NYC Environmental Protection

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

Combined Sewer Overflow Long Term Control Plan for Flushing Bay

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Department of Environmental Protection
Bureau of Wastewater Treatment

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EXECUTIVE SUMMARY

This Executive Summary is organized as follows:

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- Findings — A summary of the key findings of the water quality (WQ) data analyses, the WQ modeling simulations and the alternatives analysis.
- Evaluations and Conclusions — A list of assessments that are consistent with the Federal Combined Sewer Overflow (CSO) Control Policy and the Clean Water Act (CWA).

1. BACKGROUND

The New York City Department of Environmental Protection (DEP) prepared this Long Term Control Plan (LTCP) for Flushing Bay 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 New York State Department of Environmental Conservation (DEC). Pursuant to the CSO Order, DEP is required to submit 11 waterbody-specific LTCPs to DEC for review and approval. The Flushing Bay LTCP is the eighth of these LTCPs.

As described in the LTCP Goal Statement in the 2012 CSO Order, the goal of each LTCP is to identify, with public input, appropriate CSO controls necessary to achieve waterbody-specific water quality standards (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 water quality 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 setting of WQS. In NYS, CWA regulatory and permitting authority has been delegated to DEC.

DEC has designated Flushing Bay as a Class I waterbody. 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. 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-1 shows the Flushing Bay watershed.

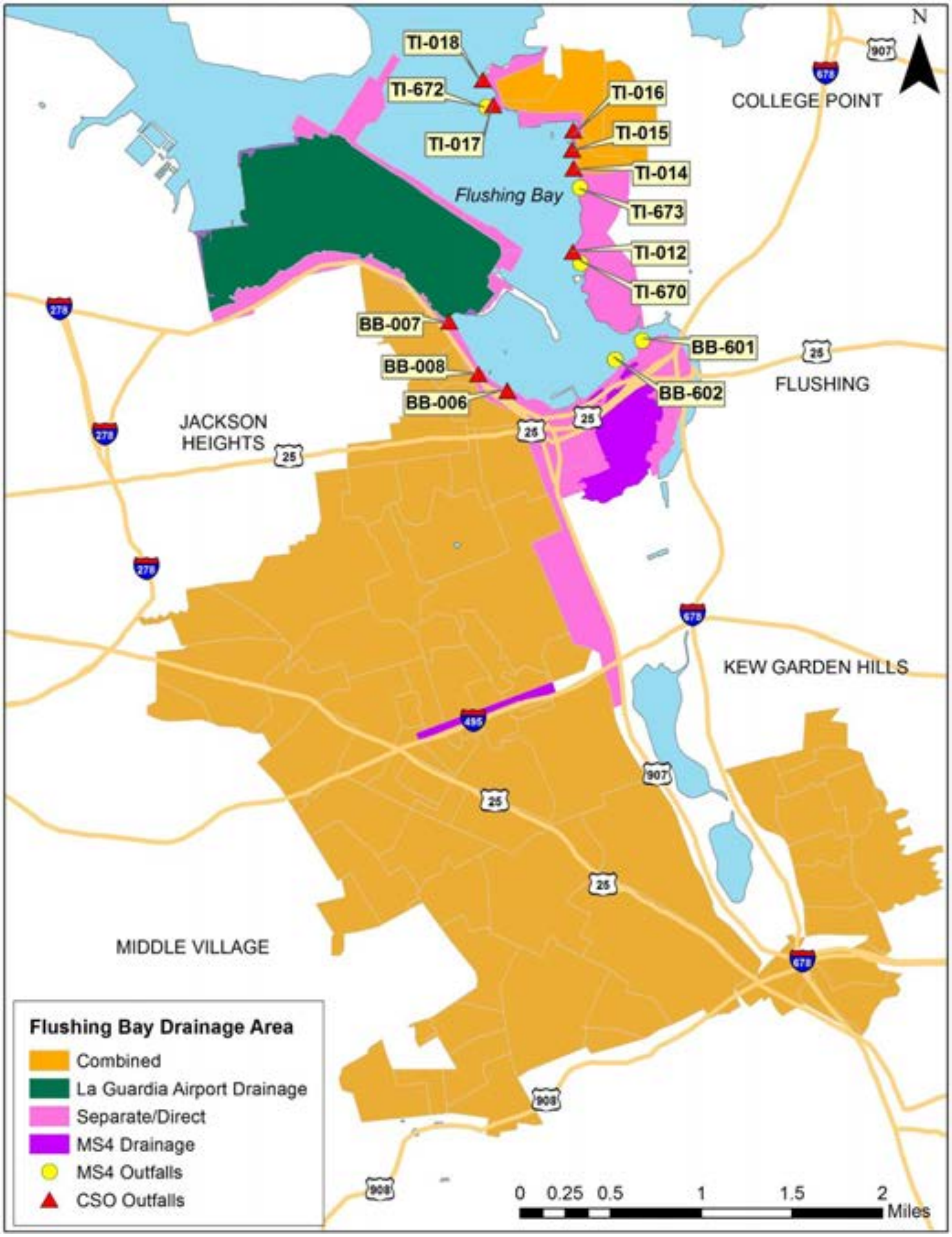

Figure ES-1. Flushing Bay Watershed Characteristics and Associated WWTP Sewershed

The criteria assessed in this Flushing Bay LTCP include the Existing WQ Criteria (Class I) and Dissolved Oxygen (DO) Class SC criteria. Enterococci criteria do not apply to tributaries such as Flushing Bay under the Beaches Environmental Assessment and Coastal Health (BEACH) Act of 2000. However, because the 2012 EPA Recreational Water Quality Criteria (RWQC) recommended certain changes to the bacterial water quality criteria for primary contact, this LTCP includes attainment analyses for both current WQ Criteria and for the proposed 2012 EPA RWQC (referred to hereinafter as the "Potential Future Primary Contact WQ Criteria"). These criteria include a 30-day rolling geometric mean (GM) for enterococci of 30 cfu/100mL with a not-to-exceed 90th percentile statistical threshold value (STV) of 110 cfu/100mL.

Table ES-1 summarizes the Existing WQ Criteria, Bacteria Primary Contact WQ Criteria/DO Class SC Criteria and Potential Future Primary Contact WQ Criteria applied in this LTCP.

Table ES-1. Classifications and Standards Applied

Analysis	Numerical Criteria Applied	
Existing WQ Criteria	Class I	Fecal Monthly GM ≤ 200; DO never <4.0 mg/L
Bacteria Primary Contact WQ Criteria / DO Class SC(1)	Class SC	Fecal Monthly GM ≤ 200 DO between > 3.0 & ≤4.8 mg/L(1, 3); DO never < 3.0 mg/L(1)
Potential Future Primary Contact WQ Criteria(2)	Entero: rolling 30-d GM – 30 cfu/100mL Entero: STV – 110 cfu/100mL	

Notes:
GM = Geometric Mean; STV = 90 Percent Statistical Threshold Value
(1) This water quality standard is not currently assigned to Flushing Bay.
(2) DEC has not yet adopted the Potential Future Primary Contact 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.

Flushing Bay Watershed

Flushing Bay watershed characteristics, including the Bay's CSO and stormwater outfalls, are shown in Figure ES-1. Flushing Bay is a saline waterbody located to the east of LaGuardia Airport and north of Willets Point in the Borough of Queens. Flushing Bay is tributary to the East River. Water quality in Flushing Bay is influenced by multiple sources including stormwater discharges, dry-weather sources and CSOs. The Flushing Bay watershed comprises approximately 6,877 acres and the majority of the land immediately surrounding the shoreline is utilized for recreational, transportation and commercial purposes. The urbanization of NYC and the Flushing Bay watershed has led to the creation of a large combined sewer system and smaller pockets served by separate sanitary and storm sewer systems, including its companion stormwater outfalls that discharge directly to the Bay. The Flushing Bay watershed is served by both the Bowery Bay Wastewater Treatment Plant (WWTP) and Tallman Island

WWTP. Dry-weather flow is conveyed to the WWTPs for treatment. During wet-weather, the combined sewage flow that exceeds the capacity of the WWTP may discharge through any one or more of the nine State Pollution Discharge Elimination System (SPDES)-permitted CSO Outfalls to Flushing Bay. Table ES-2 summarizes the model projected annual volume and frequency of overflow for each SPDES-permitted CSO Outfall under the CSO LTCP selected baseline conditions as described on page ES-13. A total of five DEP owned Municipal Separate Storm Sewer System (MS4) outfalls also discharge to Flushing Bay. Figure ES-2 illustrates the location of the MS4 outfalls as well as Department of Transportation (DOT) outfalls and other stormwater discharge points to Flushing Bay.

Table ES-2. CSO Discharges Tributary to Flushing Bay (2008 Typical Year)

Combined Sewer Outfalls	Location	Discharge Volume (MGY)	No. of Discharges	Percentage of Total CSO Discharge to Flushing Bay
BB-006 UL(2)	Inner Flushing Bay	631	45	43.4%
BB-006 LL(2)	Inner Flushing Bay	258	29	17.8%
BB-007	Inner Flushing Bay	38	40	2.6%
BB-008	Inner Flushing Bay	478	47	32.9%
TI-012	Outer Flushing Bay	0	0	0.0%
TI-014(1)	Outer Flushing Bay	10	37	0.7%
TI-015(1)	Outer Flushing Bay	3	20	0.2%
TI-016(1)	Outer Flushing Bay	29	45	2.0%
TI-017(1)	Outer Flushing Bay	2	21	0.1%
TI-018(1)	Outer Flushing Bay	4	34	0.3%
Total CSO	Flushing Bay	1,453		

Notes:

(1) To be separated as part of the College Point Sewer Separation Project as referenced in the WWFP.
(2) Outfall BB-006 is a single permitted outfall and statistics have been provided for each level of the two tiered outfall.

LL=lower level; UL=upper level; MGY=million gallons year

Green Infrastructure

Flushing Bay is a priority watershed for DEP's Green Infrastructure (GI) Program. The overall goal of the program is to saturate priority watersheds with GI to maximize benefits and cost effectiveness, based on the specific opportunities in each watershed. DEP has installed or plans to install over 1,000 GI assets, including right-of-way (ROW) practices, public property retrofits, and GI implementation on private properties, to manage approximately (2.8 percent impervious acres) in the Flushing Bay watershed. From these installations, modeling predicts a 52 MG reduction in annual CSO volume, based on the 2008 baseline rainfall condition.

As LTCPs are developed, model-based baseline GI penetration rates for each watershed may be adjusted based on the adaptive management approach described in Section 5.2, and as additional information on field conditions, feasibility, and costs becomes available. Figure ES-3 shows the current contracts in progress near CSO Outfalls BB-006 and BB-008 in Flushing Bay. DEP will continue to pursue additional GI opportunities beyond the baseline assumptions and will make necessary adjustments as needed.

Figure ES-2. Flushing Bay Outfalls

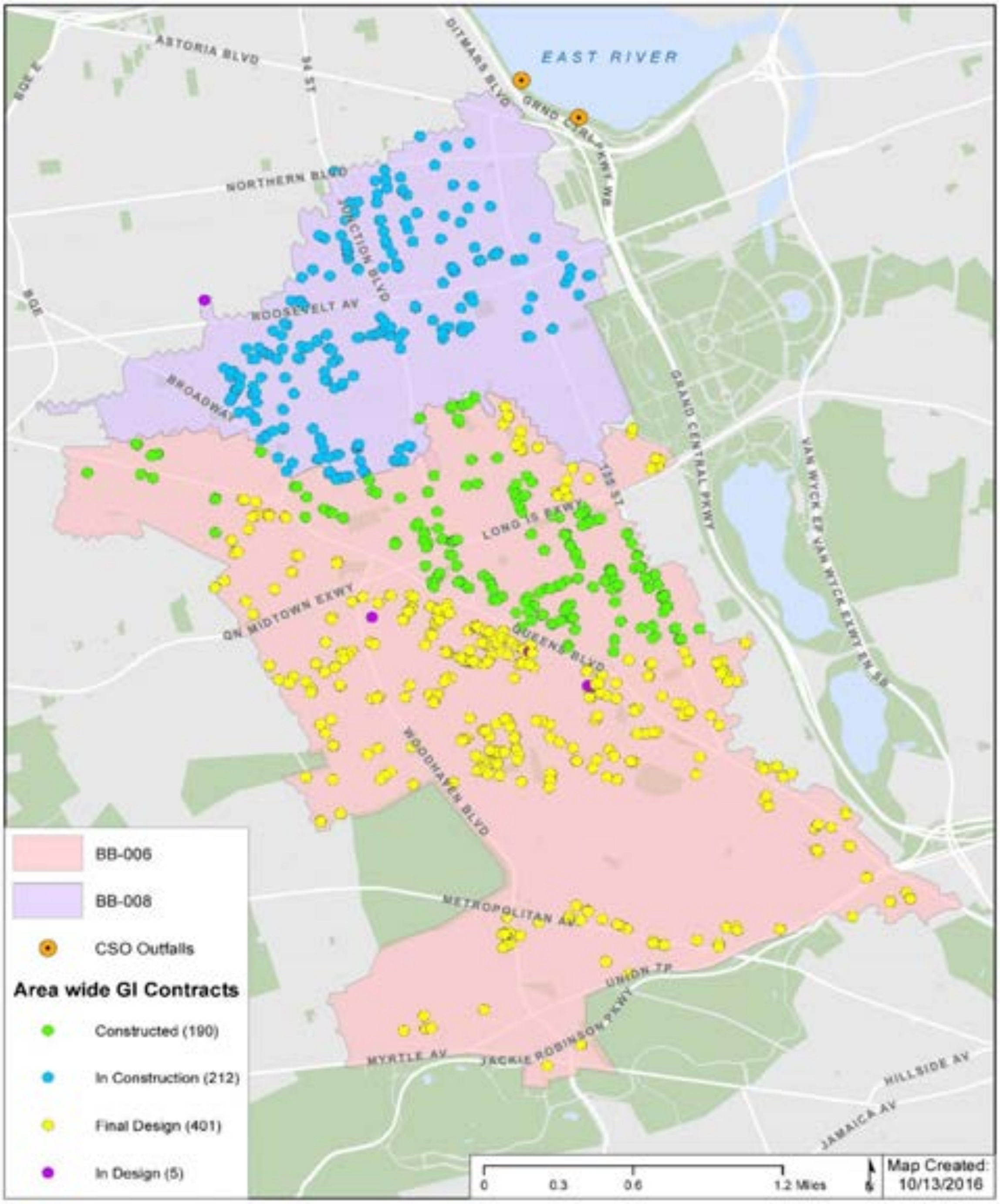

Figure ES-3. Green Infrastructure Projects in Flushing Bay

2. FINDINGS

Current Water Quality Conditions

Data collected within Flushing Bay are available from sampling conducted by DEP's Harbor Survey Monitoring Program (HSM) program between 2007 and 2015, and from sampling conducted from November 2013 through May 2014 during the implementation of the LTCP sampling program. The sampling locations of both programs are depicted in Figure ES-4. Figures ES-5 and ES-6 show the GM along with data ranges (minimum to maximum and 25th percentile to 75th percentile) for fecal coliform and enterococci, respectively, for the LTCP sampling program. Figures ES-7 and ES-8 show similar data for the HSM sampling program over the concurrent sampling period. For reference purposes, Figures ES-5 and ES-7 also show the monthly GM water quality numerical criterion for fecal coliform (200 cfu/100 ml).

Overall, the fecal coliform levels measured throughout the LTCP sampling program result in GMs indicative of the impacts of wet-weather pollution sources in Inner Flushing Bay. As shown in Figure ES-5, the wet-weather GM at the Inner Flushing Bay Stations OW-7 to OW-9 are all above 200 cfu/100mL, while the dry-weather GM are all below 200 cfu/100mL. For the Outer Flushing Bay Stations OW-10 to OW-15, wet-weather impacts are also apparent, as the wet-weather GMs are all above the dry-weather GM. However, the wet-weather GM are all below 200 cfu/100mL, except at Station OW-10, where the GM is 201. The LTCP enterococci data generally follow a similar trend as the fecal coliform data, with wet-weather GM higher than dry-weather GM, and the Inner Flushing Bay GM generally higher than the Outer Flushing Bay GM (Figure ES-6).

The HSM fecal coliform data presented in Figure ES-7 are also consistent with the LTCP sampling program data. The wet-weather geometric means at Inner Flushing Bay Station E15 are above 200 cfu/100mL for 2013 through 2015, while the dry-weather GM are below 200 cfu/100mL. The Outer Flushing Bay Station E6 showed wet-weather geometric means above the dry-weather GM, but the wet-weather GM were all below 200 cfu/100mL. The data at Station FB1, located between Stations E15 and E6, showed GM generally between the means for Stations E15 and E6 for dry- and wet-weather, respectively. In general, HSM enterococci data showed a pattern (Figure ES-8) that was reflective of the LTCP sampling program data.

Data collected by the Citizens Testing Group was also made available to the public by Riverkeeper. This dataset is limited to enterococci bacteria concentrations for three sampling stations along the southwestern shore of Flushing Bay, as shown in Figure ES-4. These data are available on Riverkeeper's website http://www.riverkeeper.org/. Consistent with the LTCP and HSM data, Riverkeeper's data showed a relationship between wet-weather conditions and higher enterococci concentrations throughout 2013, 2014 and 2015.

Figure ES-9 depicts the DO averages derived from the LTCP dataset measured during late 2013/early 2014. The measured DO concentrations portray winter conditions and hence do not capture the lower DO values expected to occur during the summer periods. However, based on the HSM program DO dataset, extremely few DO values were observed below 4.0 mg/L, except in three instances in which the DO concentration was measured slightly below the Class I criterion, throughout 2013, 2014 and 2015.

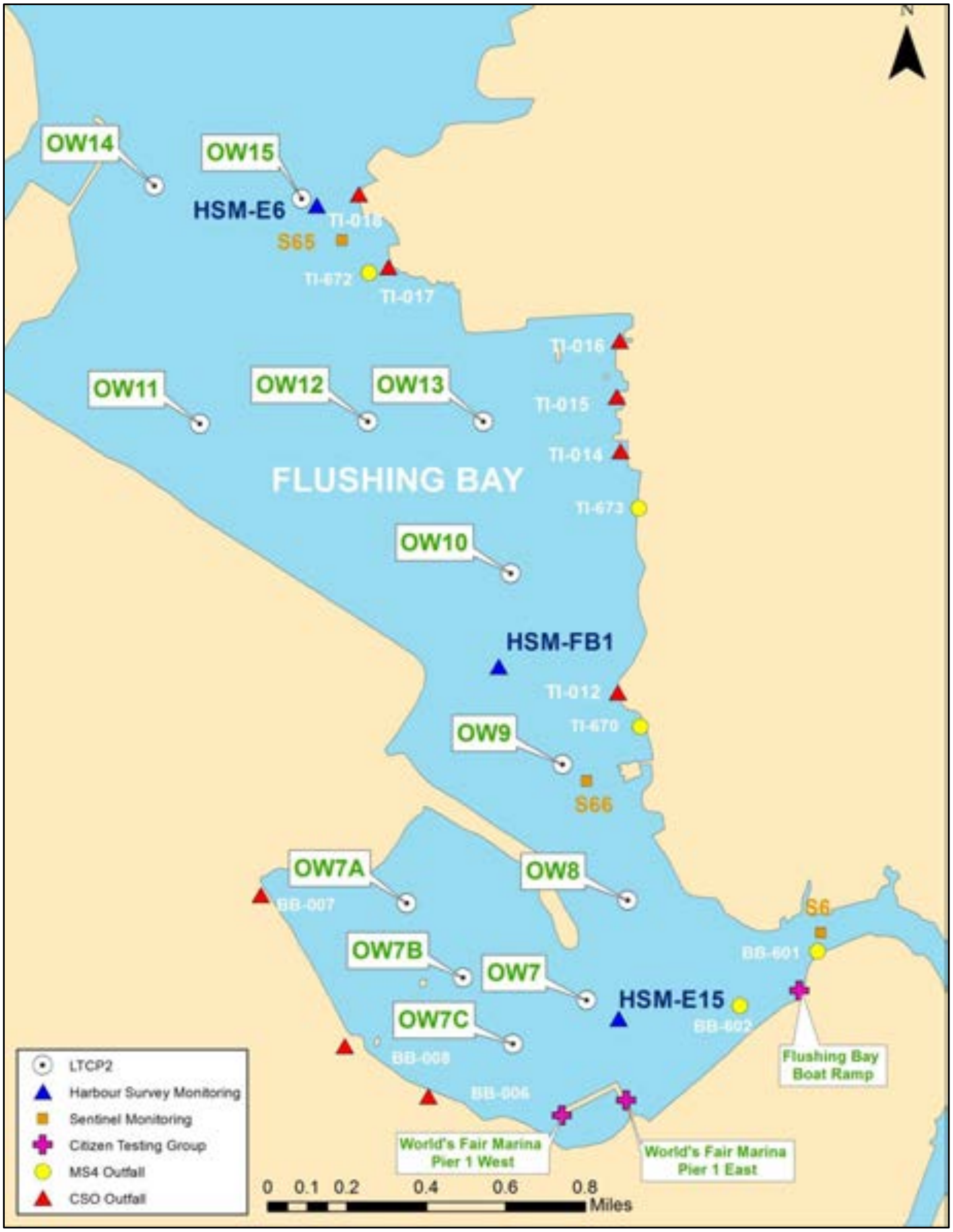

Figure ES-4. Flushing Bay LTCP Field Sampling Analysis Program and Harbor Survey Monitoring Program Sampling Locations

