)[2]	LTCP Recommended Plan (MGY)[3]	CSO Reduction (MGY)	CSO Volume Reduction (%)	Treated CSO Volume (MGY)
Alley Creek	517	132	385	74%	132	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	Included with Jamaica Bay and Tributaries	NA	Included with Jamaica Bay and Tributaries
Bronx River	1,007	455	552	55%	455	285	170	37%	---
Coney Island Creek	293	75	218	74%	75	75	0	0%	---
Citywide/Open Waters	16,165	12,207	3,958	24%	12,207	TBD	TBD	TBD	TBD
Flushing Bay	2,328	1,453	875	38%	1,453	706	747	51%	---
Flushing Creek	2,413	1,201	1,212	50%	1,201	1,201	0	0%	584
Gowanus Canal	377	263	114	30%	263	115	148	56%	---
Hutchinson River	390	323	67	17%	323	323	0	0%	65
Jamaica Bay & Tribs	2,185	1,536	649	30%	1,536	1,290	246	16%	---
Newtown Creek	1,470	1,161	308	21%	1,161	455	707	61%	---
Paerdegat Basin	1,388	616	772	56%	616	616	0	0%	---
Westchester Creek	767	290	477	62%	290	290	0	0%	---
Total	***29,300***	***19,713***	***9,587***	***33%***	***19,713***				

Notes:
(1) "Pre-WWFP" volumes are pre-Waterbody Watershed Facility Plan estimates of annual overflow volume based on 2003 WWTP wet-weather capacities, existing infrastructure in 2003, 1988 JFK rainfall data (~40" of rainfall), and CY2045 projected flows and loads.
(2) "Baseline CSO LTCP" volumes are estimates of annual overflow volume based on WWTPs 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 WWTPs 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 Jamaica Bay and Tributaries LTCP). The Citywide/Open Waters LTCP is still being developed, and therefore no CSO reductions are included for that waterbody.
(4) LTCP program CSO volume reductions will be updated and totaled in the final Citywide/Open Waters LTCP submittal.

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	$1.5
LTCP/Submitted and Approved	$5.0(1)
Total	**$9.2**

Note:

(1) Reflects costs escalated to midpoint construction for submitted and approved LTCP plans as shown in Table 9-14. Total LTCP costs are not currently known. A conceptual $5.7B in LTCP spending through 2045 is assumed for the affordability assessment. The total LTCP cost estimates will evolve over the next year and will be updated when the Citywide LTCP is completed.

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 FY2018 Revenue Plan value 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 current CIP (FY2019-2028) would result in a 66 percent rate increase by 2028 (approximately 5.2 percent average annual increase). Additional potential mandates and CIP investments from 2029 to 2045 (using an average of $2.0B per year, inflated by 3 percent per year), as well as the up to $5.7B in total LTCP spending, could result in a cumulative rate increase of 257 percent compared to 2019 values (approximately 4.83 percent annual average increase).

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
2028(1)	$708	$460	$580
2045(2)	$2,776	$1,804	$2,274

Notes:

(1) Includes costs for the current $16.3B 2019-2028 CIP, which includes approximately $1.9B in LTCP 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 2029-2045. Total LTCP costs are not currently known. For conceptual purposes, up to $5.7B in LTCP spending from 2018 through 2045 is assumed.

Table 9-18 shows the potential range of future spending and its impact on household cost compared to MHI for the analysis years of 2018 (current conditions), 2028 (end of current CIP), and 2045 (accounts for anticipated additional spending and an assumed commitment of the total $5.7B LTCP spending). The projected MHI for the analysis years of 2028 and 2045 was estimated by applying an annual inflation rate of 1.36 percent. This rate is based on the average annual inflation rate from 2012 to 2017 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 9-19 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 167, as discussed in Section 9.6.e.4. Based on this adjustment, total wastewater costs per average household account is projected to be 3.7 percent of MHI in 2045.

Figure 9-11 shows the average estimated household cost for wastewater services compared to household income, versus the percentage of households in various income brackets for 2018 (using FY2019 rates) and projected future rates for 2028 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 2018. Estimating the future rate and income increases to 2028 and 2045 (based on the projected costs in Table 9-17 and historic Consumer Price Index data), up to 53 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 2.2 percent of MHI in 2045. This is summarized in Table 9-20. 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.

Table 9-18. Total Estimated Cumulative Future Household Costs / Median Household Income

Year	Total Projected Annual Household Cost(1)			Projected MHI(2)	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	Single-family Home	Multi-family Unit	Average HH Cost
2018	$1,080	$702	$885	$61,334	1.76%	1.14%	1.44%	1.08%	0.70%	0.89%
2028	$1,788	$1,162	$1,465	$69,172	2.59%	1.68%	2.12%	1.59%	1.03%	1.30%
2045	$3,856	$2,506	$3,159	$86,956	4.43%	2.88%	3.63%	2.72%	1.77%	2.23%

Notes:
(1) Projected household costs are estimated from rate increases presented in Table 9-17.
(2) Costs were compared to assumed MHI projection which was estimated using Census and Consumer Price Index data.
HH = Household

Table 9-19. Total Estimated Cumulative Future Household Costs/Median Household Income Adjusted for Cost of Living

Year	Total Projected Annual Household Cost(1)			Projected MHI(2)	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	Single-family Home	Multi-family Unit	Average HH Cost
2018	$1,080	$702	$885	$36,727	2.94%	1.91%	2.41%	1.81%	1.17%	1.48%
2028	$1,788	$1,162	$1,465	$41,421	4.32%	2.81%	3.54%	2.65%	1.72%	2.17%
2045	$3,856	$2,506	$3,159	$52,069	7.41%	4.81%	6.07%	4.55%	2.95%	3.72%

Notes:
(1) Projected household costs are estimated from rate increases presented in Table 9-17.
(2) Costs were compared to assumed projected MHI, which was estimated using Census and Consumer Price Index data and calculated based on Cost of Living Index value of 167 for NYC in Q4 of 2016 (Source: C2ER).
HH = Household

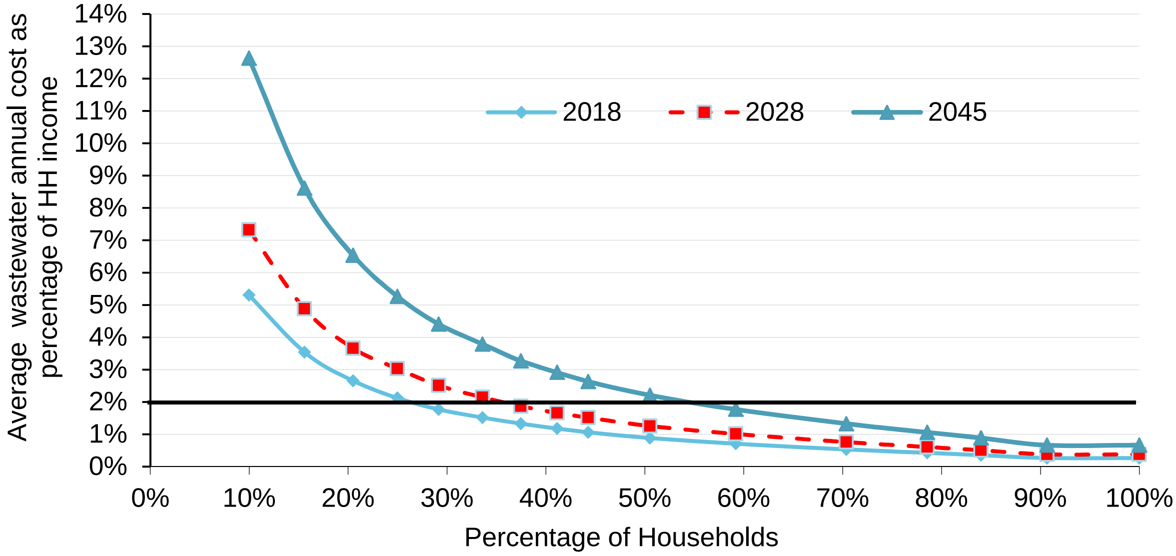


Figure 9-11. Estimated Average Wastewater Household Cost Compared to Household Income (2018, 2028, and 2045)

Table 9-20. 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
2018	0.9%	2.6%	1.2%	26%
2028	1.3%	3.8%	1.7%	37%
2045	2.2%	6.5%	2.9%	53%

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 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 9-12.

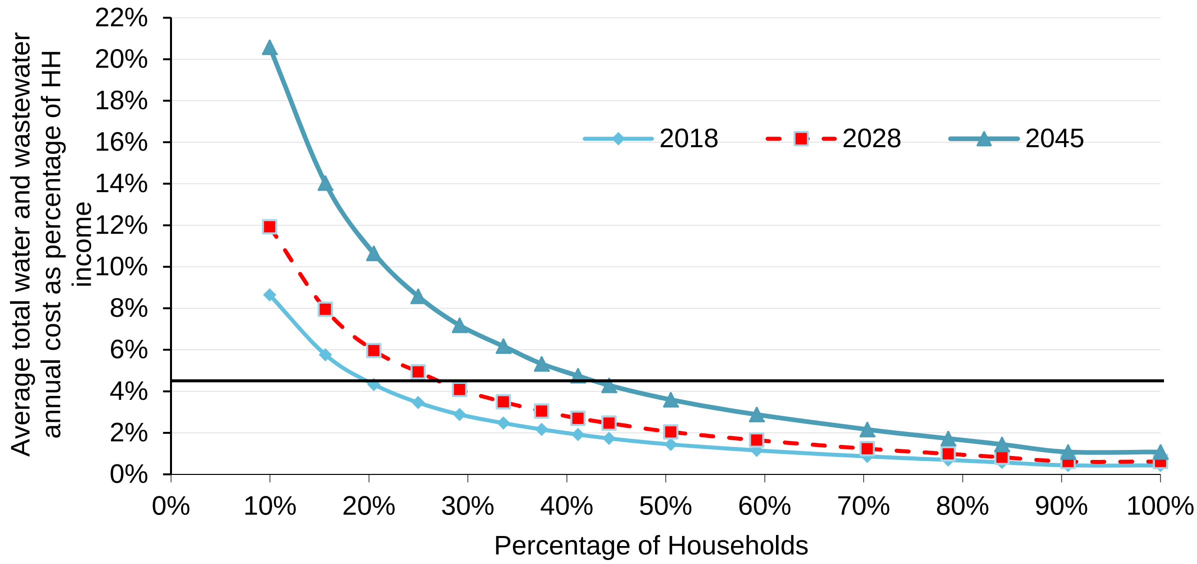


Figure 9-12. Estimated Average Total Water and Wastewater Household Cost Compared to Household Income (2018, 2028, and 2045)

9.6.i Benefits of Program Investments

DEP has been in the midst of an unprecedented period of investment to improve water quality in New York Harbor. Projects worth almost $10B 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 in the Harbor 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 Jamaica Bay and its tributaries resulting from implementation of the baseline projects.

9.6.i.1 Citywide Water Quality Benefits from Previous and Ongoing Programs and Anticipated Jamaica Bay Water Quality Benefits

Water quality benefits have been documented in the Harbor and its tributaries resulting from the almost $10B investment that NYC has already made in grey and GI since 2002. Approximately 95 percent of the Harbor is available for boating and kayaking, and 14 of NYC's beaches provide access to swimmable waters in the Bronx, Brooklyn, Queens and Staten Island.

Figure 9-13 shows the historical timeline of DEP's investments in wastewater infrastructure since the CWA of 1972. Of the $10B invested since 2002, almost 20 percent has been dedicated to controlling CSOs and stormwater. That investment has resulted in NYC capturing and treating over 70 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: GI projects in 26th Ward, Hutchinson River, and Newtown Creek watersheds; area-wide GI contracts; Avenue V

Pumping Station and Force Main; and the Bronx River Floatables Control. 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.

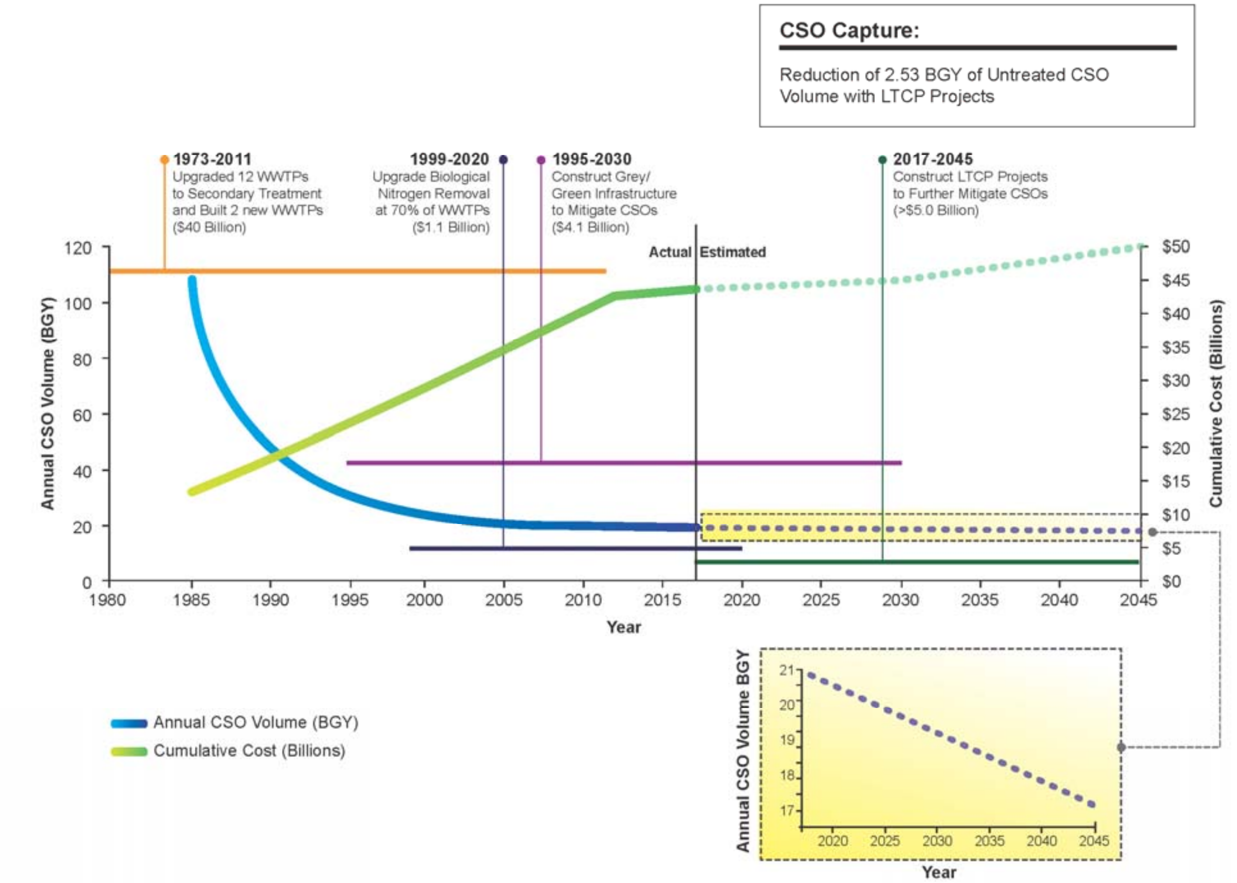


Figure 9-13. Historical Timeline for Wastewater Infrastructure Investments and CSO Reduction over Time

Although significant investments have been made for water quality improvements Harbor-wide, more work is needed. DEP has committed to working with DEC to further reduce CSOs and make other infrastructure improvements to gain additional water quality improvements. The CSO Order between DEP and DEC outlines a combined grey and green approach to reduce CSOs. This LTCP for Jamaica Bay and Tributaries is just one of the detailed plans that DEP is preparing to evaluate and identify additional control measures for reducing CSOs and improving water quality in the Harbor. DEP is also committed to extensive water quality monitoring throughout the Harbor which will allow better assessment of the effectiveness of the controls implemented.

As noted above, GI stormwater control measures are a major component of the CSO Order that DEP and DEC developed. The GI proposed as part of the preferred alternative for the Jamaica Bay and Tributaries LTCP is in addition to the CSO Order GI requirement. 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 to Jamaica Bay is included in Section 8.0.

9.6.j Conclusions

As part of the LTCP process, DEP will continue to develop and refine the affordability and financial capability assessments for each individual waterbody as it works toward an expanded analysis for the citywide LTCP. In addition to what is outlined in the 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. Furthermore, it is important to include a fuller range of future spending obligations and DEP has presented an initial picture of that in this section. Ultimately, the environmental, social, and financial benefits of all water-related obligations should be considered when priorities for spending are developed and implementation of mandates are scheduled, so that resources can be focused where the community will get the most environmental benefit.

9.7 Compliance with Water Quality Goals

Jamaica Bay (Class SB) and its tributaries (Class I) water quality can be improved through the Jamaica Bay WWFP recommendations, planned GI projects, and implementation of this LTCP. Jamaica Bay can fully support existing uses, kayaking and fish, shellfish and wildlife propagation and survival, and the waterbody is in attainment with existing Class SB WQ Criteria for fecal coliform bacteria and DO. Among the tributaries to Jamaica Bay, the existing Class I WQ Criteria for fecal coliform bacteria are projected to be attained, except in the most upstream reaches of Thurston Basin, Bergen Basin and Fresh Creek. The parts of Thurston and Bergen Basins that will not be in attainment are in areas that are not accessible to the public due to physical barriers and/or security restrictions associated with JFK International Airport. Paerdegat Basin, Fresh Creek, and Spring Creek are in attainment with existing Class I WQ Criteria for DO; however, the upstream reaches of Hendrix Creek, Bergen and Thurston Basins are not in attainment with the Class I WQ Criteria for DO.

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 Bergen Basin, Thurston Basin, and Fresh Creek are not projected to fully meet Existing WQ Criteria for fecal coliform, and Bergen Basin, Thurston Basin, and Hendrix Creek are not projected to fully attain the Existing DO Criteria, a UAA is included in this LTCP.

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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
AMP	Asset Management Plan
AWWTP	Auxiliary Wastewater Treatment Plant
BB	Bergen Basin
BEACH	Beaches Environmental Assessment and Coastal Health
BEPA	Bureau of Environmental Planning and Analysis
BGY	Billon Gallons Per Year
BMP	Best Management Practice
BNR	Biological Nutrient Removal
BOD	Biochemical Oxygen Demand
BODR	Basis of Design Report
BWSO	Bureau of Water and Sewer Operations
CEG	Cost Effective Grey
CFR	Code of Federal Regulation
CIP	Capital Improvement Plan
CSO	Combined Sewer Overflow
CSS	Combined Sewer System
CWA	Clean Water Act
CY	Cubic yards
DCIA	Directly Connected Impervious Areas
DCP	New York City Department of City Planning

DDC	New York City Department of Design and Construction
DEC	New York State Department of Environmental Conservation
DEP	New York City Department of Environmental Protection
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 and Recreation
DWF	Dry Weather Flow
DWO	Dry Weather Overflow
EBP	Environmental Benefit Project
EDC	New York City Economic Development Corporation
EPA	United States Environmental Protection Agency
ET	Evapotranspiration
FAD	Filtration Avoidance Determination
FANCJ	First Amended Nitrogen Consent Judgment
FC	Fresh Creek
FCI	Financial Capability Indicators
FMPV	Full Market Property Value
FT	Abbreviation for “Feet”
FY	Fiscal Year
GHG	Greenhouse Gases
GI	Green Infrastructure
GIS	Geographical Information System
GM	Geometric Mean
GNRA	Gateway National Recreation Area

GO	General Obligation
GRTA	NYC Green Roof Tax Abatement
HBPS	Howard Beach Pumping Station
HEAP	Home Energy Assistance Program
HGL	Hydraulic Grade Line
HLSS	High Level Storm Sewers
HSM	Harbor Survey Monitoring Program
IEC	Interstate Environmental Commission
I/I	Inflow and Infiltration
in.	Abbreviation for “Inches”.
in/hr	Inches per hour
IW	InfoWorks CS™
JEM	Jamaica Bay Eutrophication Model
JFK	John F. Kennedy International Airport
KOTC	Knee-of-the-Curve
lbs/day	Pounds per day
LF	Linear fee
LIRR	Long Island Railroad
LTCP	Long Term Control Plan
MCP	Multifamily Conservation Program
mg/L	milligrams per liter
MG	Million Gallons
MGD	Million Gallons per Day
MGY	Millions Gallons per Year
MHI	Median Household Income
MMP	Mercury Minimization Program

MOU	Memorandum of Understanding
MS4	Municipal separate storm sewer systems
MWFA	New York City Municipal Water Finance Authority
NEIWPCC	New England Interstate Water Pollution Control Commission
NMC	Nine Minimum Control
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NPW	Net Present Worth
NYC	New York City
NYCHA	New York City Housing Authority
NYCRR	New York State Code of Rules and Regulations
NYS	New York State
NYSDOH	New York State Department of Health
NYSDOS	New York State Department of State
O&M	Operation and Maintenance
ONRW	Outstanding National Resource Waters
ORR	NYC Office of Recovery and Resiliency
PANYNJ	Port Authority of New York/New Jersey
PB	Paerdegat Basin
PBC	Probable Bid Cost
PCM	Post-Construction Compliance Monitoring
POTW	Publicly Owned Treatment Plant
PS	Pumping Station
RI	Residential Indicator
RFI	Request for Information
ROD	Record of Decision

ROW	Right-of-Way
ROWB	Right-of-way bioswales
ROWRG	Right-of-way rain gardens
RTB	Retention Treatment Basins
RWQC	Recreational Water Quality Criteria
S&P	Standard and Poor
SCADA	Supervisory Control and Data Acquisition
SDWA	Safe Drinking Water Act
SEQ	Southeast Queens
SM	Sentinel Monitoring
SPDES	State Pollutant Discharge Elimination System
STV	Statistical Threshold Value
SYNOP	Synoptic Surface Plotting Model
TB	Thurston Basin
TBD	To Be Determined
TDPS	Tunnel Dewatering Pumping Station
TMDL	Total Maximum Daily Load
TRC	Total Residual Chlorine
UAA	Use Attainability Analysis
US	United States
USACE	United States Army Corps of Engineers
UV	Ultraviolet Light
WQ	Water Quality
WQBEL	Water Quality Based Effluent Limitations
WQS	Water Quality Standards
WWFP	Waterbody/Watershed Facility Plan

WWOP	Wet Weather Operating Plan
WWTP	Wastewater Treatment Plant

Appendix A: Supplemental Tables

Combined Sewer Outfalls - Volumes		
Waterbody	**Outfall**	**Total Discharge (MG/Yr)**
Paerdegat Basin	CI-004	12
Paerdegat Basin	CI-005	18
Paerdegat Basin	CI-006	8
Paerdegat Basin	CI-CIT	553
Bergen Basin	JA-003/003A	338
Bergen Basin	JA-006	2
Thurston Basin	JA-007/JA-005	213
Jamaica Bay	RO-030	0
Jamaica Bay	RO-029	0
Jamaica Bay	RO-015	0
Jamaica Bay	RO-014	0
Jamaica Bay	RO-012	0
Jamaica Bay	RO-011	0
Jamaica Bay	RO-010	0
Jamaica Bay	RO-009	0
Jamaica Bay	RO-008	0
Jamaica Bay	RO-007	0
Jamaica Bay	RO-006	0
Jamaica Bay	RO-005	0
Jamaica Bay	RO-004	0
Fresh Creek	26-003	300
Hendrix Creek	26-004	104
Spring Creek	26-005	310
	Total CSO	**1,858**

MS-4 Outfalls - Volumes		
Waterbody	**Outfall**	**Total Discharge, (MG/Yr)**
Jamaica Bay	CI-603	24
Jamaica Bay	CI-604	3
Jamaica Bay	CI-605	298
Jamaica Bay	CI-607	3
Jamaica Bay	CI-608	2
Jamaica Bay	CI-609	2
Jamaica Bay	CI-610	404
Jamaica Bay	CI-611	8
Jamaica Bay	CI-612	10
Jamaica Bay	CI-613	251
Jamaica Bay	CI-614	2
Jamaica Bay	CI-615	54
Jamaica Bay	CI-616	9
Jamaica Bay	CI-617	12
Jamaica Bay	CI-618	16
Jamaica Bay	CI-619	12
Jamaica Bay	CI-620	16
Jamaica Bay	CI-621	7
Jamaica Bay	CI-622	25
Jamaica Bay	CI-623	14
Jamaica Bay	CI-624	38
Jamaica Bay	CI-625	27
Jamaica Bay	CI-626	27
Jamaica Bay	CI-627	33
Paerdegat Basin	CI-628	30
Paerdegat Basin	CI-629	40
Paerdegat Basin	CI-630	48
Paerdegat Basin	CI-632	78
Jamaica Bay	CI-633	121
Fresh Creek	CI-634	114
Fresh Creek	CI-636	51
Fresh Creek	CI-637	50
Jamaica Bay	CI-642	11
Jamaica Bay	CI-656	5
Jamaica Bay	CI-657	83
Jamaica Bay	CI-667	9

MS-4 Outfalls - Volumes		
Waterbody	**Outfall**	**Total Discharge, (MG/Yr)**
Jamaica Bay	CI-668	5
Jamaica Bay	CI-669	9
Jamaica Bay	CI-670	7
Jamaica Bay	CI-671	11
Jamaica Bay	CI-672	20
Jamaica Bay	CI-673	5
Jamaica Bay	CI-674	2
Jamaica Bay	CI-676	15
Bergen Basin	JA-006	2,810
Bergen Basin	JA-140	25
Shellbank Basin	JA-114	4
Shellbank Basin	JA-115	7
Shellbank Basin	JA-116	4
Shellbank Basin	JA-117	6
Shellbank Basin	JA--081	5
Hawtree Basin	JA-523	4
Shellbank Basin	JA-601	10
Shellbank Basin	JA-603	54
Shellbank Basin	JA-604	6
Shellbank Basin	JA-605	9
Shellbank Basin	JA-607	41
Shellbank Basin	JA-609	34
Shellbank Basin	JA-630	12
Hawtree Basin	JA-636	5
Hawtree Basin	JA-638	3
Head of Bay	JA-649	256
Head of Bay	JA-652	0
Head of Bay	JA-653	11
Head of Bay	JA-654	1
Head of Bay	JA-655	6
Hawtree Basin	JA-656	20
Hawtree Basin	JA-657	3
Hawtree Basin	JA-658	4
Shellbank Basin	JA-802	48
Head of Bay	JA-661	11
Shellbank Basin	JA-607A	41

MS-4 Outfalls - Volumes		
Waterbody	**Outfall**	**Total Discharge, (MG/Yr)**
Hawtree Basin	JA-877	5
Jamaica Bay	RO-680	59
Jamaica Bay	RO-679	9
Jamaica Bay	RO-678	9
Jamaica Bay	RO-676	12
Jamaica Bay	RO-675	5
Jamaica Bay	RO-672	10
Jamaica Bay	RO-671	11
Jamaica Bay	RO-670	3
Jamaica Bay	RO-669	2
Jamaica Bay	RO-661	4
Jamaica Bay	RO-660	8
Jamaica Bay	RO-659	16
Jamaica Bay	RO-658	14
Jamaica Bay	RO-657	61
Jamaica Bay	RO-656	9
Jamaica Bay	RO-653	45
Jamaica Bay	RO-652	48
Jamaica Bay	RO-651	48
Jamaica Bay	RO-649	15
Jamaica Bay	RO-648	50
Jamaica Bay	RO-642	60
Jamaica Bay	RO-641	21
Jamaica Bay	RO-640	4
Jamaica Bay	RO-638	6
Jamaica Bay	RO-637	6
Jamaica Bay	RO-636	34
Jamaica Bay	RO-635	14
Jamaica Bay	RO-634	37
Jamaica Bay	RO-633	8
Jamaica Bay	RO-632	27
Jamaica Bay	RO-631	9
Jamaica Bay	RO-630	45
Jamaica Bay	RO-629	9
Jamaica Bay	RO-627	12
Jamaica Bay	RO-625	40

MS-4 Outfalls - Volumes		
Waterbody	**Outfall**	**Total Discharge, (MG/Yr)**
Jamaica Bay	RO-624	8
Jamaica Bay	RO-622	10
Jamaica Bay	RO-620	7
Jamaica Bay	RO-619	9
Jamaica Bay	RO-618	8
Jamaica Bay	RO-617	24
Jamaica Bay	RO-614	23
Jamaica Bay	RO-610	32
Hendrix Creek	26--062	23
Hendrix Creek	26-601M	12
Spring Creek	26-603M	26
	Total MS-4	**6,408**

Stormwater Outfalls - Volumes		
Waterbody	**Outfall**	**Total Discharge, (MG/Yr)**
Jamaica Bay	CI--64	56
Jamaica Bay	CI--65	19
Jamaica Bay	CI--66	96
Jamaica Bay	CI--67	17
Paerdegat Basin	CI--96	62
Paerdegat Basin	CI--98	41
Paerdegat Basin	CI--99	10
Jamaica Bay	CI-113	272
Thurston Basin	JA-005/007	611
Hawtree Basin	JA--064	0
Bergen Basin	JA--065	117
Head of Bay	JA--079	49
Hawtree Basin	JA--082	2
Thurston Basin	JA--083	182
Shellbank Basin	JA-530	6
Head of Bay	JA-640	6
Hawtree Basin	JA-DD09	27
Spring Creek	JA-S001	25
Jamaica Bay	RO--16_	70
Jamaica Bay	RO--14	94
Jamaica Bay	RO--10	52
Jamaica Bay	RO-016	10
Jamaica Bay	RO-031	72
Jamaica Bay	RO-130	16
Jamaica Bay	RO--08	29
Jamaica Bay	RO--05	34
Jamaica Bay	RO--04	84
Jamaica Bay	RO--02	64
Jamaica Bay	RO--01	206
Jamaica Bay	RO--60	9
Jamaica Bay	RO--61	4
Jamaica Bay	RO--62	8
Jamaica Bay	RO--63	11
Fresh Creek	26-HS1	110
Fresh Creek	26-HS2	90
Fresh Creek	26-HS3	11