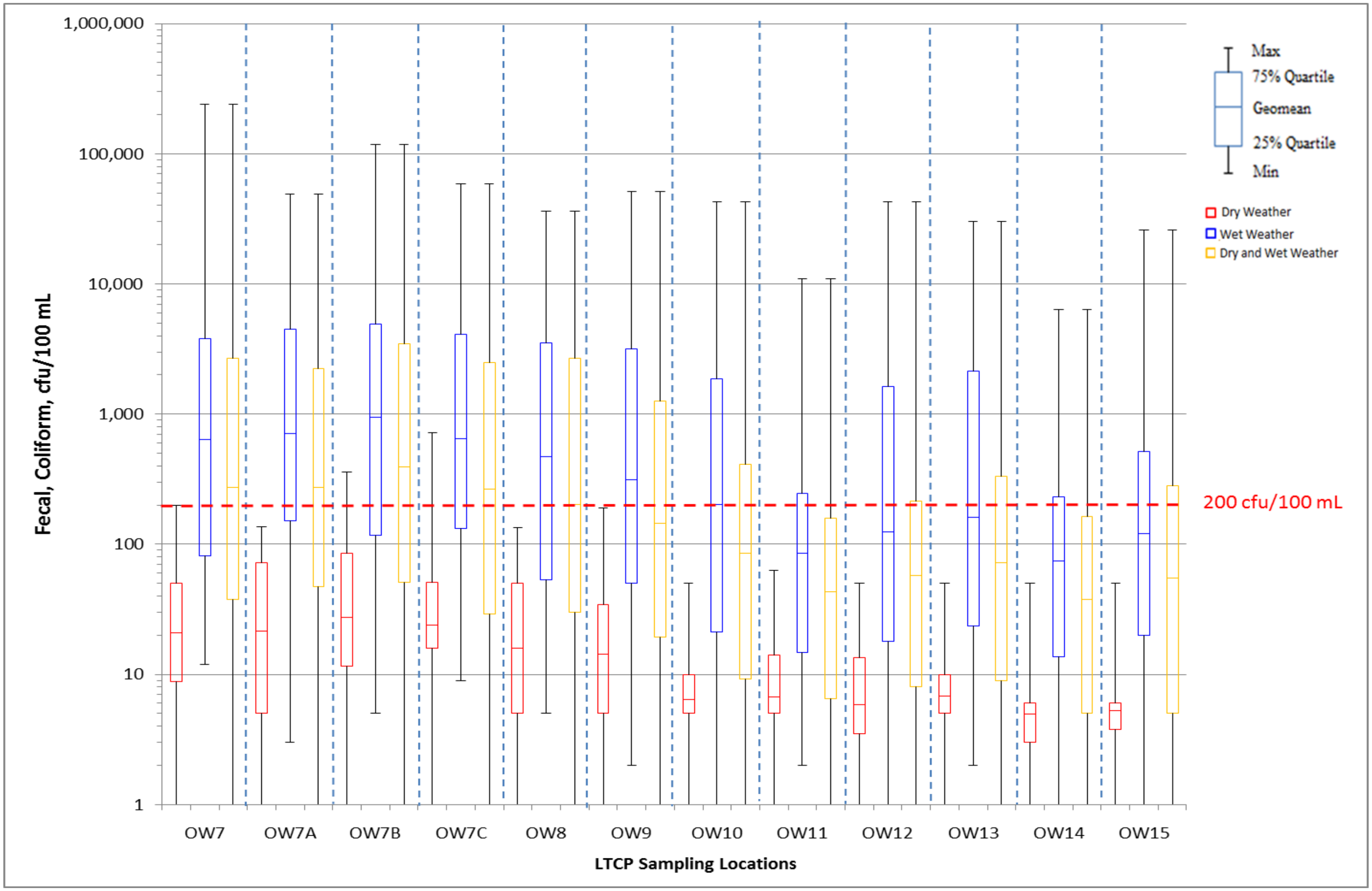

Figure ES-5. Fecal Coliform Concentrations at Flushing Bay LTCP Monitoring Stations

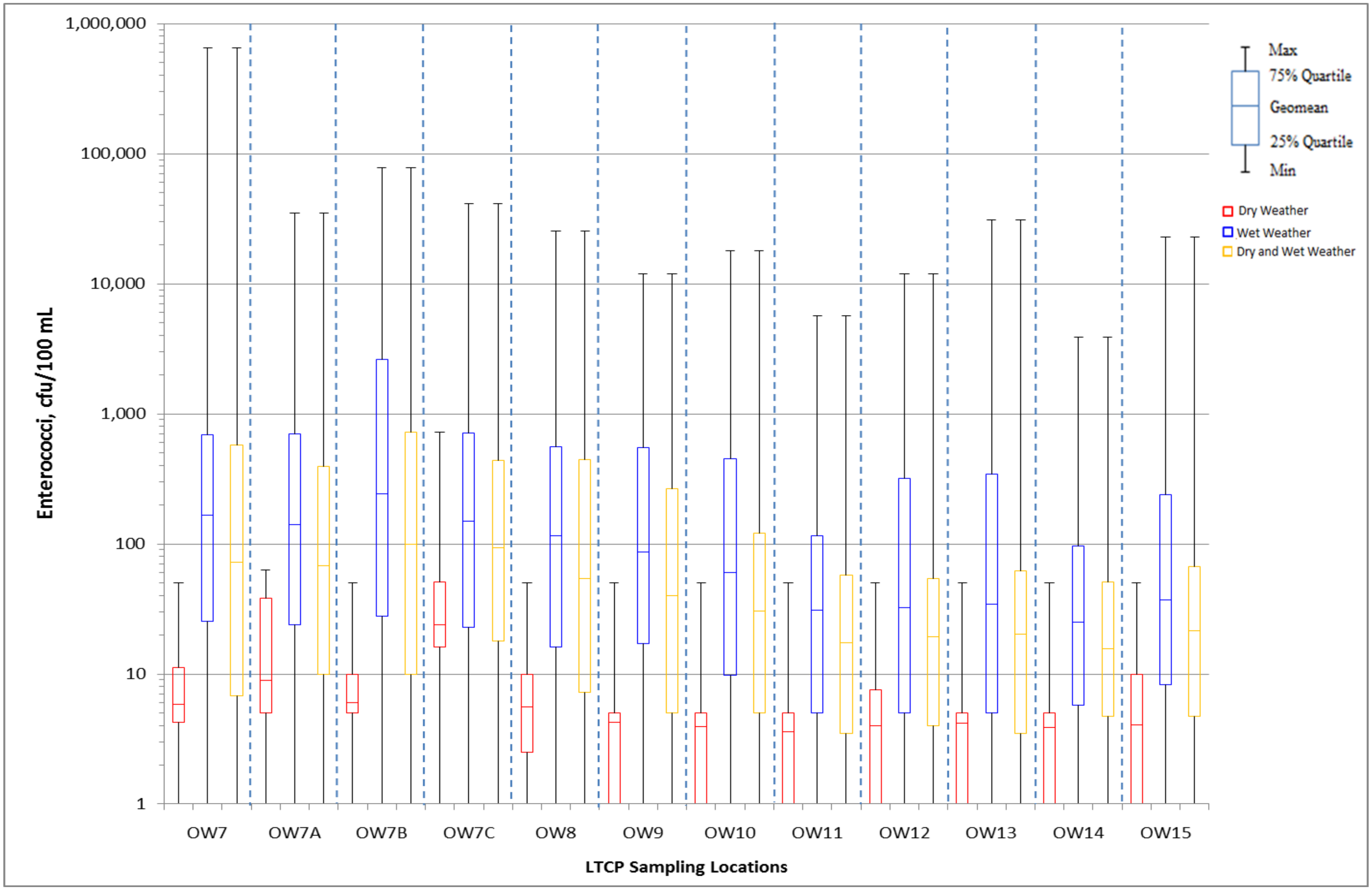

Figure ES-6. Enterococci Concentrations at Flushing Bay LTCP Monitoring Stations

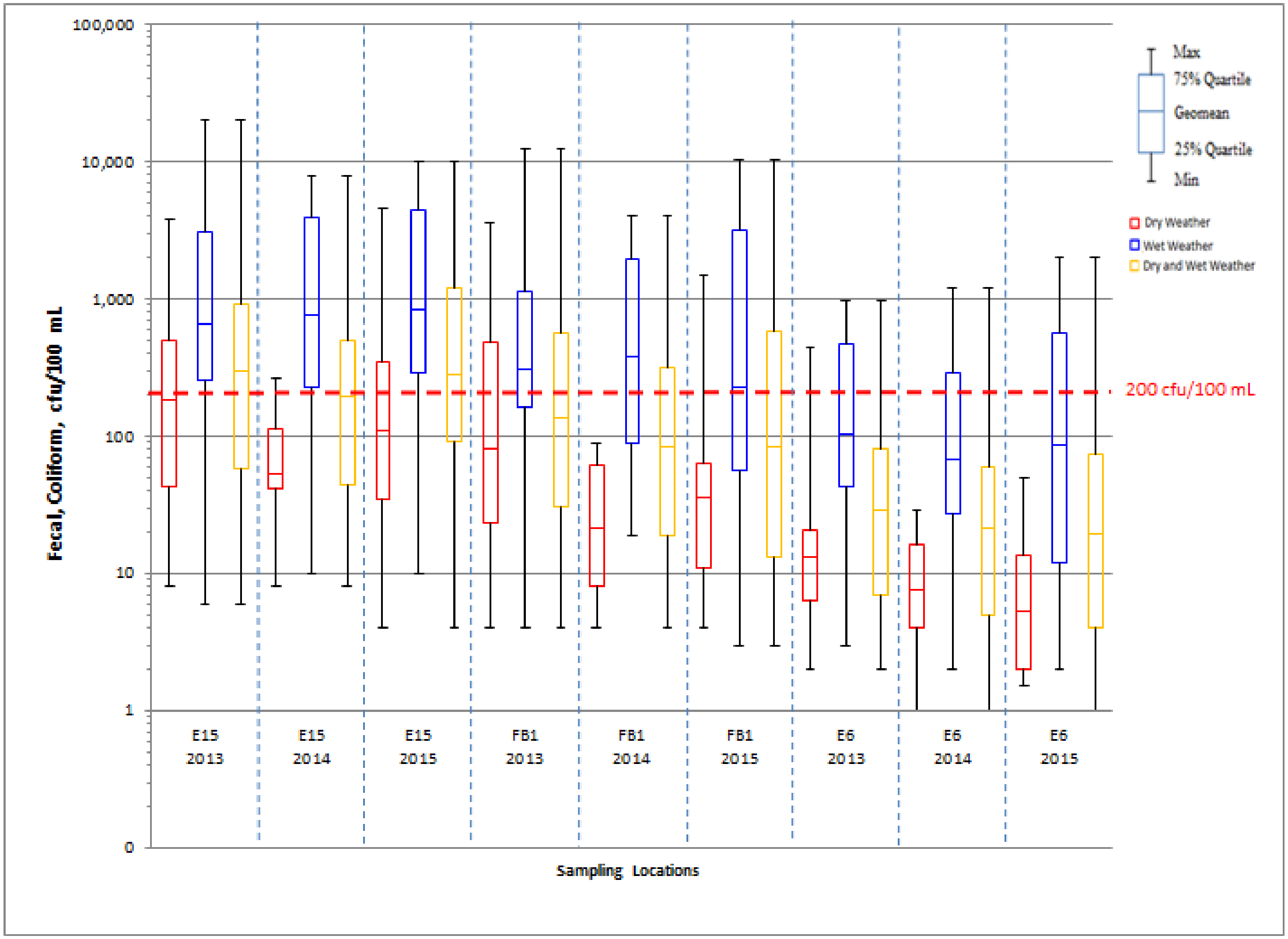

Figure ES-7. Fecal Coliform Concentrations at Flushing Bay Harbor Survey Monitoring Stations

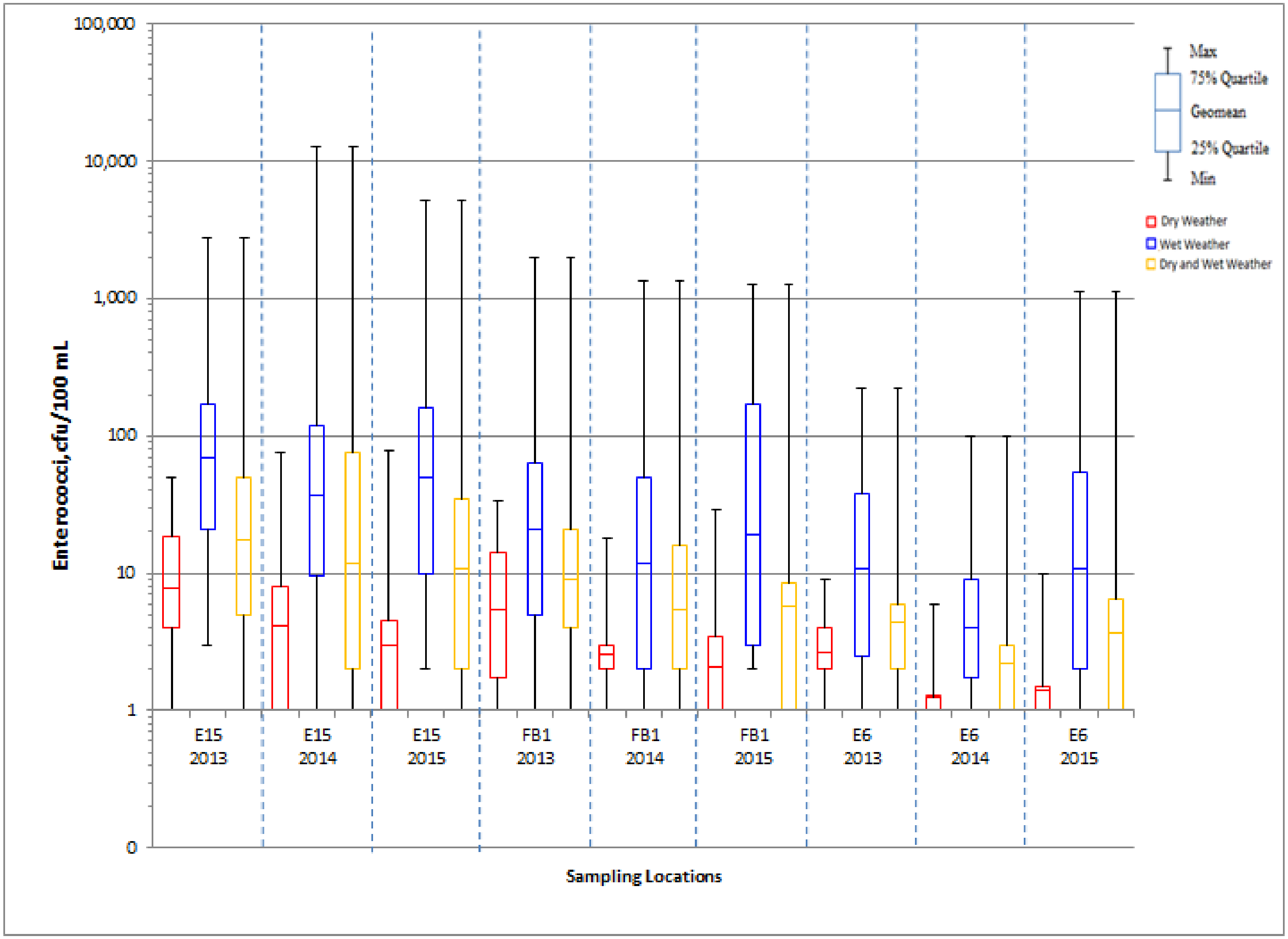

Figure ES-8. Enterococci Concentrations at Flushing Bay Harbor Survey Monitoring Stations

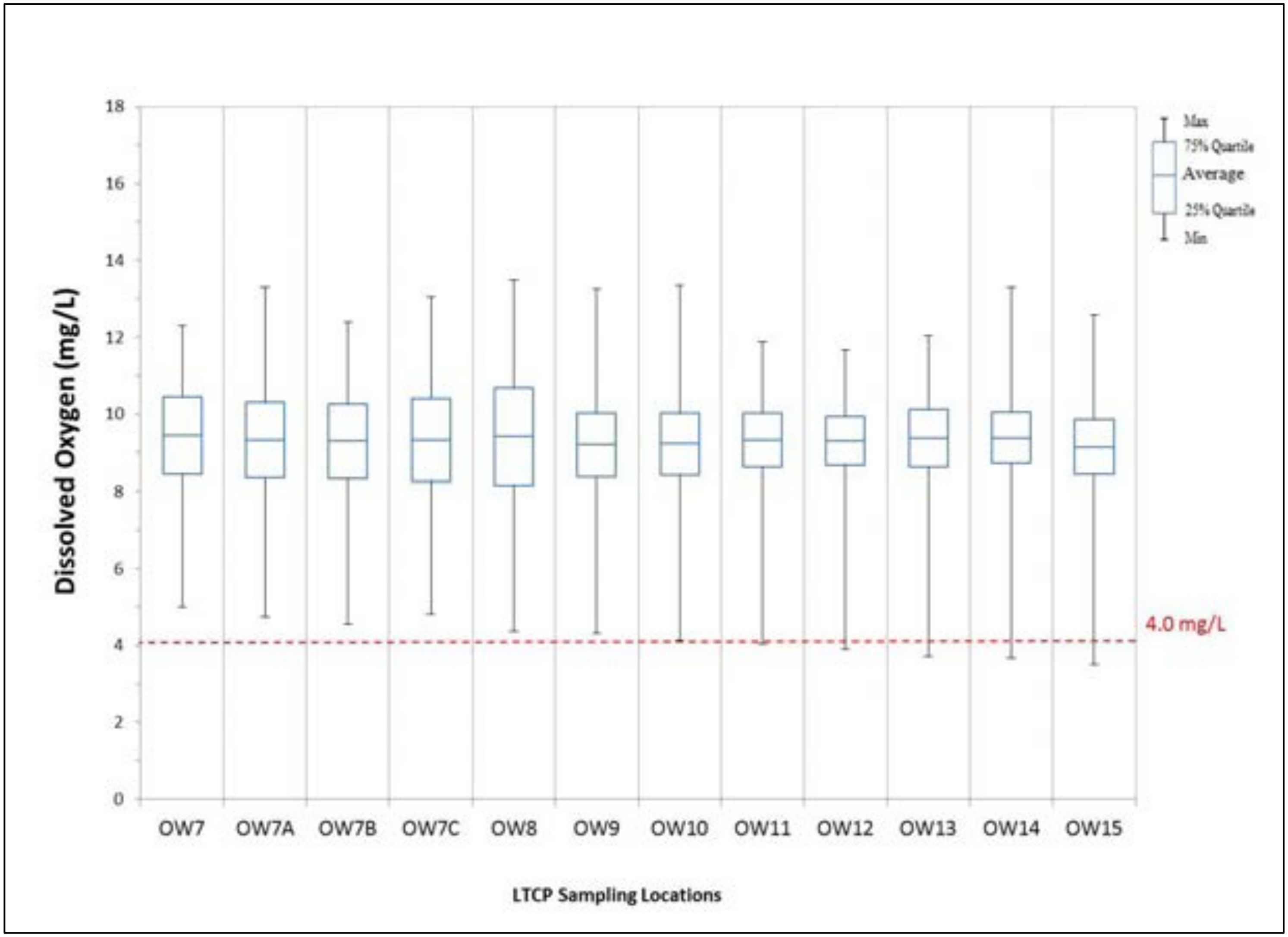

Figure ES-9. DO Concentration at Flushing Bay LTCP WQ Stations (November 2013 – May 2014)

Baseline Conditions, 100 Percent CSO Control and Performance Gap

Computer models were used to assess attainment with Existing WQ Criteria (Class I), Class SC DO Criteria and Potential Future Primary Contact WQ Criteria. The analyses focused on two primary objectives:

1. Determine the levels of compliance with water quality criteria under future baseline conditions, defined as conditions with sanitary flows based on 2040 population projections, with all other sources being discharged at existing levels to the waterbody. The primary sources would be dominated by CSO but also include stormwater, direct drainage, Flushing Creek, and the East River. This analysis is presented for Existing WQ Criteria (Class I), Class SC DO Criteria and Potential Future Primary Contact WQ Criteria.
2. Determine potential attainment levels without discharge of CSO to the waterbody (100 percent control), keeping the remaining non-CSO sources. This analysis is based on the criteria shown in Table ES-1.

DEP assessed water quality using the Flushing Bay Model (FBM). This was an existing model that was updated and validated using receiving water data collected throughout 2014. Model outputs for fecal coliform and enterococci bacteria, as well as for DO, were compared with various monitored data sets during validation. This improved the accuracy and robustness of the models for LTCP evaluations. The InfoWorks CS™ (IW) sewer system model was used to provide flows and loads from intermittent wet-weather sources as input to the FBM. The water quality model was then used to calculate ambient pathogen concentrations within the waterbody for a set of baseline conditions.

Baseline conditions were established in accordance with the guidance provided by DEC to represent future conditions. Baseline conditions included the following assumptions: the design year for projected future dry-weather flows was established as 2040; Bowery Bay WWTP and Tallman Island WWTP would receive peak flows at two times design dry-weather flow (2xDDWF); Flushing Creek CSO LTCP recommended plan in operation, grey infrastructure would include those elements recommended in the 2011 Waterbody/Watershed Facility Plan (WWFP); and waterbody-specific GI application rates would be based on the best available information. In the case of the Flushing Bay project area, DEP has plans to manage approximately 2.8 percent of impervious acres within the total tributary combined sewer impervious area.

The water quality assessments were conducted using continuous water quality simulations. A one-year (2008 rainfall) simulation for bacteria and DO assessment was used to support an alternatives evaluation. A 10-year rainfall bacteria simulation (2002 to 2011) for attainment analysis was used for the preferred alternative. The gaps between calculated baseline concentrations of bacteria, as well as DO, were then compared to the applicable pathogen and DO criteria to quantify the level of attainment.

Table ES-3 presents a summary of the baseline annual and recreational season (May 1st through October 31st) of Bacteria Existing WQ Criteria for the 2008 rainfall year, along with the maximum monthly fecal coliform GM. As shown, all stations within Flushing Bay meet Bacteria Existing WQ Criteria (200 cfu/100mL) in the recreational season and on an annual basis. As shown in Table ES-4, DO is projected to be attained for the Existing WQ Criteria with all stations exceeding the DEC attainment goal of 95 percent.

Table ES-3. Model Calculated 2008 Baseline Fecal Coliform Maximum Monthly GM and Attainment of Existing WQ Criteria

Station		Maximum Monthly Geometric Means (cfu/100mL)		% Attainment (GM <200 cfu/100mL)	
		Annual	Recreational Season	Annual	Recreational Season
OW7	Inner Bay	129	15	100	100
OW7A	Inner Bay	84	13	100	100
OW7B	Inner Bay	148	16	100	100
OW7C	Inner Bay	156	17	100	100
OW8	Inner Bay	179	16	100	100
OW9	Inner Bay	105	14	100	100
OW10	Outer Bay	77	13	100	100
OW11	Outer Bay	47	16	100	100
OW12	Outer Bay	65	14	100	100
OW13	Outer Bay	62	13	100	100
OW14	Outer Bay	49	21	100	100
OW15	Outer Bay	59	19	100	100

Table ES-4. Model Calculated Baseline DO Attainment – Existing WQ Criteria (2008)

Station		Annual Attainment (%) Entire Water Column >=4.0 mg/L
OW7	Inner Bay	100
OW7A	Inner Bay	100
OW7B	Inner Bay	100
OW7C	Inner Bay	100
OW8	Inner Bay	100
OW9	Inner Bay	100
OW10	Outer Bay	99
OW11	Outer Bay	99
OW12	Outer Bay	99
OW13	Outer Bay	99
OW14	Outer Bay	97
OW15	Outer Bay	98

Levels of attainment for the Bacteria Primary Contact WQ Criteria on an annual or recreational season basis are the same as those shown for the Bacteria Existing WQ Criteria in Table ES-3, given that both standards share the same fecal coliform numerical threshold which is 200 cfu/100mL. All stations in Flushing Bay are in attainment during the recreational season and on an annual basis.

Table ES-5 presents a comparison of the maximum monthly GM and the annual percent attainment for baseline conditions and 100% CSO control. The data in Table ES-5 show the CSO contribution to the maximum monthly fecal coliform GM. The largest impact of the 100% CSO control scenario is calculated at Station OW7B within Inner Flushing Bay where there is a 57% decrease from the baseline GM of 148 cfu/100mL. However, both the baseline and 100% CSO control fully attain the existing fecal coliform criteria.

Table ES-5. Comparison of the Model Calculated 2008 Baseline and 100% Flushing Bay CSO Control Fecal Coliform Maximum Monthly GM and Attainment of Primary Contact WQ Criteria

Station		Maximum Monthly Geometric Means (Annual)		% Attainment (Annual)	
		Baseline	100% CSO Control	Baseline	100% CSO Control
OW7	Inner Bay	129	77	100	100
OW7A		84	32	100	100
OW7B		148	63	100	100
OW7C		156	73	100	100
OW8		179	133	100	100
OW9		105	69	100	100
OW10	Outer Bay	77	55	100	100
OW11		47	38	100	100
OW12		65	48	100	100
OW13		62	45	100	100
OW14		49	44	100	100
OW15		59	47	100	100

The attainment of the DO Class SC criteria for the entire water column is presented in Table ES-6 for baseline and 100% CSO control conditions. Determination of attainment with Class SC 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. 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 project full attainment at fourteen (14) of the fifteen (15) stations with the exception of Station OW-14 that is more impacted by the East River. In addition, the gap analysis indicates that the 100% CSO control alternative provides no benefits in DO attainment at this station. Attainment of the Acute DO Criterion (never less than 3.0 mg/L) is satisfied at all locations throughout the Bay on an annual basis for the 2008 baseline conditions.

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

Station		Annual Attainment Percent Attainment (Water Column)			
		Baseline		100% Flushing Bay CSO Control	
		Chronic(1)	Acute (2)	Chronic(1)	Acute (2)
OW7	Inner Bay	100	100	100	100
OW7A	Inner Bay	100	100	100	100
OW7B	Inner Bay	100	100	100	100
OW7C	Inner Bay	100	100	100	100
OW8	Inner Bay	100	100	100	100
OW9	Inner Bay	100	100	100	100
OW10	Outer Bay	100	100	100	100
OW11	Outer Bay	97	100	97	100
OW12	Outer Bay	100	100	100	100
OW13	Outer Bay	100	100	100	100
OW14	Outer Bay	83	100	83	100
OW15	Outer Bay	96	100	97	100

Notes:
(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.

The Potential Future Primary Contact WQ Criteria attainment for baseline conditions, 2008 recreational season, is shown below in Table ES-7. Attainment of the potential future primary contact GM criterion is achieved at all stations within Flushing Bay for the recreation season. However, attainment of the 90th percentile STV criterion is not achieved at any of the stations. The percent attainment is very low in Inner Flushing Bay, ranging from 9 to 13 percent. Attainment in Upper Flushing Bay ranges from 29 to 78 percent under baseline conditions. As shown in Table ES-8, 100% CSO control would significantly improve attainment with the Potential Future Primary Contact STV Criteria but still would not enable the waterbody to fully attain this potential future STV criteria.

Baseline modeling showed that Flushing Bay exhibits a high level of attainment of the Class I fecal coliform Primary Contact WQ criterion and DO criterion on an annual basis. Attainment of the Class SC fecal coliform Primary Contact WQ criterion is also fully achieved on an annual basis. While the Class SC Acute DO Criterion is fully attained during baseline conditions, the chronic DO criteria is not fully attained under baseline conditions or 100% CSO control on an annual daily basis but the actual chronic DO WQS is a complex duration based criteria and basing the analysis on a daily average is very conservative. The projected improvement in the chronic DO WQS attainment is less than 1 percent between the baseline scenario and 100% CSO reduction indicating that there is minimal performance benefit for DO through control of CSO alone. Attainment of the GM for enterococci is fully achieved under the Potential Future

Primary Contact WQ Criteria. However, attainment of the 90th Percentile STV falls well short of criteria, particularly within Inner Flushing Bay. While significant improvement and attainment of this criterion is observed at 9 of the 12 monitoring stations, the results indicate that these proposed STV criteria may be extremely difficult to attain in these confined CSO waterbodies and the STV may not be statistically relevant in these confined CSO waterbodies as the statistical analysis used to develop this STV (90th percentile value) was based entirely on data collected at beaches in which there are no direct CSO discharges and where there is significantly more mixing occurring than in these confined CSO waterbodies.

Table ES-7. Model Calculated 2008 Baseline Enterococci Maximum 30-day GM and Attainment of Potential Future Primary Contact Water Quality Criteria

Station		Maximum Recreational Season 30-day Enterococci (cfu/100mL)		% Attainment	
		GM	90th Percentile STV	GM (<30 cfu/100mL)	90th Percentile STV (<110 cfu/100mL)
OW7	Inner Bay	18	2,890	100	9
OW7A	Inner Bay	18	4,417	100	9
OW7B	Inner Bay	22	5,696	100	9
OW7C	Inner Bay	22	6,166	100	9
OW8	Inner Bay	17	1,274	100	12
OW9	Inner Bay	14	1,565	100	13
OW10	Outer Bay	12	930	100	29
OW11	Outer Bay	11	288	100	78
OW12	Outer Bay	12	475	100	57
OW13	Outer Bay	13	648	100	60
OW14	Outer Bay	13	243	100	77
OW15	Outer Bay	13	327	100	72

Table ES-8. Model Calculated 2008 100% CSO Control Enterococci Maximum 30-day GM and Attainment of Potential Future Primary Contact WQ Criteria

Station		Maximum Recreational Season 30-day Enterococci (cfu/100mL)		% Attainment	
		GM	90th Percentile STV	GM	90th Percentile STV
OW7	Inner Bay	5	120	100	93
OW7A	Inner Bay	4	43	100	100
OW7B	Inner Bay	5	74	100	100
OW7C	Inner Bay	5	92	100	100
OW8	Inner Bay	7	180	100	81
OW9	Inner Bay	6	94	100	100
OW10	Outer Bay	6	117	100	99
OW11	Outer Bay	8	118	100	99
OW12	Outer Bay	8	123	100	97
OW13	Outer Bay	7	114	100	97
OW14	Outer Bay	11	151	100	87
OW15	Outer Bay	10	140	100	95

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 two public meetings held for this LTCP.

On September 30, 2015, DEP hosted a Public Kickoff Meeting to initiate the water quality planning process for the Flushing Bay LTCP. Approximately 80 stakeholders from 25 different non-profit, community, planning, environmental, economic development, governmental organizations, and the broader public attended the event, as did three media representatives. The two-and-half-hour event, held at Al Oerter Recreation Center, Queens, provided stakeholders with information about DEP's LTCP Program, Flushing Bay watershed characteristics, and the status of waterbody improvement projects. DEP also solicited information from the public about their recreational use of Flushing Bay, 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/.

DEP hosted a second Public Meeting on October 26, 2016 to continue the public planning process. Approximately 50 stakeholders from several different non-profit, community planning, environmental, economic development, and governmental organizations, as well as the general public, attended the event. The purpose of the almost three-hour event, held at the United States Tennis Association Billie Jean King Tennis Center, was to describe the alternatives identification and selection processes, and solicit public comment and feedback. This presentation is also available on DEP's LTCP Program Website: http://www.nyc.gov/dep/ltcp/.

DEP has received several 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. Figures and descriptions of the conceptual layouts were evaluated for the tunnel alternatives with siting of the dewatering pump stations at potential sites including but not limited to Ingraham's Mountain and Luyster Creek. These conceptual layouts and sites were developed for the purposes of developing costs and evaluating the feasibility of the various CSO storage tunnel alternatives. The final siting of the dewatering pumping station, the tunnel alignment and other associated details of the tunnel alternatives 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 operation and maintenance (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-9 presents the retained alternatives that resulted from the evaluation process.

Table ES-9. Retained Alternatives

Alternative	Description
1. Disinfection of Outfalls BB-006 and BB-008	Outfall BB-006: Install disinfection facilities at the CAVF Outfall BB-008: Install disinfection facilities at Regulator BB-09
2. Re-purpose the CAVF as a RTB	Outfall BB-006 (Lower Level only): Convert the CAVF to a RTB with disinfection facilities
3. In-line Storage Outfalls BB-006 & BB-008	Outfalls BB-006 and BB-008 • Install bending weirs for control and capture of CSO • Install dewatering pumping station to convey captured flow back to the interceptor following a storm event
4. Combination of Alternatives 2 and 3	Disinfection of Outfall BB-006 • Install disinfection facilities at the CAVF Outfalls BB-006 and BB-008 • Install bending weirs for control and capture of CSO • Install dewatering pumping station to convey captured flow back to the interceptor following a wet-weather event
5. In-Water RTB	• 72 MGD In-Water RTB with disinfection facilities
6. 25% CSO Control Tunnel	• Ingraham's: 13,300-LF, 10-ft diameter tunnel (8 MG storage), and 15 MGD dewatering pumping station • Luyster Creek: 16,600-LF, 9-ft diameter tunnel (9 MG storage) and 15 MGD dewatering pumping station

Table ES-9. Retained Alternatives

Alternative	Description
7. ***50% CSO Control Tunnel***	• Ingraham's: 13,300-LF long, 18-ft diameter tunnel (25 MG storage), and 25 MGD dewatering pumping station • Luyster Creek: 16,600-LF, 16-ft diameter tunnel (25 MG storage), and 25 MGD dewatering pumping station
8. **75% CSO Control Tunnel**	• Ingraham's: 13,300-LF long, 29-ft diameter tunnel (66 MG storage), and 70 MGD dewatering pumping station • Luyster Creek: 16,600-LF, 16-ft diameter tunnel (25 MG storage) and 60 MGD RTB
9. **100% CSO Control Tunnel**	• Ingraham's:13,300-LF long, 29-ft diameter tunnel (66 MG storage) and 400 MGD RTB • Luyster Creek: 16,600 LF, 16-ft diameter tunnel (25 MG storage) and 400 MGD RTB

Notes:
CAVF = Corona Avenue Vortex Facility
RTB = Retention Treatment Basin
Multiple sites were evaluated for the tunneling alternatives. The final site and details of the preferred alternative will be further developed during subsequent planning and design phases.

Table ES-10 summarizes the projected Flushing Bay CSO volumes, and percent reductions in CSO volume and bacteria loads for the retained alternatives. The bacteria loading reductions shown in Table ES-10 were computed on an annual basis. As indicated in Table ES-2, the combined sewers tributary to the Outer Bay CSOs (TI-013, 014, 015, 016, 017, and 018) are planned for separation, thereby reducing CSO discharges to Flushing Bay by 48 MG from 1453 MG to 1405 MG annually. As a result, evaluation of the retained alternatives focused on addressing the 1405 MG of CSO contributed to the Inner Bay from Outfalls BB-006, BB-007 and BB-008. For those alternatives with levels of control less than 100% (Alternatives 1 through 8), CSO capture focused on the largest CSOs, BB-006 and BB-008. For 100% control (Alternative 9), all of the CSO from Outfalls BB-006, BB-007 and BB-008 was captured and treated.

Table ES-10. Flushing Bay Retained Alternatives Summary (2008 Rainfall)

Alternative(1)	Untreated CSO Volume (MGY) (3)	Frequency of Overflow(5)	Untreated CSO Volume Reduction (%)	Fecal Coliform Reduction(2) (%)	Enterococci Reduction (%)(2)
Baseline Conditions(3)	1405	47	-	-	-
1. Disinfection of Outfalls BB-006 and BB-008	1405	47	0	27	27
2. Re-purpose CAVF as a RTB	1189	26/47(4)	15	17	17

Table ES-10. Flushing Bay Retained Alternatives Summary (2008 Rainfall)

Alternative[(1)]	Untreated CSO Volume (MGY)[(3)]	Frequency of Overflow[(5)]	Untreated CSO Volume Reduction (%)	Fecal Coliform Reduction[(2)] (%)	Enterococci Reduction (%)[(2)]
3. In-line Storage Outfalls BB-006 and BB-008	1208	40	14	14	14
4. Combination Alternatives 2 and 3	1189	40	15	17	17
5. In-Water RTB	1020	29	27	27	27
6. 25% CSO Control Tunnel	1056	35	25	25	25
7. 50% CSO Control Tunnel	659	14	53	53	53
8. 75% CSO Control Tunnel	346	8	75	75	75
9. 100% CSO Control Tunnel	0	0	100	100	100

Notes:
CAVF = Corona Avenue Vortex Facility
RTB = Retention Treatment Basin
(1) Alternatives 2 through 9 include floatables control using an underflow baffle & static or bending weirs. The existing containment booms would be retained under Alternative 1.
(2) Bacteria reduction is computed on an annual basis.
(3) Based upon 2008 Typical Year. As the TI Outfalls are planned for separation, Untreated CSO Volumes are based upon CSO discharges from Outfalls BB-006, BB-007 and BB-008. May differ from results reported in Section 6.0, which were based on 10 year simulations and included discharge from the TI Outfalls.
(4) Seasonal disinfection of CSOs for Outfall BB-006. No disinfection of Outfall BB-008.
(5) Frequency of overflow includes remaining CSO discharges to the Inner Flushing Bay from CSOs BB-006 and BB-008 that are not captured or receive primary treatment.

Estimated Costs of Retained Alternatives and Selection of the Preferred Alternative

The 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 3 percent over a 20-year life cycle. Design, construction management and land acquisition costs are not included in the cost estimates. All costs are in February 2016 dollars and are considered Level 5 cost estimates by AACE International with an accuracy of -50% to +100%. The retained alternative estimated PBC, annual O&M costs, and total present worth are shown below in Table ES-11. The total Net Present Worth ranges from $49M to $3,493M.

Table ES-11. Cost of Retained Alternatives

Alternative	PBC[1] ($ Million)	Annual O&M Cost ($/Yr Million)	Total Net Present Worth ($ Million) [2]
1. Disinfection of Outfalls BB-006 and BB-008	32	1.1	49
2. Re-purpose CAVF as a RTB	52	0.7	61
3. Outfall Storage (BB-006 and BB-008)	114	0.2	118
4. Combination of Alts. 2 and 3	166	0.9	179
5. In-Water RTB	533	1.3	552
6a. 25% CSO Control Tunnel at Ingraham's Mountain	434	0.6	443
6b. 25% CSO Control Tunnel at Luyster Creek	448	0.6	457
7a. 50% CSO Control Tunnel at Ingraham's Mountain	670	0.9	683
7b. 50% CSO Control Tunnel at Luyster Creek	829	0.9	842
8a. 75% CSO Control Tunnel at Ingraham's Mountain	1,114	1.4	1,136
8b. 75% CSO Control Tunnel at Luyster Creek	1,286	1.4	1,306
9a. 100% CSO Control Tunnel at Ingraham's Mountain	3,420	4.9	3,494
9b. 100% CSO Control Tunnel at Luyster Creek	2,850	4.9	2,923

Notes:
PBC = Probable Bid Cost
(1) The PBC for the construction contract based on CY2016 dollars.
(2) The Net Present Worth is calculated by taking the annual O&M cost multiplying it by a present worth factor of 14.877 and adding this value to the PBC.

After reviewing the costs and potential benefits, it is noted that the retained alternatives represent a wide range of expenditures for a relatively small improvement of attainment of bacterial and DO WQS for Primary Contact WQ Criteria. However, recreational use of Flushing Bay is heavily influenced by solids and floatables discharged by CSOs which account for over 70 percent of the wet-weather discharge by volume to Flushing Bay. The World's Fair Marina, Flushing Bay Promenade, boat launches and other recreational uses are impacted by odors associated with the deposition of organic solids and aesthetic impacts from floatables.

The selection of the preferred alternative 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 a 25 MG CSO Storage Tunnel was identified as the most cost-effective alternative for reducing the frequency and volume of CSOs to Flushing Bay. Conceptual layouts for this tunnel are provided in Section 8 and the specific dimensions and routes will be finalized during the design phase.

This preferred 25 MG CSO Storage Tunnel alternative is projected to result in full attainment of the existing pathogen criteria and will provide significant reduction in CSO volume and frequency of overflow. The preferred alternative for the Flushing LTCP is projected to reduce CSO discharges from Outfalls

BB-006 and BB-008 to Flushing Bay by 53 percent from 1,405 MG/year to 659 MG/year. CSO events are projected to be reduced by 70 percent from 47 to 14 events annually. The implementation of these elements has an estimated Net Present Worth ranging from $683M to $842M, reflecting $0.9M of annual O&M over the course of 20 years and a PBC ranging from $670M to $829M.

Affordability and Financial Capability

DEP is in the midst of an unprecedented period of investment to improve water quality in New York Harbor. Since 2002, projects worth almost $10.0B have been completed or are under way, including projects for nutrient removal, CSO abatement, marshland restoration, and hundreds of other projects. DEP has committed a total of nearly $4.2B from the WWFP ($2.7B) and the GI Program ($1.5B), slightly more than half of which has been incurred to-date. Table ES-12 provides a summary of CSO improvement projects that have been completed or are underway.

Table ES-12. Completed and Underway CSO Improvement Projects

1995 – 2015 (Completed): • NC WWTP MSP (620 MGD to 700 MGD) • Four CSO Storage Tanks (118 MG) • Pumping Station Expansions (GC & Ave V PS) • Floatables Control (Bronx & Gowanus) • NYC Green Infrastructure Program Initiated • Wet Weather Maximization (Tallman Island) • Dredging (Paerdegat Basin & Hendrix Creek) • Gowanus Canal Flushing Tunnel Expansion
2016 – 2030 (Underway): • Dredging (Flushing Bay) • Aeration (Newtown Creek) • Regulator Modifications Flushing Bay High Level Interceptor • Regulator Modifications and Floatables Control (Westchester Creek, Newtown Creek, Jamaica Tributaries) • Sewer Work (Pugsley Creek, Fresh Creek High Level Storm Sewers (HLSS), Belt Pkwy Crossing, and Flushing Bay Low Lying Sewers) • 26th Ward Plant Wet Weather Stabilization • NYC Green Infrastructure Program
Total Costs (Completed and Ongoing): • Grey Infrastructure: $2.7 Billion • Green Infrastructure: $1.5 Billion

A preliminary Financial Capability Assessment has been conducted to assess the impact of current and future expenditures, including costs associated with the LTCP, on the financial capability of NYC and on the financial burden to the rate payers. This assessment is included in Section 9.6 of this LTCP. According to EPA 1997 Guidance, a high economic impact occurs when expenditures per household exceed two percent of the Median Household Income (MHI) of the ratepayer base. The current figure for NYC is 0.92 percent for the average household, which translates to a low financial impact. When combined with the score based on six additional criteria for NYC's financial capacity, the EPA method indicates that the overall impact of the current wastewater expenditures fall into the "low burden" category. However, the standard MHI metric used by EPA to define a high economic impact to ratepayers (i.e., affordability) is poorly applicable to NYC because of NYC's skewed distribution of household income and other factors, including the very high cost of living for housing, food, transportation, and utilities relative to the nation as a whole.

EPA issued new guidance in 2014 that clarifies that permittees are encouraged to supplement the standard metrics with information that provides a more detailed and localized characterization of that permittee's financial capability and the economic status of the residential ratepayer base. The type of information that could be presented includes, but is not limited to:

- presentation of household income by quintiles;
- poverty rates and trends;
- cost of living;
- total utility expenditures including expenditures to meet Safe Drinking Water Act (SDWA) mandates;
- historical increases in rates or other dedicated revenue streams; and
- information on the percent of households who own versus rent.

The supplemental information considered for this assessment indicates that when taking into account estimates for future spending, 50 percent of households are estimated to pay more than 2.0 percent of MHI by 2042 on wastewater bills alone, suggesting a "high" financial impact on residential users based on EPA guidance. When accounting for both water and wastewater bills, the percentage of households spending at least 4.5 percent of their income could reach 42 percent by 2042. Applying cost of living adjustment factors to discount the value of household incomes and make them comparable to the U.S. average, would increase this percentage dramatically.

NYC has a poverty rate of approximately 20 percent, far higher than the national average of 15 percent. Thus, a large percentage of households would be adversely impacted by sustained rate increases. Additionally, recent data show stagnant to decreasing household incomes in the lower economic brackets. Accordingly, the snapshot picture of household income may underestimate the impacts of future rate increases.

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 is scheduled, so that resources can be focused where the community will receive the greatest possible environmental benefit.

3. EVALUATIONS AND CONCLUSIONS

DEP will implement the elements of the preferred alternative after approval of the LTCP by DEC. This LTCP also recommends the continued implementation of WWFP recommendations.

The analyses for the Flushing Bay LTCP recommended plan are summarized below for the following three areas:

1. Summary of Recommended Plan.
2. Water Quality Modeling Results.
3. Use Attainability Analysis (UAA), Water Quality Compliance and Time to Recovery.

Summary of Recommend Plan

Water quality in Flushing Bay will be improved through the implementation of the following: (1) currently planned improvements including those recommended in the 2011 WWFP; (2) planned GI projects: (3) completed and planned CSO mitigation projections in Flushing Creek; and (4) the implementation of this recommended Flushing Bay LTCP alternative which calls for the design, construction, and operation of a 25 MG CSO Storage Tunnel. A preliminary constructability analysis has been conducted and DEP has deemed these improvements to be implementable based on information currently available. These identified actions have been balanced with input from the public and awareness of the cost to the citizens of NYC.