Stormwater Outfalls - Volumes		
Waterbody	**Outfall**	**Total Discharge, (MG/Yr)**
Fresh Creek	26--061	62
Spring Creek	26--084	13
Hendrix Creek	26--092	18
Hendrix Creek	26--093	10
Hendrix Creek	26--094	13
	Total Stormwater	**2,688**

Direct Runoff Outfalls - Volumes		
Waterbody	**Outfall**	**Total Discharge, (MG/Yr)**
Fresh Creek	CI--54	10
Fresh Creek	CI--55	11
Jamaica Bay	CI--56	21
Jamaica Bay	CI--57	19
Paerdegat Basin	CI--58	7
Paerdegat Basin	CI--59	8
Paerdegat Basin	CI--60	3
Jamaica Bay	CI--68	28
Jamaica Bay	CI--69	10
Jamaica Bay	CI--70	14
Jamaica Bay	CI--71	4
Jamaica Bay	CI--72	20
Jamaica Bay	CI--73	24
Jamaica Bay	CI--74	18
Jamaica Bay	CI--75	3
Jamaica Bay	CI--76	7
Jamaica Bay	CI--77	13
Jamaica Bay	CI--78	31
Jamaica Bay	CI--79	42
Jamaica Bay	CI--80	86
Jamaica Bay	CI--82	65
Jamaica Bay	CI--83	147
Jamaica Bay	CI--88	13
Jamaica Bay	CI--89	10
Jamaica Bay	CI--90	4
Jamaica Bay	CI--91	15
Jamaica Bay	CI--92	6
Jamaica Bay	CI--93	8
Jamaica Bay	CI--94	7
Paerdegat Basin	CI--95	20
Paerdegat Basin	CI--97	3
Spring Creek	JA--060	38
Jamaica Bay	JA--061	0
Jamaica Bay	JA--062	2
Bergen Basin	JA--066	22
Thurston Basin	JA--077	61

Direct Runoff Outfalls - Volumes		
Waterbody	**Outfall**	**Total Discharge, (MG/Yr)**
Head of Bay	JA--078	106
Head of Bay	JA-888	5,900
Head of Bay	JA-999	178
Head of Bay	JA-BCK	45
Jamaica Bay	RO--17	20
Jamaica Bay	RO--16	300
Jamaica Bay	RO--15	288
Jamaica Bay	RO--13	513
Jamaica Bay	RO--09	119
Jamaica Bay	RO--07	12
Jamaica Bay	RO--06	10
Jamaica Bay	RO--03	22
Spring Creek	26--083	13
Spring Creek	26--085	3
Spring Creek	26--086	19
Spring Creek	26--087	4
Jamaica Bay	26--088	2
Jamaica Bay	26--089	8
Hendrix Creek	26--090	22
Hendrix Creek	26--091	6
Hendrix Creek	26--095	7
Jamaica Bay	26--096	7
Fresh Creek	26--097	4
Fresh Creek	26--098	5
Fresh Creek	26--099	3
	Total Direct Runoff	**8,416**

Airport/Transport Outfalls - Volumes		
Waterbody	**Outfall**	**Total Discharge (MG/Yr)**
Jamaica Bay	JA--074	23
Head of Bay	JA--075	114
Bergen Basin	JA-615	111
Bergen Basin	JA-617	62
Bergen Basin	JA-03aH	25
Jamaica Bay	JA-618	552
Jamaica Bay	JA-620	314
Bergen Basin	JA-639	104
Thurston Basin	JA-659	372
Jamaica Bay	JA-806	68
Head of Bay	JA-663	27
	Total Airport	**1,772**

Other Outfalls - Volumes		
Waterbody	**Outfall**	**Total Discharge (MG/Yr)**
Head of Bay	JA--067	14
Jamaica Bay	CI--84	15
Jamaica Bay	CI--85	11
Jamaica Bay	CI--86	13
Jamaica Bay	CI--87	10
Jamaica Bay	RO--12	10
Jamaica Bay	RO--11	10
	Total Other	**83**

WWTP Discharges - Volumes		
Waterbody	**Outfall**	**Total Discharge (MG/Yr)**
Jamaica Bay	JA-WWTP-1	24,650
Jamaica Bay	RO-WWTP-1	7,876
Hendrix Creek	26-WWTP-1	19,622
Bergen Basin	JA-WWTP-2	5,454
	Total WWTP	**57,602**

Totals by Waterbody - Volumes		
Waterbody	**Outfall**	**Total Discharge (MG/Yr)**
Bergen Basin	NA	9,070
Fresh Creek	NA	822
Hawtree Basin	NA	75
Head of Bay	NA	6724
Hendrix Creek	NA	19,837
Jamaica Bay	NA	39,182
Paerdegat Basin	NA	943
Shellbank Basin	NA	287
Spring Creek	NA	451
Thurston Basin	NA	1,439

Totals by Source - Volumes		
Source	**Outfall**	**Total Discharge (MG/Yr)**
Airport	NA	1,772
CSO	NA	1,858
Direct Runoff	NA	8,479
MS4	NA	6146
Storm	NA	2,703
WWTP	NA	57,602

Totals by Source by Waterbody - Volumes		
Waterbody	**Source**	**Total Discharge (MG/Yr)**
Paerdegat Basin	CSO	591
	MS4	197
	Storm	113
	Direct Drainage	42
	Airport/Transport	NA
	WWTP	NA
Fresh Creek	CSO	300
	MS4	216
	Storm	273
	Direct Drainage	33
	Airport/Transport	NA
	WWTP	NA
Jamaica Bay	CSO	0
	MS4	2,489
	Storm	1,243
	Direct Drainage	1,967
	Airport/Transport	957
	WWTP	32,526
Bergen Basin	CSO	340
	MS4	2,835
	Storm	117
	Direct Drainage	22
	Airport/Transport	302
	WWTP	5,454
Thurston Basin	CSO	213
	MS4	NA
	Storm	793
	Direct Drainage	61
	Airport/Transport	372
	WWTP	NA
Spring Creek	CSO	310
	MS4	26
	Storm	38
	Direct Drainage	77
	Airport/Transport	NA
	WWTP	NA

Totals by Source by Waterbody - Volumes		
Waterbody	**Source**	**Total Discharge (MG/Yr)**
Hawtree Basin	CSO	NA
	MS4	45
	Storm	30
	Direct Drainage	NA
	Airport/Transport	NA
	WWTP	NA
Head of Bay	CSO	NA
	MS4	291
	Storm	49
	Direct Drainage	6,243
	Airport/Transport	141
	WWTP	NA
Shellbank Basin	CSO	NA
	MS4	281
	Storm	6
	Direct Drainage	NA
	Airport/Transport	NA
	WWTP	NA
Hendrix Creek	CSO	104
	MS4	36
	Storm	41
	Direct Drainage	34
	Airport/Transport	NA
	WWTP	19,622

Combined Sewer Outfalls – Fecal Coliform		
Waterbody	**Outfall**	**Total Load (10^{12} cfu/Yr)**
Paerdegat Basin	CI-004	419
Paerdegat Basin	CI-005	869
Paerdegat Basin	CI-006	563
Paerdegat Basin	CI-CIT	34,582
Bergen Basin	JA-003/003A	17,641
Bergen Basin	JA-006	17
Thurston Basin	JA-007	2,673
Jamaica Bay	RO-030	0
Jamaica Bay	RO-029	0
Jamaica Bay	RO-015	0
Jamaica Bay	RO-014	0
Jamaica Bay	RO-012	0
Jamaica Bay	RO-011	0
Jamaica Bay	RO-010	0
Jamaica Bay	RO-009	0
Jamaica Bay	RO-008	0
Jamaica Bay	RO-007	0
Jamaica Bay	RO-006	0
Jamaica Bay	RO-005	0
Jamaica Bay	RO-004	0
Fresh Creek	26-003	4,014
Hendrix Creek	26-004	2,067
Spring Creek	26-005	5,406
	Total CSO	**68,250**

MS-4 Outfalls – Fecal Coliform		
Waterbody	**Outfall**	**Total Load (10^{12} cfu/Yr)**
Jamaica Bay	CI-603	108
Jamaica Bay	CI-604	16
Jamaica Bay	CI-605	1,349
Jamaica Bay	CI-607	15
Jamaica Bay	CI-608	11
Jamaica Bay	CI-609	10
Jamaica Bay	CI-610	1,828
Jamaica Bay	CI-611	35
Jamaica Bay	CI-612	44
Jamaica Bay	CI-613	1,135
Jamaica Bay	CI-614	10
Jamaica Bay	CI-615	244
Jamaica Bay	CI-616	42
Jamaica Bay	CI-617	54
Jamaica Bay	CI-618	73
Jamaica Bay	CI-619	53
Jamaica Bay	CI-620	72
Jamaica Bay	CI-621	33
Jamaica Bay	CI-622	114
Jamaica Bay	CI-623	66
Jamaica Bay	CI-624	174
Jamaica Bay	CI-625	121
Jamaica Bay	CI-626	123
Jamaica Bay	CI-627	149
Paerdegat Basin	CI-628	138
Paerdegat Basin	CI-629	184
Paerdegat Basin	CI-630	218
Paerdegat Basin	CI-632	352
Jamaica Bay	CI-633	548
Fresh Creek	CI-634	517
Fresh Creek	CI-636	232
Fresh Creek	CI-637	229
Jamaica Bay	CI-642	52
Jamaica Bay	CI-656	22
Jamaica Bay	CI-657	376
Jamaica Bay	CI-667	41

MS-4 Outfalls – Fecal Coliform		
Waterbody	**Outfall**	**Total Load (10^{12} cfu/Yr)**
Jamaica Bay	CI-668	21
Jamaica Bay	CI-669	43
Jamaica Bay	CI-670	32
Jamaica Bay	CI-671	51
Jamaica Bay	CI-672	90
Jamaica Bay	CI-673	24
Jamaica Bay	CI-674	11
Jamaica Bay	CI-676	68
Bergen Basin	JA-006	4,805
Bergen Basin	JA-140	42
Shellbank Basin	JA-114	19
Shellbank Basin	JA-115	31
Shellbank Basin	JA-116	19
Shellbank Basin	JA-117	29
Shellbank Basin	JA--081	24
Hawtree Basin	JA-523	19
Shellbank Basin	JA-601	47
Shellbank Basin	JA-603	245
Shellbank Basin	JA-604	28
Shellbank Basin	JA-605	43
Shellbank Basin	JA-607	187
Shellbank Basin	JA-609	156
Shellbank Basin	JA-630	55
Hawtree Basin	JA-636	23
Hawtree Basin	JA-638	0
Head of Bay	JA-649	1,165
Head of Bay	JA-652	3
Head of Bay	JA-653	51
Head of Bay	JA-654	6
Head of Bay	JA-655	28
Hawtree Basin	JA-656	93
Hawtree Basin	JA-657	13
Hawtree Basin	JA-658	21
Shellbank Basin	JA-802	220
Head of Bay	JA-661	50
Shellbank Basin	JA-607A	187

MS-4 Outfalls – Fecal Coliform		
Waterbody	**Outfall**	**Total Load (10^{12} cfu/Yr)**
Hawtree Basin	JA-877	25
Jamaica Bay	RO-680	78
Jamaica Bay	RO-679	13
Jamaica Bay	RO-678	13
Jamaica Bay	RO-676	17
Jamaica Bay	RO-675	7
Jamaica Bay	RO-672	13
Jamaica Bay	RO-671	15
Jamaica Bay	RO-670	4
Jamaica Bay	RO-669	3
Jamaica Bay	RO-661	6
Jamaica Bay	RO-660	10
Jamaica Bay	RO-659	21
Jamaica Bay	RO-658	18
Jamaica Bay	RO-657	80
Jamaica Bay	RO-656	12
Jamaica Bay	RO-653	59
Jamaica Bay	RO-652	64
Jamaica Bay	RO-651	63
Jamaica Bay	RO-649	20
Jamaica Bay	RO-648	66
Jamaica Bay	RO-642	79
Jamaica Bay	RO-641	28
Jamaica Bay	RO-640	6
Jamaica Bay	RO-638	9
Jamaica Bay	RO-637	8
Jamaica Bay	RO-636	46
Jamaica Bay	RO-635	18
Jamaica Bay	RO-634	49
Jamaica Bay	RO-633	11
Jamaica Bay	RO-632	36
Jamaica Bay	RO-631	12
Jamaica Bay	RO-630	59
Jamaica Bay	RO-629	12
Jamaica Bay	RO-627	17
Jamaica Bay	RO-625	53

MS-4 Outfalls – Fecal Coliform		
Waterbody	**Outfall**	**Total Load (10^{12} cfu/Yr)**
Jamaica Bay	RO-624	11
Jamaica Bay	RO-622	13
Jamaica Bay	RO-620	10
Jamaica Bay	RO-619	13
Jamaica Bay	RO-618	11
Jamaica Bay	RO-617	31
Jamaica Bay	RO-614	31
Jamaica Bay	RO-610	42
Hendrix Creek	26--062	107
Hendrix Creek	26-601M	57
Spring Creek	26-603M	120
	Total MS-4	**18,238**

Stormwater Outfalls – Fecal Coliform		
Waterbody	**Outfall**	**Total Load (10^{12} cfu/Yr)**
Jamaica Bay	CI--64	253
Jamaica Bay	CI--65	85
Jamaica Bay	CI--66	433
Jamaica Bay	CI--67	77
Paerdegat Basin	CI--96	283
Paerdegat Basin	CI--98	186
Paerdegat Basin	CI--99	46
Jamaica Bay	CI-113	1,231
Thurston Basin	JA-07S	2,798
Hawtree Basin	JA--064	4
Bergen Basin	JA--065	199
Head of Bay	JA--079	225
Hawtree Basin	JA--082	12
Thurston Basin	JA--083	829
Shellbank Basin	JA-530	8
Thurston Basin	JA-640	27
Hawtree Basin	JA-DD09	124
Spring Creek	JA-S001	113
Jamaica Bay	RO--16_	93
Jamaica Bay	RO--14	125
Jamaica Bay	RO--10	69
Jamaica Bay	RO-016	69
Jamaica Bay	RO-031	96
Jamaica Bay	RO-130	21
Jamaica Bay	RO--08	38
Jamaica Bay	RO--05	45
Jamaica Bay	RO--04	111
Jamaica Bay	RO--02	86
Jamaica Bay	RO--01	273
Jamaica Bay	RO--60	13
Jamaica Bay	RO--61	5
Jamaica Bay	RO--62	11
Jamaica Bay	RO--63	15
Fresh Creek	26-HS1	500
Fresh Creek	26-HS2	407
Fresh Creek	26-HS3	50

Stormwater Outfalls – Fecal Coliform		
Waterbody	**Outfall**	**Total Load (10^{12} cfu/Yr)**
Fresh Creek	26--061	284
Spring Creek	26--084	60
Hendrix Creek	26--092	81
Hendrix Creek	26--093	48
Hendrix Creek	26--094	62
	Total Stormwater	**9,495**

Direct Runoff Outfalls – Fecal Coliform		
Waterbody	**Outfall**	**Total Load (10^{12} cfu/Yr)**
Fresh Creek	CI--54	2
Fresh Creek	CI--55	2
Jamaica Bay	CI--56	3
Jamaica Bay	CI--57	3
Paerdegat Basin	CI--58	1
Paerdegat Basin	CI--59	1
Paerdegat Basin	CI--60	1
Jamaica Bay	CI--68	4
Jamaica Bay	CI--69	1
Jamaica Bay	CI--70	2
Jamaica Bay	CI--71	1
Jamaica Bay	CI--72	3
Jamaica Bay	CI--73	4
Jamaica Bay	CI--74	3
Jamaica Bay	CI--75	1
Jamaica Bay	CI--76	1
Jamaica Bay	CI--77	2
Jamaica Bay	CI--78	5
Jamaica Bay	CI--79	6
Jamaica Bay	CI--80	13
Jamaica Bay	CI--82	10
Jamaica Bay	CI--83	22
Jamaica Bay	CI--88	2
Jamaica Bay	CI--89	2
Jamaica Bay	CI--90	1
Jamaica Bay	CI--91	2
Jamaica Bay	CI--92	1
Jamaica Bay	CI--93	1
Jamaica Bay	CI--94	1
Paerdegat Basin	CI--95	3
Paerdegat Basin	CI--97	1
Spring Creek	JA--060	6
Jamaica Bay	JA--061	0
Jamaica Bay	JA--062	0
Bergen Basin	JA--066	3
Thurston Basin	JA--077	9

Direct Runoff Outfalls – Fecal Coliform		
Waterbody	**Outfall**	**Total Load (10^{12} cfu/Yr)**
Head of Bay	JA--078	16
Head of Bay	JA-888	893
Head of Bay	JA-999	27
Head of Bay	JA-BCK	7
Jamaica Bay	RO--17	3
Jamaica Bay	RO--16	45
Jamaica Bay	RO--15	44
Jamaica Bay	RO--13	78
Jamaica Bay	RO--09	18
Jamaica Bay	RO--07	2
Jamaica Bay	RO--06	1
Jamaica Bay	RO--03	3
Spring Creek	26--083	2
Spring Creek	26--085	0
Spring Creek	26--086	3
Spring Creek	26--087	1
Jamaica Bay	26--088	0
Jamaica Bay	26--089	1
Hendrix Creek	26--090	3
Hendrix Creek	26--091	1
Hendrix Creek	26--095	1
Jamaica Bay	26--096	1
Fresh Creek	26--097	1
Fresh Creek	26--098	1
Fresh Creek	26--099	1
	Total Direct Runoff	**1,276**

Airport Outfalls – Fecal Coliform		
Waterbody	**Outfall**	**Total Load (10^{12} cfu/Yr)**
Jamaica Bay	JA--074	17
Head of Bay	JA--075	86
Bergen Basin	JA-615	84
Bergen Basin	JA-617	47
Jamaica Bay	JA-618	418
Jamaica Bay	JA-620	238
Bergen Basin	JA-639	79
Thurston Basin	JA-659	282
Jamaica Bay	JA-806	52
	Total Airport	**1,302**

Other Outfalls – Fecal Coliform		
Waterbody	**Outfall**	**Total Load (10^{12} cfu/Yr)**
Bergen Basin	JA-03aH	19
Head of Bay	JA--067	10
Head of Bay	JA-663	21
Jamaica Bay	CI--84	12
Jamaica Bay	CI--85	8
Jamaica Bay	CI--86	10
Jamaica Bay	CI--87	8
Jamaica Bay	RO--12	8
Jamaica Bay	RO--11	8
	Total Other	**85**

WWTP Discharges – Fecal Coliform		
Waterbody	**Outfall**	**Total Load (10^{12} cfu/Yr)**
Jamaica Bay	JA-WWTP-1	35
Jamaica Bay	RO-WWTP-1	13
Hendrix Creek	26-WWTP-1	31
Bergen Basin	JA-WWTP-2	8
	Total WWTP	**86**

Totals by Waterbody – Fecal Coliform		
Waterbody	**Outfall**	**Total Load (10^{12} cfu/Yr)**
Bergen Basin	NA	22,930
Fresh Creek	NA	6,238
Hawtree Basin	NA	334
Head of Bay	NA	2,590
Hendrix Creek	NA	2,458
Jamaica Bay	NA	12,715
Paerdegat Basin	NA	37,846
Shellbank Basin	NA	1,318
Spring Creek	NA	5,711
Thurston Basin	NA	6,617

Totals by Source – Fecal Coliform		
Source	**Outfall**	**Total Load (10^{12} cfu/Yr)**
Airport	NA	1,302
CSO	NA	68,250
Direct Runoff	NA	1,276
MS4	NA	18,238
Other	NA	85
Storm	NA	1,276
WWTP	NA	86

Totals by Source by Waterbody – Fecal Coliform		
Waterbody	**Source**	**Total Load (10^{12} cfu/Yr)**
Paerdegat Basin	CSO	36,432
	MS4	892
	Storm	515
	Direct Drainage	7
	Airport/Transport	NA
	WWTP	NA
Fresh Creek	CSO	4,014
	MS4	978
	Storm	1,241
	Direct Drainage	5
	Airport/Transport	NA
	WWTP	NA
Jamaica Bay	CSO	0
	MS4	8,449
	Storm	3,165
	Direct Drainage	329
	Airport/Transport	724
	WWTP	48
Bergen Basin	CSO	17,658
	MS4	4,833
	Storm	199
	Direct Drainage	3
	Airport/Transport	229
	WWTP	8
Thurston Basin	CSO	2,673
	MS4	NA
	Storm	3,653
	Direct Drainage	9
	Airport/Transport	282
	WWTP	NA
Spring Creek	CSO	5,406
	MS4	120
	Storm	173
	Direct Drainage	12
	Airport/Transport	NA
	WWTP	NA

Totals by Source by Waterbody – Fecal Coliform		
Waterbody	**Source**	**Total Load (10^{12} cfu/Yr)**
Hawtree Basin	CSO	NA
	MS4	195
	Storm	139
	Direct Drainage	NA
	Airport/Transport	NA
	WWTP	NA
Head of Bay	CSO	NA
	MS4	1,304
	Storm	225
	Direct Drainage	943
	Airport/Transport	117
	WWTP	NA
Shellbank Basin	CSO	NA
	MS4	1,289
	Storm	29
	Direct Drainage	NA
	Airport/Transport	NA
	WWTP	NA
Hendrix Creek	CSO	2,067
	MS4	164
	Storm	191
	Direct Drainage	5
	Airport/Transport	NA
	WWTP	31

Combined Sewer Outfalls - *Enterococci*		
Waterbody	**Outfall**	**Total Load (10^{12} cfu/Yr)**
Paerdegat Basin	CI-004	186
Paerdegat Basin	CI-005	387
Paerdegat Basin	CI-006	251
Paerdegat Basin	CI-CIT	15,288
Bergen Basin	JA-003/003A	13,509
Bergen Basin	JA-006	8
Thurston Basin	JA-007	821
Jamaica Bay	RO-030	0
Jamaica Bay	RO-029	0
Jamaica Bay	RO-015	0
Jamaica Bay	RO-014	0
Jamaica Bay	RO-012	0
Jamaica Bay	RO-011	0
Jamaica Bay	RO-010	0
Jamaica Bay	RO-009	0
Jamaica Bay	RO-008	0
Jamaica Bay	RO-007	0
Jamaica Bay	RO-006	0
Jamaica Bay	RO-005	0
Jamaica Bay	RO-004	0
Fresh Creek	26-003	4,826
Hendrix Creek	26-004	587
Spring Creek	26-005	1,566
	Total CSO	**37,430**

MS-4 Outfalls - *Enterococci*		
Waterbody	**Outfall**	**Total Load (10^{12} cfu/Yr)**
Jamaica Bay	CI-603	45
Jamaica Bay	CI-604	7
Jamaica Bay	CI-605	562
Jamaica Bay	CI-607	6
Jamaica Bay	CI-608	4
Jamaica Bay	CI-609	4
Jamaica Bay	CI-610	762
Jamaica Bay	CI-611	15
Jamaica Bay	CI-612	18
Jamaica Bay	CI-613	473
Jamaica Bay	CI-614	4
Jamaica Bay	CI-615	102
Jamaica Bay	CI-616	17
Jamaica Bay	CI-617	23
Jamaica Bay	CI-618	30
Jamaica Bay	CI-619	22
Jamaica Bay	CI-620	30
Jamaica Bay	CI-621	14
Jamaica Bay	CI-622	47
Jamaica Bay	CI-623	27
Jamaica Bay	CI-624	73
Jamaica Bay	CI-625	50
Jamaica Bay	CI-626	51
Jamaica Bay	CI-627	62
Paerdegat Basin	CI-628	57
Paerdegat Basin	CI-629	76
Paerdegat Basin	CI-630	91
Paerdegat Basin	CI-632	147
Jamaica Bay	CI-633	228
Fresh Creek	CI-634	216
Fresh Creek	CI-636	97
Fresh Creek	CI-637	95
Jamaica Bay	CI-642	22
Jamaica Bay	CI-656	9
Jamaica Bay	CI-657	157
Jamaica Bay	CI-667	17

MS-4 Outfalls - *Enterococci*		
Waterbody	**Outfall**	**Total Load (10^{12} cfu/Yr)**
Jamaica Bay	CI-668	9
Jamaica Bay	CI-669	18
Jamaica Bay	CI-670	13
Jamaica Bay	CI-671	21
Jamaica Bay	CI-672	38
Jamaica Bay	CI-673	10
Jamaica Bay	CI-674	5
Jamaica Bay	CI-676	28
Bergen Basin	JA-006	5,861
Bergen Basin	JA-140	51
Shellbank Basin	JA-114	8
Shellbank Basin	JA-115	13
Shellbank Basin	JA-116	8
Shellbank Basin	JA-117	12
Shellbank Basin	JA--081	10
Hawtree Basin	JA-523	8
Shellbank Basin	JA-601	20
Shellbank Basin	JA-603	102
Shellbank Basin	JA-604	12
Shellbank Basin	JA-605	18
Shellbank Basin	JA-607	78
Shellbank Basin	JA-609	65
Shellbank Basin	JA-630	23
Hawtree Basin	JA-636	10
Hawtree Basin	JA-638	0
Head of Bay	JA-649	485
Head of Bay	JA-652	1
Head of Bay	JA-653	21
Head of Bay	JA-654	3
Head of Bay	JA-655	12
Hawtree Basin	JA-656	39
Hawtree Basin	JA-657	6
Hawtree Basin	JA-658	9
Shellbank Basin	JA-802	92
Head of Bay	JA-661	21
Shellbank Basin	JA-607A	78

MS-4 Outfalls - *Enterococci*		
Waterbody	**Outfall**	**Total Load (10^{12} cfu/Yr)**
Hawtree Basin	JA-877	10
Jamaica Bay	RO-680	34
Jamaica Bay	RO-679	5
Jamaica Bay	RO-678	6
Jamaica Bay	RO-676	7
Jamaica Bay	RO-675	3
Jamaica Bay	RO-672	6
Jamaica Bay	RO-671	7
Jamaica Bay	RO-670	2
Jamaica Bay	RO-669	1
Jamaica Bay	RO-661	3
Jamaica Bay	RO-660	4
Jamaica Bay	RO-659	9
Jamaica Bay	RO-658	8
Jamaica Bay	RO-657	34
Jamaica Bay	RO-656	5
Jamaica Bay	RO-653	25
Jamaica Bay	RO-652	28
Jamaica Bay	RO-651	27
Jamaica Bay	RO-649	9
Jamaica Bay	RO-648	28
Jamaica Bay	RO-642	34
Jamaica Bay	RO-641	12
Jamaica Bay	RO-640	3
Jamaica Bay	RO-638	4
Jamaica Bay	RO-637	4
Jamaica Bay	RO-636	20
Jamaica Bay	RO-635	8
Jamaica Bay	RO-634	21
Jamaica Bay	RO-633	5
Jamaica Bay	RO-632	15
Jamaica Bay	RO-631	5
Jamaica Bay	RO-630	25
Jamaica Bay	RO-629	5
Jamaica Bay	RO-627	7
Jamaica Bay	RO-625	23

MS-4 Outfalls - *Enterococci*		
Waterbody	**Outfall**	**Total Load (10^{12} cfu/Yr)**
Jamaica Bay	RO-624	5
Jamaica Bay	RO-622	6
Jamaica Bay	RO-620	4
Jamaica Bay	RO-619	6
Jamaica Bay	RO-618	5
Jamaica Bay	RO-617	13
Jamaica Bay	RO-614	13
Jamaica Bay	RO-610	18
Hendrix Creek	26--062	45
Hendrix Creek	26-601M	24
Spring Creek	26-603M	50
	Total MS-4	**11,506**

Stormwater Outfalls - *Enterococci*		
Waterbody	**Outfall**	**Total Load (10^{12} cfu/Yr)**
Jamaica Bay	CI--64	105
Jamaica Bay	CI--65	36
Jamaica Bay	CI--66	180
Jamaica Bay	CI--67	32
Paerdegat Basin	CI--96	118
Paerdegat Basin	CI--98	78
Paerdegat Basin	CI--99	19
Jamaica Bay	CI-113	513
Thurston Basin	JA-07S	1,166
Hawtree Basin	JA--064	2
Bergen Basin	JA--065	243
Head of Bay	JA--079	94
Hawtree Basin	JA--082	5
Thurston Basin	JA--083	345
Shellbank Basin	JA-530	3
Thurston Basin	JA-640	11
Hawtree Basin	JA-DD09	52
Spring Creek	JA-S001	47
Jamaica Bay	RO--16_	40
Jamaica Bay	RO--14	54
Jamaica Bay	RO--10	30
Jamaica Bay	RO-016	29
Jamaica Bay	RO-031	41
Jamaica Bay	RO-130	9
Jamaica Bay	RO--08	16
Jamaica Bay	RO--05	19
Jamaica Bay	RO--04	48
Jamaica Bay	RO--02	37
Jamaica Bay	RO--01	117
Jamaica Bay	RO--60	5
Jamaica Bay	RO--61	2
Jamaica Bay	RO--62	5
Jamaica Bay	RO--63	7
Fresh Creek	26-HS1	208
Fresh Creek	26-HS2	170
Fresh Creek	26-HS3	21