Water Quality Modeling Results

The water quality modeling results associated with the recommended plan for Flushing Bay are shown in Tables ES-13 through ES-16. These results provide the calculated annual and recreational attainment of the fecal coliform bacteria concentrations and the recreational season attainment for enterococci. The results show, for the different calculated levels of attainment, when concentrations would be at or lower than the Existing WQ Criteria and Potential Future Primary Contact WQ Criteria under the 10-year simulation. Class SC DO criteria are also shown based on the 2008 WQ simulation.

The Existing WQ Criteria for fecal coliform attainment levels (monthly GM<200 cfu/100mL) as determined using the 10-year simulation are shown below in Table ES-13. This table indicates that the recommended plan will achieve attainment of the existing fecal coliform criteria annually and during the recreational season.

The Potential Future Primary Contact WQ Criteria attainment levels for enterococci are shown in Table ES-14 for the 10-year simulation. As indicated in this table, Potential Future Primary Contact WQ Criteria for enterococci (rolling 30-day geometric mean <30 cfu/100mL) are met 100 percent of the time. However, the 90^{th} percentile STV of <110 cfu/100mL is attained between 48 and 81 percent of the time.

The DO attainment for Existing WQ Criteria for Class I as well as Class SC is the same as that reported for baseline conditions in Tables ES-4 and ES-6. The LTCP framework does not evaluate DO attainment under a 10-year simulation.

Table ES-13. Model Calculated 10-year Preferred Alternative Attainment of Existing WQ Criteria and Primary Contact WQ Criteria

Station		Fecal Coliform % Attainment	
		Annual Monthly GM < 200 cfu/100mL	**Recreational Season**(1) Monthly GM < 200 cfu/100mL
OW-7	Inner Bay	100	100
OW-7A		100	100
OW-7B		100	100
OW-7C		100	100
OW-8		100	100
OW-9		100	100
OW-10	Outer Bay	100	100
OW-11		100	100
OW-12		100	100
OW-13		100	100
OW-14		100	100
OW-15		100	100

Notes:
(1) The Recreational Season is from May 1st through October 31st.

Table ES-14. Model Calculated 10-year Preferred Alternative Attainment of Potential Future Primary Contact WQ Criteria

Station		Enterococci Attainment During Recreational Season (%)	
		30-day rolling GM <30 cfu/100mL	**90th Percentile STV <110 cfu/100mL**
OW-7	Inner Bay	98	57
OW-7A		99	48
OW-7B		98	55
OW-7C		98	57
OW-8		98	52
OW-9		98	62
OW-10	Outer Bay	99	66
OW-11		99	81
OW-12		99	71
OW-13		99	69
OW-14		99	73
OW-15		99	72

Notes:
(1) The Recreational Season is from May 1st through October 31st.

The LTCP assessment shows that Flushing Bay meets the Existing GM WQ Criteria for fecal coliform bacteria during the recreational season. The same is true for the Primary Contact WQ Criteria for fecal coliform bacteria. Table ES-15 presents an overview of the attainment status.

Table ES-15. Recommended Plan Compliance with Bacteria WQ Criteria Attainment

Location	Meets Existing WQ Criteria (Class I)	Meets Primary Contact WQ Criteria (Class SC)	Meets Potential Future Primary Contact WQ Criteria
Flushing Bay	YES(1)	YES(1)	NO(2)

Notes:
YES indicates attainment is calculated to occur ≥ 95 percent of time.
NO indicates attainment is calculated to be ≤ 95 percent of time.
(1) Annual attainment achieved.
(2) STV Criteria not met annually or during the recreational season (May 1st through October 31st). GM Criteria attained annually at all monitoring stations.

UAA, WQ Compliance and Time to Recovery

The 2012 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 Flushing Bay is projected to fully attain primary contact water quality criteria, fully attain the Existing DO Criteria, and largely attain the Primary Contact DO Criteria, a UAA is not included in this LTCP.

DEP has performed an analysis to determine the amount of time following the end of rainfall periods required for Flushing Bay to recover and return to fecal coliform concentrations of less than 1,000 cfu/100mL. The analyses consisted of examining water quality model bacteria concentrations for the August 15, 2008 storm event. The basis for selection of the August 15, 2008 event for this analysis is described in Section 6. The time to recovery, defined as return to fecal coliform concentrations below 1,000 cfu/100mL, was then tabulated for each water quality station within the waterbody. The results of these analyses are summarized in Table ES-16 for Flushing Bay.

As noted in the table, the duration of time for the bacteria concentrations to return to levels that the NYS Department of Health (DOH) considers safe for primary contact varies according to location. Generally, a value of approximately 24 hours would be reasonable to cover the extent of Flushing Bay. All stations recovered within 21 hours or less.

Table ES-16. Time to Recovery within the Flushing Bay (August 14-15 2008)

Sampling Location and Waterbody Conditions		Preferred Alternative Time to Recovery (hrs) Fecal Coliform Target (1,000 cfu/100mL)
OW-7	Inner Bay	21
OW-7A		21
OW-7B		22
OW-7C		21
OW-8		17
OW-9		19
OW-10	Outer Bay	19
OW-11		8
OW-12		11
OW-13		11
OW-14		9
OW-15		10

1.0 INTRODUCTION

This LTCP for Flushing Bay was prepared pursuant to the Combined Sewer Overflow Consent Order (DEC Case No. CO2-20110512-25), dated March 8, 2012 (2012 CSO Order), which modified a 2005 CSO Consent Order (DEC Case No. CO2-20000107-8) (2005 CSO Order). Under the 2012 CSO Order, DEP is required to submit ten waterbody-specific and one citywide LTCP to DEC by December 2017. The Flushing Bay LTCP is the eighth of those 11 LTCPs.

1.1 Goal Statement

The following is the LTCP Introductory Goal Statement, which appears as Appendix C in the 2012 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 CSO Control Policy and 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 Flushing Bay LTCP.

1.2 Regulatory Requirements (Federal, State, Local)

The waters of NYC are subject to Federal and NYS 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 pollutants into waters of the United States. CSOs and MS4 are also subject to regulatory control under the NPDES permit program. In New York, the NPDES permit program is administered by DEC, and is thus a 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 stressor 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.

Table 1-1 shows, as of September 2014, Flushing Bay remains delisted as a Category 4b waterbody for which required control measures (i.e., an approved LTCP) other than a TMDL are expected to restore uses in a reasonable period of time.

Table 1-1. 2014 DEC 303(d) Impaired Waters Listed and Delisted (with Source of Impairment)

Waterbody	DO/Oxygen Demand	Floatables
Flushing Bay	Delisted Category 4b CSOs, Urban/Storm	Delisted 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 part 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. Flushing Bay is classified as a Class I waterbody. Based on recent revisions to the NYS regulations, Class I waterbodies are defined as follows: 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 these new regulatory standards, i.e., Primary Contact Water Quality Criteria.

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 Flushing Bay. 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. Flushing Bay is classified as Type B-1 under the IEC system. Details of the IEC Classifications are presented in Section 2.2.

1.2.d Administrative Consent Order

NYC and DEC entered into a 2005 CSO Order to address CSOs in NYC. Among other requirements, the 2005 CSO Order, as successively modified in 2012, 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. The CSO Order also requires that DEP, in accordance with the 1994 EPA CSO Control Policy, meet construction milestones, complete the Flushing Bay CSO Retention Facility, and incorporate GI into the LTCP process, as proposed under NYC's Green Infrastructure Plan. In a separate MOU, DEP and DEC provided for WQS reviews in accordance with the EPA CSO Control Policy.

1.3 LTCP Planning Approach

The LTCP planning approach 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 involves the identification and analysis of 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. Following the analysis of 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 UAA 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 WWFP.

In August 2011, DEP issued the Flushing Bay WWFP. The WWFP, which was prepared pursuant to the 2005 CSO Order, 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 system within the watershed. DEC approved the Flushing Bay WWFP on May 4, 2012.

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 Flushing Bay LTCP.

DEP shared the Flushing Bay 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 place greater reliance upon that sustainable strategy. In September 2010, DEP published the *NYC Green Infrastructure Plan* (GI Plan). Consistent with the GI Plan, the 2012 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 Flushing Bay 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 Flushing Bay LTCP are summarized in Section 7.0.

2.0 WATERSHED/WATERBODY CHARACTERISTICS

This section summarizes the major characteristics of the Flushing Bay watershed and waterbody, building upon earlier documents that characterize the area including, most recently, the WWFP for Flushing Bay (DEP, 2011). Section 2.1 addresses watershed characteristics and Section 2.2 addresses waterbody characteristics.

2.1 Watershed Characteristics

The Flushing Bay watershed is highly urbanized, comprised primarily of residential areas with some commercial, industrial, institutional and open space/outdoor recreation areas within the Borough of Queens, NY. The most notable outdoor recreation area within this watershed is the Flushing Bay Promenade along the southwestern shoreline of Flushing Bay.

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 Flushing Bay watershed is comprised of approximately 6,877 acres on the north shore of Queens County. The Flushing Bay watershed is highly urbanized. With the exception of NYC park areas, cemeteries and the World's Fair Marina, the watershed is a dense mixture of residential, transportation, commercial, industrial and institutional development. Flushing Bay shares waters with the East River through tidal exchange processes. Flushing Creek discharges into the Bay at its southeastern corner and is the Bay's sole tributary. The neighborhoods of East Elmhurst, North Corona, College Point and Flushing surround the Bay. The predominant uses of the eastern shore include industrial, residential, and maritime-related uses. The southern shore is mostly outdoor recreational area, while the west mostly supports LaGuardia Airport. As described later in this section, the area is served by a complex collection system of: combined sewers, separate sanitary and storm sewers; interceptor sewers and pumping stations; nine CSO and five stormwater outfalls under the jurisdiction of DEP. The majority of the watershed (6,012 acres) is served by the Bowery Bay WWTP. A smaller drainage area (438 acres) on the northeastern shore of the Bay is served by the Tallman Island WWTP. LaGuardia Airport adds 427 acres of drainage area to the watershed.

As the watershed was developed, the condition of the waterbody and its shoreline 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 Flushing Bay watershed has led to the creation of a large combined sewer system, as well as areas served by a municipal separate storm sewer system (MS4). A total of five SPDES-permitted MS4 outfalls also discharge to Flushing Bay. Generally, the combined sewage is conveyed to the WWTPs for treatment. Combined sewage flow that exceeds the capacity of the WWTP and combined sewer system (2xDDWF) during wet-weather, may discharge through any one or more of the nine SPDES-permitted CSO Outfalls to Flushing Bay. The predominant source of CSO to Flushing Bay is associated with three CSO outfalls which provide wet-weather relief to the combined sewer system tributary to the Bowery Bay WWTP. A smaller drainage area served by the Tallman Island WWTP, on the northeastern end of the watershed, has multiple CSO outfalls that discharge low volumes of CSO infrequently. As shown in Figure 2-1, the Flushing Bay watershed is located between the western end of the Tallman Island WWTP tributary area and the eastern end of the Bowery Bay WWTP tributary area.

Further inland lie the neighborhoods of Elmhurst, Corona, Corona Heights, Rego Park, Lefrak City, Forest Hills, Forest Hills Gardens, Briarwood, and Kew Gardens Hills.

As a residential community within NYC, Flushing Bay has several large and notable transportation corridors that cross the watershed to provide access between industrial, commercial and residential areas, such as the Van Wyck Expressway, the Whitestone Expressway, the Long Island Expressway, the Grand Central Parkway, and the Long Island Rail Road (Figure 2-2). These transportation corridors limit access to some portions of the waterbody and are taken into consideration when developing CSO control solutions.

The watershed includes approximately 5,203 acres (81 percent) of low- medium- and high-density residential, commercial, industrial and institutional lands, as well as streets, highways, railroads, and 454 acres of transportation related areas, including LaGuardia Airport. Approximately 1,220 acres (19 percent) of the watershed consists of parks, open water, and cemeteries. The portion of the Flushing Bay watershed that is occupied by Flushing Meadows-Corona Park complex in the Flushing Bay watershed includes a mixture of pervious and impervious areas, such as parking lots, roads, Citi Field, and open space. Other relatively open space developments representing previously developed lands include: 1,093 acres of major parks (Cunningham, Forest, and College Point Shorefront Parks); 126 acres of major cemeteries; and several large school campuses.

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

The existing land uses within the Flushing Bay watershed are shown in Figure 2-3. The existing land uses along Flushing Bay follow a four-part division: a mix of industrial, commercial, and residential use in the College Point area on the northeast side of the Bay; predominant parkland on the southern side of the Bay; mixed residential and shoreline parkland on the southwestern side of the Bay; and LaGuardia Airport on the northwest side of the Bay.

Table 2-1 summarizes the land use characteristics of the Flushing Bay watershed area.

Table 2-1. Existing Land Use within the Flushing Bay Drainage Area

Land Use Category	Percent of Area	
	Riparian Area (1/4-mile radius) (%)	Drainage Area (%)
Commercial	3	6
Industrial	8	5
Open Space and Outdoor Recreation	13	5
Mixed Use and Other	1	4
Public Facilities	3	6
Residential	15	52
Transportation and Utility	49	15
Parking Facilities	2	2
Vacant Land	6	5

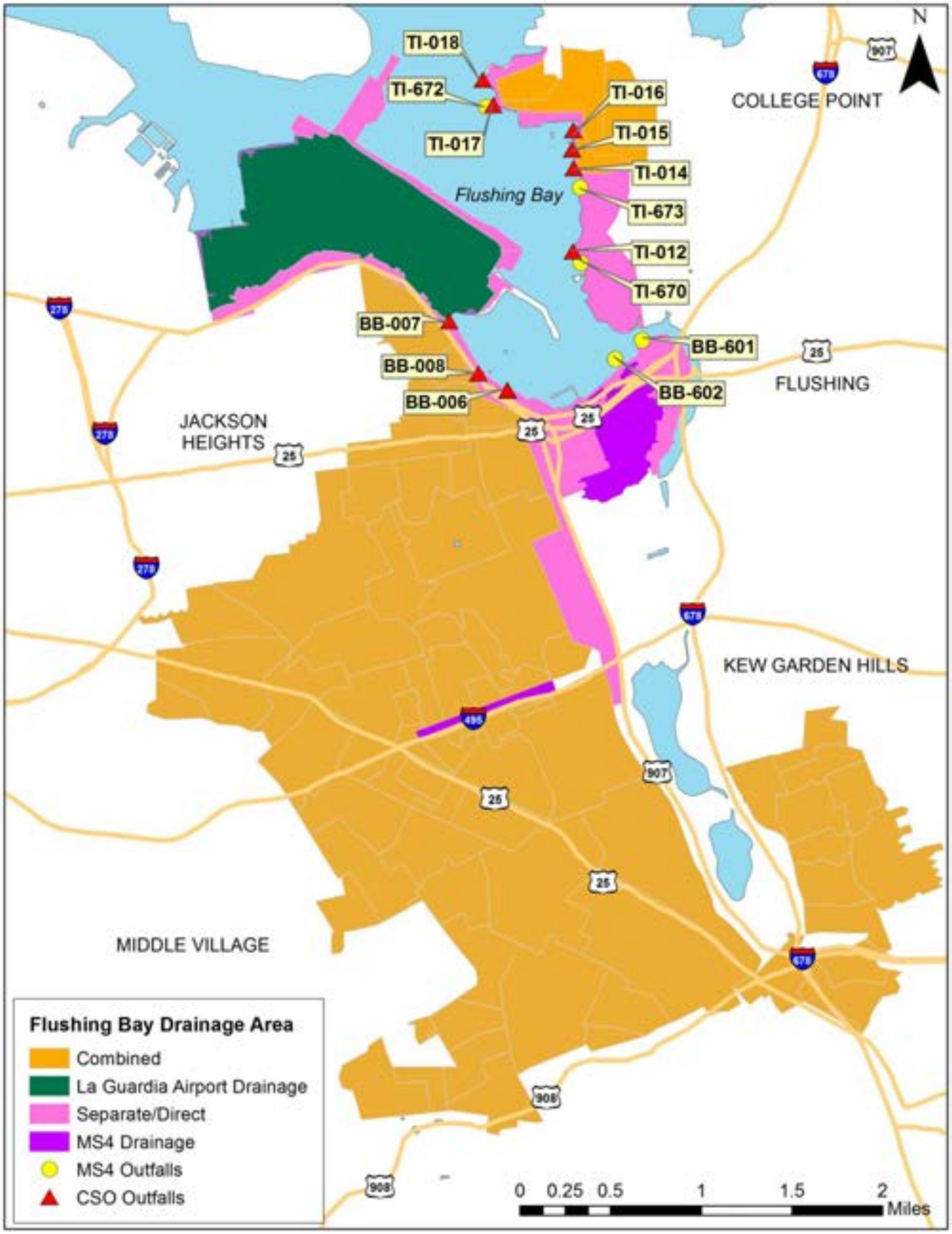

Figure 2-1. Flushing Bay Watershed and Associated WWTP Sewershed

Figure 2-2. Major Transportation Features of Flushing Bay Watershed

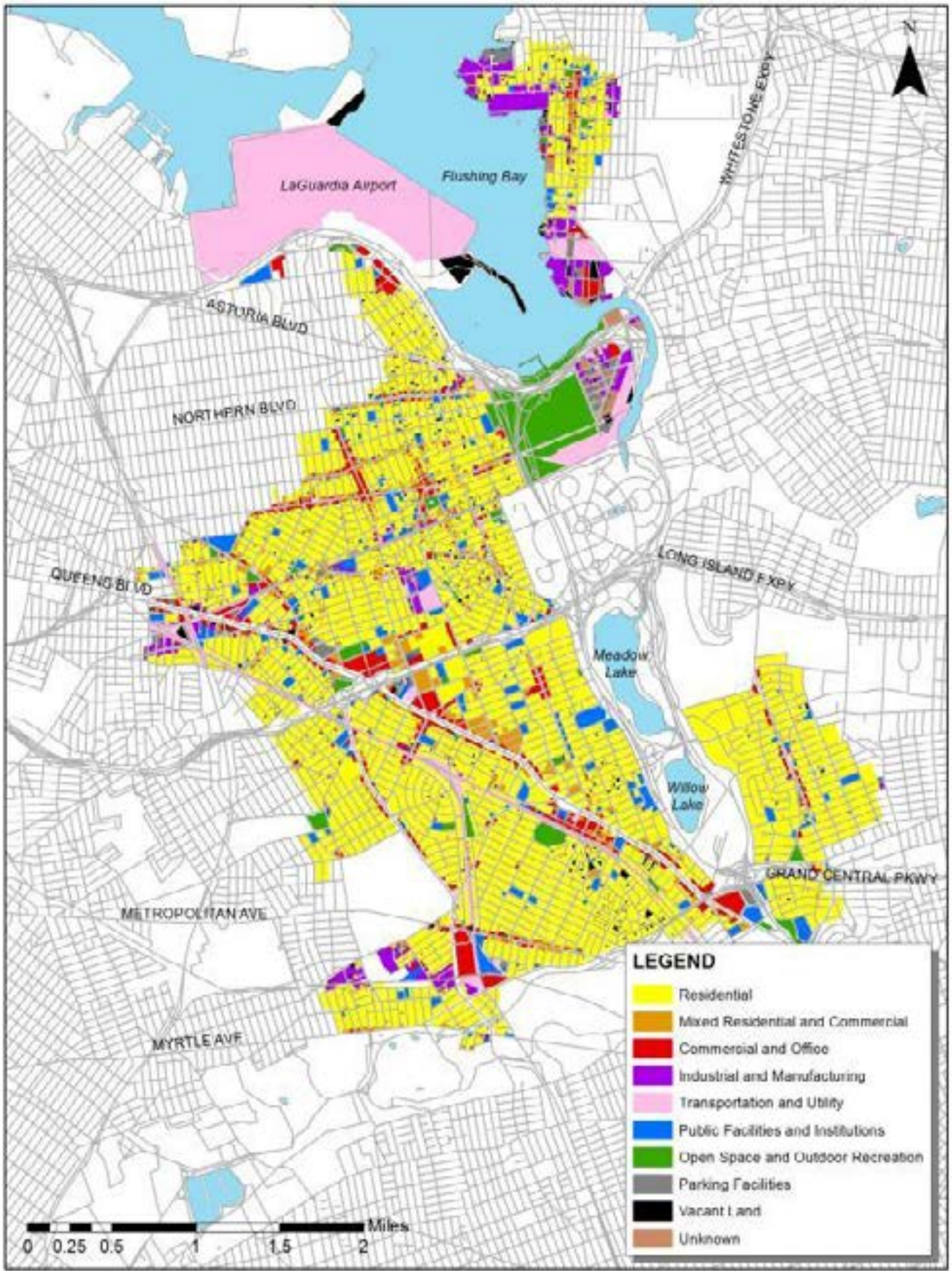

Figure 2-3. Land Use in Flushing Bay Watershed

The College Point area on the northeast side of the Bay is mostly residential and industrial, with several commercial and institutional uses mixed in. The industrial areas of College Point are mostly located along the waterfront and adjacent to residential areas. A large mass of industry is located in the area due to historic land use and development patterns. College Point experienced significant industrial development in its early years. It is now comprised mostly of manufacturing and construction uses. Several marinas and yacht clubs are located along the eastern shore of College Point. Recent redevelopment on portions of the inland section of the College Point area includes the first phase of NYC's new Police Academy located west of the former Flushing Airport, which has been closed since 1984 and has returned to largely a wetland state. The former airport, and much of the surrounding area, lies within the Special College Point District which was established in 2009 to maintain an attractive, well-functioning business park setting for business uses and ensure that there are minimal effects on adjacent residential blocks. Specific regulations pertaining to yards, signage, parking and bulk storage are based in large measure on the former Urban Renewal Plan that successfully guided the transformation of the area beginning in 1971. The corporate park environment is sustained by requiring front and side yards, restricting signage and loading locations, and setting higher parking requirements for certain commercial uses. Street tree planting and landscaping for front yards and parking lots are required for manufacturing and industrial uses.

The Flushing Bay Promenade runs for 1.4 miles along the southern shore of the Bay, from approximately 126th Street to 27th Avenue. Inland of the promenade, on the western shore of the Bay, is a large residential area made up of small apartment buildings, three-story rowhouses and garden apartments. A commercial node at the northern terminus of the promenade is primarily comprised of hotels serving LaGuardia Airport. Citi Field (home of the New York Mets professional baseball team) is located directly south of Flushing Bay on the eastern side of Grand Central Parkway, within Flushing Meadows-Corona Park. LaGuardia Airport lies on the northwest edge of Flushing Bay. The airport has a water shuttle that operates between its Marine Terminal and locations in Downtown and Midtown Manhattan. A portion of the Rikers Island correctional facility lies within the quarter-mile cut-off of Flushing Bay, but is in the East River watershed.

The Willets Point peninsula spans the western shore of Flushing Creek and the southern shore of Flushing Bay. Known as the Iron Triangle, current land uses in this unsewered, locked-in area primarily include automotive-related businesses and junkyards. A 61-acre portion of the peninsula generally bounded by the Van Wyck Expressway, Northern Boulevard, 126th Street, and Willets Point Boulevard, was the subject of a comprehensive planning, rezoning, and redevelopment strategy adopted in 2008. The 2008 Willets Point Development Plan is further discussed below.

The zoning classifications within the riparian area comprised of blocks wholly or partially within a quarter-mile of Flushing Bay are shown in Figure 2-4. The zoning in the inland College Point area is low-density residential, R2A, R4, R4A and R4-1 with a small C3 commercial zone located immediately south of Herman MacNeil Park to reflect the boating-related uses in the area. This area was rezoned in 2005 as a part of the Department of City Planning's Whitestone rezoning. The remainder of the College Point shoreline is predominantly industrial and zoned M1-1, M2-1 and M3-1. A segment of the shoreline between 23rd and 25th Street, extending to 120th Street, was rezoned to C3, to promote marina, restaurant and residential development. A portion of College Point Boulevard was also rezoned to R5B/C1-3 and R5B/C2-3 to encourage mixed use and infill development on College Point Boulevard to reinforce its traditional character. Citi Field and the Flushing Bay Promenade are designated parkland. The railroad corridor is zoned M1-1, while the industrial area to the northeast of it is zoned M3-1. The residential area south of LaGuardia Airport is R3-2 and R5, while the airport is zoned M1-1. Further inland, and to the west of the Flushing Bay Promenade is the East Elmhurst neighborhood. East Elmhurst was rezoned in 2013 to R3A, R3X, and R3-1 to reflect the neighborhood's one- and two-family residential character.

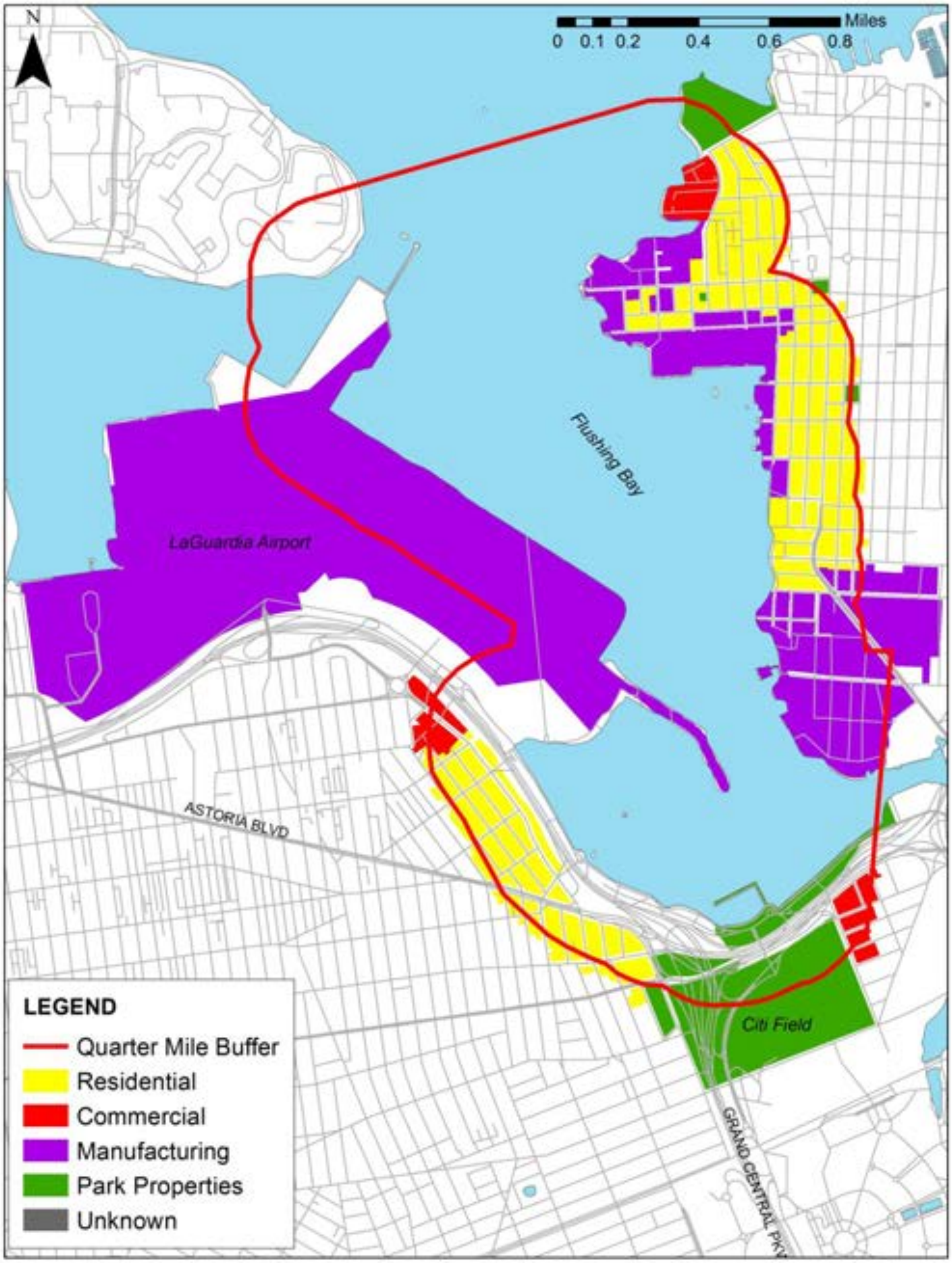

Figure 2-4. Quarter-Mile Riparian Zoning in the Flushing Creek Vicinity

Plans for significant development and redevelopment within the Flushing Bay watershed are noted below.

The 2008 Willets Point Development Plan aims at transforming a 61-acre largely under-utilized site with substandard conditions and substantial environmental degradation into a lively, sustainable mixed use community. The Plan calls for up to 5,850 residential units, 1.7 million square feet of retail space, a 400,000 square foot convention center, a 700-room hotel, 500,000 square feet of office space, and 6,700parking spaces. To provide quality-of-life amenities for residents and visitors, the program would also include an 850-seat school, 150,000 square feet of community facility space and a minimum of eight acres of public open space. In 2013, the NYC Council adopted a series of actions to facilitate an initial phase of development on a 23-acre portion of the 61-acre Special Willets Point District along 126th Street that would set the stage for a long term redevelopment of the entire Special District.

The Willets Point redevelopment will require a comprehensive remediation of the site and, according to the Environmental Impact Statement, will create separate sanitary sewered areas which will direct sanitary sewage to the Bowery Bay WWTP and send stormwater to Flushing Bay. The Willets Point/Downtown Flushing redevelopments are located within Recommendation Area 4 of the NYC Vision 2020 Comprehensive Waterfront Plan, shown in Figure 2-5. Vision 2020 also includes Recommendation Area 3 that encompasses the shore of inner Flushing Bay. The Plan proposes the study of the hydrology and means of improving water circulation and siltation, exploration of options for expanding mooring fields for recreational boats, improving maintenance of the Flushing Bay Promenade, and improving pedestrian and bicycle connections to upland areas to the west and south of the Flushing Bay Promenade including Flushing Meadows-Corona Park.

The proposed LaGuardia Airport redevelopment depicted in Figure 2-6 includes the construction of a new terminal south of the existing Central Building, four new concourses, roadways and parking with direct access to the new terminal, releasing space for aircraft maneuvering.

Another significant redevelopment is the conversion of the LaGuardia Convention Center into the Eastern Emerald Hotel. The proposed plans include a 12 story, 106,000 square foot mixed use building comprised of 197 hotel guestrooms, 206 residential apartments, a community facility and a parking garage.

2.1.a.2 Permitted Discharges

Five permitted MS4 stormwater outfalls and nine permitted CSO outfalls are located along Flushing Bay. These discharge locations, as well as other entities that hold industrial SPDES permits in the Flushing Bay watershed, are discussed in more detail in Section 2.1.c. No permitted dry-weather discharges are associated with this waterbody. Based on data available on-line at the date of submittal of this LTCP, it was determined that a total of three State-significant industrial SPDES permit holders are operating facilities located in the watershed.

Figure 2-5. NYC Vision 2020 – Reach 11 Comprehensive Waterfront Plan

Figure 2-6. Proposed LaGuardia Airport Redevelopment

Table 2-2 lists these permits, their owners and location.

Table 2-2. Industrial SPDES Permits within the Flushing Bay Watershed

Permit Number	Owner	Location
NY0008133	Port Authority of NY and NJ	Grand Central Pkwy and 94th Street
NY0032816	Lefferts Oil Terminal INC	31-70 College Point Blvd
NY0201278	Tully Environmental INC	127-20 34th Avenue

2.1.a.3 Impervious Cover Analysis

Impervious surfaces within a watershed are those characterized by an artificial surface that prevents 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 combined sewer system or into a separate stormwater system, may flow to a pervious area and soak into the ground, or may flow directly to a waterbody. Impervious surface that is directly connected to the combined sewer system, is an important parameter in the characterization of a watershed and in the development of hydraulic models used to simulate combined sewer system performance.

A representation of the impervious cover was made in the models for the 13 NYC WWTPs that serve combined drainage areas which were developed in 2007 to support the several WWFPs that were submitted to DEC in 2009. 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 street runoff of stormwater by either slowing it down prior to entering the combined sewer network, or preventing it from entering the network entirely, it became clear that a more detailed evaluation of the impervious cover would be beneficial. In addition, DEP determined that the distinction between impervious surfaces that introduce storm runoff directly to the sewer system (Directly Connected Impervious Areas [DCIA]) and impervious surfaces that may not contribute runoff directly to the sewers was important. For example, a rooftop with drains directly connected to the combined sewers (as required by the NYC Plumbing Code) would be an impervious surface that is directly connected. However, a sidewalk or impervious surface adjacent to parkland might not contribute runoff to the combined sewer system 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 required to conduct the analyses that improved the differentiation between pervious and impervious surfaces, as well as the different 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). The result of this effort yielded an updated model representation of the areas that contribute runoff to the combined sewer system. This improved set of data aided in model recalibration, and better informed the deployment of GI projects to reduce runoff from impervious surfaces that contribute flow to the combined sewer system. As a result of the recalibration efforts, it was determined that the volume of runoff that enters the Bowery Bay High Level Interceptor system decreased significantly, particularly upstream of Outfall BB-006, from prior WWFP results. The reduction in runoff in turn resulted in a reduction in the predicted annual baseline CSO volumes to Flushing Bay. Additional information on model changes between the WWFP and LTCP2 versions of the InfoWorks model, and calibration of the LTCP2 InfoWorks model is presented in the sections below.

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 City Planning (DCP) and the New York Transportation Metropolitan 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 Bowery Bay WWTP and Tallman Island 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 Tallman Island and Bowery Bay WWTP sewershed.

2.1.a.5 Updated Landside Modeling

The majority of the Flushing Bay watershed is included within the overall Bowery Bay WWTP system IW model. A smaller portion of the watershed, at the northeastern end, is served by the Tallman Island WWTP and is represented within the Tallman Island IW model. Several modifications to both collection systems have occurred since the models were calibrated in 2007. Given that both 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 Flushing Creek CSO Retention Facility, also known as Flushing Bay CSO Retention Facility, 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>Tallman Island IW Model</u>

- The Flushing Creek and Alley Creek CSO Retention Tanks were added to the model, including the dewatering operations for each facility.
- The Bowery Bay drainage areas that contribute CSOs to the Flushing Creek CSO Retention Facility were added to the Tallman Island model. Because the overflows from three of the Bowery Bay high level sewershed regulators are conveyed to this facility through the Park Avenue outfall, this model update was performed to avoid the need to run the Bowery Bay model as a precursor to every Tallman Island model run.
- Weirs at Regulators 10, 10A and 13 were modified, per final design.
- The weir in Regulator TI-09 was raised.
- Stormwater areas were modified based on information provided by DEP. Boundaries for stormwater Outfalls TI-71, TI-608, TI-639, TI-641, and MS4 Outfalls TI-670 and TI-673 were modified.

Bowery Bay IW Model

- A new subcatchment representing the Lutheran Cemetery was added.
- The Corona Avenue Vortex Facility was removed from the model because it was out-of-service since 2011.
- The BB-006 outfall pipe dimensions were revised.
- The 24th Street weir model setup was revised.
- The representation of several weirs was updated based on new information.
- Stormwater areas tributary to stormwater Outfalls BB-54, BB-55, and MS4 Outfalls BB-601 and BB-602 were modified based on information provided by DEP .
- Stormwater areas for LaGuardia Airport and Citi Field were added.
- The Bowery Bay High-level (BBH) and Bower Bay Low-level (BBL) models were combined to better simulate the effects of linking the high- and low-level wet wells.

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

- ***Runoff Generation Methodology***. The identification of pervious and impervious surfaces. 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 will provide 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 over approximately 136 miles of NYC's interceptor sewers were inspected. Data on the average and maximum sediment 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 2012 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 are used for the alternatives analysis as part of the Flushing 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, December 2012). 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 2-7 shows the annual rainfall at JFK for 1969 through 2014. As indicated in Figure 2-7, 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. Based on an analysis of 30 years of rainfall data at four rain gauges (JFK, LGA, EWR, CPK), the rainfall recorded at the JFK gauge in 2008 was also determined to be closest in characteristics to the 30-year average of all four gauges together. The 2008 JFK data had a higher total rainfall volume than the JFK 1988 data, and was considered to be more reflective of current climate conditions. The 10-year period of 2002 to 2011 is also used to assess long term performance of the LTCP recommended plans (see Section 6).

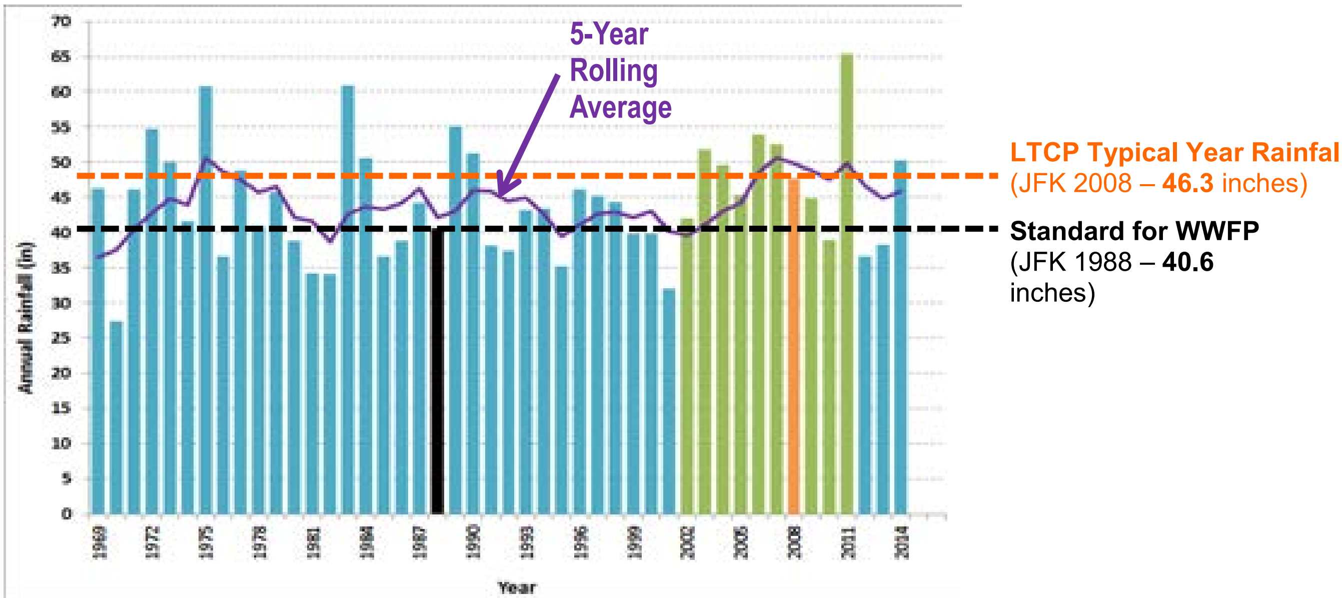

Figure 2-7. Annual Rainfall Data and Selection of the Typical Year

2.1.c Description of Sewer System

The Flushing Bay watershed/sewershed is located within the Borough of Queens (Queens County, within NYC). The western shore of the watershed is served by the Bowery Bay WWTP and its collection system, which is the major contributor of CSO to the waterbody. Table 2-1 shows the different land uses within the drainage areas served by the Bowery Bay WWTP and tributary to the Flushing Bay watershed. The Tallman Island WWTP collection system contributes small volumes of CSO to Flushing Bay at the northeastern end of the watershed. The locations of these wastewater treatment facilities and the respective sewershed boundaries are as shown in Figures 2-9 and 2-12. The CSO and stormwater outfalls associated with Flushing Bay are shown in Figure 2-8. As the figure shows, numerous discharge points are located around the perimeter of Flushing Bay. In total, 72 discharge points have been documented to exist along the shoreline of Flushing Bay by the Shoreline Survey Unit of the DEP, as shown in Table 2-3.

Table 2-3. Outfalls Discharging to Flushing Bay

Identified Ownership of Outfalls	Number of Outfalls
NYCDEP	DEP MS4 Permitted = 5
	DEP CSO Permitted = 9
NYS Department of Transportation	18
Private	34
Unknown	7
Total	72

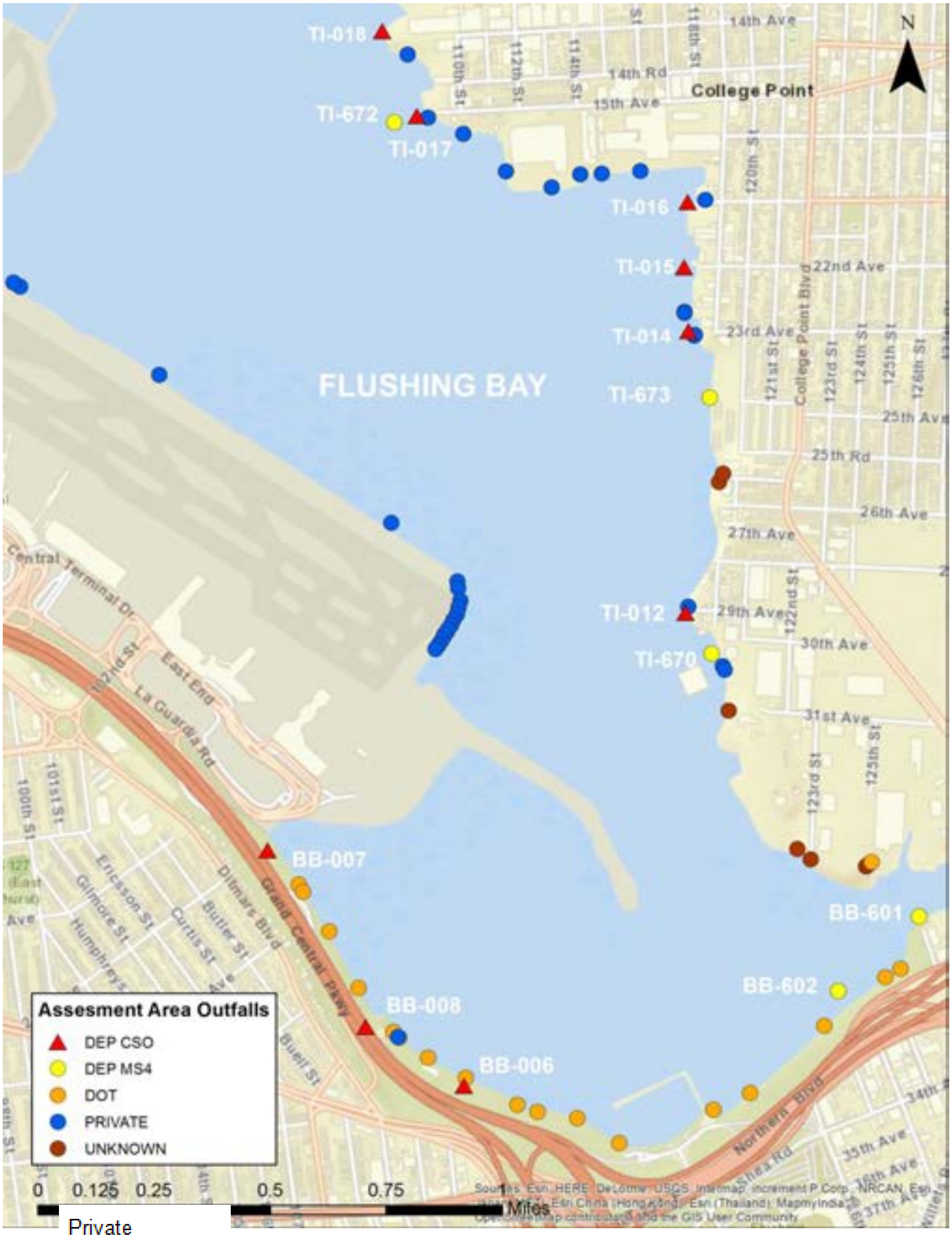

Figure 2-8. Flushing Bay Outfalls

AECOM *with* Hazen

The following sections describe the major features of the Bowery Bay and Tallman Island WWTP sewersheds within the Flushing Bay watershed. Table 2-4 shows the areas served by the various drainage system categories.