Stormwater Outfalls - *Enterococci*		
Waterbody	**Outfall**	**Total Load (10^{12} cfu/Yr)**
Fresh Creek	26--061	118
Spring Creek	26--084	25
Hendrix Creek	26--092	34
Hendrix Creek	26--093	20
Hendrix Creek	26--094	26
	Total Stormwater	**4,129**

Direct Runoff Outfalls - *Enterococci*		
Waterbody	**Outfall**	**Total Load (10^{12} cfu/Yr)**
Fresh Creek	CI--54	2
Fresh Creek	CI--55	2
Jamaica Bay	CI--56	5
Jamaica Bay	CI--57	4
Paerdegat Basin	CI--58	2
Paerdegat Basin	CI--59	2
Paerdegat Basin	CI--60	1
Jamaica Bay	CI--68	6
Jamaica Bay	CI--69	2
Jamaica Bay	CI--70	3
Jamaica Bay	CI--71	1
Jamaica Bay	CI--72	4
Jamaica Bay	CI--73	5
Jamaica Bay	CI--74	4
Jamaica Bay	CI--75	1
Jamaica Bay	CI--76	2
Jamaica Bay	CI--77	3
Jamaica Bay	CI--78	7
Jamaica Bay	CI--79	9
Jamaica Bay	CI--80	19
Jamaica Bay	CI--82	15
Jamaica Bay	CI--83	33
Jamaica Bay	CI--88	3
Jamaica Bay	CI--89	2
Jamaica Bay	CI--90	1
Jamaica Bay	CI--91	4
Jamaica Bay	CI--92	1
Jamaica Bay	CI--93	2
Jamaica Bay	CI--94	2
Paerdegat Basin	CI--95	5
Paerdegat Basin	CI--97	1
Spring Creek	JA--060	9
Jamaica Bay	JA--061	0
Jamaica Bay	JA--062	0
Bergen Basin	JA--066	5
Thurston Basin	JA--077	14

Direct Runoff Outfalls - *Enterococci*		
Waterbody	**Outfall**	**Total Load (10^{12} cfu/Yr)**
Head of Bay	JA--078	24
Head of Bay	JA-888	1,340
Head of Bay	JA-999	40
Head of Bay	JA-BCK	10
Jamaica Bay	RO--17	5
Jamaica Bay	RO--16	68
Jamaica Bay	RO--15	65
Jamaica Bay	RO--13	117
Jamaica Bay	RO--09	27
Jamaica Bay	RO--07	3
Jamaica Bay	RO--06	2
Jamaica Bay	RO--03	5
Spring Creek	26--083	3
Spring Creek	26--085	1
Spring Creek	26--086	4
Spring Creek	26--087	1
Jamaica Bay	26--088	1
Jamaica Bay	26--089	2
Hendrix Creek	26--090	5
Hendrix Creek	26--091	1
Hendrix Creek	26--095	2
Jamaica Bay	26--096	2
Fresh Creek	26--097	1
Fresh Creek	26--098	1
Fresh Creek	26--099	1
	Total Direct Runoff	**1,914**

Airport Outfalls - *Enterococci*		
Waterbody	**Outfall**	**Total Load (10^{12} cfu/Yr)**
Jamaica Bay	JA--074	7
Head of Bay	JA--075	34
Bergen Basin	JA-615	34
Bergen Basin	JA-617	19
Jamaica Bay	JA-618	167
Jamaica Bay	JA-620	95
Bergen Basin	JA-639	32
Thurston Basin	JA-659	113
Jamaica Bay	JA-806	21
	Total Airport	**521**

Other Outfalls - *Enterococci*		
Waterbody	**Outfall**	**Total Load (10^{12} cfu/Yr)**
Bergen Basin	JA-03aH	8
Head of Bay	JA--067	4
Head of Bay	JA-663	8
Jamaica Bay	CI--84	5
Jamaica Bay	CI--85	3
Jamaica Bay	CI--86	4
Jamaica Bay	CI--87	3
Jamaica Bay	RO--12	3
Jamaica Bay	RO--11	3
	Total Other	**34**

WWTP Discharges - *Enterococci*		
Waterbody	**Outfall**	**Total Load (10^{12} cfu/Yr)**
Jamaica Bay	JA-WWTP-1	18
Jamaica Bay	RO-WWTP-1	6
Hendrix Creek	26-WWTP-1	15
Bergen Basin	JA-WWTP-2	4
	Total WWTP	**43**

Totals by Waterbody - *Enterococci*		
Waterbody	**Outfall**	**Total Load (10^{12} cfu/Yr)**
Bergen Basin	NA	19,768
Fresh Creek	NA	5,758
Hawtree Basin	NA	139
Head of Bay	NA	2,099
Hendrix Creek	NA	759
Jamaica Bay	NA	5,632
Paerdegat Basin	NA	16,709
Shellbank Basin	NA	549
Spring Creek	NA	1,706
Thurston Basin	NA	2,470

Totals by Source - *Enterococci*		
Source	**Outfall**	**Total Load (10^{12} cfu/Yr)**
Airport	NA	521
CSO	NA	37,430
Direct Runoff	NA	1,914
MS4	NA	11,506
Other	NA	34
Storm	NA	1,914
WWTP	NA	43

Totals by Source by Waterbody - *Enterococci*		
Waterbody	**Source**	**Total Load (10^{12} cfu/Yr)**
Paerdegat Basin	CSO	16,113
	MS4	372
	Storm	215
	Direct Drainage	10
	Airport/Transport	NA
	WWTP	NA
Fresh Creek	CSO	4,826
	MS4	408
	Storm	517
	Direct Drainage	8
	Airport/Transport	NA
	WWTP	NA
Jamaica Bay	CSO	0
	MS4	3,535
	Storm	1,331
	Direct Drainage	452
	Airport/Transport	290
	WWTP	24
Bergen Basin	CSO	13,517
	MS4	5,907
	Storm	243
	Direct Drainage	5
	Airport/Transport	92
	WWTP	4
Thurston Basin	CSO	821
	MS4	NA
	Storm	1,522
	Direct Drainage	14
	Airport/Transport	113
	WWTP	NA
Spring Creek	CSO	1,566
	MS4	50
	Storm	72
	Direct Drainage	18
	Airport/Transport	NA
	WWTP	NA

Totals by Source by Waterbody - *Enterococci*		
Waterbody	**Source**	**Total Load (10^{12} cfu/Yr)**
Hawtree Basin	CSO	NA
	MS4	81
	Storm	58
	Direct Drainage	NA
	Airport/Transport	NA
	WWTP	NA
Head of Bay	CSO	NA
	MS4	543
	Storm	94
	Direct Drainage	1,415
	Airport/Transport	47
	WWTP	NA
Shellbank Basin	CSO	NA
	MS4	537
	Storm	12
	Direct Drainage	NA
	Airport/Transport	NA
	WWTP	NA
Hendrix Creek	CSO	587
	MS4	68
	Storm	80
	Direct Drainage	8
	Airport/Transport	NA
	WWTP	15

Combined Sewer Outfalls - BOD		
Waterbody	**Outfall**	**Total Load (Lbs/Yr)**
Paerdegat Basin	CI-004	1,697
Paerdegat Basin	CI-005	3,500
Paerdegat Basin	CI-006	2,336
Paerdegat Basin	CI-CIT	140,852
Bergen Basin	JA-003/003A	84,929
Bergen Basin	JA-006	404
Thurston Basin	JA-007	38,788
Jamaica Bay	RO-030	0
Jamaica Bay	RO-029	0
Jamaica Bay	RO-015	0
Jamaica Bay	RO-014	0
Jamaica Bay	RO-012	0
Jamaica Bay	RO-011	0
Jamaica Bay	RO-010	0
Jamaica Bay	RO-009	0
Jamaica Bay	RO-008	0
Jamaica Bay	RO-007	0
Jamaica Bay	RO-006	0
Jamaica Bay	RO-005	0
Jamaica Bay	RO-004	0
Fresh Creek	26-003	61,702
Hendrix Creek	26-004	24,307
Spring Creek	26-005	67,080
	Total CSO	**425,593**

MS-4 Outfalls - BOD		
Waterbody	**Outfall**	**Total Load (Lbs/Yr)**
Jamaica Bay	CI-603	2,957
Jamaica Bay	CI-604	438
Jamaica Bay	CI-605	37,109
Jamaica Bay	CI-607	420
Jamaica Bay	CI-608	295
Jamaica Bay	CI-609	273
Jamaica Bay	CI-610	50,269
Jamaica Bay	CI-611	963
Jamaica Bay	CI-612	1,214
Jamaica Bay	CI-613	31,220
Jamaica Bay	CI-614	276
Jamaica Bay	CI-615	6,709
Jamaica Bay	CI-616	1,147
Jamaica Bay	CI-617	1,491
Jamaica Bay	CI-618	1,995
Jamaica Bay	CI-619	1,463
Jamaica Bay	CI-620	1,976
Jamaica Bay	CI-621	912
Jamaica Bay	CI-622	3,124
Jamaica Bay	CI-623	1,812
Jamaica Bay	CI-624	4,789
Jamaica Bay	CI-625	3,324
Jamaica Bay	CI-626	3,374
Jamaica Bay	CI-627	4,091
Paerdegat Basin	CI-628	3,795
Paerdegat Basin	CI-629	5,048
Paerdegat Basin	CI-630	6,001
Paerdegat Basin	CI-632	9,689
Jamaica Bay	CI-633	15,081
Fresh Creek	CI-634	14,224
Fresh Creek	CI-636	6,382
Fresh Creek	CI-637	6,291
Jamaica Bay	CI-642	1,433
Jamaica Bay	CI-656	605
Jamaica Bay	CI-657	10,345
Jamaica Bay	CI-667	1,118

MS-4 Outfalls - BOD		
Waterbody	**Outfall**	**Total Load (Lbs/Yr)**
Jamaica Bay	CI-668	589
Jamaica Bay	CI-669	1,178
Jamaica Bay	CI-670	874
Jamaica Bay	CI-671	1,408
Jamaica Bay	CI-672	2,484
Jamaica Bay	CI-673	646
Jamaica Bay	CI-674	314
Jamaica Bay	CI-676	1,868
Bergen Basin	JA-006	351,554
Bergen Basin	JA-140	3,083
Shellbank Basin	JA-114	516
Shellbank Basin	JA-115	854
Shellbank Basin	JA-116	521
Shellbank Basin	JA-117	797
Shellbank Basin	JA--081	672
Hawtree Basin	JA-523	530
Shellbank Basin	JA-601	1,298
Shellbank Basin	JA-603	6,729
Shellbank Basin	JA-604	769
Shellbank Basin	JA-605	1,187
Shellbank Basin	JA-607	5,138
Shellbank Basin	JA-609	4,284
Shellbank Basin	JA-630	1,505
Hawtree Basin	JA-636	644
Hawtree Basin	JA-638	0
Head of Bay	JA-649	32,044
Head of Bay	JA-652	81
Head of Bay	JA-653	1,394
Head of Bay	JA-654	167
Head of Bay	JA-655	783
Hawtree Basin	JA-656	2,556
Hawtree Basin	JA-657	370
Hawtree Basin	JA-658	572
Shellbank Basin	JA-802	6,055
Head of Bay	JA-661	1,386
Shellbank Basin	JA-607A	5,134

MS-4 Outfalls - BOD		
Waterbody	**Outfall**	**Total Load (Lbs/Yr)**
Hawtree Basin	JA-877	688
Jamaica Bay	RO-680	7,384
Jamaica Bay	RO-679	1,182
Jamaica Bay	RO-678	1,212
Jamaica Bay	RO-676	1,574
Jamaica Bay	RO-675	655
Jamaica Bay	RO-672	1,272
Jamaica Bay	RO-671	1,457
Jamaica Bay	RO-670	399
Jamaica Bay	RO-669	246
Jamaica Bay	RO-661	588
Jamaica Bay	RO-660	970
Jamaica Bay	RO-659	2,022
Jamaica Bay	RO-658	1,737
Jamaica Bay	RO-657	7,585
Jamaica Bay	RO-656	1,146
Jamaica Bay	RO-653	5,581
Jamaica Bay	RO-652	6,066
Jamaica Bay	RO-651	5,958
Jamaica Bay	RO-649	1,875
Jamaica Bay	RO-648	6,257
Jamaica Bay	RO-642	7,487
Jamaica Bay	RO-641	2,602
Jamaica Bay	RO-640	569
Jamaica Bay	RO-638	808
Jamaica Bay	RO-637	779
Jamaica Bay	RO-636	4,309
Jamaica Bay	RO-635	1,740
Jamaica Bay	RO-634	4,625
Jamaica Bay	RO-633	1,062
Jamaica Bay	RO-632	3,348
Jamaica Bay	RO-631	1,146
Jamaica Bay	RO-630	5,605
Jamaica Bay	RO-629	1,104
Jamaica Bay	RO-627	1,581
Jamaica Bay	RO-625	5,032

MS-4 Outfalls - BOD		
Waterbody	**Outfall**	**Total Load (Lbs/Yr)**
Jamaica Bay	RO-624	1,070
Jamaica Bay	RO-622	1,269
Jamaica Bay	RO-620	956
Jamaica Bay	RO-619	1,213
Jamaica Bay	RO-618	1,059
Jamaica Bay	RO-617	2,959
Jamaica Bay	RO-614	2,900
Jamaica Bay	RO-610	4,001
Hendrix Creek	26--062	2,946
Hendrix Creek	26-601M	1,568
Spring Creek	26-603M	3,299
	Total MS-4	**802,529**

Stormwater Outfalls - BOD		
Waterbody	**Outfall**	**Total Load (Lbs/Yr)**
Jamaica Bay	CI--64	6,950
Jamaica Bay	CI--65	2,345
Jamaica Bay	CI--66	11,900
Jamaica Bay	CI--67	2,125
Paerdegat Basin	CI--96	7,785
Paerdegat Basin	CI--98	5,129
Paerdegat Basin	CI--99	1,255
Jamaica Bay	CI-113	33,862
Thurston Basin	JA-07S	76,942
Hawtree Basin	JA--064	100
Bergen Basin	JA--065	14,603
Head of Bay	JA--079	6,197
Hawtree Basin	JA--082	320
Thurston Basin	JA--083	22,796
Shellbank Basin	JA-530	785
Thurston Basin	JA-640	735
Hawtree Basin	JA-DD09	3,412
Spring Creek	JA-S001	3,112
Jamaica Bay	RO--16_	8,729
Jamaica Bay	RO--14	11,808
Jamaica Bay	RO--10	6,515
Jamaica Bay	RO-016	6,465
Jamaica Bay	RO-031	9,027
Jamaica Bay	RO-130	1,982
Jamaica Bay	RO--08	3,582
Jamaica Bay	RO--05	4,266
Jamaica Bay	RO--04	10,479
Jamaica Bay	RO--02	8,064
Jamaica Bay	RO--01	25,788
Jamaica Bay	RO--60	1,209
Jamaica Bay	RO--61	516
Jamaica Bay	RO--62	1,054
Jamaica Bay	RO--63	1,455
Fresh Creek	26-HS1	13,757
Fresh Creek	26-HS2	11,196
Fresh Creek	26-HS3	1,362

Stormwater Outfalls - BOD		
Waterbody	**Outfall**	**Total Load (Lbs/Yr)**
Fresh Creek	26--061	7,812
Spring Creek	26--084	1,653
Hendrix Creek	26--092	2,237
Hendrix Creek	26--093	1,326
Hendrix Creek	26--094	1,693
	Total Stormwater	**342,326**

Direct Runoff Outfalls - BOD		
Waterbody	**Outfall**	**Total Load (Lbs/Yr)**
Fresh Creek	CI--54	1,260
Fresh Creek	CI--55	1,359
Jamaica Bay	CI--56	2,642
Jamaica Bay	CI--57	2,446
Paerdegat Basin	CI--58	934
Paerdegat Basin	CI--59	1,075
Paerdegat Basin	CI--60	433
Jamaica Bay	CI--68	3,520
Jamaica Bay	CI--69	1,221
Jamaica Bay	CI--70	1,749
Jamaica Bay	CI--71	524
Jamaica Bay	CI--72	2,468
Jamaica Bay	CI--73	2,980
Jamaica Bay	CI--74	2,297
Jamaica Bay	CI--75	471
Jamaica Bay	CI--76	915
Jamaica Bay	CI--77	1,597
Jamaica Bay	CI--78	3,929
Jamaica Bay	CI--79	5,209
Jamaica Bay	CI--80	10,677
Jamaica Bay	CI--82	8,106
Jamaica Bay	CI--83	18,339
Jamaica Bay	CI--88	1,669
Jamaica Bay	CI--89	1,240
Jamaica Bay	CI--90	587
Jamaica Bay	CI--91	1,928
Jamaica Bay	CI--92	767
Jamaica Bay	CI--93	1,001
Jamaica Bay	CI--94	850
Paerdegat Basin	CI--95	2,529
Paerdegat Basin	CI--97	414
Spring Creek	JA--060	4,707
Jamaica Bay	JA--061	0
Jamaica Bay	JA--062	229
Bergen Basin	JA--066	2,803
Thurston Basin	JA--077	7,622

Direct Runoff Outfalls - BOD		
Waterbody	**Outfall**	**Total Load (Lbs/Yr)**
Head of Bay	JA--078	13,236
Head of Bay	JA-888	737,068
Head of Bay	JA-999	22,236
Head of Bay	JA-BCK	5,706
Jamaica Bay	RO--17	2,579
Jamaica Bay	RO--16	37,528
Jamaica Bay	RO--15	35,930
Jamaica Bay	RO--13	64,134
Jamaica Bay	RO--09	14,927
Jamaica Bay	RO--07	1,487
Jamaica Bay	RO--06	1,230
Jamaica Bay	RO--03	2,755
Spring Creek	26--083	1,699
Spring Creek	26--085	392
Spring Creek	26--086	2,434
Spring Creek	26--087	562
Jamaica Bay	26--088	316
Jamaica Bay	26--089	1,095
Hendrix Creek	26--090	2,771
Hendrix Creek	26--091	772
Hendrix Creek	26--095	848
Jamaica Bay	26--096	915
Fresh Creek	26--097	535
Fresh Creek	26--098	644
Fresh Creek	26--099	428
	Total Direct Runoff	**1,052,724**

Airport Outfalls - BOD		
Waterbody	**Outfall**	**Total Load (Lbs/Yr)**
Jamaica Bay	JA--074	2,866
Head of Bay	JA--075	14,219
Bergen Basin	JA-615	13,841
Bergen Basin	JA-617	7,802
Jamaica Bay	JA-618	68,928
Jamaica Bay	JA-620	39,254
Bergen Basin	JA-639	13,055
Thurston Basin	JA-659	46,461
Jamaica Bay	JA-806	8,502
	Total Airport	**214,929**

Other Outfalls - BOD		
Waterbody	**Outfall**	**Total Load (Lbs/Yr)**
Bergen Basin	JA-03aH	3,142
Head of Bay	JA--067	1,727
Head of Bay	JA-663	3,425
Jamaica Bay	CI--84	1,944
Jamaica Bay	CI--85	1,344
Jamaica Bay	CI--86	1,697
Jamaica Bay	CI--87	1,263
Jamaica Bay	RO--12	1,259
Jamaica Bay	RO--11	1,292
	Total Other	**13,953**

WWTP Discharges - BOD		
Waterbody	**Outfall**	**Total Load (Lbs/Yr)**
Jamaica Bay	JA-WWTP-1	1,486,683
Jamaica Bay	RO-WWTP-1	332,734
Hendrix Creek	26-WWTP-1	951,515
Bergen Basin	JA-WWTP-2	329,691
	Total WWTP	**3,100,623**

Totals by Waterbody – BOD		
Waterbody	**Outfall**	**Total Load (Lbs/Yr)**
Bergen Basin	NA	824,788
Fresh Creek	NA	126,952
Hawtree Basin	NA	9,192
Head of Bay	NA	839,670
Hendrix Creek	NA	989,983
Jamaica Bay	NA	2,658,120
Paerdegat Basin	NA	192,470
Shellbank Basin	NA	36,245
Spring Creek	NA	84,937
Thurston Basin	NA	193,343

Totals by Source – BOD		
Source	**Outfall**	**Total Load (Lbs/Yr)**
Airport	NA	214,929
CSO	NA	425,593
Direct Runoff	NA	1,052,724
MS4	NA	802,529
Other	NA	13,953
Storm	NA	1,052,724
WWTP	NA	3,100,623

Totals by Source by Waterbody – BOD		
Waterbody	**Source**	**Total Load (Lbs/Yr)**
Paerdegat Basin	CSO	148,384
	MS4	24,534
	Storm	14,168
	Direct Drainage	5,384
	Airport/Transport	NA
	WWTP	NA
Fresh Creek	CSO	61,702
	MS4	26,897
	Storm	34,126
	Direct Drainage	4,227
	Airport/Transport	NA
	WWTP	NA
Jamaica Bay	CSO	0
	MS4	311,973
	Storm	160,673
	Direct Drainage	246,506
	Airport/Transport	119,550
	WWTP	1,819,417
Bergen Basin	CSO	85,333
	MS4	354,518
	Storm	14,603
	Direct Drainage	2,803
	Airport/Transport	37,840
	WWTP	329,691
Thurston Basin	CSO	38,788
	MS4	NA
	Storm	100,473
	Direct Drainage	7,622
	Airport/Transport	46,461
	WWTP	NA
Spring Creek	CSO	67,080
	MS4	3,299
	Storm	4,764
	Direct Drainage	9,794
	Airport/Transport	NA
	WWTP	NA

Totals by Source by Waterbody – BOD		
Waterbody	**Source**	**Total Load (Lbs/Yr)**
Hawtree Basin	CSO	NA
	MS4	5,360
	Storm	3,832
	Direct Drainage	NA
	Airport/Transport	NA
	WWTP	NA
Head of Bay	CSO	NA
	MS4	35,856
	Storm	6,197
	Direct Drainage	778,245
	Airport/Transport	19,372
	WWTP	NA
Shellbank Basin	CSO	NA
	MS4	35,460
	Storm	785
	Direct Drainage	NA
	Airport/Transport	NA
	WWTP	NA
Hendrix Creek	CSO	24,307
	MS4	4,514
	Storm	5,255
	Direct Drainage	4,391
	Airport/Transport	NA
	WWTP	951,515

Appendix B: Public Meeting Materials

Jamaica Bay and Tributaries Long Term Control Plan Public Meeting #1 Public Kickoff Meeting

Summary of Meeting and Public Comments

On September 22, 2016 the New York City Department of Environmental Protection (DEP) hosted the first public meeting for the water quality planning process for the Combined Sewer Overflow (CSO) Long Term Control Plan (LTCP) in Jamaica Bay and its tributaries. The two-hour event, held at Jamaica Chamber of Commerce in Jamaica, Queens, provided overview information about DEP's Long Term Control Plan (LTCP) Program, presented information on Jamaica Bay watershed characteristics and status of waterbody improvement projects, obtained public information on waterbody uses in Jamaica Bay, and described additional opportunities for public input and outreach. Four breakout sessions were held to further discuss Jamaica Bay Water Quality sampling, CSO controls, affordability, and Green Infrastructure (GI) and the MS4 program. The presentation can be found on DEP's LTCP Program website: http://www.nyc.gov/ dep/ltcp.

Approximately 15 people from the public attended the event, as well as representatives from DEP and the New York State Department of Environmental Conservation (DEC). Information presented included:

- Overview of Consent Order and LTCP Process;
- Jamaica Bay and Tributaries Waterbody and Watershed Characteristics;
- Jamaica Bay and Tributaries Classification and Water Quality Standard;
- Jamaica Bay and Tributaries Sampling and Monitoring Program;
- Jamaica Bay and Tributaries Water Quality Sampling Results;
- Jamaica Bay and Tributaries Water Quality Programs and CSO Mitigation Projects;
- Jamaica Bay and Tributaries Green Infrastructure Projects & Green Infrastructure Opportunities;
- LTCP Modeling and the Alternatives Development Process; and
- Summary of Next Steps, Additional Information and Resources.

The following summarizes the questions and comments from attendees as well as responses given.

Q1: An attendee asked to explain Request for Information (RFI) for private programs.

A1: DEP stated that they have comprehensive knowledge about green infrastructure on public properties; however there are additional opportunities for private property incentives. The purpose of the RFI was to procure a third party entity to support DEP's effort to develop a private incentive program.

Q2: An attendee asked how much funding is needed for the CSO program and how the specific areas within CSO watershed will be targeted.

A2: As part of the LTCP development process, DEP conducts costs/benefit analyses to determine the costs and benefits of various CSO alternatives. DEP acknowledged that the final recommendation would include information about the projected costs.

Q3: An attendee asked if DEP is considering using permeable pavement on parking lots, and if so, by whom they will be paid.

A3: DEP acknowledged that parking lots can be a source of stormwater runoff and good opportunities for green infrastructure. Currently DEP partners with City agencies to retrofit City-owned parking lots with green infrastructure.

Q4: An attendee acknowledged that parking lots within the New York City Housing Authority (NYCHA) are the biggest impervious areas.

A4: DEP agreed and stated that it has a robust partnership with NYCHA to incorporate green infrastructure where cost-effective and feasible.

Q5: An attendee asked if DEP will reach out to the NYCHA residents.

A5: DEP stated that it is currently working with NYCHA property managers to bring green infrastructure projects onto NYCHA property and involve youth and other residents in City programs. DEP stated that maintenance of GI projects is key to having them working properly; therefore, even though bioswales, rain gardens, etc. are City-owned, help from the community is always welcome.

Q6: An attendee asked to explain the Green Infrastructure Grant Program and how DEP will encourage Queens's community for bioswales implementation despite opposition from local elected officials.

A6: DEP is aware that some elected officials in the area of Northeast Queens have expressed concerns about bioswales. DEP is planning on having a community meeting with them and local community representatives to explain the process. DEP is planning on clearing up misconceptions about bioswales and explaining the benefits of GI. DEP stated that the Green Infrastructure Grant Program provides up to 100 percent of design and construction costs for projects that manage one inch of stormwater runoff. Active projects within the program are green roofs, rain gardens, and permeable pavement installation. The program is effective in targeting large properties. Some of the institutions that are part of the Grant Program are Lenox Hill Neighborhood House in Manhattan, the Osbourne Association in the Bronx, colleges including Queens College and Pratt Institute, the Brooklyn Navy Yard, and the Bronx Zoo.

Q7: An attendee asked what kind of disinfection DEP is planning on using.

A7: DEP explained that disinfection was only proposed for the Alley Creek, Hutchinson River, and Flushing Creek LTCPs and stated that it is considering hypochlorite chlorination and sodium bisulfide for dechlorination. DEP looked into parasitic acid and ultraviolet light but both did not provide successful results for CSO related wastewater disinfection.

Q8: An attendee pointed out that a lot of non-profit organizations are concerned about the residue from chlorination.

A8: DEP stated that it is aware of this problem and is actively performing a Spring Creek Pilot Study and Bench Scale studies. LTCP projects that include chlorination will also include dechlorination.

Q9: An attendee asked about water quality in Jamaica Bay in the next 50 years.

A9: DEP stated that there will be continuous improvement of water quality in Jamaica Bay.

Q10: An attendee asked what is DEP's water quality goal.

A10: DEP stated that the water quality is based on the standards provided by DEC. For fecal coliform, the current standard is 200 cfu/100mL and all LTCPs have this value as a target. The second criterion evaluated is *Enterococci*. The *Enterococci* criterion is more restrictive than fecal coliform; however, the *Enterococci* target has not been adopted by the CSO Program yet.

Jamaica Bay and Tributaries Long Term Control Plan Public Meeting #2 Public Status Update Meeting

Summary of Meeting and Public Comments

On October 19, 2017 the New York City Department of Environmental Protection (DEP) hosted a public meeting to provide a status update for the Combined Sewer Overflow (CSO) Long Term Control Plan (LTCP) for Jamaica Bay and Tributaries. The nearly two-hour event, held at the Jamaica Bay Wildlife Refuge Center in Broad Channel, Queens, provided stakeholders with information regarding: the one-year time extension for the Jamaica Bay and Tributaries LTCP; details about planned projects in the Jamaica Bay watershed; an overview of Southeast Queens Green Infrastructure and Bluebelt Projects; and described additional opportunities for public input and outreach.

Approximately 15 stakeholders from 7 different non-profit, community, planning, environmental, economic development, and governmental organizations and the broader public attended the event, as did representatives from DEP and the New York State Department of Environmental Conservation (DEC). Information presented included:

- Jamaica Bay and Tributaries Committed CSO Mitigation Projects;
- Jamaica Bay and Tributaries Projected Wet Weather Volumes;
- Jamaica Bay and Tributaries Revised CSO LTCP Submittal Date;
- Jamaica Bay and Tributaries LTCP Status and Schedule Update;
- Jamaica Bay and Tributaries Regional Ongoing and New Projects;
- Southeast Queens Program Overview;
- Jamaica Bay and Tributaries Green Infrastructure and Bluebelt Projects;
- Jamaica Bay and Tributaries Public Outreach and Education;
- Summary of Next Steps, Additional Information and Resources; and
- Discussion and Question & Answer Session.