Table 2-4. Bowery Bay WWTP and Tallman Island WWTP Sewersheds Tributary to Flushing Bay: Acreage Per Sewer Category

Sewer Area Description	Area (acres)
Combined	**5,291**
Separate MS4	**122**
Direct Overland and Other	**1,037**
LaGuardia Airport	**427**
Total	**6,877**

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

Bowery Bay WWTP Drainage Area and Sewer System

The Bowery Bay WWTP is located at 43-01 Berrian Blvd. in the Astoria section of Queens, on a 34.6 acre site adjacent to the Rikers Island Channel. The Bowery Bay WWTP serves an area in the northwest section of Queens, including the communities of Kew Garden Hills, Rego Park, Forest Hills, Forest Hills Gardens, North Corona, South Corona, Lefrak City, Elmhurst, Jackson Heights, Maspeth, Woodside, Sunnyside Gardens, Sunnyside, Hunters Point, Long Island City, Astoria, Astoria Heights, Steinway, Ravenswood, and Roosevelt Island. Wastewater flows to the Bowery Bay WWTP through two interceptors. The Low Level Interceptor flows east toward the plant and the High Level Interceptor flows west toward the plant. The elevation differential between the High Level and Low Level Interceptors at the Bowery Bay WWTP is 29 feet. The Low Level Interceptor serves approximately 3,502 acres in the western side of the Bowery Bay sewershed, carrying flow from individual drainage basins along the East River extending to Newtown Creek. The High Level Interceptor serves approximately 8,392 acres in the central and eastern part of the Bowery Bay sewershed, carrying flows from individual drainage basins extending from Steinway Creek, Bowery Bay itself, and Flushing Bay. Figure 2-9 shows the Bowery Bay Collection System. The drainage areas of the Bowery Bay WWTP sewershed are depicted in Figure 2-10.

The major conveyance and regulation components of the High Level Interceptor include seven combined sewer pump stations and 19 diversion regulator structures.

Table 2-5 shows the drainage areas that contribute CSO to Flushing Bay. Regulators 06, 07, 08 and 09 are located in series from downstream to upstream, so for example, the tributary area to Regulator 06 includes all of the Regulator 07 tributary area, plus some additional area downstream of Regulator 07.

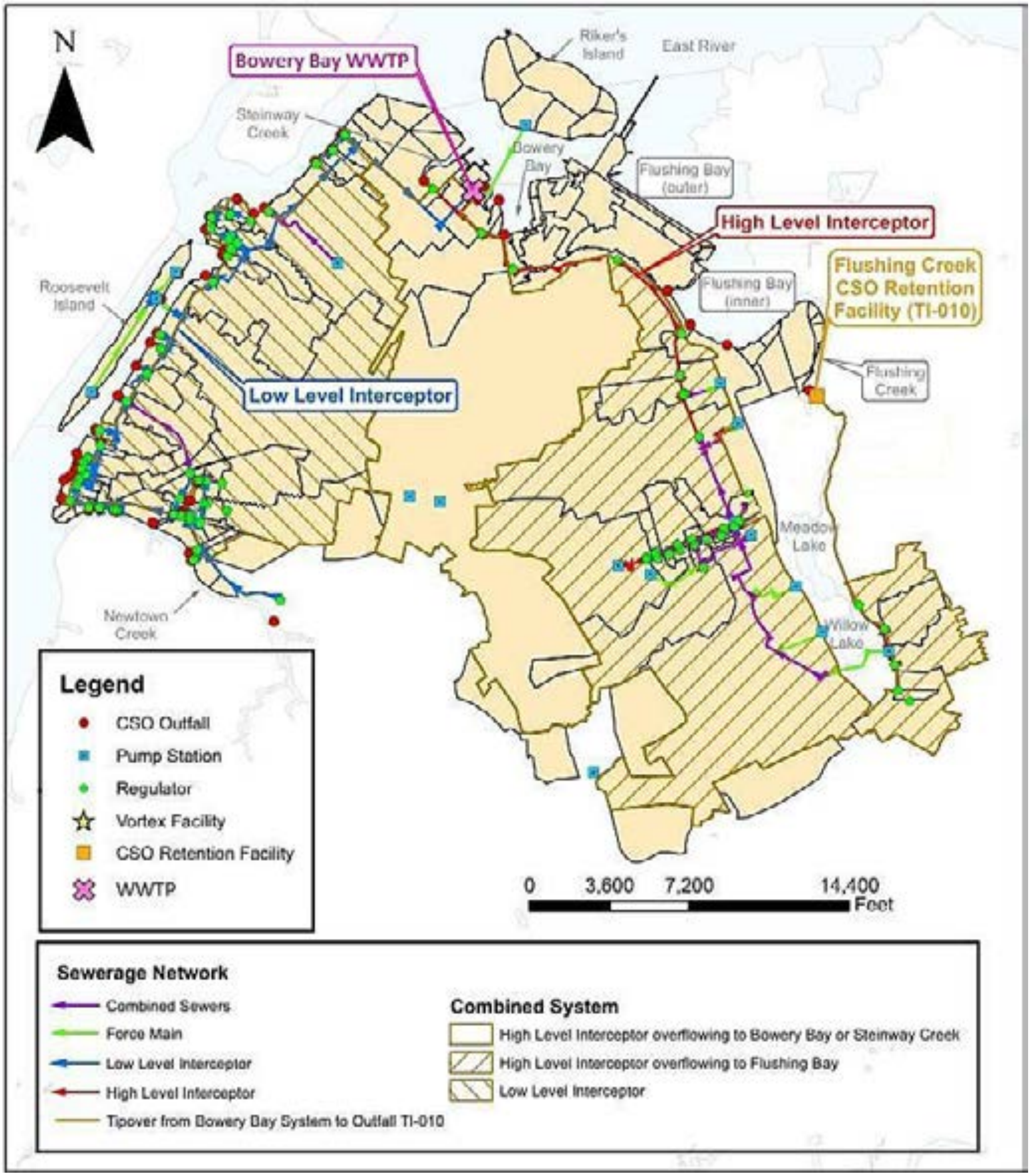

Figure 2-9. Bowery Bay WWTP Collection System

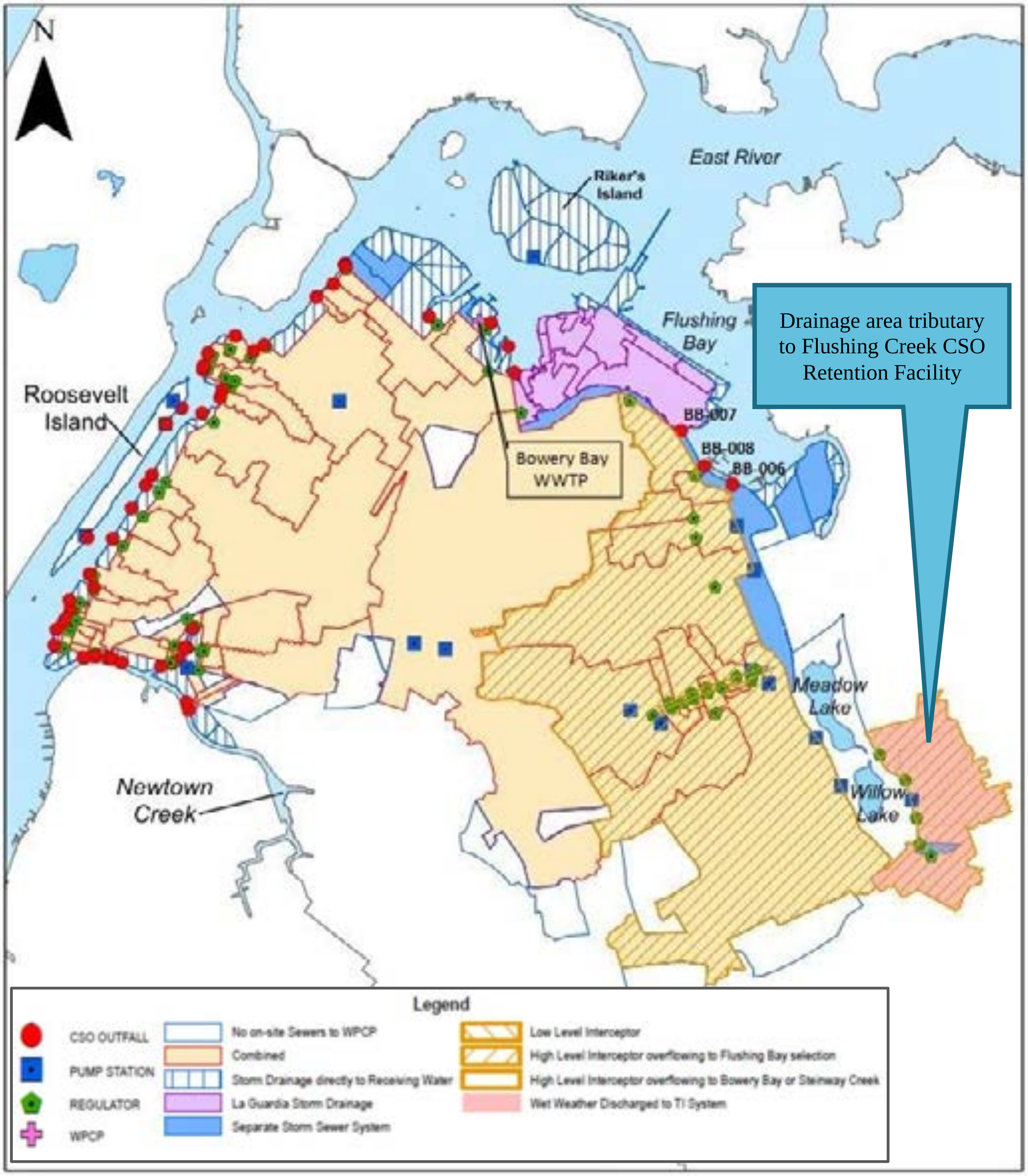

Figure 2-10. Bowery Bay WWTP Drainage Areas

Table 2-5. Bowery Bay WWTP Drainage Area Contributing to Flushing Bay: Acreage by Outfall/Regulator

Outfall	Outfall Drainage Area	Regulator	Regulator Drainage Area (acres)	Regulated Drainage Area Type	Receiving Water
BB-006	**3,775**	10 (Upper Deck)	2,707	**Combined**	Flushing Bay
		13 (Lower Deck)	1,068		
		Total	**3,775**		
BB-008	**1,151**	06	1,151[1]	**Combined**	
		07	1,107[2]		
		08	1,026[3]		
		09	811		
		Total	**1,151**		
BB-007	**146**	**Total**	**146**	**Combined**	

Notes:
(1) Area tributary to BB-008 Regulator 09, Regulator 08, Regulator 07, and Regulator 06.
(2) Area tributary to BB-008 Regulator 09, Regulator 08, and Regulator 07.
(3) Area tributary to BB-008 Regulator 09 and Regulator 08.

Bowery Bay Non-Sewered Areas

Some areas within the Bowery 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 2-10, these areas are generally located along the shoreline. Some areas, also shown in Figure 2-10, are not served by sanitary sewers, relying on on-site septic systems for sanitary sewage disposal. In one of these areas, the Willets Point redevelopment will include build-out of sanitary sewers tributary to the Bowery Bay WWTP combined sewer system and storm sewers discharging through outfalls along Flushing Bay. This redevelopment is part of Reach 11 - Queens Upper East River of the Vision 2020 New York City Comprehensive Waterfront Plan. The Willets Point/Downtown Flushing redevelopments are located within Recommendation Area 4 shown in Figure 2-11. As shown, the Vision 2020 Plan also includes Recommendation Area 3 that encompasses the shore of inner Flushing Bay. The Plan proposes the study of the hydrology and means of improving water circulation and siltation, exploration of options for expanding mooring fields for recreational boats, improving maintenance of the Flushing Bay Promenade, and improving pedestrian and bicycle connections to upland areas to the west and south of the Flushing Bay Promenade including Flushing Meadows-Corona Park.

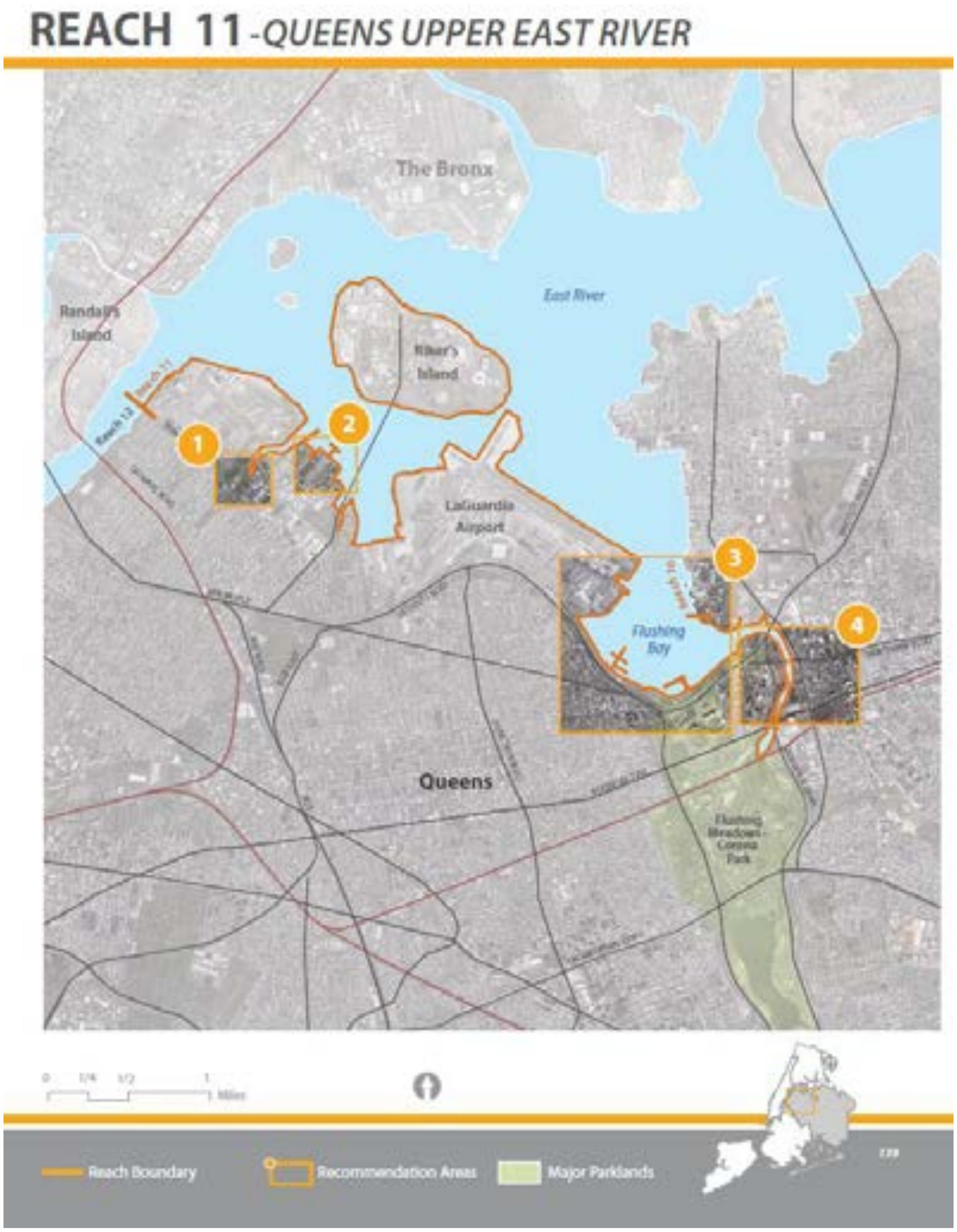

Figure 2-11. NYC Vision 2020 – Reach 11 Comprehensive Waterfront Plan

Bowery Bay MS4 Outfalls

Two SPDES-permitted MS4 outfalls (BB-601 and BB-602) are associated with the Bowery Bay WWTP sewershed served by the High Level Interceptor. These MS4 outfalls, shown in Figure 2-7, both discharge to Flushing Bay near the mouth of Flushing Creek. These outfalls drain stormwater runoff from the separate sanitary sewer areas around the Willets Point area. While runoff from these areas does not enter the combined system, the stormwater discharging to Flushing Bay can impact water quality in the Bay and Creek.

Bowery Bay CSOs

Three SPDES-permitted Bowery Bay CSO outfalls associated with the High Level Interceptor discharge to Flushing Bay. These three outfalls, BB-006, BB-007 and BB-008, are shown in Figure 2-7. It should be noted that BB-006 discharges the largest annual CSO volume of all the CSO outfalls citywide.

Tallman Island WWTP Drainage Area and Sewer System

The northeastern portion of the Flushing Bay watershed is served by the Tallman Island WWTP. The Tallman Island sewershed includes sanitary and combined sewers. The Tallman Island service area includes:

- 16 pumping stations, with five serving combined system areas;
- 49 combined sewer flow regulator structures; and
- 24 CSO outfalls, two of which are permanently bulkheaded.

The Tallman Island WWTP is located at 127-01 134th Street, in the College Point section of Queens, on a 31-acre site adjacent to Powells Cove. The Tallman Island WWTP serves the sewered area in the northeast section of Queens, including the communities of Little Neck, Douglaston, Oakland Gardens, Bayside, Auburndale, Bay Terrace, Murray Hill, Fresh Meadows, Hillcrest, Utopia, Pomonok, Downtown Flushing, Malba, Beechhurst, Whitestone, College Point, and Queensboro Hill. A total of 490 miles of sanitary, combined, and interceptor sewers feed into the Tallman Island WWTP, as shown on Figure 2-12. The corresponding Tallman Island WWTP sewershed are shown in Figure 2-13. A total of 438 acres of the Flushing Bay watershed area are served by the Tallman Island WWTP.

The Tallman Island WWTP has provided full secondary treatment since 1978. Treatment processes include primary screening, raw sewage pumping, grit removal and primary settling, air-activated sludge capable of operating in the step aeration mode, final settling, and chlorine disinfection. The Tallman Island WWTP has a design dry-weather flow (DDWF) capacity of 80 million gallons per day (MGD), and is designed to receive a maximum flow of 160 MGD (two times design dry-weather flow) with 120 MGD (one and one-half times design dry-weather flow) receiving secondary treatment. Flows over 120 MGD receive primary treatment and disinfection.

The Tallman Island WWTP includes four principal interceptors: the Main Interceptor, the College Point Interceptor, the Flushing Interceptor, and the Whitestone Interceptor.

- The Main Interceptor is a direct tributary to the Tallman Island WWTP, and picks up flow from the College Point and Flushing interceptors.