The Jamaica Bay and Tributaries LTCP Public Status Update Meeting provided an opportunity for DEP and the public to discuss the extension and other projects within Jamaica Bay watershed. The following summarizes the questions and comments from attendees, as well as responses given. The presentation can be found at http://www.nyc.gov/dep/ltcp.

Q1: An attendee asked if there is an outfall discharge pipe from the Jamaica Wastewater Treatment Plant (WWTP).

A1: DEP stated yes and that the Jamaica WWTP is shown with the red triangle symbol on slide 6. The actual outfall pipe is not shown on the slide but it discharges in the middle of Grassy Bay [speaker pointed to location].

Q2: An attendee asked where is the JFK Airport expansion and how does it impact the LTCP.

A2: DEP stated that it is uncertain of the details surrounding the expansion but there is a large interceptor which runs along the northeastern portion of the JFK Airport that needs to be considered during the airports expansion.

Q3: An attendee asked when the Spring Creek Pilot results will be available.

A3: DEP stated that the results are expected to be posted on DEP's website in the spring of 2018. DEP explained that the pilot does not include dechlorination but that the three approved LTCP projects that include chlorination will also include dechlorination.

Q4: An attendee asked how dechlorination is performed.

A4: DEP stated that another chemical is added to the wastewater, sodium metabisulphite. The 26th Ward WWTP has been discharging chlorinated effluent for several years at concentrations of about 2 mg/L. DEP has performed several evaluations, but have found no detrimental ecologic impacts.

Q5: An attendee asked if there is any concern about the impacts of disinfection to wildlife.

A5: DEP is aware that community groups have expressed concerns about the impacts of disinfection to wildlife and stated that any disinfection projects will include environmental assessments during the design phase.

Q6: An attendee asked how has the shut-down of the Jamaica water wells impacted groundwater and the ability to infiltrate rainfall into the ground.

A6: DEP stated that there are ongoing discussions regarding this issue. Evaluations are underway to study the water quality impacts of pumping groundwater to tributaries of Jamaica Bay.

Q7: An attendee asked if the intent of the sewer build-out is to separate the sewers.

A7: DEP stated that the primary goal is to address flooding and identify early action sewer improvements for expediting relief in areas that are flood prone. DEP is also looking at GI opportunities for intercepting runoff before it enters the sewer system.

Q8: An attendee asked if new storm sewers will increase CSO discharges.

A8: DEP stated that new sewers are being designed for the purposes of improving conveyance capacity and relieving flooding. The new sewers will typically divert stormwater from combined and sanitary sewers to separate storm sewers, thereby reducing CSO discharges.

Q9: An attendee asked if catch basin hoods are included in the sewer build-out for the purposes of floatables control.

A9: DEP stated that hoods will be provided on catch basins.

Q10: An attendee asked if DEP has considered how they will address contaminants introduced to the soils by GI projects.

A10: DEP stated that they have been collecting data for nearly five years on GI assets to determine whether pollutants in storm runoff are captured or bypass the facility. They are also looking at maintenance procedures for proper removal and disposal of contaminants. This may require periodic removal of the top layer of permeable soil media or other measures to maintain facility performance and address captured pollutants.

Q11: An attendee asked if DEP is looking at newer forms of GI.

A11: DEP stated that they are looking at strategies used in other communities and countries. Copenhagen is particularly aggressive in their application of GI. While allowing street flooding may not be a strategy that is appropriate for DEP, other strategies may be adaptable to NYC. Pilot studies are being performed. Some newer approaches include joint City/school owned parks which will provide benefits to the school children, as well as the surrounding neighborhood. At JHS 218, a synthetic turf field was installed along with trees and permeable pavers in place of the original paved playground.

Q12: An attendee stated that rain barrels are provided to interested homeowners and asked if there are programs with incentives for installing cisterns to capture runoff and re-introduce it to the ground.

A12: DEP stated that currently there is no program to provide incentives for installation of cisterns. However, the team will bring this thought back to MS4 program leadership for consideration. DEP also has a robust rain barrel giveaway program.

Q13: An attendee asked if Bluebelt projects will be an issue with attracting birds to the airports.

A13: DEP stated it will review and follow-up on the question.

Q14: An attendee asked if DEP has a design center for GI.

A14: DEP stated that standard details, design criteria, and capacity requirements are provided on DEP's website.

Q15: An attendee asked if standards have been developed for cloudburst designs and for GI to be applied in separate storm sewer areas.

A15: DEP stated that these standards are under development and cloudburst designs are being piloted.

Q16: An attendee asked if rain gardens are the same as bioswales.

A16: DEP stated that they recently changed the terminology to rain gardens instead of bioswales.

Q17: An attendee asked if DEP considers the impact of oysters on reducing the nitrogen loads.

A17: DEP stated that the impact of oysters on nitrogen loading to the Bay is not currently considered. While it is not clear whether the impacts can be accurately measured and accounted for in determining nitrogen allocations, the water quality will ultimately benefit from oyster beds.

Q18: An attendee asked if year 2040 is still used for LTCP planning and design.

A18: DEP stated that this is correct.

Q19: An attendee stated that Long Island directs most of its stormwater runoff back into the ground and asked if it is possible in the Jamaica watershed as well.

A19: DEP stated that due to the groundwater levels, the poor infiltration rates of the soils in some areas of the watershed and the high level of impervious cover, DEP does not believe that this is feasible in Jamaica.

Attendees expressed concerns that application of GI will further increase the groundwater table and the frequency of basement flooding.

Q20: An attendee asked about resiliency projects within Jamaica Bay watershed.

A20: DEP stated that resiliency is taken into consideration in planning projects as they evolve. Coordination is ongoing.

Q21: An attendee asked if new stormwater retention requirements will address the runoff associated with the proposed redevelopment of downtown Jamaica.

A21: DEP stated that builders are required to comply with the 2012 Stormwater Performance Standard and many install detention tanks. It is expected that new development will expand upon existing facilities for compliance with the stormwater requirements. DEP is also assessing wastewater capacity needs associated with the more aggressive rezoning of the Jamaica Redevelopment Zone.

Q22: An attendee asked if new projects will require LEED certification.

A22: DEP stated that they do not require LEED certification, but stormwater management practices will need to be addressed and coordinated among agencies.

Q23: An attendee asked if new school toilets are using grey water.

A23: DEP stated that the new school toilets installed through the conservation program are not using grey water; they use potable water. Low flow toilets are being installed.

Q24: An attendee asked if inclusion of GI will allow developers to build more floors on buildings.

A24: DEP stated that not necessarily, but DEP is discussing stormwater banking and credits to encourage developers to maximize the management and control of stormwater runoff.

Q25: An attendee asked if DEP has a policy requiring the usage of waterless urinals.

A25: DEP stated not yet.

Q26: An attendee asked how is the $1.7 billion in storm sewer build-out improvements being funded.

A26: DEP stated that capital projects such as the sewer build-out are funded through water rates and the capital fund. The latest 10 year capital program is budgeted for about $16.3 billion, but extends beyond storm and sanitary sewer improvements. This budget covers all DEP programs. The $1.7 billion storm sewer program has been encumbered. Further funds will be committed for future projects.

Jamaica Bay and Tributaries Long Term Control Plan Public Meeting #3 Alternatives and Recommended Plan Public Meeting

Summary of Meeting and Public Comments

On April 18, 2018 the New York City Department of Environmental Protection (DEP) hosted a public meeting for the Combined Sewer Overflow (CSO) Long Term Control Plan (LTCP) for Jamaica Bay and Tributaries. The nearly two-hour event, held at the Jamaica Bay Wildlife Refuge Center in Broad Channel focused on alternatives and recommended plan selection. The meeting provided stakeholders with information regarding: water quality of Jamaica Bay and Tributaries; baseline conditions and performance gap; evaluation of alternatives and recommended plan; and described additional opportunities for public input and outreach.

Approximately 12 people from the public attended the event, as did representatives from DEP and the New York State Department of Environmental Conservation (DEC). Information presented included:

- Overview of Consent Order and Recap of LTCP Process;
- Southeast Queens Proposed Sewer Build-out;
- Jamaica Bay and Tributaries Watershed Protection Plan;
- Review of Jamaica Bay and Tributaries Public Comments Received;
- Review of Waterbody Classification, Water Quality Standards and LTCP Goals for Jamaica Bay and Tributaries;
- Jamaica Bay and Tributaries CSO Mitigation Projects and GI Commitments;
- Jamaica Bay and Tributaries Annual CSO and Stormwater Volumes;
- Jamaica Bay and Tributaries Fecal, Entero and Dissolved Oxygen Attainment of Existing Water Quality Standards;
- Jamaica Bay and Tributaries Evaluation of Watershed Based Alternatives;
- Jamaica Bay and Tributaries Evaluation of Retained Grey Alternatives;
- Jamaica Bay and Tributaries Watershed Protection Plan;
- Jamaica Bay and Tributaries LTCP Recommended Plan; and
- Summary of Next Steps, Additional Information and Resources.

The Jamaica Bay and Tributaries LTCP Alternatives and Recommended Plan Public Meeting was the third opportunity for public participation in the development of this LTCP. The following summarizes the questions and comments from attendees as well as responses given. The presentation can be found at http://www.nyc.gov/dep/ltcp.

Q1: An attendee asked about status of Water Quality Standards changes.

A1: DEP stated that the standards have not been changed yet and the attainment of the new criteria is being looked at. DEP considers these potential future standards in the LTCP analysis.

Q2: An attendee asked has there been any communication with JFK Airport regarding the use of any abandoned fuel storage tanks. Could these tanks be used to store CSO? CSO could be pumped to available tanks, stored and then drained back to the system when capacity is available.

A2: DEP stated that they have not contacted the Port Authority of New York and New Jersey (PANYNJ) regarding the availability of abandoned tankage at the airport.

Q3: An attendee expressed concern that ribbed mussels are on decline in Jamaica Bay.

A3: DEP stated that new marshlands helps ribbed mussels and vice versa.

Q4: An attendee stated that it appears that when marshes die off the mussels seem to follow. Those areas where tidal marshes have been restored, mussel populations appear to be on the rise.

A4: DEP agreed and stated that marsh restoration and mussels go hand-in-hand.

Q5: An attendee asked if other clams are good for marsh restoration as well.

A5: DEP stated that not all clams go hand-in-hand with marsh restoration.

Q6: An attendee asked where DEP plans to get the mussel spat to support mussel growth.

A6: DEP stated that they had relied on natural recruitment in the past. However, this strategy is not recommended in the future. Pre-seeding should be considered for future installations.

Q7: An attendee asked if the City is the owner of a vacant land at the head of Bergen Basin across from JFK Airport.

A7: DEP stated based on the OASIS website the land is owned by PANYNJ. Although some of the properties near JFK Airport may be owned by the City, there are long-term leases with the PANYNJ for their use.

Q8: An attendee asked about GI funding.

A8: DEP stated that the initial $300 million is part of $1.5 billion commitment under the Consent Order. The LTCP Recommended Plan investment is estimated to be $310 million.

Q9: An attendee asked if areas designed for stormwater GI include sewer separation.

A9: DEP stated that stormwater GI will be implemented in the area proposed for storm sewer build-out. DEP intends to focus the application of additional GI on MS4 areas as part of this recommended plan.

Q10: An attendee asked how DEP will get seed to support mussel growth. As ribbed mussels are not edible, seed may not be commercially available.

A10: DEP stated that sources within the Bay will be looked at, as well as other opportunities will be assessed. DEP may consider developing seed in tanks.

Q11: An attendee asked DEP to discuss any assumptions related to climate change, sea level rise, and storm surge.

A11: DEP stated that they have not run a model for sea level rise. LTCP evaluations typically consider the collection system response to the 2008 typical storm and perform water quality modeling to assess attainment over a 10 year period from 2002 to 2011.

Q12: An attendee asked if DEP will get advice from DEC on how to apply climate change and sea level rise to the LTCP.

A12: DEP stated it is working with the Mayor's Office of Recovery and Resiliency and they are evaluating various sea level rise models.

Q13: An attendee stated that the public should be involved in initiatives intended to address climate change, sea level rise, and storm surge.

A13: DEP stated that this concern will be addressed during further stakeholder workshops.

Q14: An attendee asked if any of the GI projects in the proposed LTCP Recommended Plan can also be applied to MS4 requirements.

A14: Green infrastructure under the MS4 requirements is different from GI under the Consent Order. Currently, the City is implementing pilot projects. For example, DEP plans to test cluster planning to change street elevations to provide temporary storage during a storm event. The street would convey stormwater to a property where it could infiltrate the ground. DEP is pursuing permission and coordinating with New York City Department of Transportation to perform this as a pilot project.

Q15: An attendee asked for a timeline of that implementation.

A15: DEP stated that it will host additional stakeholder meetings to develop a timeframe for implementation.

Q16: An attendee stated that a side-to-side comparison of the benefits of the Recommended Plan with additional GI and environmental improvements versus a grey-based CSO LTCP will be appreciated.

A16: DEP stated that considering the large water quality benefits associated with past projects, the gap analysis shows that further CSO reduction provides a marginal improvement in attainment of water quality standards for pathogens. As a result, DEP believes that Jamaica Bay and its tributaries are at a point where the current cost-benefit ratio of further CSO control is high and justifies looking at additional GI and environmental improvements. The strategy going forward is addressing the impacts of stormwater discharges which can ultimately provide the greatest long-term benefit for Jamaica Bay and its tributaries.

Q17: An attendee asked if ribbed mussels can be installed to a level that the entire tidal exchange can be filtered.

A17: DEP stated that low, medium, and high density mussel installations were looked at to assess the range in footprint size of the proposed shellfish beds. These footprint sizes were used to assess the feasibility of installing shellfish beds in the tributaries. Further evaluation will be performed to estimate the pathogen reduction benefits.

Q18: An attendee stated that the public likes the creative solutions, but wants to get a better handle on the benefits of a more traditional CSO LTCP.

A18: DEP acknowledged the comment.

Q19: An attendee asked if DEP is looking at the re-establishing pumping of groundwater. Can the groundwater pumps be restored and discharged to Bergen and Thurston Basins to improve flushing? Drawing down the water table could also help to reduce basement flooding throughout the region.

A19: DEP stated that impacts of pumping on basements is being looked at separately, but not under the CSO LTCP. The Storm Sewer Build-out Program will provide flood reduction benefits, but this is a long term program with no established milestones for completion of program elements. In addition, funding is currently limited to the 10 year capital plan.

Q20: An attendee stated that the current Consent Order does not address an integrated plan. How will the schedule be enforced?

A20: DEP stated that the CSO LTCP will include an implementation schedule that would be approved upon DEC review. The recommended plan does not change the Consent Order requirements or regulatory enforcement ability.

Q21: An attendee stated concern that resiliency could impact LTCP strategies. For example, the proposed flood barrier could influence the recommended LTCP projects by limiting flow of water in and out of the Bay.

A21: DEP stated that they were advised that the Army Corps of Engineers is looking at smaller interventions in addition to the perimeter barrier, which could have less impact on the flow of water in and out of the Bay.

Jamaica Bay and Tributaries Long Term Control Plan Public Comment Response Summary

Public Letters Received:

1. Email from Ira Gershenhorn, April 19, 2018.
2. Email from Dr. Harold Paez, May 16, 2018.
3. Letter from SWIM Coalition Steering Committee, June 4, 2018.
4. Letter from Marcha Johnson, ASLA, PhD, Landscape Architect and Ecological Restorationist, May 17, 2018.
5. Letter from Jamaica Bay Ecowatchers, June 26, 2018.

1. Consider a plan for Bergen and Thurston Basins that will increase dissolved oxygen (DO) levels and reduce bacteria concentration.

<u>*Response:*</u>

- *The recommended plan presented in the LTCP will reduce bacterial concentrations in Bergen and Thurston Basins, resulting in improved attainment of the water quality criteria for bacteria. The increase in seasonal attainment is expected to be modest (from 70 to 77 in the upstream reach of Bergen Basin, and from 85 to 88 percent in the upstream reach of Thurston Basin), due primarily to the impacts of remaining stormwater volumes. Grey infrastructure alternatives that would reduce combined sewer overflow (CSO) volumes by 50 to 100 percent would provide a similar level of attainment as the recommended plan in Thurston Basin, but would result in lower attainment than the recommended plan in Bergen Basin. The DO levels in Bergen and Thurston Basis are not affected by additional CSO control. The gap analysis presented in the LTCP shows that even with 100% CSO control, the average DO levels in Bergen and Thurston Basins are not projected to change significantly. Overall DO levels in Jamaica Bay have generally improved over the years as a result of projects implemented by the DEP related to WWTP improvements and CSO reduction.*

2. Include a plan for obtaining ribbed mussel seed.

<u>*Response:*</u>

- *Specific project details such as where and how ribbed mussel seed will be obtained will be developed when the recommended plan project moves into the implementation stage.*

3. Targets must be set for gaging the effects of habitat restoration and ribbed mussel introduction.

<u>*Response:*</u>

- *DEP will develop a post-construction monitoring program to evaluate the performance of the recommended plan. DEP will engage stakeholders for developing the post-construction monitoring program and its elements.*

4. **Costs for the integrated plan and grey infrastructure alternatives need to be compared.**

   Response:
   - *Section 8 of the LTCP presents the relative costs of the recommended plan compared to the grey infrastructure alternatives. The cost comparisons were also presented at follow-up stakeholder meetings conducted after the April 18, 2018 public meeting.*

5. **A plan should be developed for keeping the public from accessing the ribbed mussels, and for harvesting mature ribbed mussels to avoid toxicity of the ribbed mussel bed.**

   Response:
   - *Operations and maintenance plans will be developed for all components of the recommended plan including the ribbed mussel installations. This plan will address the concerns noted as part of the implementation phase for the recommended plan,*

6. **Comments specific to the Vernam Barbadoes Peninsula Preserve:**
   a. **Investigate extent of industrial/commercial land uses within the preserve**
   b. **Formulate plan of action to remedy observed encroachment on public land**
   c. **Improve accessibility of the Peninsula by increasing trails**
   d. **Clean up the Peninsula to improve habitat**
   e. **Improve signage to direct visitors and clarify accessibility rules**

   Response:
   - *Addressing current land use issues on the Vernam Barbadoes Peninsula Preserve is not in the scope of the Jamaica Bay and Tributaries LTCP, as the issues do not directly relate to combined sewer overflows. However, DEP acknowledges and appreciates the comments, and will pass these comments along to other appropriate City agencies.*

7. **SWIM is generally in favor of an integrated approach and supports the proposed expansion of green infrastructure development in the separate sewer areas, wetland restoration, environmental dredging, and restoring ribbed mussel populations in the Bay.**

   Response:
   - *Thank you, the comment is noted.*

8. **The public requests additional formal opportunity to review and provide comments on DEP's final submitted Jamaica Bay LTCP before DEC issues a decision to approve or reject the LTCP.**

   Response:
   - *The comment is noted and has been referred to DEC.*

9. Given that the integrated plan seeks to address discharges from both the combined and separate sewer systems, the LTCP should include all of the plan elements from EPA's Integrated Planning for Municipal Stormwater and Wastewater framework.

Response:

- *The recommended plan is being submitted as a LTCP in accordance with the CSO Consent Order requirements and consistent with the EPA CSO Policy. It is not being submitted to align with the EPA's Integrated Planning Framework. However, many of the technical elements included in the Integrated Planning Framework are covered in one form or another in the LTCP. See responses to comments related to specific elements of the EPA Integrated Planning Framework below.*

10. It is not clear whether the triple-bottom-line analyses are intended to be the metrics to satisfy EPA's integrated plan Element 1 that include "metrics for evaluating and meeting human health and water quality objectives".

Response:

- *The human health and water quality objectives for the LTCP are established by the EPA's CSO Policy as compliance with existing water quality standards. Where water quality standards cannot be met, the LTCP must include a Use Attainability Analysis. The triple-bottom-line evaluation was included in the Jamaica Bay and Tributaries LTCP as a means for demonstrating the benefits of watershed based, non-grey infrastructure alternatives, and for comparing benefits to more traditional grey-only alternatives. The triple-bottom-line assessment introduced differentiating factors which allowed for an appropriate evaluation of the benefits of alternatives versus the costs, and supported selection of the cost-effective recommended plan.*

11. Under EPA's integrated plan Element 3, relevant community stakeholders would be engaged "during the identification, evaluation, and selection of alternatives and other appropriate aspects of plan development". This did not appear to be the process used to develop DEP's proposed integrated plan.

Response:

- *The public participation process for the Jamaica Bay and Tributaries LTCP included three formal public meetings and additional meetings with stakeholders. As described in Section 7 of the LTCP, the first public meeting was kickoff meeting, providing an overview of LTCP process, public participation schedule, watershed characteristics and sampling program. The second meeting presented information regarding the one-year extension for Jamaica Bay and Tributaries LTCP. The third meeting presented a review of alternatives and the recommended plan. Subsequent to the third public meeting, DEP met with stakeholder groups to present further information on the recommended plan.*

12. No implementation schedule was provided to the public.

Response:

- *The implementation schedule for the recommended plan was still under development at the time of the April 18, 2018 public meeting. The proposed implementation schedule is included in Section 9 of the LTCP.*

13. Include performance criteria and measures of success along with a monitoring program and evaluation of green infrastructure (GI) performance.

<u>*Response:*</u>

- *As described in DEP's 2016 Green Infrastructure Performance Metrics Report, DEP has initiated a Green Infrastructure Research and Development (GI-RD) project to assist the agency in closing identified gaps in GI performance data and developing additional GI designs as part of the overall toolbox for both public and private property. Future GI performance monitoring activities under the GI-RD project will provide additional information for better understanding of GI performance and further refinement of GI modeling representation for subsequent performance metrics evaluations. The post-construction monitoring program for the recommended plan will incorporate findings from the GI-RD project in terms of methods of monitoring and evaluating GI performance.*

14. The public is unclear how the Jamaica Bay LTCP Alternatives and Recommended Plan would be made enforceable and whether it would be incorporated into the existing CSO Consent Order and/or the MS4 Permit and Stormwater Management Program Plan.

<u>*Response:*</u>

- *The milestones for implementing the elements of the recommended plan will be incorporated into the CSO Order similar to the milestones for the recommended plans for previously submitted and approved LTCPs.*

15. What assumptions and modeling conclusions did DEP make about the quantity and quality of combined sewer overflows and MS4 runoff, and what are the differences in the inputs to the Bay and its tributaries in terms of loading for fecal coliform, *Enterococci*, biological oxygen demand, chemical oxygen demand and nutrients for the evaluated alternatives (e.g., the Recommended Plan and 0%, 25%, 50%, 75%, and 100% capture) and other hypothetical modeled scenarios (e.g., 100% stormwater reduction)?

<u>*Response:*</u>

- *Specific information regarding the quantity and quality of CSO and stormwater discharges is presented in Section 6 and the Appendices of the LTCP. To summarize, the volumes of CSO and stormwater used to assess water quality impacts were generated by the calibrated InfoWorks collection system model. Fecal coliform, Enterococci, and BOD CSO loadings were developed by employing an hourly Monte Carlo randomization based on the measured range of CSO concentrations for the four outfalls contributing CSOs to Fresh Creek (26W-003), Bergen Basin (JAM-003 and JAM-003A), and the Paerdegat CSO Retention Facility (PB-CSO). The "measured range of concentrations" was from the LTCP sampling program, where samples were taken from CSO outfalls. Other CSO outfalls were assigned loadings based on a mass balance procedure, where the model calculated the CSO concentrations based on the mix of sanitary sewage and stormwater in the discharge. Stormwater concentrations were based on local sampling data where available, and other published sources where site-specific sampling data were not available. Section 8 of the LTCP presents curves of loadings for the various alternatives that were retained for the cost/performance evaluations.*

16. What are the modeled ambient water quality results for each of the above scenarios, for each of the pollutants? While DEP's PowerPoint presented some water quality modeling results for pathogens, maps were provided to illustrate the locations of non-compliance only for certain water quality criteria.

<u>*Response:*</u>

- *The water quality modeling results presented in the LTCP focus on percent attainment of water quality criteria for bacteria and DO. Section 6 of the LTCP presents tables of results of water quality modeling of baseline conditions and 100% CSO control, and Section 8 of the LTCP presents tables of results of water quality modeling for the retained alternatives selected for the recommended plan. For the recommended plan, the bacteria attainment is based on 10-year continuous model simulations, while the DO attainment is based on the 2008 typical year. Percent attainment of bacteria criteria for other retained alternatives (i.e., 0%, 25%, 50%, 75% and 100% capture) evaluated in Section 8 of the LTCP are presented in the form of cost/performance curves based on the 2008 typical year simulation.*

17. How does DEP define the metric of "percent attainment" with water quality standards? Based on DEP's previously submitted LTCPs, we assume this refers to "percent annual attainment". However, this term has also not been clearly defined; please explain, in mathematical terms, what this metric represents.

<u>*Response:*</u>

- *For the existing water quality criteria for bacteria, the LTCP presents model results of percent attainment on both an annual and recreational season (May 1st through October 31st) basis. The criterion is a monthly fecal coliform geometric mean* of *≤200 cfu/100mL. As has been the convention in previously submitted and approved LTCPs, the percent attainment has been calculated at the model cells corresponding to sampling stations within the waterbodies. The model calculates the depth-averaged concentration in the model cell for each hour, then calculates the geometric mean of those values for each month. For the 10-year model runs, the annual percent attainment is calculated by dividing the number of months where the geometric mean is ≤200 cfu/100mL by the total number of months in 10 years (120 months). The recreational season percent attainment is calculated by dividing the number of months within the recreational season (May 1st through October 31st) where the geometric mean is ≤200 cfu/100mL by the total number of recreational season months in 10 years (60 months).*

  For DO, attainment is calculated at each of the 10 layers in the model and then averaged. This represents a volume based attainment. In Class I waterbodies, annual attainment is based on hourly model output where the number of hours greater than or equal to 4.0 mg/L is divided by the number of hours in a year (8,760 or 8,784 for leap years). In Class SB waterbodies, the acute criterion attainment is calculated in the same manner, but with respect to the criterion of 3.0 mg/L. The chronic SB DO criterion is based on a daily average of not less than 4.8 mg/L. In this case, the daily average concentration is calculated based on hourly model output, and the number of days with an average DO concentration greater than or equal to 4.8 mg/L is divided by the number of days in a year.

18. What retrofits are guaranteed to be completed by the City to separate the storm sewers in Southeast Queens, and by when? Why aren't any such major sewer modifications written into the LTCP as enforceable milestones? What are the modeled CSO volume, CSO frequency, pollutant loading, and water quality effects of that sewer separation?

Response:

- *The current implementation schedule for the build-out of drainage facilities in Southeast Queens (SEQ), including proposed sewer separation in the Laurelton area, extends beyond the 2030 planning horizon for the LTCP. DDC, DEP, and DOT are currently coordinating a series of infrastructure projects with construction set to begin before the end of 2025 at the estimated cost of almost $2 billion. To-date, 35 projects have been fully scoped and are being advanced toward construction, and several more projects are expected to be added to this list in the next few years. This program is the largest of its kind in the City and will bring significant improvements to local communities of Southeast Queens. While significant funding has been allocated to initial phases of the storm sewer build-out, the scope, timing and funding for implementation of future phases will not align with the needs and requirements of the LTCP Program. The SEQ build-out program was therefore not included in the LTCP Baseline Conditions.*

19. How will we know DEP is on track with the Recommended Plan?

Response:

- *The implementation schedule for the recommended plan will be incorporated as enforceable milestones in the CSO Order upon approval of the LTCP by DEC. DEP regularly tracks project implementation progress against the CSO Order milestones, and reports on that progress on a quarterly basis to DEC. The Quarterly Reports are available to the public on the DEP's website:* http://www.nyc.gov/html/dep/html/cso_long_term_control_plan/quarterly_progress_reports.shtml

20. What metrics can we use to ensure permit compliance or to assess progress?

Response:

- *As noted in the response to Comment No. 19, progress towards implementing the recommended plan will be tracked against the schedule milestones, which will be incorporated into the CSO Order upon approval of the LTCP by DEC. Progress will be reported on a quarterly basis to DEC. A post-construction monitoring plan will be developed to evaluate performance of the recommended plan following completion of construction or implementation of the recommended plan.*

21. What will the milestones be? Will there be both narrative and quantitative water quality standards by which the proposed plan will be measured over time? Which pollutants of concern will DEP's Recommended Plan seek to address?

Response:

- *Schedule milestones for CSO recommended plans that have typically been incorporated into the CSO Order include: GI facility planning, design consultant procurement, initiate final design, final design completion, notice to proceed to construction, and construction completion. The specific milestones for the Jamaica Bay and Tributaries LTCP recommended plan will be identified as part of DEC's LTCP approval process. The existing water quality* *standards define the criteria through which attainment of those standards will be determined. Pollutants of concern affecting attainment of numerical criteria have been identified as fecal coliform bacteria and substances exerting an oxygen demand on the waterbodies. In March 2018 DEC proposed Enterococci water quality standards for coastal class SB waters during the recreational season that were also evaluated in the LTCP.*

22. **Are any of the proposed wetland restoration efforts included in other local, state, or federal plans or proposals relating to Jamaica Bay? What is the likelihood that any portion of the proposed wetland restoration efforts would occur – using other sources of funding or lead agencies – absent inclusion in this proposed LTCP?**

    Response:

    - *The wetlands restoration projects proposed in the LTCP recommended plan do not overlap with current wetlands restoration projects that are planned or underway. It is not clear whether the LTCP-proposed wetlands restoration projects would have been implemented by other programs at some time in the future. However, by incorporating the projects into the LTCP recommended plan, the implementation schedules for the proposed wetlands restoration projects will become enforceable under the CSO Order.*

23. **SWIM is opposed to chlorination in the event the integrated plan does not move forward.**

    Response:

    - *Thank you, the comment is noted and has been referred to DEC.*

24. **The public would like the wetland restoration effort to be expanded to include an annual Wetland Maintenance program.**

    Response:

    - *All DEP tidal wetland restoration projects have a 2-year maintenance period to help in the establishment of the wetlands. Once the wetlands are established and have increased in spatial coverage, future maintenance is not required as the wetlands become self-sustaining. In addition, our regulatory permits typically have a 5-year reporting requirement to address any other issues that may arise."*

25. **SWIM is not satisfied with how DEP and DEC have handled comments submitted on prior LTCPs. The Responsiveness Summaries were published months after DEC had approved the LTCPs and members of the public were not notified of the availability of these responses. DEP must provide responses to public comments prior to any DEC approval or disapproval of a LTCP, and DEC, in turn, must respond to public comments prior to or concurrent its approval or disapproval. The public should be given immediate notice of the availability of such responses and of DEC determination approving or disapproving a LTCP. Recommended alternatives submitted by DEP, and determinations by DEC to approve or disapprove a plan, must take into account comments received, by making changes warranted by the merits of those comments.**

Response:

- *Appendix B of the LTCP includes a listing of comments received at the public meetings held on the Jamaica Bay and Tributaries LTCP, along with DEP's responses to those comments. This responsiveness summary of written public comments is also included in Appendix B. DEP solicited input on the elements of the recommended plan at the April 18, 2018, public meeting as well as subsequent follow-up meetings with stakeholders, and the final configuration of the recommended plan reflects that input.*

26. The reconstructed A Train support infrastructure that was installed on an emergency basis following Superstorm Sandy hinders water circulation. The support structures should be studied, and plans developed for a more porous system to be installed.

Response:

- *Addressing the A Train support infrastructure is not in the scope of the Jamaica Bay and Tributaries LTCP, as this issue does not directly relate to combined sewer overflows. However, DEP acknowledges and appreciates the comment, and will pass this comment along to the Metropolitan Transit Authority.*

E-mail from Ira Gershenhorn (ira@gershenhorn.com) on Jamaica Bay and Tributaries LTCP received on 4/19/2018

I love the idea of using ribbed mussels and habitat restoration to clean the water.

The presentation indicated that CSO reduction in Jamaica Bay (particularly the Bergen and Thurston Basins) would not significantly increase DO levels and reduce bacteria.

Therefore any competing plan must show it can increase DO levels and reduce bacteria.

Even if their is no model for gauging effects of habitat restoration and ribbed mussel introduction, targets must be set. The targets need only be as high as necessary to be better than competing plans.

Costs must be compared.

A plan for getting ribbed mussel seed must be presented. As I've heard ribbed mussel is simply not currently available. It is not produced commercially.

And while ribbed mussels are not the attractive nuisance that blue mussels and oysters are, there should still be some plan for security because people will eat anything and its possible that unscrupulous shellfish providers will mix ribbed mussels in with blue mussel batches and ribbed mussels by their nature of heavy metal concentration are probably more dangerous to eat than oysters and blue mussels.

A plan must exist to harvest and destroy mature ribbed mussels to mediate the toxicity of the ribbed mussel beds.

E-mail from Dr. Harold Paez (hpod1@aol.com) on Jamaica Bay and Tributaries LTCP received on 5/16/2018

16 May 2018

Dear Department of Environmental Protection,

As a resident of Rockaway and a member of the local Community Board (14), I would like to commend you on the planned efforts to expand green infrastructure, expand wetlands and restore aquatic fauna populations. Jamaica bay is a vital green resource which should be preserved and maintained for the benefit of future generations, and the continued enjoyment of New York City residents.
My comment is concerned with a part of Jamaica bay which is not well known to the general public, even those of us who live in Rockaway. Specifically, I'm referring to the Vernam Barbadoes Peninsula Preserve which is a large portion of land jutting out into the Bay just East of the A train viaduct as it enters the Rockaway Peninsula.
This large area is visible from aerial views of the Peninsula but not easily seen or accessed from the ground. In fact, I have never heard of anyone in the community actually exploring this green space, nor has it ever been presented to the public as a natural resource to be enjoyed.
In my evaluation of Google Earth views over this area, I can see that there is a large portion of the land being used for industrial purposes directly adjacent to Jamaica Bay. I make this assumption based on the large amount of heavy machinery, trucks and shipping containers visible on the property.

I'm taking the time to comment out of my concern for the future of this large expanse of nature, and I would urge the Department of Environmental Protection to consider the following ideas for Vernam Barbadoes Peninsula Preserve as part of the Jamaica Bay Long Term Control Plan:

1-Investigate and evaluate the extent of industrial/commercial activity going on within the confines of the Barbadoes Preserve, and whether these activities are in keeping with the overall mission of protecting coastal wetlands and coastal habitat restoration.

2-If such an investigation determines that the current use of this land is inconsistent with the long term goals of the Jamaica Bay Plan then an immediate plan of action should be formulated to remedy the existing situation. I would not presume to limit private industry, but if the Preserve is indeed public land, it should be well delineated as such, with encroachment by private concerns on public space strictly mitigated.

3-The Barbadoes Peninsula Preserve should be made accessible to the public through simple land trails and trails along the water. In doing so, we are able to bring the community, school children, and the public in general, more in contact with Jamaica Bay and nature. This spot along the A-train makes it easily accessible to school trips and the Rockaway Community which is sorely in need of additional green park spaces. For far too long, New Yorkers have been cut off from access to the beautiful waterways surrounding our city. It's ironic because all of these areas still retain the old wooden piers from the vibrant and daily use of Jamaica Bay a hundred years ago.

4-The Barbadoes Peninsula Preserve should be cleaned up as soon as possible in order to improve the habitat for both flora and fauna. As the city continues to grow in population and density, our planning for improved green spaces and more spaces for individuals to access should be a top priority. This large area of land sits untapped with huge potential.

5-If public access is part of the overall design of this green space, there should be large signage posted along Beach Channel Drive to direct visitors and at the entrance to this space on Amstel Boulevard to clearly indicate the name of the public area and accessibility rules. At this time, the

entrance to this space is a parking field for trucks with no indication that there is public accessibility to the larger green space.

-Through grass roots efforts, and in conjunction with the NYC Parks Department, there is a small park taking shape, on Jamaica Bay, just to the West of the Barbadoes Peninsula Preserve, at Beach 86th Street. This park will be providing access to Kayaks through a small non-profit organization run by locals from Rockaway. One can envision a time in the future where people from across NYC can take the ferry to Rockaway, disembark at B108th street and walk down to this kayak launch at B86th. From there they can explore Jamaica Bay in an eco-friendly manner with a trip around Barbadoes Peninsula Perserve to see wildlife and marshlands as they would have appeared 300 years ago. It s my strong opinion that the key to improving public education about maintaining our environment is to have them directly involved in the environment through activity and engagement.

I thank you again for taking the time to read my comments and I hope that there is a future for the Vernam Barbadoes Preserve within the larger Jamaica Bay plan.

Sincerely,
Dr. Harold Paez
126-10 Rockaway Beach Boulevard
Belle Harbor, NY 11694
(917) 579-3557

SWIM Coalition
Stormwater Infrastructure Matters

June 4, 2018

Vincent Sapienza, P.E.
Commissioner
NYC Department of Environmental Protection
59-17 Junction Boulevard
Flushing, NY 11373

Sent via email
ltcp@dep.nyc.gov

RE: NYC DEP Jamaica Bay LTCP Alternatives and Recommended Plan

Dear Commissioner Sapienza,

The Stormwater Infrastructure Matters (SWIM) Coalition submits this letter in response to the New York City Department of Environmental Protection's (DEP) invitation for public comments concerning the development of the Jamaica Bay Long Term Control Plan (LTCP).

The SWIM Coalition represents over 70 organizations dedicated to ensuring swimmable and fishable waters around New York City through natural, sustainable stormwater management practices. Our members are a diverse group of community-based, citywide, regional and national organizations, water recreation user groups, institutions of higher education, and businesses. On behalf of the SWIM Coalition Steering Committee, please accept these comments regarding DEP's powerpoint and oral presentation of the Jamaica Bay LTCP "Alternatives and Recommended Plan" that DEP intends to submit pursuant to the Combined Sewer Overflow (CSO) Consent Order.

We thank you for inviting feedback prior to DEP's submission of the LTCP to the NYS Department of Environmental Conservation (DEC). We also thank you for having your staff meet with the SWIM Steering Committee members and community representatives on May 9th and again on May 29th to discuss the challenges faced and the rationale for the alternatives proposed.

We appreciate that DEP staff are pursuing innovative, holistic solutions to address sewage and stormwater pollution, and we are generally in favor of an integrated approach that will reduce pollutants of concern from all sources and restore ecological function in the Bay. For example, we support the proposed expansion of green infrastructure development in the separate sewer areas, wetland restoration, environmental dredging, and restoring ribbed mussel populations in the Bay. Each of these measures would have a beneficial water quality impact, albeit not easily quantifiable. We are also excited about the potential of ribbed mussels as natural water filters and find this approach highly promising to supplement reductions in pollutant discharges from the combined and separate sewer systems. And we support expanding the City's Green Infrastructure repertory to include wetland and habitat restoration.

We are encouraged that DEP's proposal seeks to move the City's overall efforts towards a holistic approach, and we urge DEC (copied on this letter) to consider this proposed approach seriously.

However, based on DEP's powerpoint slides and oral discussions with DEP – without the opportunity to review a complete Long Term Control Plan with all required technical documentation pursuant to the CSO Control Policy – we urge the DEC to neither approve nor reject DEP's proposal at this time. We instead request that both DEP and DEC provide the public a formal opportunity to review and provide additional comments on DEP's final submitted Jamaica Bay LTCP. Based on the information provided by DEP to date, we submit the following comments and recommendations.

EPA guidance on Integrated Watershed Planning; CSO Long Term Control Policy

We understand that DEP is submitting the Jamaica Bay LTCP Alternatives and Recommended Plan to fulfill the requirements under the 2018 Combined Sewer Overflows Consent Order, Revised Appendix A, and that DEP is not proposing it under EPA's Integrated Planning for Municipal Stormwater and Wastewater framework.[1] However, given that the plan seeks to address, in an integrated fashion, discharges from both the combined and separate sewer systems, the proposal does not appear to be traditional Long Term Control Plan, but rather is more akin to an integrated plan as described in EPA's integrated planning framework. Accordingly, the "plan elements" under that framework should serve as a guide for developing and evaluating the plan. All of the elements of an integrated plan, under the framework, are critical to allow all stakeholders to ensure that DEP's approach would put us on the right track to meet the requirements of the Clean Water Act.

We would like to understand additional details of DEP's analysis so that we can weigh and meaningfully comment on the alternatives presented. While we appreciate the purpose of the Consent Order's deadlines driving the LTCP for Jamaica Bay, it is crucial to get final plan right. **We believe very strongly that this is a once-in-a-generation opportunity for significantly improving the health of the Bay. As such, we are willing to help convene a meeting of relevant stakeholders, including DEP and DEC, to discuss the potential benefits of a fully integrated planning approach for Jamaica Bay and other New York City waters and help map out a process for consideration of an integrated plan.**

As it stands now, DEP's plan does not include all "plan elements" of the integrated planning framework. For instance:

- Under Element 1, an integrated plan would include "metrics for evaluating and meeting human health and water quality objectives." It is not clear whether the triple bottom line analyses are intended to be the metrics to satisfy this plan element.
- Under Element 3, relevant community stakeholders would be engaged "during the identification, evaluation and selection of alternatives and other appropriate aspects of plan development." To our knowledge, this was not the process used to develop DEP's proposed integrated plan. Groups like Jamaica Bay Ecowatchers may have relevant ideas to optimize alternatives.
- Under Element 4, "proposed implementation schedules" would be included but no such schedule is included in the information that DEP shared with us.
- And, most importantly under Element 5, performance criteria and measures of success along with a monitoring program and evaluation of GI performance would be included.

Many or all of these missing elements, such as public participation, implementation schedules, and post-construction monitoring, are also required of all LTCPs pursuant to the CSO Control Policy

Accountability & enforceability

The EPA's framework document[2] also includes sections on permits and enforcement (see pages 6 and 7 of the linked document). Based on what DEP has presented thus far, we are unclear how the Jamaica Bay LTCP Alternatives and Recommended Plan would be made enforceable, including, specifically, whether it would be incorporated into the

[1] https://bit.ly/2LqynwX
[2] https://bit.ly/2LqynwX

existing CSO Consent Order and/or the MS4 Permit and Stormwater Management Program Plan. (We note, however, that based on conversations with DEP, we understand that DEP intends that the plan's proposed green infrastructure in the MS4 portion of the watershed is intended to be in addition to – not credited towards – DEP's existing green infrastructure obligations under the CSO Consent Order.)

Further, based on the written materials provided, we unclear exactly what data DEP used, what assumptions DEP made, and what methodologies DEP applied in the analysis that supports its proposal. While conversation with DEP has helped improve our understanding, that conversation cannot substitute for an opportunity -- for us, and others -- to review the relevant details and technical information in writing.

As of now, our questions include the following:

- What assumptions and modeling conclusions did DEP make about the quantity <u>and quality</u> of combined sewer overflows and MS4 runoff, and what are the differences in the inputs to the bay and its tributaries in terms of loading for fecal coliform, *Enterococci*, biological oxygen demand, chemical oxygen demand and nutrients for the evaluated alternatives (e.g., the Recommended Plan and 0%, 25%, 50%, 75%, and 100% capture) and other hypothetical modeled scenarios (e.g., 100% stormwater reduction)[3]?
- What are the modeled ambient water quality results for each of the above scenarios, for each of the pollutants? While DEP's powerpoint presented some water quality modeling results for pathogens, maps were provided to illustrate the locations of non-compliance only for certain water quality criteria.
- How does DEP define the metric of "percent attainment" with water quality standards? (Based on DEP's previously submitted LTCPs, we assume this refers to "percent annual attainment". However, this term has also not been clearly defined; please explain, in mathematical terms, what this metric represents.)
- What retrofits are guaranteed to be completed by the City to separate the storm sewers in Southeast Queens, and by when? Why aren't any such major sewer modifications written into the LTCP as enforceable milestones? What are the modeled CSO volume, CSO frequency, pollutant loading, and water quality effects of that sewer separation?
- How will we know DEP is on track with the Recommended Plan?
- What metrics can we use to ensure permit compliance or to assess progress?
- What will the milestones be? Will there be both narrative and quantitative water quality standards by which the proposed plan will be measured over time? Which pollutants of concern will DEP's Recommended Plan seek to address?
- Are any of the proposed wetland restoration efforts included in other local, state, or federal plans or proposals relating to Jamaica Bay? What is the likelihood that any portion of the proposed wetland restoration efforts would occur – using other sources of funding or lead agencies – absent inclusion in this proposed LTCP?

We are unable to fully assess the merits of the integrated plan without the inclusion of these details.

<u>No chlorination</u>

We wish to state for the record our opposition to chlorination in the event the integrated plan does not move forward. We appreciate that DEP has not included chlorination as part of its Recommended Plan. Jamaica Bay is an ecologically important waterbody with one of the largest coastal wetland systems in New York State. Jamaica Bay is already burdened by chlorination in Spring Creek, we believe any additional chlorination in other tributaries must be avoided.

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[3] The existing model should allow DEP to easily produce plots of flow, concentrations, and loading for each parameter for each type of input or each outfall on a an hourly, daily, monthly, and annual basis. We believe such plots would assist in the understanding of what are the main pollutant sources to the Bay.

Ribbed mussel planting

We fully support installation of suspension feeders as a method to filter pathogens that would remain even after all necessary and appropriate CSO reductions. Increasing suspension feeder populations would work to turn pathogens and much of the rest of the plankton into the Jamaica Bay food web for striped bass, bluefish, white perch, blue crab, etc. Chlorination, on the other hand, would not contribute to the growth, development or ecological integrity of life in this estuary. Indeed, disinfectants and disinfectant byproducts would have adverse impacts on the estuary and would obstruct the success of suspension feeder filtration.

Expansion of wetland restoration projects

Wetland restoration is, of course, a vital element of restoring the Jamaica Bay ecosystem. We would like to see wetland restoration efforts expanded to include an additional element. Specifically, Jamaica Bay would see both water quality and habitat benefits from a recurring, annual Wetland Maintenance program.

Stakeholders have long advocated for a program that would replicate the very successful first wetland project in Jamaica Bay, which was based on enriching existing marshes with adjacent sediment. This process of using adjacent sediment and placing it on identified areas would "save" the marsh areas that are currently in serious decay. Local advocates have identified numerous areas where the sediment enrichment process could be employed. The wetlands help clean the waters, sequester carbon and, given the loss of wetlands the bay has seen, this concept would, along with the current proposed larger islands planned, help the bay to finally turn the tide on the loss and see a net gain of these critical wetlands.

Full draft for public review

While we are aware of the time constraints under which DEP must operate to submit a plan to the state DEC by the end of June 2018, it is important to note that at the December 2017 City Council public hearing on Wastewater Infrastructure: Current and Future Plans, Deputy Commissioner Licata promised (in response to City Council member Donovan Richards' question about why DEP was not sharing the final drafts of the City's proposed CSO LTCP's with the public before they are submitted to the State) that, going forward, DEP would share the final proposed LTCPs with the public (prior to their submission to DEC). We took this as a clear commitment to provide the public with the opportunity to review and comment on a full draft plan document, not a powerpoint presentation document. We believe the public needs to be given an opportunity to review the full draft LTCP before it is sent to the State.

Moreover, we cannot emphasize strongly enough that the way in which DEP and DEC have handled comments submitted on prior LTCPs is hollow and completely undermines public confidence that community concerns are taken seriously. DEC published responses to public comments -- which we understand to have been written jointly by DEC and DEP after DEC had approved the LTCPs – many months after DEC approved the plans. Members of the public who submitted comments were not even notified directly of the availability of these responses.[4] To make public input meaningful, DEP must provide responses to public comments prior to any DEC approval or disapproval of a LTCP, and DEC, in turn, must respond to public comments prior to or concurrent its approval or disapproval. The public should be given immediate notice of the availability of such responses and of DEC determination approving or disapproving a LTCP. Moreover, comments and responses are not merely a box to check-off – the actual plans and recommended alternatives submitted by DEP, and determinations by DEC to approve or disapprove a plan, must actually *take into account* the comments received, by making changes where warranted by the merits of those comments. It is obvious from the process DEC and DEP followed that the agencies made little or no serious attempt to do so for the previous LTCPs.

[4] The "Responsiveness Summaries" are dated 7 months after DEC approved most of DEP's LTCPs. Since we and other commenters received no notification of the availability of these comment, we do not know whether there was any further delay in posted them after that date. And we did not become aware of them until well over a year after DEC approved most of the LTCPs.

Regarding the Jamaica Bay LTCP, specifically, DEP's powerpoint presentation issued for public review conveys the overall concept and approach of the plan and includes pertinent graphs and tables, but, to fully understand the true impacts of the proposed plan, the public deserves the opportunity to review the final proposed plan. As noted earlier, we will request that DEC provide the public a formal opportunity to review and provide additional comments on DEP's final submitted Jamaica Bay LTCP.

We are interested in reviewing the details (such as assumptions made, methods used in various analyses, and references— particularly for the novel approach proposed for this LTCP, as well as key milestones and metrics by which to measure them, timelines for program completion, as well as program monitoring and reporting schedules, and enforceability, etc.) because we know details matter.

As a point of reference, the public participation model used by the DEP for the development of the MS4 Stormwater Management Plan has been exemplary and it is our hope that all DEP programs can follow suit going forward.

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In closing, we would like to reiterate that the LTCP and MS4 plans in development and under review right now provide us with a once in a generation opportunity to make long term improvements in NYC's waterways and specifically in Jamaica Bay. We are excited about the prospect of an integrated plan for the Bay and look forward to further discussions with DEP, DEC and local stakeholders to ensure that a final plan aligns with the CSO Policy and with EPA's Integrated Municipal Stormwater and Wastewater Planning Approach and Framework.

Thank you again for the opportunity to provide public comment and for your consideration of our recommendations for the proposed integrated plan for Jamaica Bay.

Sincerely,

The Stormwater Infrastructure Matters (SWIM) Coalition Steering Committee:

Mike Dulong – Riverkeeper

Michelle Lubke – Bronx River Alliance

Larry Levine – NRDC (Natural Resources Defense Council)

Paul Mankiewicz - The Gaia Institute

Jaime Stein – Pratt Institute

Korin Tangtrakul – NYCSWCD (NYC Soil & Water Conservation District)

Shino Tanikawa - NYCSWCD (NYC Soil & Water Conservation District)

Cc

Pinar Balci, Ph.D., Assistant Commissioner, NYC Environmental Protection, Bureau of Environmental Planning and Analysis

Edward Hampston, P.E, Chief, Water Upstate Compliance Section, Division of Water, Dept. of Environmental Conservation

Angela Licata, Deputy Commissioner, NYC Environmental Protection, Sustainability

Daniel Mundy Sr. , Jamaica Bay Ecowatchers

Daniel Mundy Jr., Jamaica Bay Ecowatchers

Don Riepe, Jamaica Bay Program Director, American Littoral Society

May 17, 2018

John McLaughlin
Director of Ecological Services
Bureau of Environmental Planning and Assessment
New York City Department of Environmental Protection
59-17 Junction Blvd.
Flushing, NY 11373

Brad Sewell
Advisory Committee Co-chair
c/o Megan Lew, Natural Resources Defense Council
40 West 20th Street
New York, NY 10011

Comments on Jamaica Bay Planning

Gentlemen:

I did not see any mention of the MTA's A line tracks which cross the bay. The support infrastructure – steel sheeting, raised bed, and associated in-water fill-- hinders water circulation. Aeration and circulation are important contributors to the health and function of the bay. Under emergency orders to get the city moving as soon as possible, it was rebuilt after Superstorm Sandy with no environmental review or mitigation of impacts, to the best of my knowledge. The train line is an essential part of NYC's transportation and circulation network, however, the way it is supported as it crosses the bay has direct negative impacts on the bay's health. I suggest that this issue be included in the long range plan, so that there is a strategy in place to calmly, systematically, under non-emergency conditions, convert the current supportive infrastructure to a more porous system.

If I somehow missed that the A line is already included in this effort, please accept my thanks and apology.

All the best,

Marcha Johnson

Marcha Johnson, ASLA, PhD
Landscape Architect and Ecological Restorationist
Brooklyn, NY

Jamaica Bay Ecowatchers

Working to preserve, protect and enhance the natural resources of Jamaica bay

56 West 14th road, Broad Channel, New York, NY 11693

Jamaicabayecowatchers.org

June 26 2018

Commissioner Basil Seggos
625 Broadway
Albany, NY 12233-1011
518-402-8545

RE: Jamaica Bay Ecowatcher's Comments on the NYCDEP Long Term Control Plan (LTCP) for Jamaica Bay

The Jamaica Bay Ecowatcher's have been the leading advocacy group working to protect Jamaica Bay since 1995. We were the first to identify the wetlands loss issue in Jamaica Bay (it was our group that brought this to the attention of the NYSDEC) , were the lead proponents in the successful battle to oppose the 2010 plan to expand JFK runways into the bay, with the tremendous support of the NRDC brought forth a clean water lawsuit against Mayor Bloomberg that resulted in the Nitrogen Agreement. This Agreement mandated that NYC upgrade the waste water treatment systems to drastically reduce the nitrogen loading of these waters and required that an additional $15,000,000 be set aside for wetland island restoration. Towards that end we have partnered with the American Littoral Society, the ACOE, and the NYS DEC in the restoration of Rulers and Black wall wetland islands. We have worked to restore oyster populations in Jamaica Bay thru our partnerships with Stony Brook University, and other academic institutions. We are the lead NGO on the next major restoration project about to break ground in Jamaica Bay- the Sunset Cove wetland and maritime forest which will break ground this coming July. We were also the lead NGO involved with the planning and concept behind the Rockaway Artificial Reef replenishment project which was funded at our urging by the Trancso Williams company as part of an offset mitigation requirement.

We have been working for over 20 years to preserve and protect the waters and habitat of Jamaica Bay. Our comments are based on the hundreds of years of combined observational time that our members have accrued in their time out on the bay and we hope they will be considered by the NYSDEC as it reviews the NYCDEP LTCP.

We have reviewed NYC DEP proposal and support their integrated concept and the details laid out in this plan. We feel that the concepts of the integrated plan including the; 50 acres of new wetlands, the 7 acres of ribbed mussel creation, the removal of 50,000 cubic yards of spoil fill that is currently impeding water flow in Bergen Basin and the commitment to an additional Marsh/Wetland creation opportunity using the concept of adjacent enrichment sediment displacement method are all projects which will see benefits to the water quality of the bay. In addition, these concepts will have benefits beyond water quality as they each will create new habitat for the numerous species that call Jamaica Bay home.
Our Organization led the efforts to upgrade the four waste treatment plants thru the Nitrogen Agreement, signed in 2010, and have a full understanding and appreciation for “hard grey” upgrades where necessary. Those types of upgrades were the foundation of the Nitrogen Agreement and have had their intended positive effects on the water quality and the nitrogen reduction. However, we have also seen the benefits of wetland creation in the bay including recent restoration projects funded by that Nitrogen agreement and it has highlighted the multiple benefits derived from Natural and Nature based features. The recently created wetland islands not only benefit the water quality but play host to numerous species of fish, turtles, horseshoe crabs, and various bird species including osprey. They also work to sequester Carbon and as recently proven by research from Professor Zarnoch remove Nitrogen from the waters of the bay. The cumulative positive effects of these nature-based features are still being discovered.

At this time the integrated approach that the DEP is proposing is one that we feel will have the greatest benefit for the waters and habitat of the bay and one that we hope the DEC will approve.

Daniel T Mundy

Vice President Jamaica Bay Ecowatcher’s

President Broad Channel Civic Association

Appendix C: Jamaica Bay and Tributaries Use Attainability Analysis

Executive Summary

The New York City Department of Environmental Protection (DEP) has performed a Use Attainability Analysis (UAA) for Jamaica Bay and Tributaries in accordance with the Combined Sewer Overflow (CSO) Order. Jamaica Bay and its tributaries are tidal waterbodies spanning the Boroughs of Brooklyn and Queens and exchange waters with the Lower Bay (Figure 1). The Jamaica Bay watershed is located throughout south Brooklyn and south Queens and is served by the Rockaway, Jamaica, 26th Ward, and Coney Island Wastewater Treatment Plants (WWTPs). The waters of Jamaica Bay and its tributaries are saline and receive freshwater input from groundwater, stormwater, direct drainage, and CSO discharges.

The gap analyses performed as part of the Jamaica Bay and Tributaries Long Term Control Plan (LTCP) concluded that under baseline conditions, the Existing Water Quality (WQ) Criteria for fecal coliform in this waterbody would be attained at all of the monitored water quality stations on an annual basis, and during the recreational season (May 1st through October 31st) for Jamaica Bay, Paerdegat Bay, Hendrix Creek, and Spring Creek. However, attainment is not achieved at the head ends of Thurston Basin, Bergen Basin, and Fresh Creek. The gap analyses also indicated that the Existing WQ Criteria for fecal coliform would not be attained at all stations in Thurston Basin, Bergen Basin, and Fresh Creek on an annual or recreational season basis, even with the implementation of 100% CSO control. This finding is not unexpected, as bacteria levels in Thurston Basin, Bergen Basin, and Fresh Creek are also affected by stormwater loads and poor tidal flushing, largely due to man-made conditions.

The gap analyses also demonstrated that Class SB dissolved oxygen (DO) criteria is attained under baseline conditions at least 95 percent of the time on an annual average basis for Jamaica Bay. Class I DO criteria are attained for all monitoring stations within Paerdegat Basin, Fresh Creek, and Spring Creek. Attainment of Class I DO criteria are met at most monitoring stations within Thurston Basin, Bergen Basin, and Hendrix Creek with the exception of TBH1, TBH3, TB9, TB10, BB5, and HC1. With the implementation of 100% CSO control, monitoring Station HC1 would achieve attainment, while the others would all continue to fall below the 95 percent metric.

The Recommended Plan includes the following projects:

- Thurston Basin
  - 147 greened acres of Green Infrastructure (GI) Expansion
  - 3 acres of Ribbed Mussel Colony Creation
- Bergen Basin
  - 232 greened acres of GI Expansion
  - 50,000 CY Environmental Dredging
  - 4 acres of Ribbed Mussel Colony Creation
- Spring Creek
  - 13 acres of Tidal Wetland Restoration
- Hendrix Creek
  - 3 acres of Tidal Wetland Restoration
- Fresh Creek
  - 14 acres of Tidal Wetland Restoration
- Paerdegat Basin
  - 4 acres of Tidal Wetland Restoration

Figure 1. Overview of Water Quality Stations and Permitted Outfalls in Jamaica Bay and its Tributaries

- Jamaica Bay
  - 16 acres of Tidal Wetland Restoration

The LTCP assessment shows that the Recommended Plan would achieve recreational season (May 1st through October 31st) attainment of the Existing WQ Criteria for fecal coliform bacteria at all sampling locations in Jamaica Bay and its tributaries with the exception of TBH1, TBH3, BB5, and FC1 for the 10-year continuous model run. Annual attainment of the Existing WQ Criteria for fecal coliform would be achieved at all stations except TBH1, TBH3, TB9, BB5, BB6, and FC1. Assessment of compliance using a 10-year continuous model run indicated that recreational season compliance for those stations that do not achieve attainment would be in the range of 77 to 93 percent, and annual compliance would range from 59 to 92 percent.