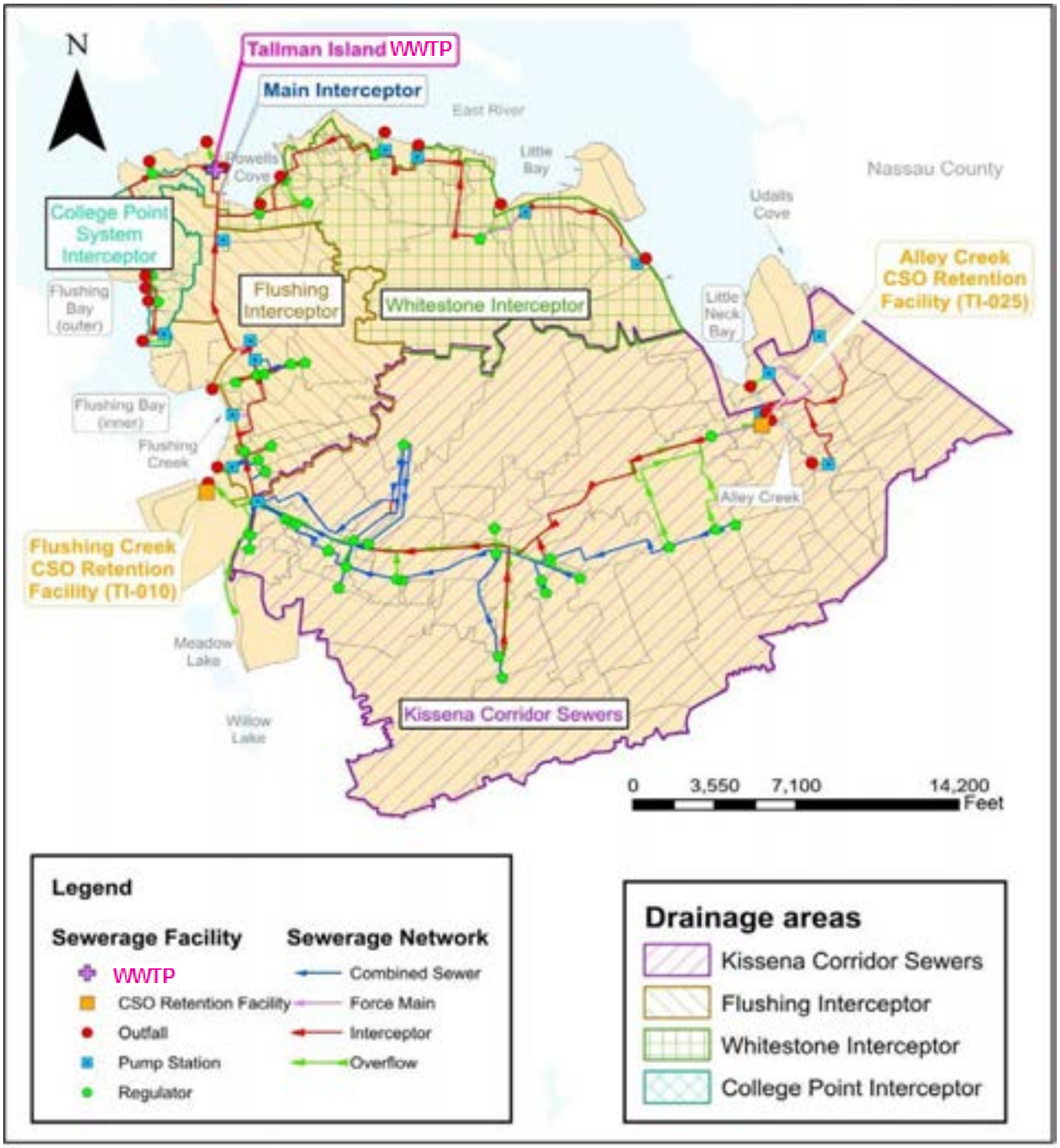

Figure 2-12. Tallman Island WWTP Sewershed Collection System

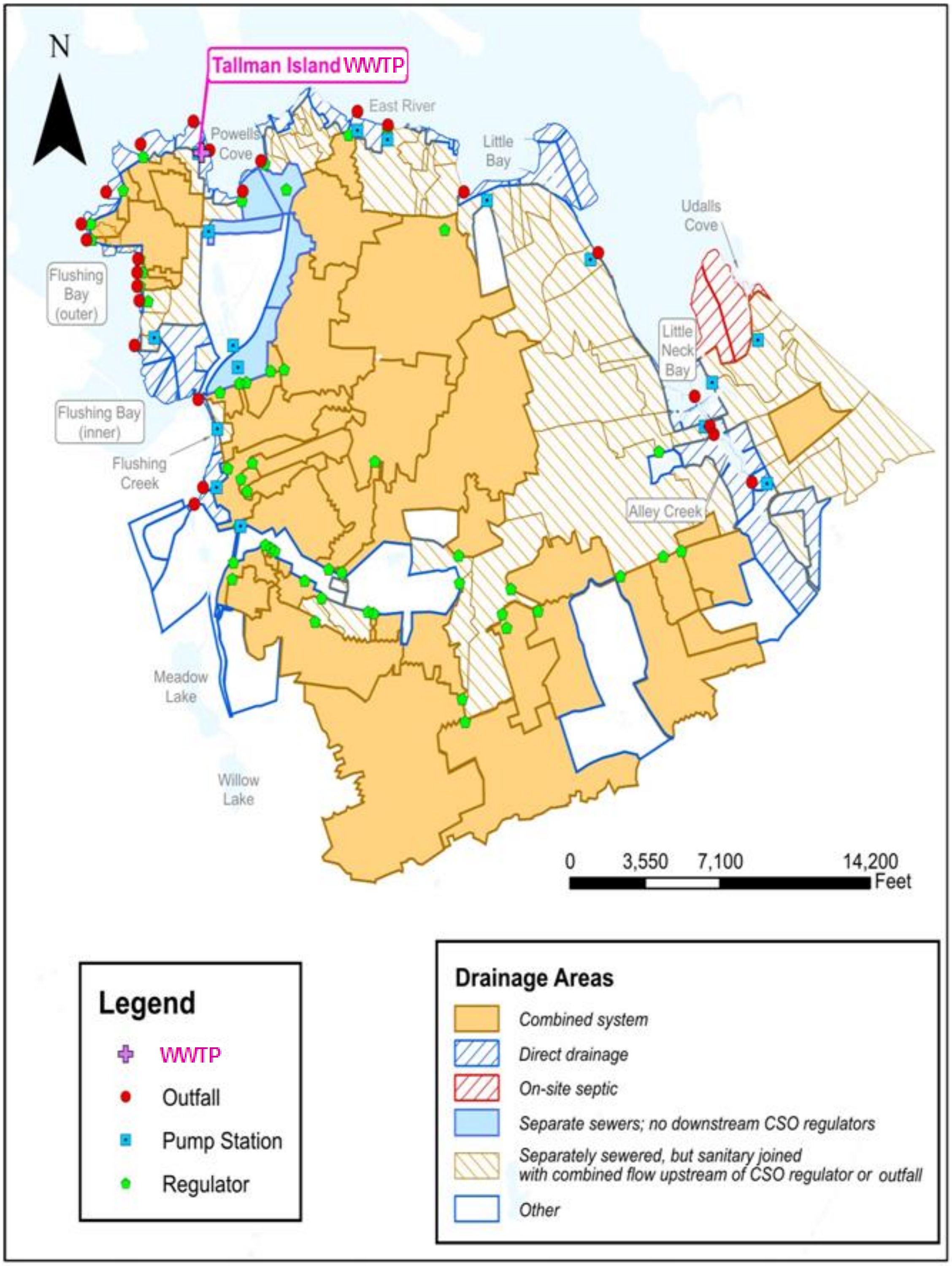

Figure 2-13. Tallman Island WWTP Drainage Areas

- The College Point Interceptor carries flow from sewersheds to the west of the treatment plant, and discharges into the Powell's Cove Pumping Station, which discharges into the Main Interceptor within the WWTP premises.
- The Flushing Interceptor is an extension of the Main Interceptor south of the Whitestone connection, and serves most of the areas to the south in the system. The Flushing Interceptor also receives flow from the southeast areas of the system, along the Kissena Corridor Interceptor (via trunk sewers upstream of the TI-R31 regulator), and from the Douglaston area. The Alley Creek sewershed drains to the Tallman Island WWTP via the Kissena Corridor Interceptor.
- The Whitestone Interceptor conveys flow from the area east of the treatment plant along the East River. Until recently, the Whitestone Interceptor used to discharge to the Main Interceptor from the west side, just upstream of the College Point Interceptor connection, via gravity discharge. As proposed in the Flushing Creek WWFP, the Whitestone Interceptor was extended and disconnected from the Flushing Interceptor. The new extension came on-line in mid-2014.

This service area also includes two CSO retention facilities that were developed from the East River Facility Planning and WWFP processes. The first facility is the Flushing Creek CSO Retention Facility, also referred to as Flushing Bay CSO Retention Facility, with a total capacity of 43.4 million gallons (MG) (28.4 MG of off-line storage and 15 MG of in-line storage in large outfall pipes). This facility has been operational since May 2007. Post-event, retained flow is pumped to the upper end of the Flushing Interceptor, upstream of Regulator TI-009. This regulator was reconstructed in 2005 to provide adequate capacity to convey both sanitary flows and dewatered flow from the retention tank following wet-weather events.

The second facility is the Alley Creek Retention Tank, which was put into operation in March 2011. This retention tank has an off-line storage capacity of 5 MG. During wet-weather, flows are directed to the off-line storage tank by the diversion weir in Chamber 6 of the Alley Creek CSO Retention Tank. When the retention tank reaches capacity, excess water overflows the storage basin and is discharged to Alley Creek through Outfall TI-025, after receiving floatables control. Post-event dewatering of this tank is accomplished through the upgraded Old Douglaston Pumping Station, which has a peak capacity of 8.5 MGD.

Tallman Island Non-Sewered Areas

Some areas within the Tallman Island WWTP sewershed are considered direct drainage areas, where stormwater drains directly to receiving waters without entering the combined sewer system. These areas are generally located along the shoreline, and were delineated based on topography. Some areas are not served by sanitary sewers, relying on on-site septic systems for wastewater disposal. The direct drainage and septic system areas are shown in Figure 2-13.

Tallman Island MS4 Outfalls

The Tallman Island WWTP SPDES permit currently includes three permitted MS4 outfalls tributary to Flushing Bay, as shown in Figure 2-7. Outfalls TI-670, TI-672 and TI-673 drain stormwater runoff from the separate sanitary sewer areas around Flushing Bay. Runoff from these areas contributes stormwater discharges to Flushing Bay.

Tallman Island/Flushing Creek CSOs

Six SPDES-permitted CSO outfalls discharge to Flushing Bay from the Tallman Island system. The six CSO outfalls, identified as TI-012, TI-014, TI-015, TI-016, TI-017 and TI-018, are shown in Figure 2-7.

2.1.c.2 Stormwater and Wastewater Characteristics

The 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 carbonaceous biochemical oxygen demand ($CBOD_5$), total suspended solids, fecal coliform bacteria and enterococci bacteria to use in calculating loadings from various sources.

Table 2-6 shows both the sanitary and stormwater concentrations assigned to the service areas of the collection systems that discharge to Flushing 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) is used to generate the flows from NYC CSO and storm sewer outfalls.

Table 2-6. Flushing Bay Source Loadings Characteristics

Source	Enterococci (cfu/100mL)	Fecal Coliform (cfu/100mL)	BOD_5 (mg/L)
Urban Stormwater(2)	15,000	35,000	15
CSOs (BB-006 and BB-008)(1)	Monte Carlo	Monte Carlo	Mass Balance (Sanitary =140)
Sanitary for Mass Balance CSOs(1)	600,000	4,000,000	Mass Balance (Sanitary=140)
Highway/Airport Runoff (3)	8,000	20,000	15
Direct Drainage(3)	6,000	4,000	15

Notes:
(1) Flushing Bay LTCP Sewer System and Water Quality Modeling, 2016.
(2) HydroQual Memo to DEP, 2005a.
(3) Basis – NYS Stormwater Manual, Charles River LTCP, National Stormwater Data Base.

A flow monitoring and sampling program targeting CSO tributary to Flushing 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 local sanitary sewage and runoff entering the combined sewers.

CSO concentrations were measured in 2015 to provide site-specific information for Outfalls BB-006 and BB-008. The CSO bacteria concentrations were characterized by direct measurements of four CSO events during various storms occurring during the months of July 2015 through October 2015. These concentrations are shown in the form of a cumulative frequency distribution in Figures 2-14 and 2-15. Individual sample points are shown, as well as the trend line that best fits the data distribution. For Outfall BB-006, CSO discharges measured fecal coliform concentrations are log-normally distributed and values range from 78,000 to 4,400,000 cfu/100mL (Figure 2-14). As shown in the figure, one analytical fecal coliform result of 2,000 cfu/100mL does not follow the same distribution as the remainder data points and is therefore not used within the LTCP processes. Similarly, enterococci concentrations are also log-normally distributed and range from 63,000 to 12,700,000 cfu/100mL. For Outfall BB-008, measured CSO fecal coliform concentrations are log-normally distributed, and values range from 90,000 to 4,600,000 cfu/100mL (Figure 2-15). Similarly, enterococci concentrations are also log-normally distributed and range from 90,000 to 2,700,000 cfu/100mL.

Flow monitoring data were collected for CSO Outfalls BB-006 and BB-008 to support the development of the Flushing Bay LTCP. A description of the Bowery Bay WWTP IW model update and calibration processes based on the flow monitoring data gathered for Outfalls BB-006 and BB-008 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.

2.1.c.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 can be 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 year 2008 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 contained 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 contribution from the Tallman Island WWTP collection system to Flushing Bay is minimal in comparison to the CSO contribution from the Bowery Bay system, the following summary of the 2012 recalibration effort is presented for the Bowery Bay WWTP exclusively.

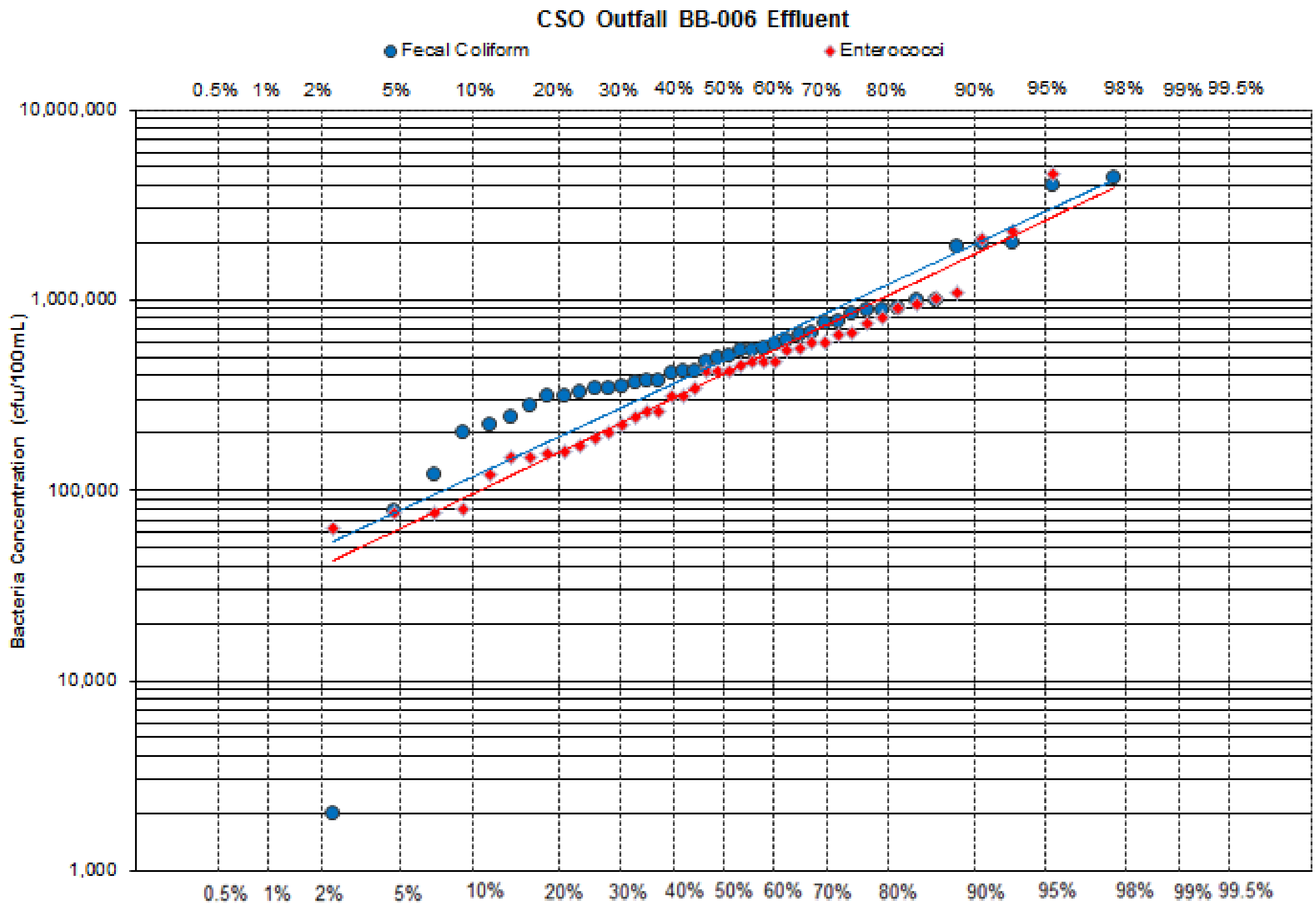

Figure 2-14. Outfall BB-006 Measured CSO Bacteria Concentrations

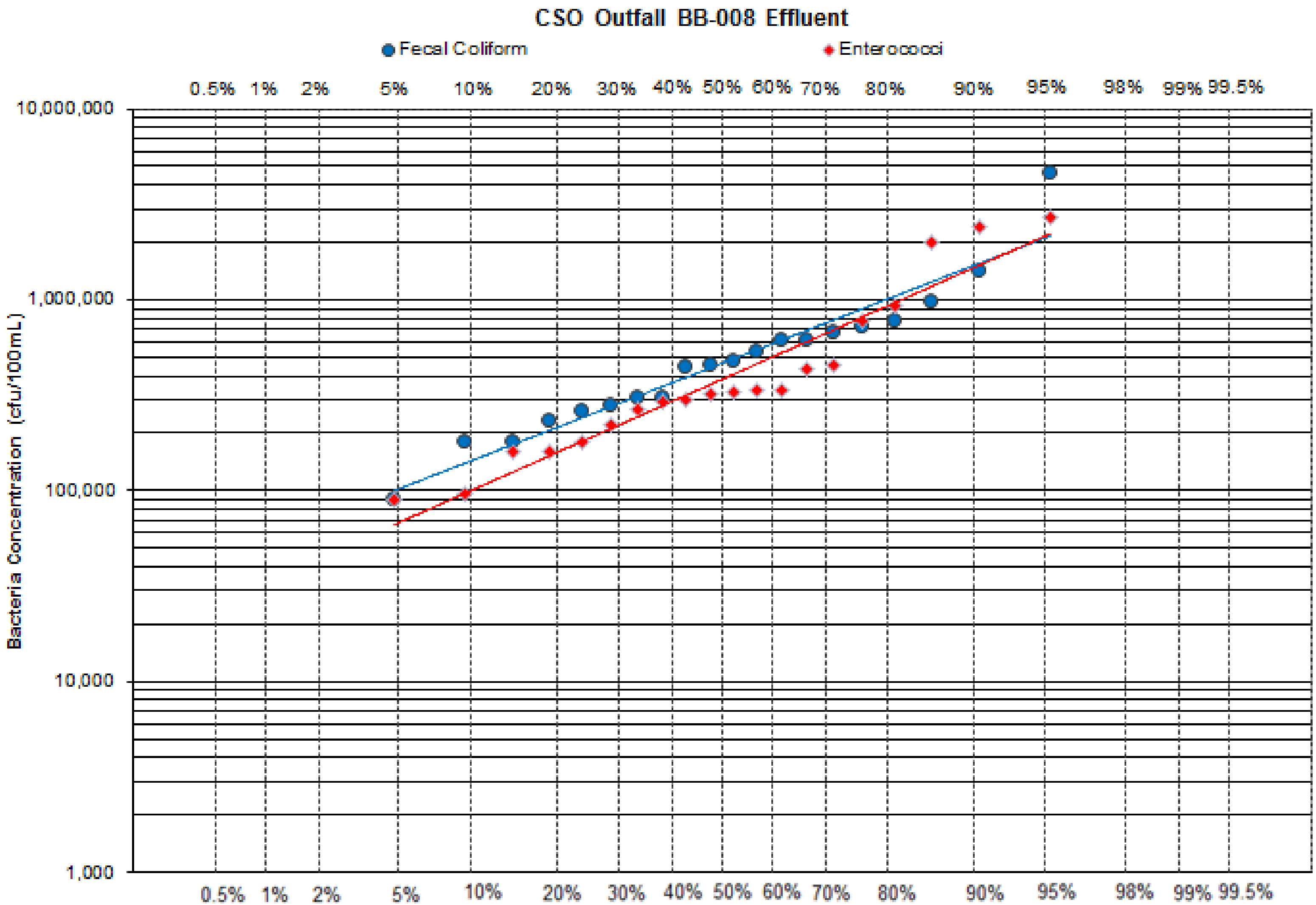

Figure 2-15. Outfall BB-008 Measured CSO Bacteria Concentrations

Annual Hours at 2xDDWF for 2008 with Projected 2040 DWF

Model simulations were conducted to estimate the annual number of hours that the Bowery Bay 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 service area. The CEG elements represent the CSO controls that became part of the 2012 CSO Order. For these simulations, the primary input conditions applied were as follows:

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

Key observations/findings are summarized below:

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

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

- The total annual CSO volume predicted for the outfalls in the Bowery Bay sewershed were as follows:
    - 2008 non-CEG: 4,720 MG
    - 2008 with CEG: 4,333 MG

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

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 in the modeled WWFP 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. Key observations/findings of this analysis are described below.

- 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.
- For the single storm event simulated, the model predicted that between 70 and 84 percent (by length) of the High Level Interceptor sewer segments would exceed full-pipe capacity flow for the non-CEG and CEG scenarios, respectively. About 38 percent (by length) of the upstream combined sewers would exceed their full-pipe flow under both scenarios. For the same event, the model predicted that between 91 and 96 percent (by length) of the Low Level Interceptor sewer segments would exceed full-pipe capacity flow for the non-CEG and CEG scenarios, respectively. About 32 to 34 percent (by length) of the upstream combined sewers would exceed their full-pipe flow under the same scenarios.
- For both the non-CEG and CEG scenarios, the full lengths of all of the interceptors (High Level Interceptor [HLI] and Low Level Interceptor [LLI]) were predicted to flow at full depth or higher.
- The results for the system condition with CEG improvements showed that the overall peak plant inflow near the plant improved, in comparison to the non-CEG conditions in the Bowery Bay sewershed.
- About 70 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 Bowery Bay system generally exhibits full or near full-pipe flows during wet-weather, allowing little potential for in-line storage capability.

2.1.c.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. Though 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.c.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 repair as necessary. Figure 2-16 illustrates the intercepting sewers that were inspected in the Borough of Queens, encompassing the entire Flushing Bay watershed. Throughout 2015, 22 cubic yards of sediment was removed from Tallman Island WWTP intercepting sewers and 37 cubic yards of sediment was removed from Bowery Bay WWTP intercepting sewers. Citywide, the inspection of 66,262 feet of intercepting sewers resulted in the removal of 3,306 cubic yards of sediment.

DEP recently conducted a sediment accumulation analysis to quantify levels of sediments in the combined sewer system. 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 was approximately 1.25 percent, with a standard deviation of 2.02 percent.

2.1.c.6 Status of Receiving Wastewater Treatment Plants

The majority of the Flushing Bay basin is served by the Bowery Bay WWTP sewershed and the CSO outfalls associated with its collection system are the major contributors of CSO to Flushing Bay. The Bowery Bay WWTP underwent upgrades for Biological Nutrient Removal (BNR) and improvements that enable the collection system and treatment facility to deliver, accept, and treat influent at twice the plant's DDWF of 150 mgd during storm events.

2.2 Waterbody Characteristics

This section of the report describes the features and attributes of Flushing 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.

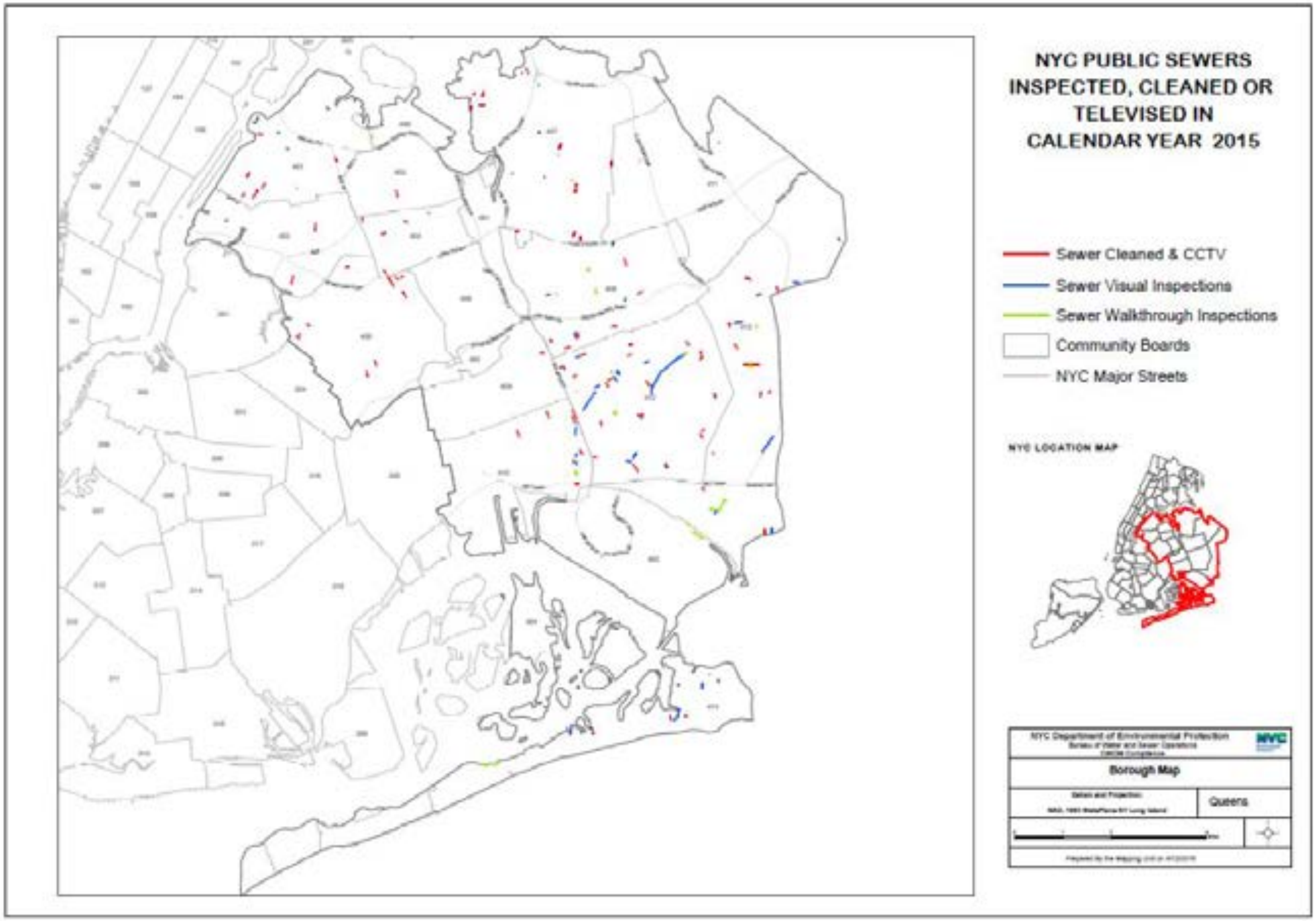

Figure 2-16. Sewers Inspected and Cleaned in Queens Throughout 2015

2.2.a Description of Waterbody

Flushing Bay is a tidal waterbody located in Queens, New York. Flushing Creek is the sole tributary to the Bay and the Bay is tributary to the Upper East River. Water quality in Flushing Bay is influenced by CSO, stormwater discharges and the tidal exchange with the Upper East River. The following section describes the present-day physical and water quality characteristics of Flushing 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. DEC considers the Class SA and Class SB classifications to fulfill the CWA goals. 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 Flushing Bay as a Class I waterbody.