With the Recommended Plan, the existing Class SB DO criteria is predicted to be met at least 95 percent of the time at all stations within Jamaica Bay on an annual average basis. Class I DO criteria are attained at least 95 percent of the time at all stations within the tributaries, with the exception of monitoring stations in Thurston Basin (TBH1, TBH3, TB9, TB10), Bergen Basin (BB5, BB6) and Hendrix Creek (HC1).

In March 2018, New York State Department of Environmental Conservation (DEC) released Proposed *Enterococci* WQ Criteria* for coastal Class SB waters, which, if adopted would apply to Jamaica Bay (a coastal Class SB waterbody), but not the tributaries (all Class I waterbodies). Based on DEC's March 2018 proposed rulemaking and information provided by DEC, the Proposed *Enterococci* WQ Criteria* will include a 90-day rolling geometric mean (GM) for *Enterococci* of 35 cfu/100mL with a not-to-exceed 90th percentile statistical threshold value (STV) of 130 cfu/100mL.

Although these proposed criteria have not been finally adopted, the UAA also addresses the attainability of these criteria at each of the applicable modeled water quality stations in Jamaica Bay. For the Recommended Plan, the 90-day GM<35 cfu/100mL Proposed *Enterococci* WQ Criteria* are attained at all monitoring stations within Jamaica Bay, while the 90-day STV criteria are attained for all stations except J7, which is located at the confluence with Bergen Basin. Proposed *Enterococci* WQ Criteria* do not apply to the tributaries.

Each applicable criterion is discussed below for the waterbodies where Existing WQ Criteria are not predicted to be met at least 95 percent of the time.

Fecal Coliform

Water quality modeling analyses performed during the Jamaica Bay and Tributaries LTCP concluded that under baseline conditions for a 10-year continuous model simulation, attainment of the Existing WQ Criteria for bacteria during the recreational season (May 1st through October 31st) is 70, 85, and 93 percent, respectively, at the head ends of Bergen Basin, Thurston Basin, and Fresh Creek. Attainment increases towards the mouth of each waterway, reaching 100 percent before the confluence with Jamaica Bay. Annual attainment ranges from 51 percent at the head end of Bergen Basin, to 71 percent for Thurston Basin and 86 percent for Fresh Creek. Attainment reaches 100 percent before the confluence of each waterway with Jamaica Bay.

The Recommended Plan was also modeled for a 10-year continuous model simulation. Recreational season (May 1st through October 31st) attainment of the Existing WQ Criteria for fecal coliform bacteria

*Proposed *Enterococci* WQ Criteria, if adopted as proposed, would only apply to coastal Class SB and SA waters.

ranges from 77 percent at the head end of Bergen Basin, to 88 percent for Thurston Basin, 93 percent for Fresh Creek, and 100 percent at the confluence of each of these waterbodies with Jamaica Bay. However, annual attainment of the Existing WQ Criteria for fecal coliform is predicted to range from 59 percent at the head end of Bergen Basin, to 75 percent for Thurston Basin, 88 percent for Fresh Creek, and 100 percent at the confluence with Jamaica Bay based on the 10-year continuous model simulation.

Dissolved Oxygen

Under baseline conditions for the 2008 rainfall year, water quality modeling analysis projects attainment of Existing WQ Criteria for DO (Class SB) at all monitoring stations within Jamaica Bay. For the Class I tributaries, Existing WQ Criteria for DO are attained at all montioring stations in Spring Creek, Fresh Creek and Paerdegat Basin. However, attainment at the head ends of Bergen Basin, Thurston Basin and Fresh Creek were projected to be 89, 90 and 94 percent respectively. Attainment progressively increases towards the mouth of each of these waterways, reaching 100 percent before the confluence with Jamaica Bay. Modeling for the Recommended Plan for the 2008 rainfall year indicates no improvement in DO attainment.

Waterbody Access and Uses

Bergen Basin and Thurston Basin are navigable waterways that primarily support recreational boating, shipping traffic associated with JFK International Airport, and the servicing of the DEP floatables booms with skimmer boats. Public access to these waterbodies is prohibited by JFK Airport security at points near their confluence with Jamaica Bay. In addition, access to the head ends of these waterways is limited due to physical barriers. Floatables and oil containment booms prevent access of small watercraft to the head end of both waterways. The head end of Thurston Basin is also blocked by a floating chain link fence at a point downstream of an airport runway. As shown on Figure 2, public access is not available to these waterways except for private boat docks near the confluence of Thurston Basin with Jamaica Bay. In addition, no Department of Health and Mental Hygiene (DOHMH) certified bathing beaches are located along Bergen and Thurston Basins.

Hendrix Creek is a navigable waterway that primarily supports recreational boating and skimmer boat access for servicing the floatables boom. The 26th Ward WWTP traverses the western shoreline and head end of the creek, limiting public access. While Fountain Avenue Park bounds the eastern shoreline of Fresh Creek, heavy vegetation along the banks limits access. No docks or certified bathing beaches exist along Hendrix Creek or near its confluence with Jamaica Bay.

Portions of Fresh Creek are navigable; however, narrow stretches and shallow water depths limit access to the head end of the waterway to small watercraft. At the head end of Fresh Creek, access is limited by heavy commercial, institutional, and residential development. While Figure 2 identifies Fresh Creek Park, Canarsie Park, and Pennsylvania Avenue Landfill as access areas, heavy vegetation along the shorelines limits access to the waterway. No docks or certified bathing beaches exist along Fresh Creek or near its confluence with Jamaica Bay.

As illustrated in Figure 3, the shorelines of Bergen and Thurston Basins are composed of a mix of natural areas, rip-rap, marina docks, and bulkheads. The shoreline adjacent to the JFK Airport fuel tanks is armored with rip-rap and piers for docking fuel delivery vessels. The shoreline along Pan Am Road is armored with bulkheads adjacent to CSO Outfalls JAM-003/003A and JAM-006. The Thurston Basin shoreline is primarily composed of natural areas, except the head end which is bulkheaded and armored

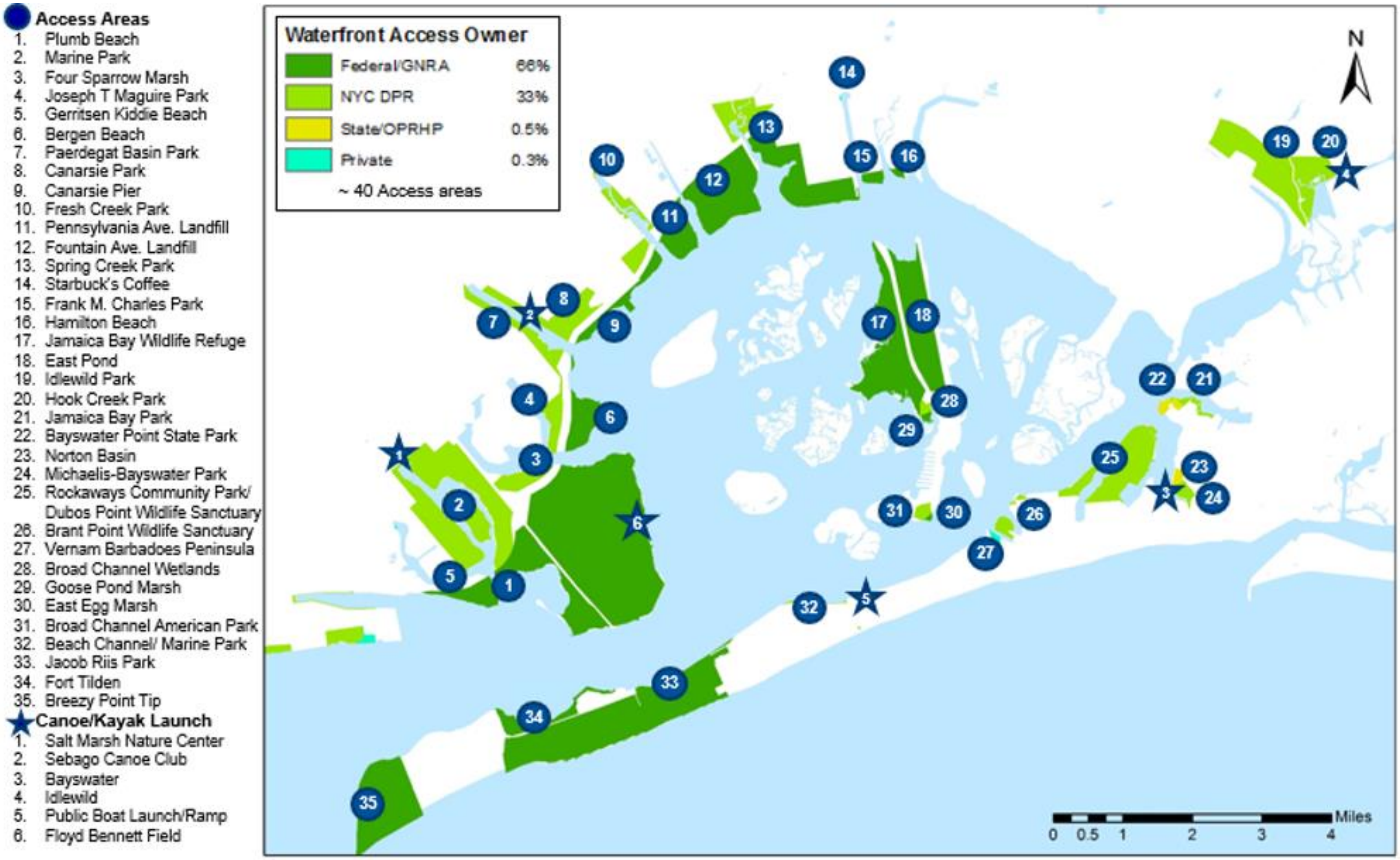

Figure 2. Shoreline Access Locations Along Jamaica Bay and its Tributaries

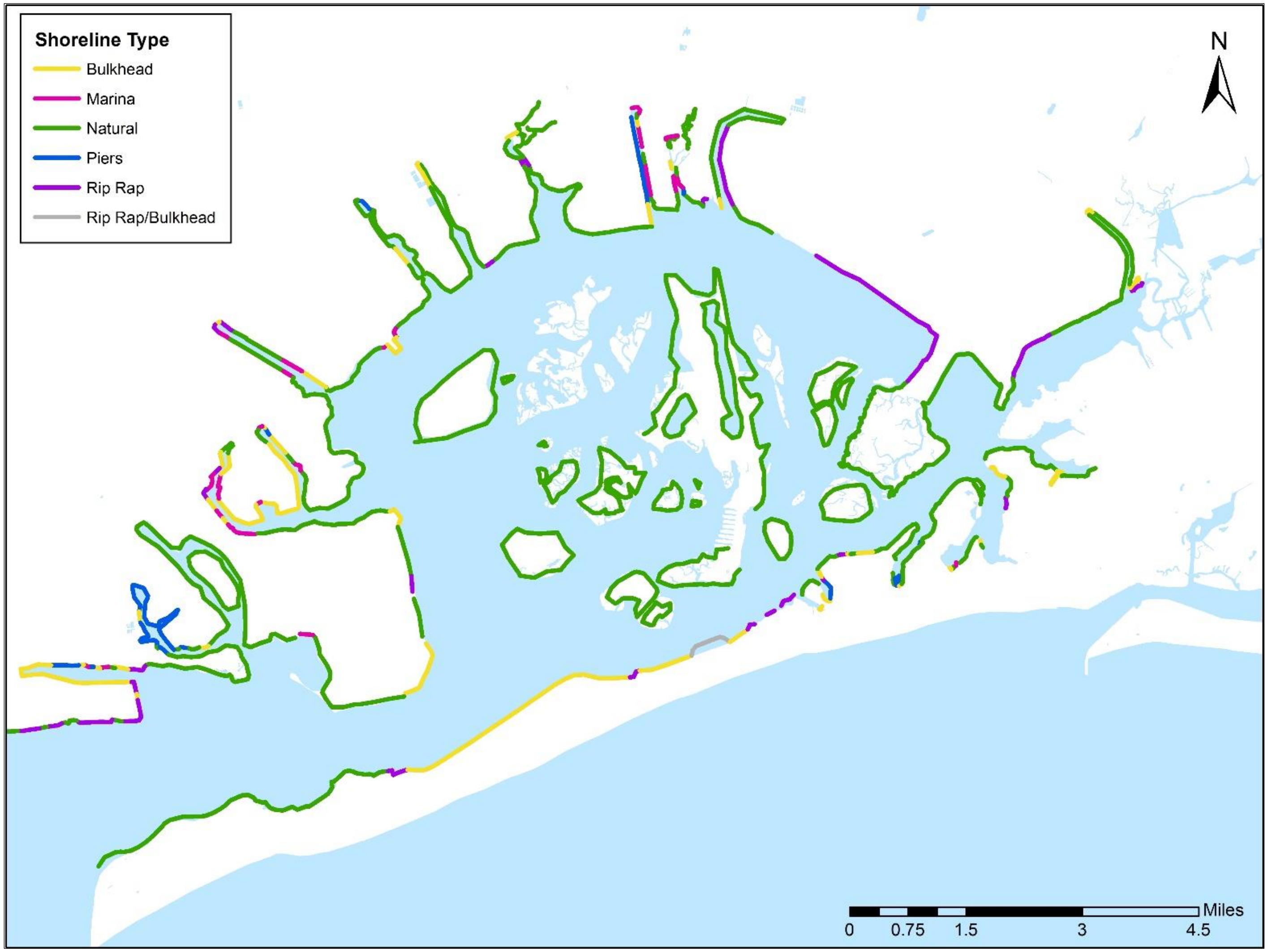

Figure 3. Jamaica Bay Shoreline Characteristics

with rip-rap. Three docks exist off the rear yards of private residences near the confluence of Thurston Basin with Jamaica Bay.

The Hendrix Creek shoreline is composed of a mix of natural areas, rip-rap, and bulkhead. Most of the Hendrix Creek shoreline is composed primarily of natural shoreline except for bulkhead along the head end and the western shoreline adjacent to the 26th Ward WWTP. Docks for sludge transport vessels span the western shoreline of the confluence of Hendrix Creek with Jamaica Bay.

The shoreline of Fresh Creek is composed of a mix of natural areas, rip-rap, and bulkhead. Most of the Fresh Creek shoreline is composed primarily of natural shoreline except for pockets of development with rip-rap shoreline and small pockets of bulkhead.

Based on the analyses summarized above, projected fecal coliform levels do not meet the Existing WQ Criteria on an annual or recreational season (May 1st through October 31st) basis for portions of Bergen Basin and Thurston Basin to which public access is prohibited by JFK Airport security. Station FC1 in Fresh Creek falls just short of the 95 percent metric. Non-attainment of the Existing WQ Criteria at these stations appears to be primarily related to stormwater sources discharging at the head end of these tributaries. This is supported by the gap analysis which indicates that even 100% CSO control would not achieve annual compliance at all of the stations. It is recommended that the current designated uses of the tributaries and Class I 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 I WQ Criteria and the best use of the tributaries could be revised accordingly. DEP will continue to issue wet-weather advisories informed by the time to recovery analyses presented in the Jamaica Bay and Tributaries LTCP. However, it should be noted that although the water quality is projected to be protective of primary contact in Jamaica Bay and the publicly accessible portions of the tributaries during the recreational season (May 1st through October 31st) based on the 10-year continuous model simulation, other factors, such as adjacent land use, prohibited access by JFK Airport security, current marine industrial uses, and safety must be taken into account in considering appropriate uses of the waterbody.

For the Recommended Plan, the 90-day GM<35 cfu/100mL Proposed *Enterococci* WQ Criteria* are attained at all monitoring stations within Jamaica Bay, while the 90-day STV criteria are attained for all stations except J7, which is located at the confluence of Bergen Basin. For 100% CSO control conditions, Station J7 would still not achieve attainment with the 90-day STV criteria. Proposed *Enterococci* WQ Criteria* do not apply to the tributaries.

*Proposed *Enterococci* WQ Criteria, if adopted as proposed, would only apply to coastal Class SB and SA waters.

INTRODUCTION

Regulatory Considerations

The DEC has designated Jamaica Bay as a Class SB waterbody and the tributaries as Class I waterbodies. The best usages of Class SB waters are primary and secondary contact recreation and fishing, while the best usages of Class I waters are secondary contact recreation and fishing. These waters shall also be "suitable for fish, shellfish, and wildlife propagation and survival. In addition, the water quality shall be suitable for primary contact recreation, although other factors may limit the use for this purpose" (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 water quality standard (WQS) in such a case. While Jamaica Bay is projected to achieve attainment with Existing WQ Criteria (Class SB), Thurston Basin, Bergen Basin and Fresh Creek do not meet the Existing WQ Criteria (Class I) for bacteria on an annual or recreational season (May1st through October 31st) basis with the implementation of the LTCP Recommended Plan for a continuous 10-year model simulation. Under baseline conditions, Existing WQ Criteria for DO (Class SB) are projected to be achieved in Jamaica Bay for a 2008 typical year continuous model simulation. However, Existing WQ Criteria for DO in the tributaries (Class I) is projected to be achieved in Paerdegat Basin, Fresh Creek, and Spring Creek. DO attainment in Fresh Creek (94 percent) falls just short of the 95 percent metric. DO at the upstream ends of Bergen Basin and Thurston Basin are projected to achieve 89 and 90 percent attainment, respectively.

This UAA identifies the attainable and existing uses of Jamaica Bay and its tributaries and compares them to those designated by DEC in order to provide data to establish appropriate water quality goals for this waterway. An examination of several factors related to the physical condition of the waterbody and the actual and possible uses suggests that annual attainment of bacteria and DO criteria associated with existing Class SB and I standards is not projected to occur, and even 100 percent CSO reduction would not bring the waterbody into compliance on an annual basis. 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

The waterfront area surrounding Bergen and Thurston Basins is predominantly altered along its banks throughout its length to protect Port Authority of New York and New Jersey (PANYNJ) JFK Airport infrastructure. Due to JFK Airport security restrictions, public access to these waterbodies is prohibited. The majority of the property on either side of Bergen and Thurston Basin is owned by PANYNJ and is fenced to prevent unauthorized access and to secure airport operations. Due to the presence of altered shorelines (piers, bulkheads, and rip-rap), floatables and fuel/oil containment booms, a security fence, and industrial maritime uses, the bulk of Bergen and Thurston Basins is not conducive to primary contact or secondary contact recreation. While secondary contact recreation has been observed at the confluence of these waterbodies with Jamaica Bay, Existing WQ Criteria are being achieved at these locations on an annual and recreational season (May 1st through October 31st) basis. No DOHMH certified bathing beaches exist anywhere within Bergen and Thurston Basins. Figures 4 and 6 illustrate the typical shoreline conditions along Bergen and Thurston Basins. Figure 5 shows the headwall for CSO Outfall JAM-003/003A and rip-rap armor protection along the banks of Bergen Basin to either side of the outfall. Figure 7 shows the floating airport security fence downstream of CSO Outfall JAM-005/007. An airport security vehicle can be seen in the background monitoring use of the waterway. Permission from the U.S. Coast Guard was required to access the upstream reaches of both Bergen and Thurston Basins for each site visit during the development of the LTCP.

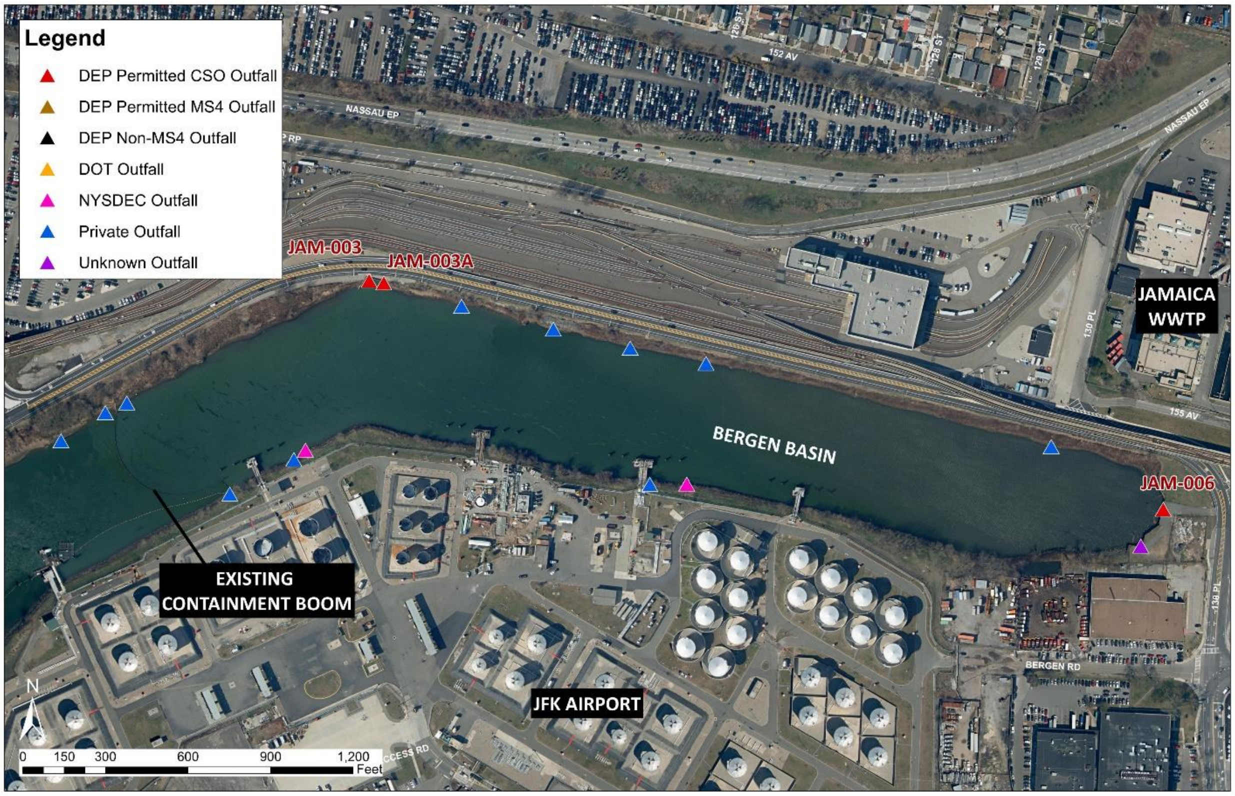

Figure 4. Bergen Basin Shoreline

Figure 5. Bergen Basin Shoreline
(Armored banks and Headwall for JAM-003/003A)

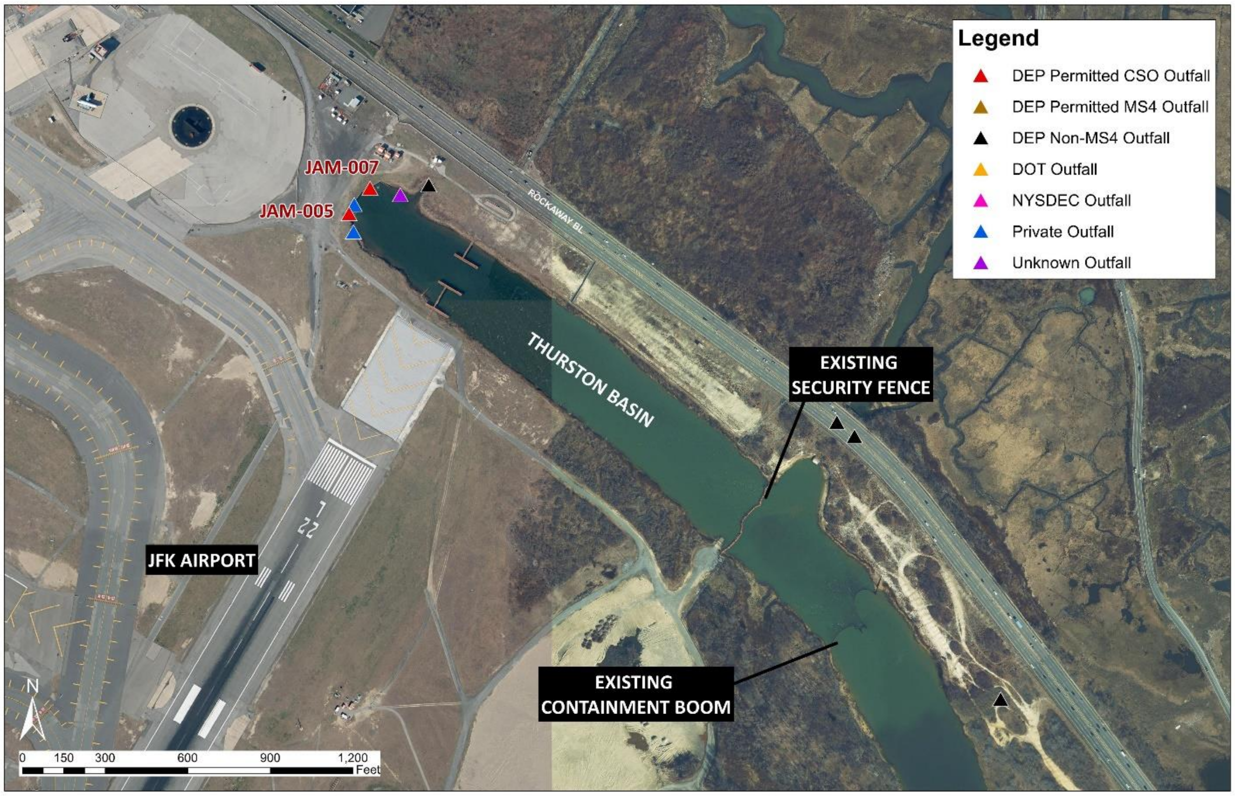

Figure 6. Thurston Basin Shoreline

Figure 7. Thurston Basin Shoreline (Airport Security Fence with Bulkhead and CSO Outfalls JAM-005/007 in Background)

As shown in Figure 8, Hendrix Creek passes between two parks that were created from former landfills at its confluence with Jamaica Bay. The Pennsylvania Avenue Landfill Park is located along the western shoreline, while the Fountain Avenue Landfill Park is located along the eastern shoreline. The creek measures approximately 600 feet wide between the landfills, but narrows to about 190 feet upstream of the Belt Parkway. National Oceanic and Atmospheric Administration (NOAA) charts indicate that the depth of the waterway becomes much shallower (less than 2 feet deep) as the waterway narrows, thereby limiting access to the narrower stretch to small watercraft, particularly during low tide. However, the closest dock or boat launch is the Sebago Canoe Club located in Paerdegat Basin. Existing WQ Criteria at the confluence of Hendrix Creek with Jamaica Bay are attained on an annual and recreational season (May 1st through October 31st) basis, thereby supporting secondary contact recreation activities. The shallow depth and presence of the WWTP along the western shoreline of the upstream reaches discourage secondary recreation. In addition, a floatables boom exists at the upstream end of the creek which prevents small watercraft from accessing the head end of the creek. No DOHMH certified bathing beaches exist anywhere along Hendrix Creek or portions of the northern shore of Jamaica Bay.

Fresh Creek, as shown in Figure 9, is of similar configuration to Hendrix Creek. The width of the waterway ranges from about 300 to 400 feet at the downstream end, but narrows to about 150 feet at a point approximately 2,500 feet north of the Belt Parkway overpass. While the downstream segment is supportive of secondary contact recreation, the depth becomes shallow (less than 3 feet deep) at the point where the creek narrows, significantly limiting access to the upstream reaches of the waterway for boating and fishing. These limitations were confirmed during a field visit by the LTCP2 staff, where the boat's sonar system indicated extremely shallow conditions preventing access to the upstream reaches of the waterway. No docks, marinas, or boat launches exist along Fresh Creek. In addition, no DOHMH certified beaches exist along the creek.

Figure 8. Hendrix Creek Shoreline

Figure 9. Fresh Creek Shoreline

ATTAINMENT OF DESIGNATED USES

The Jamaica Bay tributaries are Class I waterbodies, whose best uses are aquatic life protection, as well as secondary contact recreation. As noted previously, physical features of Thurston Basin, Bergen Basin, Hendrix Creek, and Fresh Creek create obstacles to secondary contact recreation. However, the Recommended Plan includes ecological improvement projects to enhance fish and wildlife habitats.

As part of this LTCP, an analysis was performed to assess the level of attainment of the Existing WQ Criteria for fecal coliform associated with Class I waters, although other factors may preclude the attainment of the use. Water quality modeling analyses performed during the Jamaica Bay and Tributaries LTCP concluded that for a 10-year simulation under baseline conditions, attainment of the Existing WQ Criteria for bacteria during the recreational season (May 1st through October 31st) ranges from 70 percent to 85 percent and 93 percent, respectively, in the upstream reaches of Bergen Basin, Thurston Basin, and Fresh Creek. Attainment in the downstream monitoring stations within these tributaries is 100 percent. Annual attainment ranges from 51 percent to 71 percent and 86 percent, respectively, in Bergen Basin, Thurston Basin, and Fresh Creek in the upstream reaches. Attainment is 100 percent in the downstream monitoring stations approaching the confluence with Jamaica Bay. The non-attainment is due to CSO, direct drainage, airport runoff and other stormwater discharges accruing within these tributaries due to poor tidal flushing conditions, largely due to man-made conditions.

Assessment of compliance upon implementation of the Recommended Plan was evaluated using a 10-year continuous model run. While the Recommend Plan will not achieve annual or recreational season (May 1st through October 31st) attainment of the Existing WQ Criteria for fecal coliform bacteria at all sampling locations in Bergen Basin and Thurston Basin, attainment is achieved at those stations that are not prohibited from public access by JFK Airport security. These accessible stations achieve greater than 95 percent attainment of the Existing WQ Criteria for fecal coliform. Fresh Creek was predicted to achieve 93 percent attainment of the Existing WQ Criteria for fecal coliform during the recreational season at the head of the waterbody. However, all other downstream stations are projected to achieve 100 percent attainment and fully support the intended uses of the waterbody.

Table 1 presents the attainment levels for the Existing WQ Criteria for fecal coliform (monthly GM<200 cfu/100mL) and, for stations in Jamaica Bay only, the Proposed *Enterococci* WQ Criteria*, as determined using the 10-year simulation for the Recommended Plan. Table 1 also presents the attainment with the Class I DO criteria in the tributaries for the 2008 rainfall year. All of the stations in Jamaica Bay met the Class SB DO criteria. As described in Section 8 of the LTCP, the values presented in Table 1 for the 10-year simulation were post-processed to estimate the water quality attainment benefits associated with the installation of ribbed mussels in Bergen and Thurston Basins.

*Proposed *Enterococci* WQ Criteria, if adopted as proposed, would only apply to coastal Class SB and SA waters.

Table 1. Projected Attainment of WQ Criteria for the Recommended Plan

Waterbody	Station	10-Year Simulation				2008 Rainfall Year
		Fecal Coliform Annual Monthly GM <200 cfu/100mL	Fecal Coliform Recreational Season(2) Monthly GM <200 cfu/100mL	*Enterococci* Recreational Season(2)(4) 90-day GM <35 cfu/100mL	*Enterococci* Recreational Season(2)(4) 90-day STV <130 cfu/100mL	Dissolved Oxygen Class I (>4.0 mg/l)
Thurston Basin(1)	TBH1(3)	75	88	N/A	N/A	90
	TBH3(3)	87	92	N/A	N/A	90
	TB9(3)	91	95	N/A	N/A	92
	TB10(3)	99	98	N/A	N/A	92
	TB11	100	100	N/A	N/A	97
Bergen Basin(1)	BB5(3)	59	77	N/A	N/A	89
	BB6(3)	91	95	N/A	N/A	95
	BB7(3)	100	100	N/A	N/A	99
	BB8	100	100	N/A	N/A	100
Hendrix Creek	HC1(3)	98	97	N/A	N/A	94
	HC2	100	100	N/A	N/A	98
	HC3	100	100	N/A	N/A	100
Fresh Creek	FC1(3)	86	93	N/A	N/A	99
	FC2	96	98	N/A	N/A	100
	FC3	100	100	N/A	N/A	100
	FC4	100	100	N/A	N/A	100
Paerdegat Basin	PB1	97	95	N/A	N/A	99
	PB2	100	100	N/A	N/A	100

Table 1. Projected Attainment of WQ Criteria for the Recommended Plan

Waterbody	Station	10-Year Simulation				2008 Rainfall Year
		Fecal Coliform Annual Monthly GM <200 cfu/100mL	Fecal Coliform Recreational Season(2) Monthly GM <200 cfu/100mL	*Enterococci* Recreational Season(2)(4) 90-day GM <35 cfu/100mL	*Enterococci* Recreational Season(2)(4) 90-day STV <130 cfu/100mL	Dissolved Oxygen Class I (>4.0 mg/l)
Jamaica Bay (Northern Shore)	J10	100	100	100	99	N/A
	J3	100	100	100	100	N/A
	J9a	100	100	100	100	N/A
	J8	100	100	100	100	N/A
	J7	100	100	100	55	N/A
	JA1	100	100	100	95	N/A
Jamaica Bay (Inner Bay)	J2	100	100	100	100	N/A
	J12	100	100	100	100	N/A
	J14	100	100	100	100	N/A
	J16	100	100	100	100	N/A
Jamaica Bay (Rockaway Shore)	J1	100	100	100	100	N/A
	J5	100	100	100	100	N/A

Notes:

(1) Values were post-processed from 10-year simulations to estimate the water quality attainment benefits associated with the installation of ribbed mussels in Bergen and Thurston Basins
(2) The recreational season is from May 1st through October 31st.
(3) Monitoring station is located in a portion of the waterbody where access is prohibited by JFK Airport security and/or prevented by a physical barrier.
(4) These proposed criteria, if adopted as proposed, will not apply to the tributaries to Jamaica Bay.

Upon implementation of the LTCP Recommended Plan, Existing WQ Criteria for DO (Class I) is projected to be attained on an annual basis at least 95 percent of the time for the accessible portions of Bergen Basin, Thurston Basin, and Hendrix Creek. DO attainment at the inaccessible portions of these waterways ranges from 89 to 94 percent.

Table 1 shows that the 90-day GM<35 cfu/100mL Proposed *Enterococci* WQ Criteria* are attained at all monitoring stations within Jamaica Bay, while the 90-day STV criteria are attained for all stations except J7, which is located at the confluence of Bergen Basin. Attainment of the GM criteria indicates that water quality is supportive of the designated uses. However, the lower percent attainment of the STV criteria at Station J7 indicates that wet-weather events may peridically impact designated uses in the vicinity of that station.

CONCLUSIONS

Bergen Basin, Thurston Basin, and Fresh Creek do not attain the Existing WQ Criteria (Class I) for bacteria under baseline conditions. These waterbodies cannot fully achieve the Existing WQ Criteria for fecal coliform on an annual basis, even with 100% CSO control. However, the analyses show that with the Recommended Plan, Existing WQ Criteria for fecal coliform is projected to be attained in the unrestricted segments of these waterways throughout the recreational season (May 1st through October 31st) based on continuous 10-year simulation. Regardless of the timeframe used to assess compliance, bacteria levels will be elevated during and after rain events. No permitted swimming locations exist along these waterways. Thus, the non-attainment of swimmable standards during and after rainfall or during the non-recreational season (November 1st through April 30th) would not impact such uses. Secondary contact recreation has been reported in these waterbodies, although physical features limit the extent of those activities.

Under baseline conditions, Bergen Basin, Thurston Basin, and Hendrix Creek do not attain the Existing WQ Criteria (Class I) for DO. Under 100% CSO control conditions, DO attainment in Hendrix Creek improves from 94 to 95 percent; however, Bergen and Thurston Basins do not achieve attainment. The analysis of the Recommended Plan projects DO attainment in Bergen and Thurston Basins to be 89 and 90 percent, respectively, at the head ends of these waterways. Attainment of DO standards in the unrestricted segments of the Bergen and Thurston Basins exceeds the 95 percent metric and is supportive of aquatic life.

Non-attainment of the Existing Class I WQ Criteria is attributable to the following UAA factors:

Fecal Coliform:

- Human caused conditions (direct drainage and urban runoff) create high bacteria levels that prevent the attainment of the use and that cannot be fully remedied for large storms (UAA factor #3).

DO:

- Human caused conditions (direct drainage and urban runoff) create low DO levels that prevent the attainment of the use and that cannot be fully remedied for large storms (UAA factor #3).

*Proposed *Enterococci* WQ Criteria, if adopted as proposed, would only apply to coastal Class SB and SA waters.

It should be emphasized that the Bergen Basin, Thurston Basin, and Fresh Creek watersheds, although surrounded by commercial and industrial uses in most areas, provide very few shoreline access points for on-shore and in-water recreation, limiting the ability of the public to take advantage of the recreational uses of these waterways. These uses should be protected in recreational periods, with the exception of during rain events when advisories will be in place.

RECOMMENDATIONS

The head ends of Bergen Basin, Thurston Basin, and Fresh Creek are not projected to attain the Existing WQ Criteria for fecal coliform (Class I) on an annual or recreational basis, even with 100% CSO control. Upon implementation of the Recommended Plan, Existing WQ Criteria is attained in the unrestricted portions of these waterways on an annual and recreational seasonal basis (based on a 10-year continuous model run). Recreational season (May 1st through October 31st) compliance in the segments of these waterways to which public access is prohibited by JFK Airport security would be in the range of 77 to 93 percent, and annual compliance would be slightly lower. However, as noted above, no DOHMH sanctioned locations for primary contact recreation exist along these waterbodies, and physical features limit the extent of secondary contact recreation. The current uses are primarily associated with on-shore activities at specific access locations, as well as boating/kayaking facilitated by the Sebago Canoe Club boat launching location.

The Class I criteria for DO are projected to be attained in the tributaries to Jamaica Bay except for the upstream ends of Bergen and Thurston Basin. Those locations would not achieve attainment even with 100% CSO control. Under the Recommended Plan, DO attainment in Bergen and Thurston Basins is projected to be 89 and 90 percent, respectively, at the head ends of these waterways. Attainment of the Class I criteria for DO in the publicly accessible segments of Bergen and Thurston Basins exceeds the 95 percent metric and is supportive of aquatic life.

The above conclusions support that Bergen Basin, Thurston Basin, Fresh Creek, and Hendrix Creek should remain as designated Class I waterbodies after the implementation of the LTCP Recommended Plan. Future Post-Construction Compliance Monitoring data collection efforts may later support a revision of the best uses and designated WQ classification for these waterways.

Appendix D: Modeling Approach for Estimating the Pathogen Bioextraction in Jamaica Bay and Tributaries, June 19, 2018

The New York City Department of Environmental Protection (DEP) has proposed the use of nutrient and pathogen bioextraction methods through the placement of *Geukensia demissa* (ribbed mussels) in two of the tributaries to Jamaica Bay that receive combined sewer overflows (CSOs) during wet-weather. The proposed introduction of *G demissa* to Thurston and Bergen Basins is a component of the Recommended Plan to be presented in the Jamaica Bay and Tributaries CSO Long Term Control Plan (LTCP). Potential benefits of installing *G demissa* include bacteria and nutrient reduction, improved water clarity, and improving ecological habitat. These benefits would accrue during both dry- and wet-weather conditions, as the filtering action would occur continuously and potentially provide greater benefits as the population density increases over time.

Studies of the potential use of *G. demissa* for nutrient and pathogen bioextraction in the Bronx River in New York, and in the Chesapeake Bay area have indicated that *G. demissa* may be effective in reducing pollutants. Although not the proposed configuration and density (~2,500 mussels/m^2) we are implementing, the Ribbed Mussel Pilot Study in the Bronx River, New York reported the following findings (http://longislandsoundstudy.net/our-vision-and-plan/clean-waters-and-healthy-watersheds/nutrient-bioextraction-overview/ribbed-mussel-pilot-study/):

- Laboratory experiments with ribbed mussels showed that after three days of submersion, there were no differences in feeding between the intertidal and submerged mussels. These results support the use of ribbed mussels for bioextraction purposes using traditional mussel aquaculture techniques.

- The native ribbed mussel populations were studied by a shellfish pathologist and compared to a population in a suburban environment to look at occurrence of physiological abnormalities and disease. There were no significant differences in the health of the urban and suburban mussels.

- The ribbed mussels demonstrated a high tolerance of a wide range of environmental conditions. For this reason, researchers believe the ribbed mussel is a good candidate for use in future nutrient bioextraction projects.

  Researchers were also able to use measurements of mussel feeding to determine that a fully stocked, one-acre raft of ribbed mussels would filter 19 million gallons of water every day, removed 1,358 pounds of particles. These filtration rates will vary depending on density of ribbed mussels.

A study of biofiltration potential of ribbed mussel populations conducted by the Virginia Institute of Marine Science characterized the ribbed mussel population along the York River, Virginia, and estimated their water processing potential (https://scholarworks.wm.edu/cgi/viewcontent.cgi?referer=https://www.bing.com/&httpsredir=1&article=1703&context=reports).

The findings from that study included the following:

- Ribbed mussels were most abundant within the first meter of the marshes. Mussel abundance was highly variable among marsh types/position.

- Fringing marshes along the main stem of the river possessed the highest average number of mussels. Even though they were smaller in number of mussels in creek, fringing marshes had the highest average biomass (0.7 g dry weight [DW] of tissue) compared to other marsh types (0.24 g DW).

- The mussel population on the York River was estimated to be ~ 197 million animals (range: 8.3 to 313 million, 95% CI). The water filtration potential of mussels on the York River is between 111 and 464 million liters per hour (mean: 286 million L/hr) on the basis of observed biomass and previously estimated clearance rates. These filtration rates will vary depending on the density of ribbed mussels.

Other literature indicates that *G. demissa* are effective at filtering bacteria sized particles from the water column. DEP is interested in quantifying the effect of *G. demissa* if they were deployed as a means to reduce bacteria and nutrients in NYC waters. Several modeling approaches were considered in an effort to quantify the effect of bioextraction methods on bacteria concentrations. This memorandum presents the modeling approaches considered, and describes the selected approach.

Approach Option 1 – Modify Existing Filter Feeder Model

The first approach that was considered was to modify an existing filter feeder model to represent the filtration processes of *G. demissa*. HDR has a filter feeder model that was developed for use in the Jamaica Bay Eutrophication Model (HydroQual, 2002), but the model is set up based on the filtration of phytoplankton by hard clams (*Mercenaria mercenaria*), which have different filtering rates and efficiency than *G. demissa*. Without the data to calibrate the existing model, this approach was seen as too complicated and time consuming to pursue for the Jamaica Bay and Tributaries LTCP, given time constraints and limited data to calibrate and validate the model.

Approach Option 2 – Represent Filtering as an Effective Settling Rate

The second approach to modeling involved calculating an effective settling rate that would represent the bacteria loss due to filtering. The effective settling rate would then be incorporated into the existing Jamaica Bay Eutrophication Model.

Based on available data for *G. demissa* filtration rates, a filtering rate of 5.1 L/hr-g was estimated by Kreeger (unpublished data as reported in Bilkovic and Mitchell 2014) along with *G. demissa* biomass of 0.7 g dry weight per individual. Riisgaard (1988) developed a power function for *G. demissa* filtration of

$$F = 6.15W^{0.83}$$

where F is filtration in L/hr and W is the dry weight biomass of the *G. demissa*. These rates indicate that filtration rates change with the size of the organism, but rates can also change with temperature, oxygen levels, and available food (Wilbur et al., 1989; Jorgensen et al., 1990; Aldridge et al., 1995; Kittner and Riisgard, 2005; Galimany et al., 2013). Using an estimated weight of 0.7 g, an individual *G. demissa* could filter approximately 100 L/d or 0.1 m^3/d.

DEP reviewed several *G. demissa* density levels for placement in Bergen and Thurston Basins. For planning purposes, a moderate *G. demissa* density of 2,500 mussels/m^2 was selected for consideration in the modeling analysis (the final configuration of the *G. demissa* colonies will be determined during the implementation phase). Using the filtration rate of 0.1 m^3/d, an effective settling rate can be calculated that can be applied as a loss term in a model.

$$V_{se} = \text{Density*Filtration Rate} = 2{,}500 \text{ mussels/m}^2 * 0.1 \text{ m}^3\text{/ mussel-day} = 250 \text{ m/day}$$

where V_{se} is the effective settling velocity in m/day.

G. demissa do not filter bacteria with 100 percent efficiency. That is, not all of the bacteria that are filtered by *G. demissa* will be retained. Riisgard (1988) reported that *G. demissa* could filter down to a particle size of 4 µm with close to 100 percent efficiency, and down to 2 µm with 35-70 percent efficiency. *E. coli* is approximately 1 to 3 µm in size. *Clostridium perfringens* is approximately 4 to 8 µm, and *Enterococcus* are approximately 1 to 2.5 µm in size. These sizes are within the particle size filtering capability of *G. demissa*, although at different uptake efficiencies for each. *G. demissa* are known to filter particle sizes less than 2 µm (e.g., clay particle sizes down to 1 micron) with lower efficiencies. *Clostridium* would be filtered at closer to the 100 percent efficiency range, and the *E. coli* and *Enterococcus* would be filtered closer to the 35 to 70 percent efficiency range. Fecal coliform covers a group of bacteria, which includes bacteria from non-feces origins. *E. coli* is included within the fecal coliform group, so it can be expected that filtering efficiencies for fecal coliform bacteria would be similar to *E. coli.* Langdon and Newell (1990) estimated that *G. demissa* can filter unattached bacteria with an efficiency of 15.8 percent of the efficiency of larger particle filtration. Kemp et al. (1990) estimated the efficiency of filtration of bacteria by ribbed mussels to be 25-56 percent/hr.

Kemp's estimates of filtration efficiency, which include a time component, bring up other uncertainties as to how much water in a tributary flows within the area of influence of filtration by ribbed mussels and how long the water remains within the area of influence. Based on the filtering efficiency of *G. demissa* and water contact efficiency of *G. demissa* deployment, the actual effective settling rate could be less than the estimated effective settling calculated above. However, it should be noted that the filtering effects and proposed density of the *G. demissa* for Bergen and Thurston Basins would be occurring constantly, in both dry- and wet-weather conditions, providing constant benefits in terms of reduction in bacteria and nutrient concentrations in the waterbody.

To provide some insight as to how effective *G. demissa* could be in reducing bacteria concentrations, two model sensitivities were conducted using the Jamaica Eutrophication Model. The Bergen Basin portion of the Jamaica Eutrophication Model is represented by a series of connected model cells or segments. In both cases, an effective settling rate was applied to one model segment downstream of the CSO outfall in Bergen Basin to replicate the deployment of *G. demissa* racks. One model sensitivity run used an effective settling rate of 5 m/day, and the other used an effective settling rate of 50 m/day. The current formulation of the model allows bacteria to settle up to 5 m/day, so the model sensitivities provide insight into the effect of doubling the rate of settling or increasing it by approximately an order of magnitude while staying within the theoretical maximum of 250 m/day. If the model showed the additional settling representing the *G. demissa* filtering had no impact on percent attainment of water quality criteria, then the concept of using *G. demissa* could be discarded. If the model showed the potential for improved attainment, then the concept could move forward. The impact was assessed on both the existing water quality criteria for bacteria (fecal coliform monthly geometric mean (GM) less than or equal to 200 cfu/100mL), and Proposed *Enterococci* WQ Criteria* (*Enterococci* 90-day GM of 35 cfu/100mL and 90-day, 90th percentile statistical threshold value [STV] of 130 cfu/100mL).

*Proposed *Enterococci* WQ Criteria, if adopted as proposed, would only apply to coastal Class SB and SA waters.

The results of the model sensitivity analyses are presented in Table 1. As indicated in Table 1, the model sensitivities showed that *G. demissa* could be effective in reducing bacteria concentrations and improving the percent attainment with GM concentration bacteria water quality criteria. The additional settling had no impact on 90th percentile STV criteria attainment. However, due to the uncertainties in the calculations, and since no data were available to confirm the use of an equivalent settling rate to represent the removal of bacteria by *G. demissa*, this methodology was not adopted for the Jamaica Bay and Tributaries LTCP.

Table 1. Calculated 2008 Attainment at BB5 Based on Effective Settling Sensitivities

Criteria	Percent Attainment of Criteria at Station BB5		
	Baseline(1)	Additional 5 m/day Settling	Additional 50 m/day Settling
Fecal Coliform Monthly GM (200 cfu/100mL)	50%	58%	100%
Enterococci 90-day GM (35 cfu/100mL)(2)	0%	26%	100%
Enterococci 90-day STV (130 cfu/100mL)(2)	0%	0%	0%

Note:
(1) Note the final LTCP baseline was not completed at the time these sensitivities were conducted. Results were based on an earlier baseline configuration, but the relative performance should not be significantly affected.
(2) These criteria, if adopted as proposed, will not apply to the tributaries to Jamaica Bay.

Approach Option 3 – Simplified Approach Applying a Percent Reduction to Completed Model Results

In order to provide estimates of bacteria concentrations due to the influence of filtration by *G. demissa* that could be included in the LTCP, a simplified and conservative approach was applied. Rather than directly model the effects of *G. demissa*, a percent reduction in bacteria concentration was applied to existing model output to approximate the reduction of bacteria due to filtering. Based on the review of literature referenced above, low end estimates of filtration could justify a 10 percent reduction in bacteria where *G. demissa* would be installed. Model runs were completed using the LTCP preferred alternative conditions, and then a 10 percent reduction of model calculated concentrations in the waterbodies, where the *G. demissa* colonies would be located, was applied as part of post-processing the model output to represent the impact of the *G. demissa* colonies.

The literature indicates that the application of a 10 percent reduction could be a conservatively low level of filtration, given that *G. demissa* would filter the bacteria and nutrients constantly, during both dry- and wet-weather. An optimized sub-tidal design and deployment of *G. demissa* could provide a higher level of bacteria and nutrient reduction.

Conclusions

The installation of *G. demissa* as a bioextraction method has good support in the literature. Ribbed mussels have high filtration rates and are more efficient than other bivalves at filtering small particles. In addition, they are native to Jamaica Bay and would not be considered an attractive nuisance since they are not consumed by humans. Modeling suggests that the placement of *G. demissa* in waterbodies with high bacteria concentrations would be effective in reducing bacteria concentrations and improve attainment with water quality standards. The results indicate that it is reasonable to apply a 10 percent reduction to the modeled bacteria concentrations in Bergen and Thurston Basins to account for the placement of *G. demissa* in those Jamaica Bay tributaries. This approach will be the basis for the performance of the *G. demissa* colonies presented in the Jamaica Bay and Tributaries LTCP. It is anticipated that additional studies and analyses will be conducted during the implementation phase to provide further support of the design and performance of the *G. demissa* colonies.

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Appendix E: Technical Memorandum on Further Evaluation of Outfall Disinfection for Outfalls JAM-005 and JAM-007 in Thurston Basin, June 29, 2018

As described in Section 8 of the Jamaica Bay and Tributaries Long Term Control Plan (LTCP), the New York City Department of Environmental Protection (DEP) evaluated a range of CSO control alternatives for outfalls JAM-005 and JAM-007, which discharge to Thurston Basin. Following a preliminary analysis of alternatives, a number of alternatives were retained for more detailed evaluations based on relative cost, performance and benefits. Although disinfection was identified as a potential low cost alternative, it was not retained as part of this preliminary evaluation due to siting constraints, constructability issues, and operational concerns. Based on technical discussions with the New York State Department of Environmental Conservation (DEC), DEP developed this technical memorandum to provide additional details on the disinfection alternative, and based on information provided, DEP has deemed that disinfection is not a viable alternative for this particular waterbody. DEP also notes that in addition to these technical challenges that during public outreach for this LTCP and others, many public participants voiced fundamental concerns about the use of disinfection as a CSO management technology.

Summary of Alternative

The concept for the outfall disinfection alternative for Outfalls JAM-005 and JAM-007 is presented in Figure 1. Due to space constraints and other issues described later on in this memo, the concept for this alternative includes the installation of a sodium hypochlorite feed system that would add chlorine into two double barrel conduits near 148th Avenue. The analysis assumed that an above ground chlorination facility would be constructed on a vacant Parks Department parcel of land located at the intersection of 148th Avenue and 226th Street. An above ground dechlorination facility would be sited near the Outfalls JAM-005 and JAM-007 on a parcel of land in Idlewild Park or potentially JFK Airport. The dechlorination feed line would be located along the 2-quadrupple barrel outfall barrels located on JFK property. To address the tidal impacts and ensure adequate contact time, tide gate chambers would need to be installed on all eight of the outfall barrels.

The JAM-007 outfall is a quadruple barrel outfall that starts near 148th Avenue, and each barrel is 17 feet wide by 6 feet high with an approximate length of 4,500 feet. The JAM-005 outfall starts as a double barrel outfall downstream of regulator 6, and each barrel is 13.5 feet wide by 8 feet high with an approximate length of 2,600 feet. It then transitions to a quadruple barrel just south of Rockaway Boulevard, with each barrel 16 feet wide by 8 feet high, with an approximate length of 2,300 feet. The transition from the double barrel to a quadruple barrel outfall occurs just south of Rockaway Boulevard, where the outfall picks up stream flow from a stream that runs along Rockaway Boulevard.

Siting

As shown in Figure 1, the evaluation considered siting the chlorination facility on a vacant Parks Department parcel at the corner of 148th Avenue and 226th Street with an approximate 7,500 square-foot land area. If DEP acquired this parcel for the chlorination facility, the chemical feed piping would likely have to pass through Idlewild Park property. An access road may be required through the park both during construction and for permanent access for maintenance of the chlorination facility and delivery of sodium hypochlorite to the site. The proximity of the construction to the wetlands of Idlewild Park would create additional permitting challenges. The sodium hypochlorite diffusers and flow meters would need to

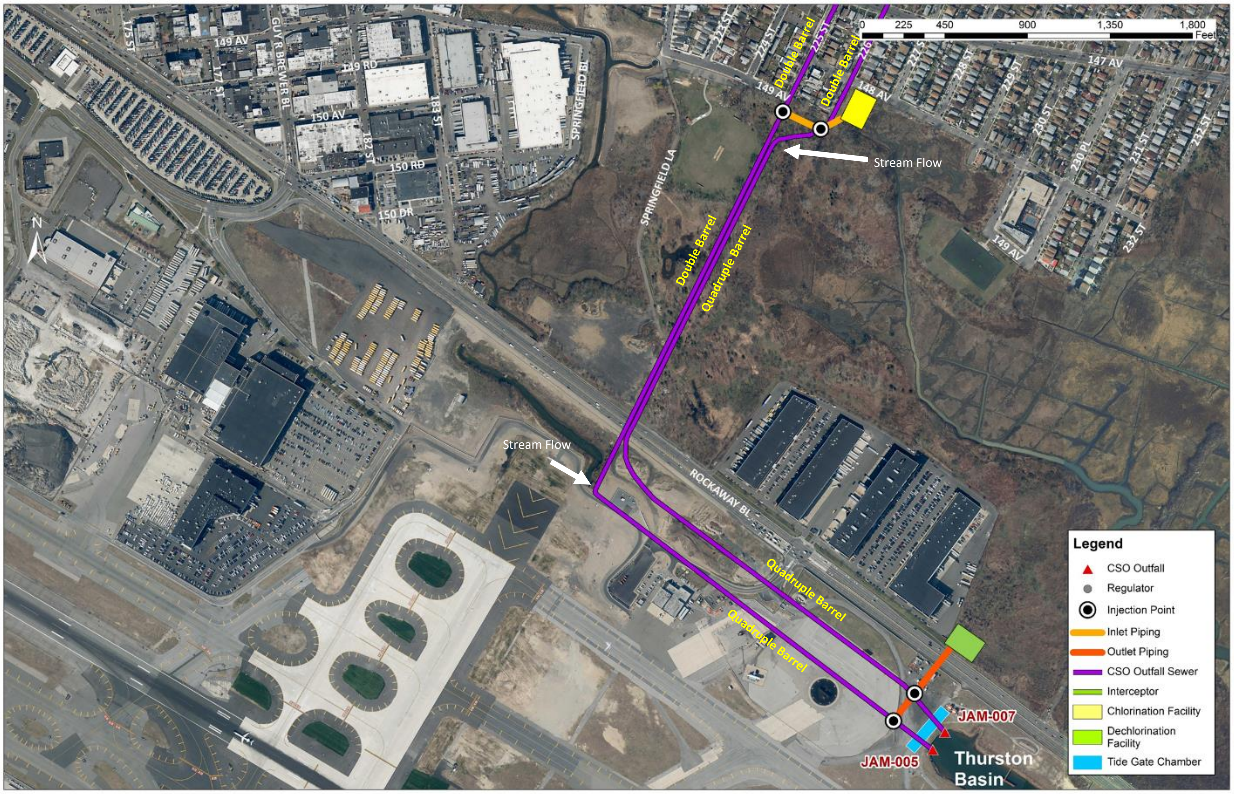

Figure 1. Layout of Alternative for Outfall Disinfection of CSOs JAM-005/007

be installed in the two existing double barrel conduits and this construction work would take place either within or immediately adjacent to the park property.

The dechlorination building would need to be sited either in Idlewild Park or within a secure area of the JFK Airport property. Installation of the sodium bisulfite feed system, flow meters, and tide gates would all need to be installed within JFK Airport property. Therefore, coordination and approval from the Port Authority of New York and New Jersey (PANYNJ) would be required to install that equipment and likely a modification of the long-term lease between the City and the PANYNJ, with an uncertain outcome. Siting of the dechlorination building within Idlewild Park would likely require park alienation legislation. Thus, siting would be extremely challenging and could require lengthy legal processes, the outcomes of which are beyond the sole control of DEP or the City.

Construction

The main construction challenges associated with this alternative derive from the proximity of the work to Idlewild Park and JFK Airport. The chlorination facility, dechlorination facility and the chemical dosing points are located in close proximity to the flight paths of two of the JFK Airport runways. Construction at these selected locations would be constrained by equipment height restrictions as well as other restrictions imposed by FAA/PANYNJ for construction work within runway flight paths. Construction in and adjacent to Idlewild Park would require additional permitting and mitigation measures to minimize the impacts on the parkland as well as likely requiring park alienation legislation. These construction challenges, alone, make this project unfeasible.

Operations

Operability of this disinfection system would be extremely challenging, as sodium hypochlorite feed would need to be controlled into two double barrel conduits, each with significantly different water quality characteristics and extremely variable flow rates. An additional complication to operability is that additional stormwater and stream flow is introduced into the outfall barrels downstream of the chlorination location. Finally, dechlorination would need to be introduced downstream into the two quadruple outfall barrels, each of which would likely have significantly different water quality characteristics and extremely variable flow rates. This is unlike disinfection at a wastewater treatment plant in which the wastewater characteristics and flow rates are much more consistent. Precise control of disinfection is especially important for this project in light of the plan to utilize rib mussels to improve water quality, as rib mussels are particularly sensitive to chlorine toxicity. The outfall disinfection alternative for Outfalls JAM-005 and JAM-007 presents a number of serious operational challenges that, in addition to the siting and construction issues noted above, make this required level of control infeasible to achieve reliably.

Sodium Hypochlorite Dosing Control. For reliable disinfection to occur, the sodium hypochlorite will need to be fed into each of the two double barrel conduits upstream of the JAM-005 and JAM-007 outfalls. The water quality characteristics in these four upstream conduits would likely vary greatly depending on a range of unpredictable parameters including rainfall intensity, sewer system hydraulics, duration, etc. In addition, the amount of sodium hypochlorite dosed to each barrel would need to be controlled independently as dosage regimens can't be standardized under these conditions. Further, the variability of contact time requirements for effective disinfection to occur within these barrels would be critically dependent on quantities and quality of flow being disinfected, for which robust and reliable hypochlorite dosing control system would need to be developed.

Sodium Bisulfite Dosing Control. For reliable dechlorination to occur, the sodium bisulfite would need to be fed into each of the eight outfall barrels just prior to being discharged from CSO outfalls JAM-005 and JAM-007. Again the water quality characteristics and flow rates in each of these barrels will likely vary greatly, requiring a robust and reliable sodium bisulfite control strategy to be developed. In addition, stormwater and stream flow is introduced downstream of the hypochlorite dosing points that further complicates the overall effectiveness and operability of this disinfection alternative. Having to control the sodium hypochlorite and bisulfite dosing into so many multiple barrels, with such greatly variable flow rates and water quality characteristics, is a major difference between this alternative and previously recommended CSO LTCP disinfection alternatives (Alley Creek, Hutchinson River, and Flushing Creek).

Thurston Basin directly feeds the Head of Bay where active oyster demonstration projects are located. The remnant effects of a disinfection process could result in residual chlorine, or the improper dosage of sodium bisulfate for dechlorination could result in depressed DO, both of which could have an adverse impact on sensitive population of aquatic organisms.

O&M Access to Sodium Bisulfite Dosing Location and Tide Gates. The sodium bisulfite feed system, monitoring equipment, and tide gates would need to be located on JFK Airport property, where access is restricted.

Tidal Impacts. The inverts of the JAM-005 and JAM-007 outfalls are just above the mean low water elevation, and the crowns are just above mean high water. Tide gates would need to be provided as part of this alternative to keep the tidal backwater out of the outfalls. However, the contact time within the outfalls would vary depending on the tide stage during the rainstorms.

Cost/Performance Assessment

As described above, the outfall disinfection alternative for Outfalls JAM-005 and JAM-007 presents a number of serious siting, construction and operational challenges that make this alternative infeasible to construct and operate effectively. Thus, DEP had not initially prepared cost/performance curves for this potential project. However, DEP has now plotted the JAM-005 and JAM-007 outfall disinfection alternative on curves for cost versus fecal coliform load reduction (Figure 2), and cost versus percent attainment with existing and proposed Water Quality Criteria* (Figures 4 to 9). Figure 3 shows the locations of the water quality stations plotted in Figures 4 to 9. Consistent with the approach for outfall disinfection alternatives presented in other approved LTCPs under this program, it was assumed that the disinfection system would be operated only during the recreational season (May 1st to October 31st). Given the uncertainties over the disinfection process control, it was further assumed that a 50 percent bacteria load reduction would be achieved during the recreational season. Figure 2 presents points representing the recreational season load reduction (approximately 50%), and the annual load reduction (approximately 25%) for the outfall disinfection alternative.

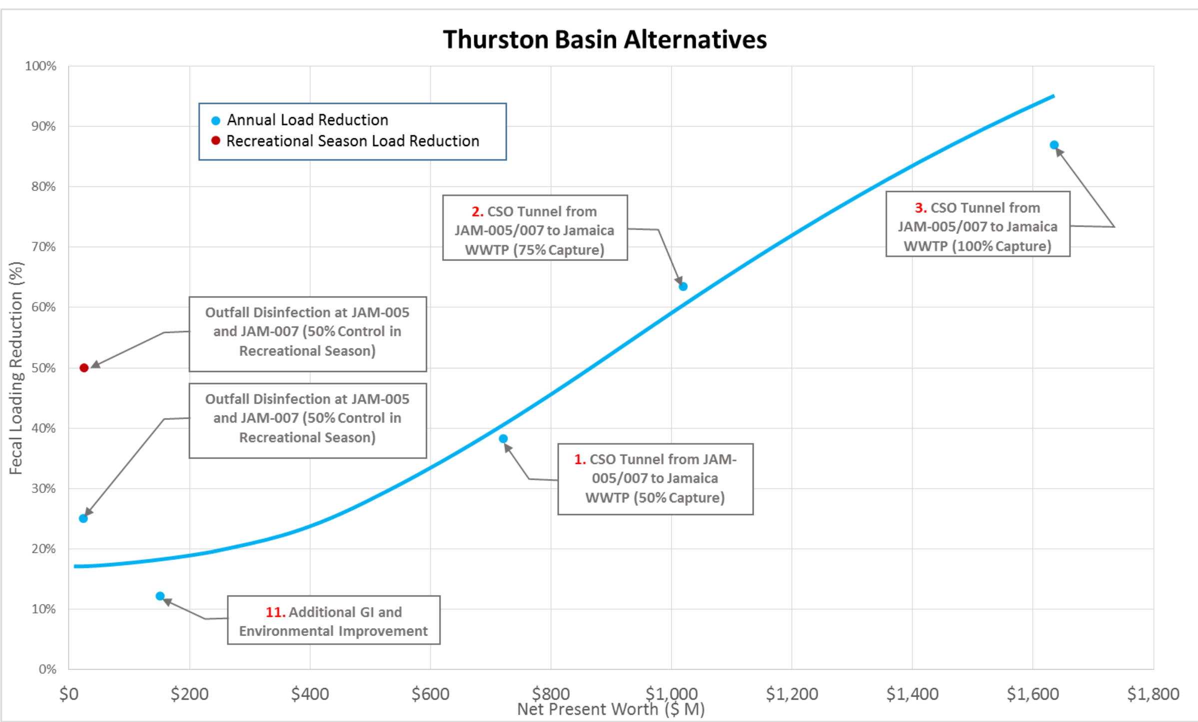

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Figure 2. Cost Versus Fecal Coliform Loading Reduction for Thurston Basin

*Proposed *Enterococci* WQ Criteria, if adopted as proposed, would only apply to coastal Class SB and SA waters.

Figure 3. Location of Water Quality Stations in Thurston Basin

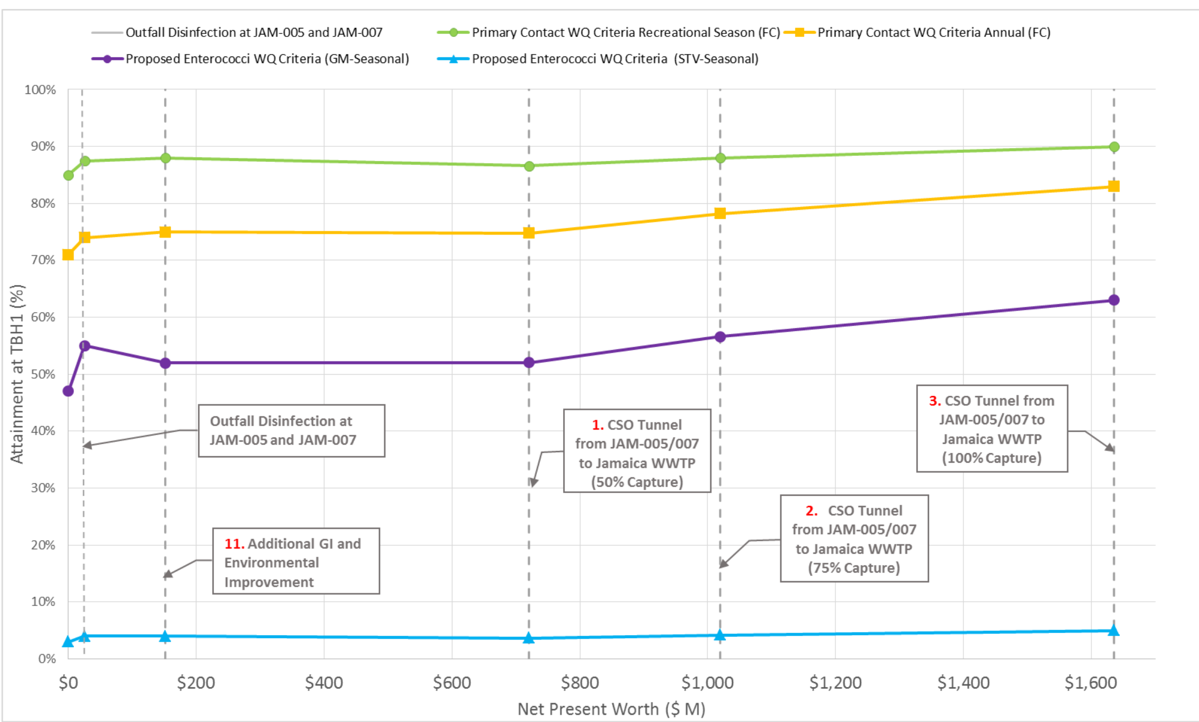


Figure 4. Cost versus Percent Attainment at TBH1

*Proposed *Enterococci* WQ Criteria, if adopted as proposed, would only apply to coastal Class SB and SA waters.

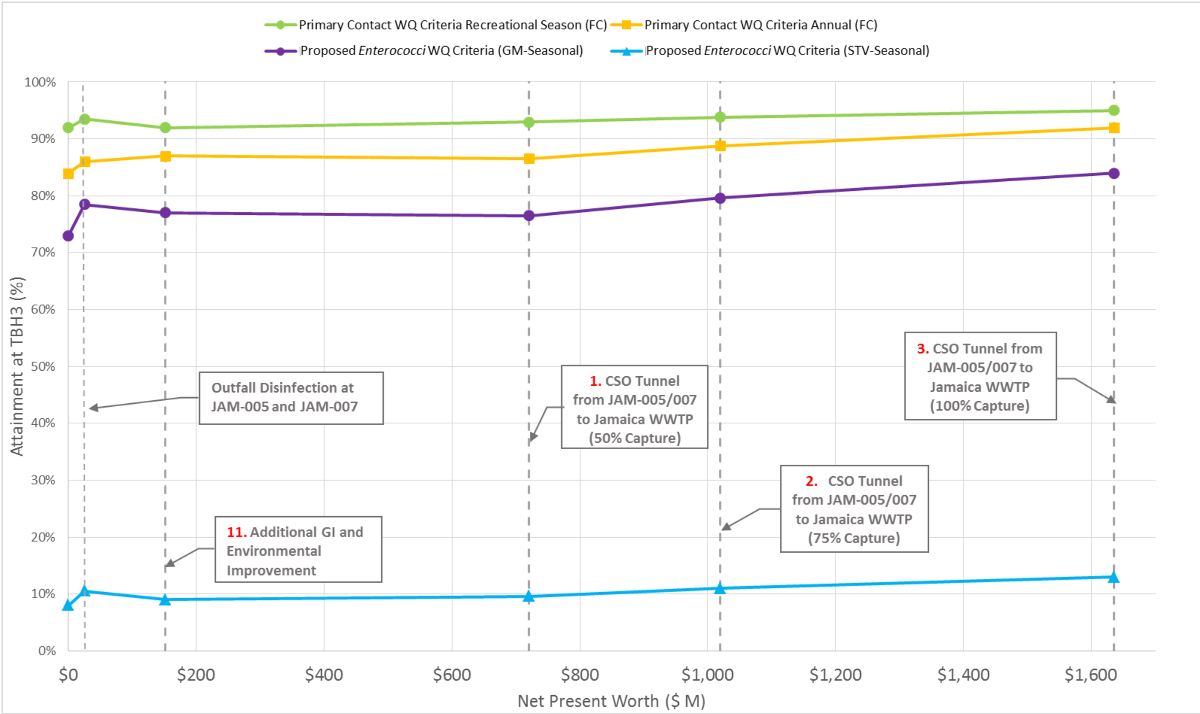


Figure 5. Cost versus Percent Attainment at TBH3

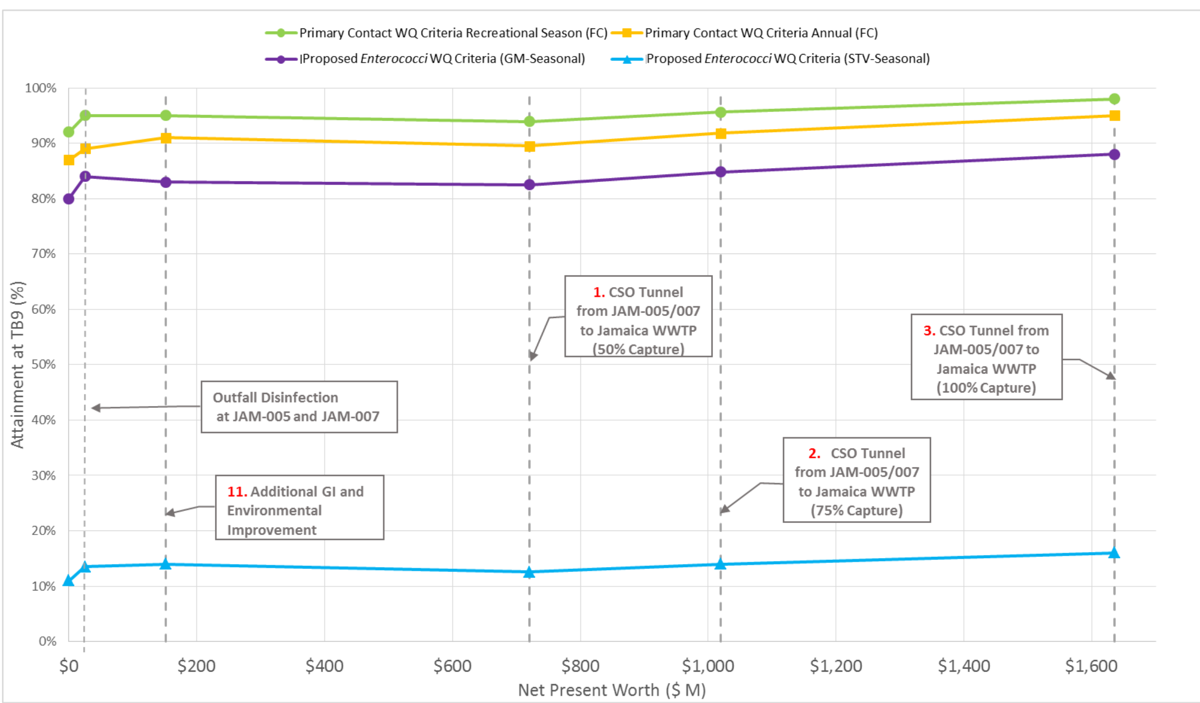


Figure 6. Cost versus Percent Attainment at TB9

*Proposed *Enterococci* WQ Criteria, if adopted as proposed, would only apply to coastal Class SB and SA waters.

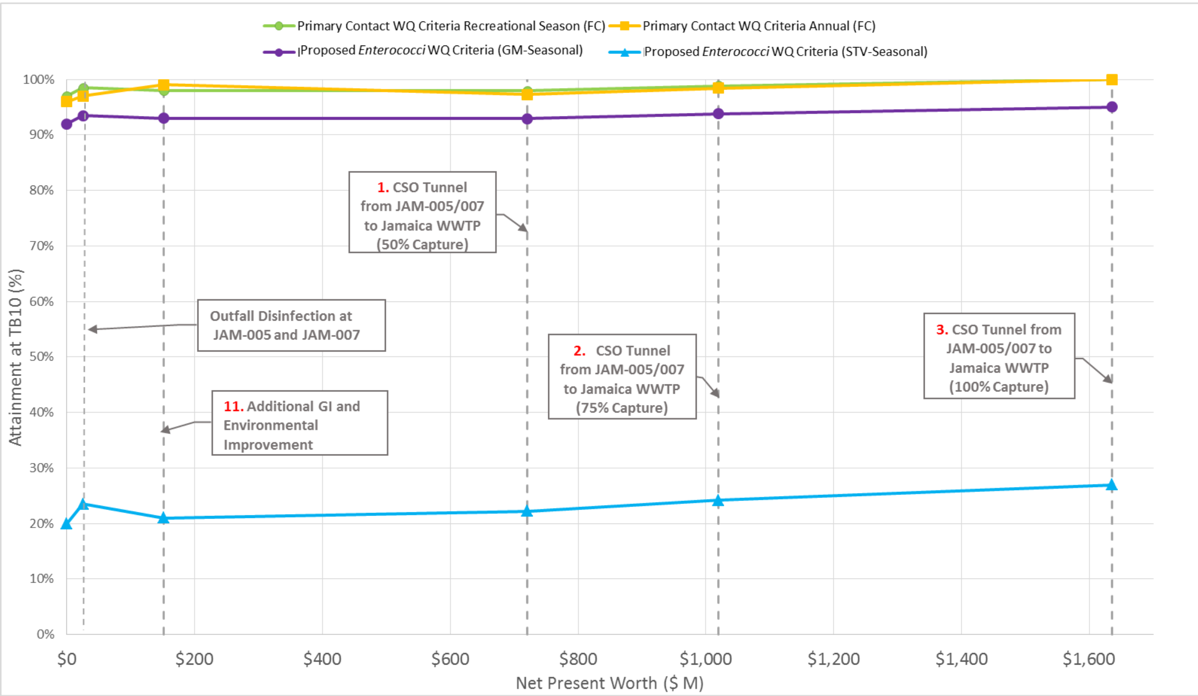


Figure 7. Cost versus Percent Attainment at TB10

Figure 8. Cost versus Percent Attainment at TB11

*Proposed *Enterococci* WQ Criteria, if adopted as proposed, would only apply to coastal Class SB and SA waters.

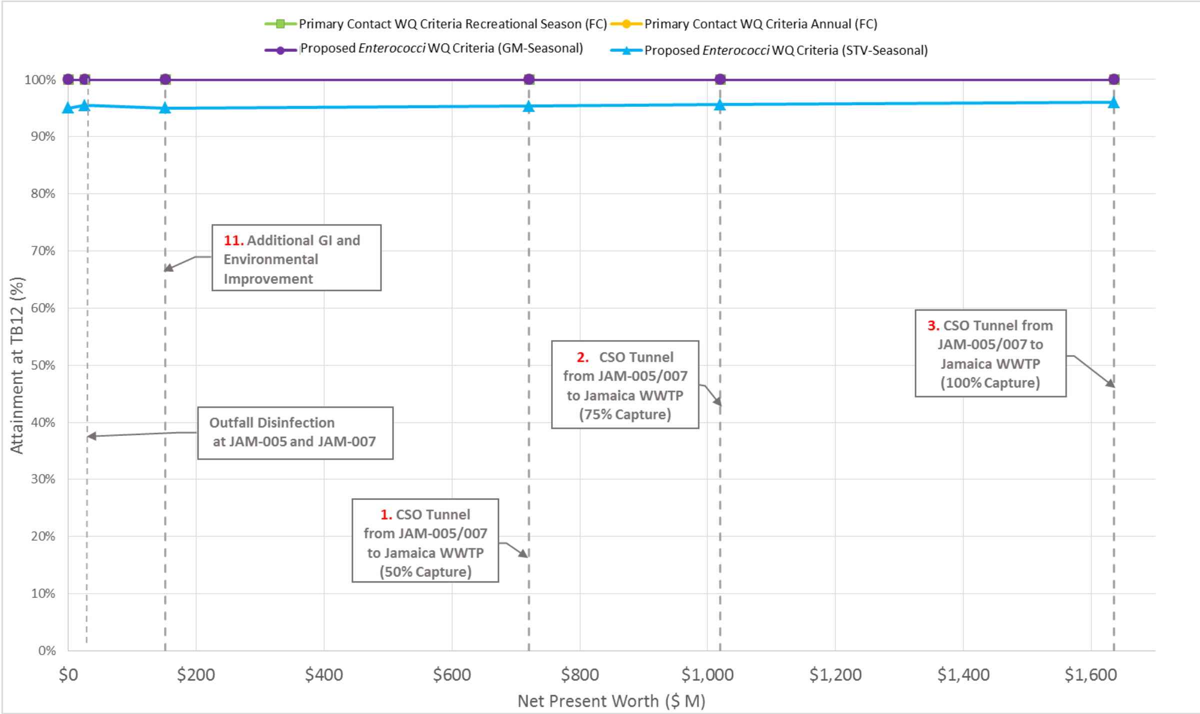


Figure 9. Cost versus Percent Attainment at TB12

For the cost versus percent attainment curves, the percent attainment for the outfall disinfection alternative was interpolated based on load reductions relative to other alternatives. As indicated in Figure 2, and assuming the outfall disinfection alternative was buildable and operable, this alterative would theoretically provide marginal benefits when compared to bacteria load reduction from the recommended plan. However, as indicated in Figures 4 to 9, it would not significantly improve attainment of water quality standards. The recommended plan presented in the LTCP would provide a more sustainable and reliable approach to mitigating wet weather impacts to Thurston Basin and therefore, DEP does not recommend further pursuing disinfection for this LTCP.

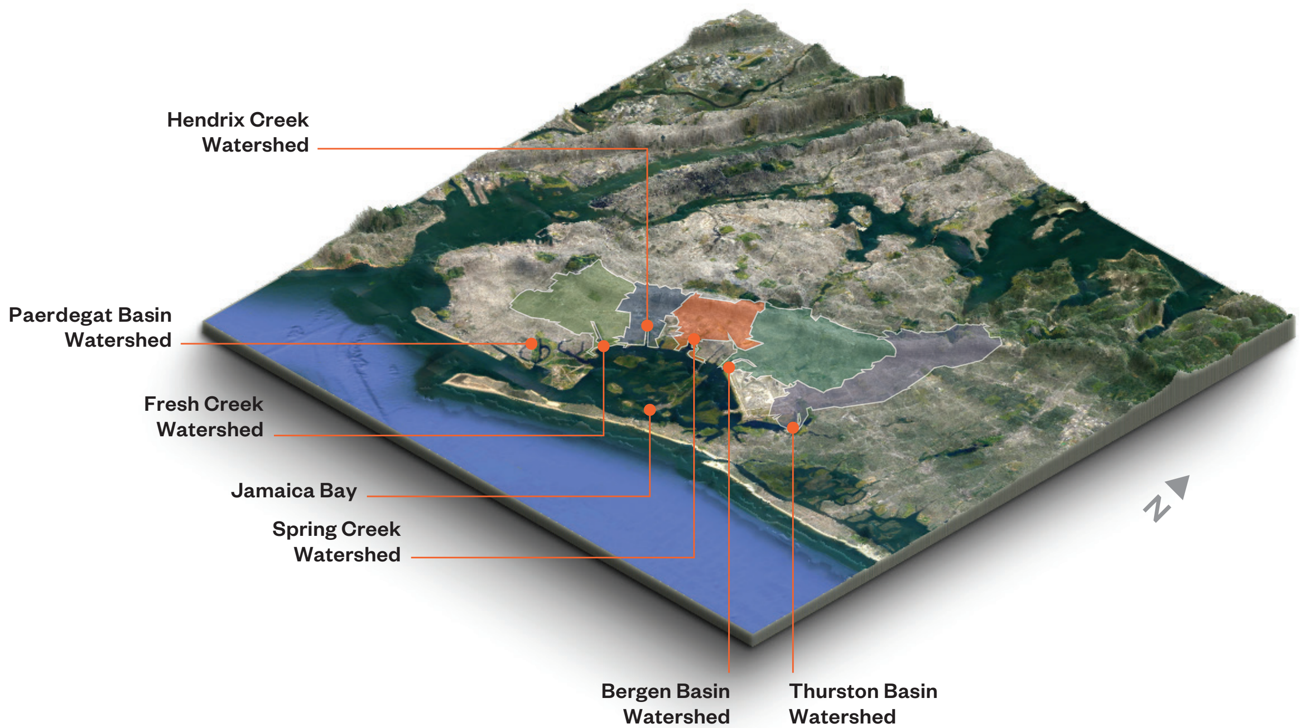
Discussion

The siting, construction, and operational challenges for a disinfection facility, as described above, further support DEP's decision not to retain this alternative for final consideration in the LTCP. Taken together, the siting and construction issues are quite challenging. Critically, the operational challenges related to process control called into question whether the facilities could be reasonably operated in a manner that would consistently achieve the bacteria reduction goals without creating risks of chlorine residual impacts in the receiving waters. Because of the multiple outfall barrels, the additional stream flow entering the outfall, and the tidal impacts, it is not at all clear how a control strategy could be developed to consistently achieve the intended two-log bacteria kills while at the same time ensuring that the chlorine residual is minimized. Since ribbed mussels are proposed for Thurston Basin as part of the recommended plan, lack of reliable control of the chlorine residual could adversely affect the ribbed mussels, as well as other aquatic species in Thurston Basin.

*Proposed *Enterococci* WQ Criteria, if adopted as proposed, would only apply to coastal Class SB and SA waters.

Appendix F:
The Recommended Plan for Jamaica Bay and Tributaries

Provides economic, social and environmental co-benefits beyond what can be achieved through a traditional Grey Infrastructure approach of underground CSO Storage Tunnels.



Jamaica Bay

26 000 acres of water, islands, marshes and shorelines

Wildlife Preserves

Parks

Marinas

Recreational Boating and Fishing

Historically, Jamaica Bay has served as an important ecological resource for many flora and fauna. The Bay has evolved as an important and complex network of open water, salt marsh, grasslands, coastal woodlands, maritime shrub lands, brackish and freshwater wetlands. Jamaica Bay , one of the largest coastal wetland ecosystems in New York State, is a component of the National Park Service's Gateway National Recreation Area.

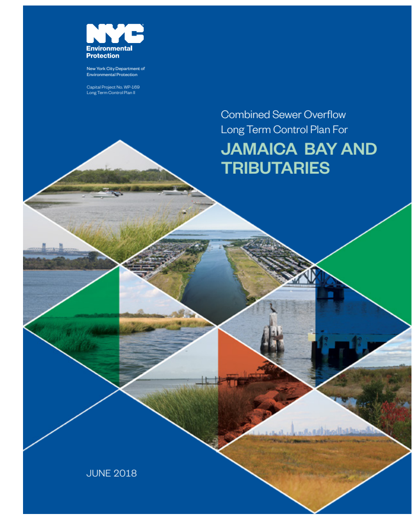
This LTCP has been developed in an effort to better understand and address CSO impacts on water quality within Jamaica Bay. Throughout the process for developing this LTCP, DEP collected water quality data, performed extensive collection system and water quality modeling, held multiple public meetings and analyzed potential CSO control alternatives based on costs and model predicted water quality improvement.

The selection of the Recommended Plan was based on multiple considerations including:

- Public input
- Environmental and water quality benefits
- Community and societal impacts
- Issues related to implementation, operation and maintenance (O&M)
- Cost-performance and cost-attainment evaluations

THE RECOMMENDED PLAN

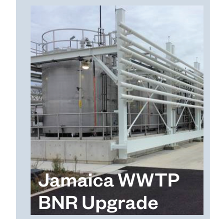
- Can be implemented in 14 years as opposed to retained grey alternatives projected to take over 25 years
- Provides higher levels of water quality attainment at much lower cost than grey alternatives
- Supplements prior grey infrastructure improvements while providing holistic environmental, social, and economic benefits



- Additional 379 greened acres in Bergen and Thurston Basin tributary areas
- 7 acres of ribbed mussel colony creation
- 50,000 CY of environmental dredging in Bergen Basin
- 50 acres of wetland restoration
- Reduce CSO discharges to Bergen and Thurston Basins by 15 MGY
- Reduce Stormwater discharges by 234 MGY
- Provide air quality improvement
- Carbon footprint reduction
- Habitat creation
- Heat island construction reduction
- Property value improvement
- Water quality improvement through the filtering of the ribbed mussels

WATER QUALITY IMPROVEMENTS

Achieved through Strategic Investments

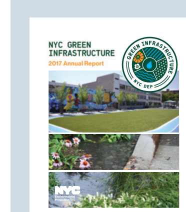


$600 Million
Biological Nutrient Reduction (BNR) Upgrades across four wastewater treatment plants (JA, 26W, RK, and CI) that discharge to Jamaica Bay

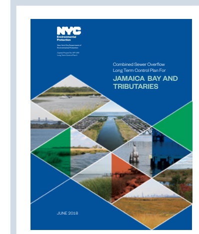
$32 Million
Ecosystem Restoration and Research Efforts to support pathogen reduction and dissolved oxygen improvement under the Jamaica Bay Watershed Protection Plan

$1 Billion
Past and Existing Grey Infrastructure investments to reduce combined sewer overflows

$1.7 Billion
Southeast Queens Sewer Buildout commitment over the next decade under the OneNYC Plan



$300 Million
Existing and Planned Green Infrastructure commitment over the next decade under the OneNYC Plan



LTCP Recommended Plan will build upon these past investments and provide further water quality improvements.