Numerical standards corresponding to these waterbody classifications are shown in Table 2-7. Dissolved oxygen (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 2-7, these narrative criteria apply to all five classes of saline waters. Narrative WQS criteria are presented in Table 2-8.

Note that the enterococci criterion of 35 cfu/100mL listed in Table 2-7, although not promulgated by DEC, is now an enforceable standard in NYS, because EPA established January 1, 2005 as the date upon which the criteria must be adopted for all coastal recreational waters. According to DEC’s interpretation of the Beaches Environmental Assessment and Coastal Health (BEACH) Act of 2000, the criterion applies on a 30-day moving geometric mean (GM) basis during the recreational season (May 1st through October 31st). Furthermore, this criterion is not applicable to the tributaries of the Long Island Sound and the East River tributaries and therefore would not apply to Flushing Bay under current water quality classifications.

Currently, DEC is conducting its Federally-mandated "triennial review" of the NYS WQS, in which States are required to review their WQS every three years. DEC is in the pre-public proposal phase of this rule, and staff is considering a wide range of revisions/additions to WQS regulations. DEC has indicated that in accordance with the 2012 EPA Recreational Water Quality Criteria (RWQC), DEC intends to establish the enterococci criterion as a promulgated standard through a formal rulemaking within NYS sometime in the future.

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	
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	≤ 2,400(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 geometric mean of five or more samples.
(7) This standard, although not promulgated by DEC, is now an enforceable standard in New York State 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 geometric mean 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.

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 IEC). The IEC includes all saline waters of greater NYC. Flushing Bay is an interstate water and is regulated by IEC as Class B-1 waters. Numerical standards for IEC-regulated waterbodies are shown in Table 2-9, 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 combined sewer system 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.

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. For example, Douglas Manor Association is a private club located in Little Neck Bay with a permit to operate a beach by New York City Department of Health and Mental Hygiene (DOHMH). DOHMH uses a 30-day moving GM of 35 cfu/100mL to trigger such 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.

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; 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.

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.

Flushing Bay is classified as a Class I waterbody (secondary contact recreation best use). 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. No areas of the Flushing Bay shoreline are authorized by the DOHMH for bathing.

In December 2012, the EPA released RWQC recommendations that are designed to protect human health in coastal and non-coastal waters designated 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 statistical threshold value (STV) based on exceeding a 90th percentile value associated with the geometric mean. 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

Based upon its understanding that DEC will implement EPA's RWQC Recommendation 2, DEP has based its LTCP analysis for Flushing Bay on the enterococci numerical criteria associated with that Recommendation.

2.2.a.2 Physical Waterbody Characteristics

Flushing Bay is located in northern Queens, NY. Its sole tributary, Flushing Creek, opens into the southeast end of Flushing Bay. Flushing Bay opens to the Upper East River, between College Point and Rikers Island, north of LaGuardia Airport. At the northern end of the airport, a short, narrow strait connects Flushing Bay and Bowery Bay. The Bay has a navigational channel formally known as Flushing Bay Navigational Channel that extends into the Creek up to the Whitestone Expressway overpass.

Flushing Bay starts at the northwestern end of Flushing Creek and extends to the Upper East River. The World's Fair Marina and promenade are located along the southwestern shoreline. LaGuardia Airport filled-in perimeter defines most of the northwestern shore of the Bay. The eastern shore accommodates primarily industrial and residential uses.

Inner Flushing Bay is located within the Coastal Zone Boundary as designated by DCP. DCP has also designated inner Flushing Bay as a Significant Natural Waterfront Area (SNWA). As defined by DCP, SNWA is a large area of concentrated natural resources, such as wetlands and natural habitats, which possesses a combination of important coastal ecosystem features.

Proposed redevelopment and re-zoning of the Iron Triangle area of Willets Point may include revitalization of the waterfront and habitats of the southern shore of Flushing Bay and western shore of Flushing Creek.

Shoreline Physical Characterization

The shorelines of Flushing Bay are composed of a mix of natural areas, rip-rap, marina and bulkhead, as shown in Figure 2-17. The shoreline of the inner bay from the mouth of the Creek to LaGuardia Airport is composed mainly of rip-rap and a marina with a small extent of natural shoreline. The shoreline defined by the LaGuardia Airport perimeter is mainly composed of rip-rap within the inner bay and natural slopes along the outer bay. The eastern shoreline is composed of a mix of natural, rip-rap and marina, with small pockets of bulkhead and a few piers. Figures 2-18, 2-19 and 2-20 show the predominant shoreline characteristics along the Bay. Figure 2-18 shows the typical rip-rap protection found throughout the Bay, Figure 2-19 shows a typical natural shoreline and Figure 2-20 depicts the World's Fair Marina.

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 Flushing Bay.

Waterbody Sediment Surficial Geology/Substrata

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

Waterbody Type

Flushing Bay is a tidal tributary of the Upper East River that receives freshwater from stormwater and CSOs, as well as groundwater inflows from the man-made freshwater lakes located upstream of the tidal portion of Flushing Creek, the Bay's sole tributary.

Tidal/Estuarine Systems Biological Systems

Tidal/Estuarine Wetlands

Tidal/estuarine wetlands reported by the U.S. Fish and Wildlife Service (USFWS) National Wetlands Inventory (NWI) maps show limited tidal/estuarine wetlands throughout the Flushing Bay study area, as shown in Figure 2-21. The three identified classes of estuarine wetlands shown in Figure 2-21 are described in Table 2-12.

Table 2-12. NWI Classification Codes

NWI Classification	Description
E2EM1P	Estuarine, inter-tidal, emergent-persistent, irregular
E2EM1N	Estuarine, inter-tidal, persistent, regularly flooded
E2US2N	Estuarine, inter-tidal, unconsolidated shore, regularly flooded

Aquatic and Terrestrial Communities

The DCP Plan for the Queens Waterfront (DCP, 1993) reports a diverse range of species supported by the habitat in the Flushing Creek area. A more detailed summary of the aquatic and terrestrial communities can be found in the 2011 Flushing Bay WWFP.

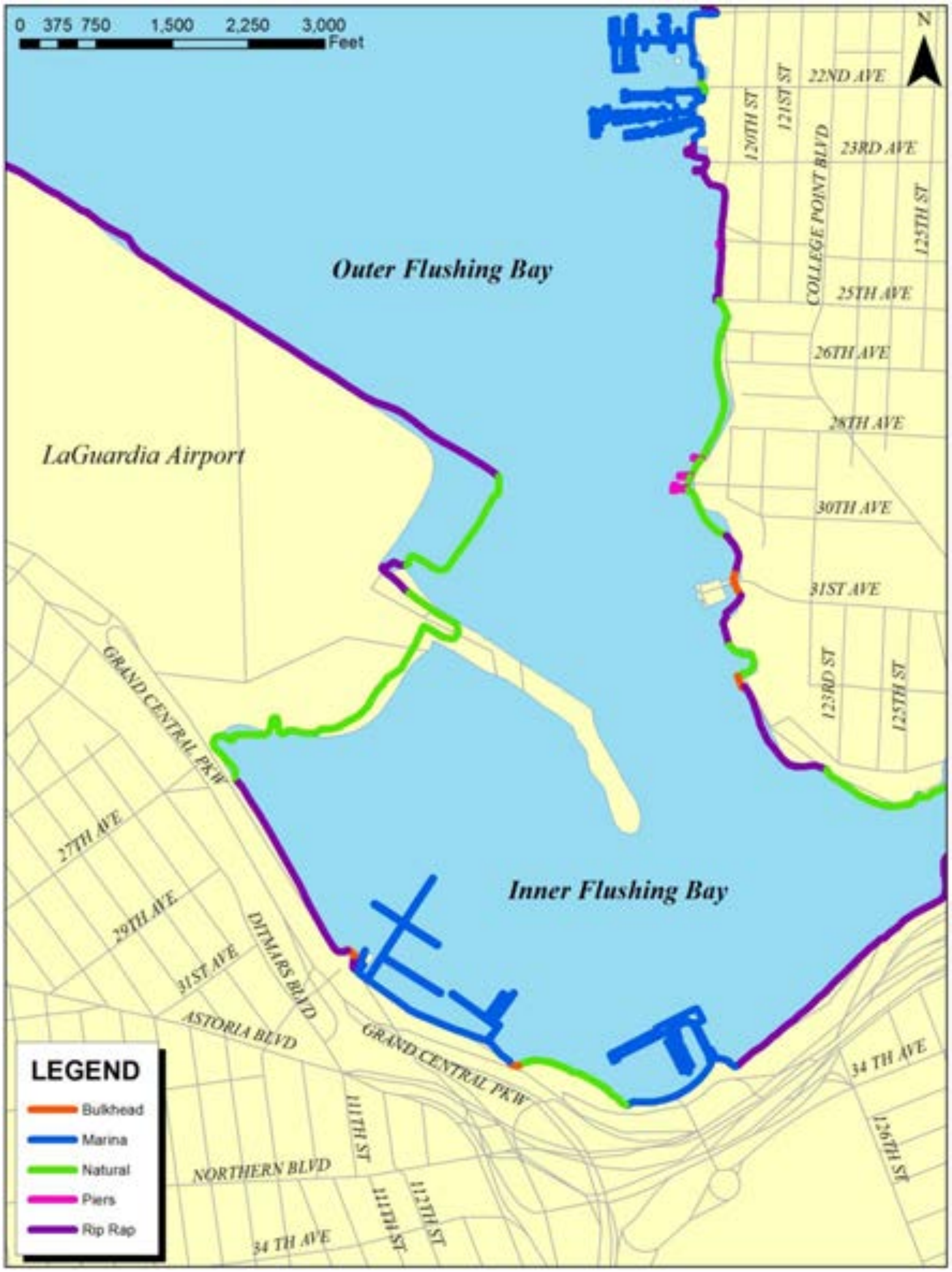

Figure 2-17. Flushing Bay Shoreline Characteristics

Figure 2-18. Rip-rap Shoreline View of Flushing Bay from Whitestone Expressway (Looking West)

Figure 2-19. Natural Shoreline of Flushing Bay (Looking West)

Figure 2-20. World's Fair Marina

Figure 2-21. National Wetlands Inventory Source: NYS GIS Clearinghouse-2014

Freshwater Systems Biological Systems

Three generalized freshwater wetlands areas are shown in DEC's Freshwater Wetlands Maps. Within the Flushing Bay watershed, these areas are mapped solely in the former Flushing Airport property.

2.2.a.3 Current Public Access and Uses

In Flushing Bay, swimming (primary contact recreation use) is not the best use, as defined by New York State Codes, Rules and Regulations for Class I waterbodies. Secondary contact recreation opportunities are facilitated exclusively by access points along Flushing Bay as shown in Figure 2-22. Figure 2-23 identifies a public boat/kayak launch located at the east end of the Flushing Bay Promenade. Two other locations along Flushing Bay depicted in Figures 2-24 and 2-25 have been identified to promote waterfront observation and do not promote primary or secondary contact recreational activities.

2.2.a.4 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

Flushing Bay was analyzed under the federal CSO Policy as set forth in Table 2-13.

Table 2-13. 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
Flushing Bay	None	None	No	No[4]	None[5]	None[5]	None

Notes:
(1) Classifications or Designations per CSO Policy.
(2) NOAA.
(3) Department of State - Significant Coastal Fish and Wildlife Habitats.
(4) Existing uses include secondary contact recreation and fishing, Class I.
(5) These waterbodies contain salt water.

Figure 2-22. Access Points to Flushing Bay

Figure 2-23. Boat/Kayak Launch at the East End of Flushing Bay Promenade

Figure 2-24. Flushing Bay Promenade and Marina

Figure 2-25. Professional Service Center for the Handicapped

2.2.a.5 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 Harbor Survey Monitoring (HSM) Program has been the responsibility of DEP's Marine Sciences Section for the past 27 years. These initial surveys were performed in response to public complaints about quality-of-life near polluted waterways. The initial effort has grown into a survey that consists of 72 stations distributed throughout the open waters of the Harbor and smaller tributaries within NYC. The number of water quality parameters measured has also increased from 5 in 1909, to over 20 at present.

Harbor water quality has improved dramatically since the initial surveys. Infrastructure improvements and the capture and treatment of virtually all dry-weather sewage are the primary reasons for this improvement. During the last decade, water quality in New York Harbor has improved to the point that the waters are now utilized for recreation and commerce throughout the year. The LTCP process has begun to focus on those areas that could be improved still further. The LTCP program evaluates 11 waterbodies and their drainage basins and develops a comprehensive improvement plan for each.

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. Flushing Bay is located within the Upper East River – Western Long Island Sound (UER-WLIS) section. This area contains nine open-water monitoring stations and five tributary sites. Figure 2-26 shows the location of three HSM tributary Stations: E6, FB1 and E15.

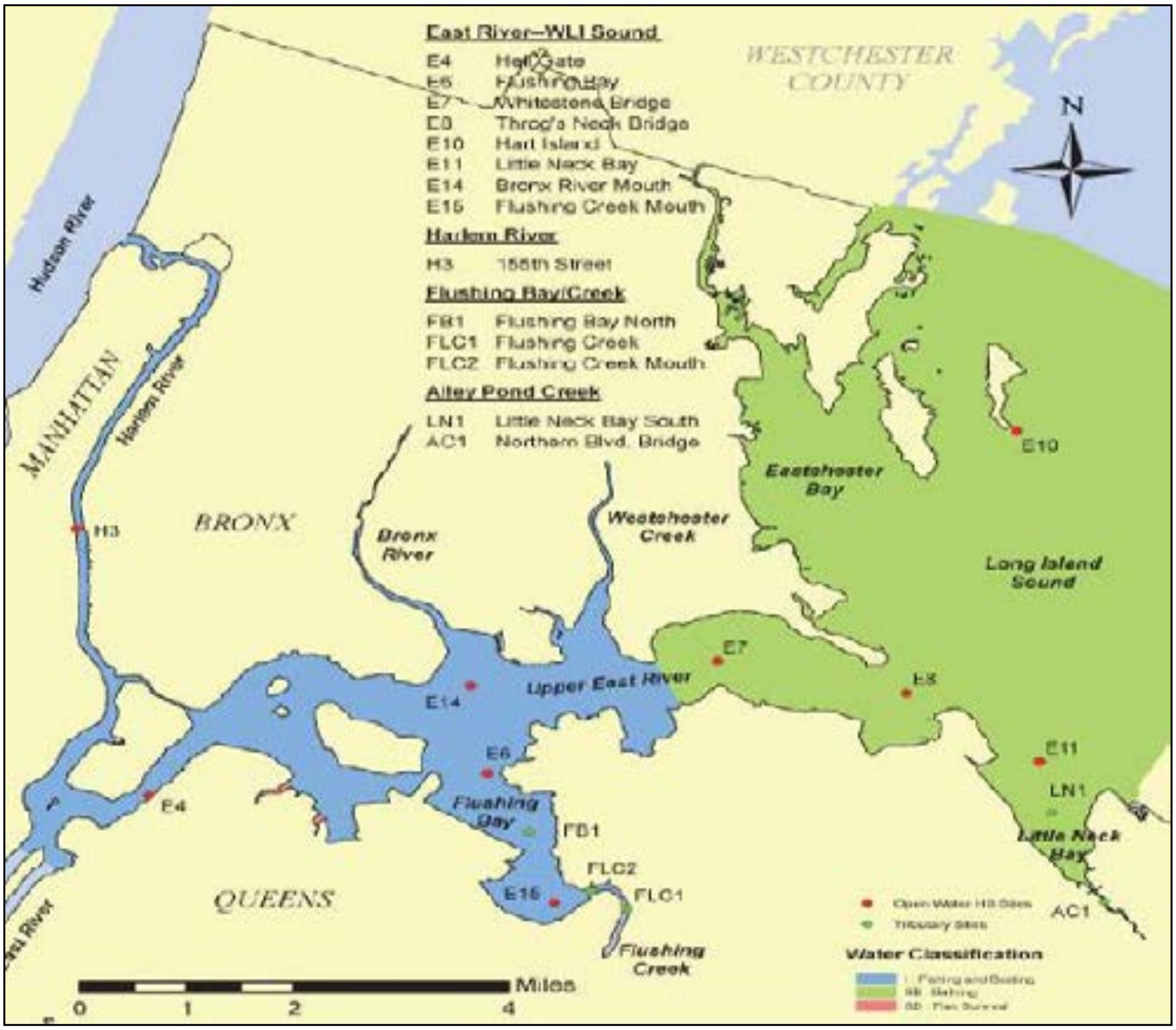

Figure 2-26. Harbor Survey UER-WLIS Region

Fecal coliform and enterococci are indicators of human waste and pathogenic bacteria. According to 2013 through 2015 HSM program data, fecal coliform geometric means representative of wet- and dry-weather conditions for the period range from 23 cfu/100mL at Station E6 to 255 cfu/100mL at Station E15. The computed enterococci GMs range from 3 cfu/100mL at Station E6 to 13 cfu/100mL at Station E15.

DO is the oxygen in a waterbody available for aquatic life forms. Throughout recent years, average DO levels have been measured consistently above the compliance requirement of 4.0 mg/L most of the time. Throughout 2013, 2014 and 2015, DO was measured slightly below 4.0 mg/L on three days. These low DO measurements are listed in Table 2-14. The average at Station E6 was measured at 6.8 mg/L. For FB1, average DO was measured at 7.1 mg/L, while the average DO at Station E15 was measured at 7.2 mg/L. During summer months, the Flushing Bay waters essentially met their DO classification requirement. Hypoxia is another water quality condition associated with DO, and occurs when DO levels fall below 3.0 mg/L. DO measurements below 3.0 mg/L were never taken at Stations E16, FB1 and E16 in Flushing Bay throughout 2013, 2014 and 2015.

Table 2-14. Measured Low DO Levels (2013 throughout 2015)

Station	8/12/2013	9/2/2014	8/31/2015
E15			3.9
FB1		3.8	3.8
E6	3.9	3.8	3.7

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. Based on the HSM program data, the average chlorophyll 'a' concentration in the Bay from 2013 throughout 2015 was 8.3 µg/L.

Secchi transparency is a measure of the clarity of surface waters. Clarity is measured as a depth when the Secchi disk blends in with the water. 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 2015 was 2.8 feet for E15, 2.9 for FB1 and 3.7 for E6. All stations in Flushing Bay reported a significant number of low transparency values (under 3.0 feet).

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

Data collected within Flushing Bay are available from sampling conducted by DEP's HSM program from 2007 to 2015, and from intensive sampling conducted from November 2013 through May 2014 to support the Flushing Bay LTCP. The sampling locations of both programs are shown in Figure 2-27. Figures 2-29 through 2-32 show the GM of both datasets over the concurrent sampling period along with data ranges (minimum to maximum and 25^{th} percentile to 75^{th} percentile) for fecal coliform and enterococci, respectively. For reference purposes, each figure also shows the monthly GM water quality numerical criterion for the respective pathogen.

Overall, the fecal coliform levels measured throughout the LTCP sampling program result in geometric means indicative of the impacts of wet-weather pollution sources on inner Flushing Bay. As shown in Figure 2-29, the wet-weather geometric means at the inner Flushing Bay Stations OW-7 to OW-9 are all above 200 cfu/100mL, while the dry-weather geometric means at those stations are all below 200 cfu/100mL. For the outer-Flushing Bay Stations OW-10 to OW-15, wet-weather impacts are also apparent, as the wet-weather geometric means are all above the dry-weather geometric means. However, the wet-weather geometric means are all below 200 cfu/100mL except at Station OW-10, where the geometric mean is 201. The LTCP enterococci data generally follow a similar trend as the fecal coliform data, with wet-weather geometric means higher than dry-weather geometric means, and the inner bay geometric means generally higher than the outer bay geometric means (Figure 2-30), consistent with the more favorable tidal exchange conditions near the East River.

The HSM fecal coliform data presented in Figure 2-31 are also consistent with the LTCP2 data. The wet-weather geometric means at inner bay Station E-15 are above 200 cfu/100mL for 2013 through 2015, while the dry-weather geometric means at Station E-15 are below 200 cfu/100mL. The outer bay Station E6 showed wet-weather geometric means above the dry-weather geometric means, but the wet-weather geometric means were all below 200 cfu/100mL. The data at Station FB1, located between Stations E-15 and E-6, showed geometric means generally between the means for Stations E-15 and E-6 for dry- and wet-weather, respectively. HSM enterococci data showed generally a similar pattern (Figure 2-32).

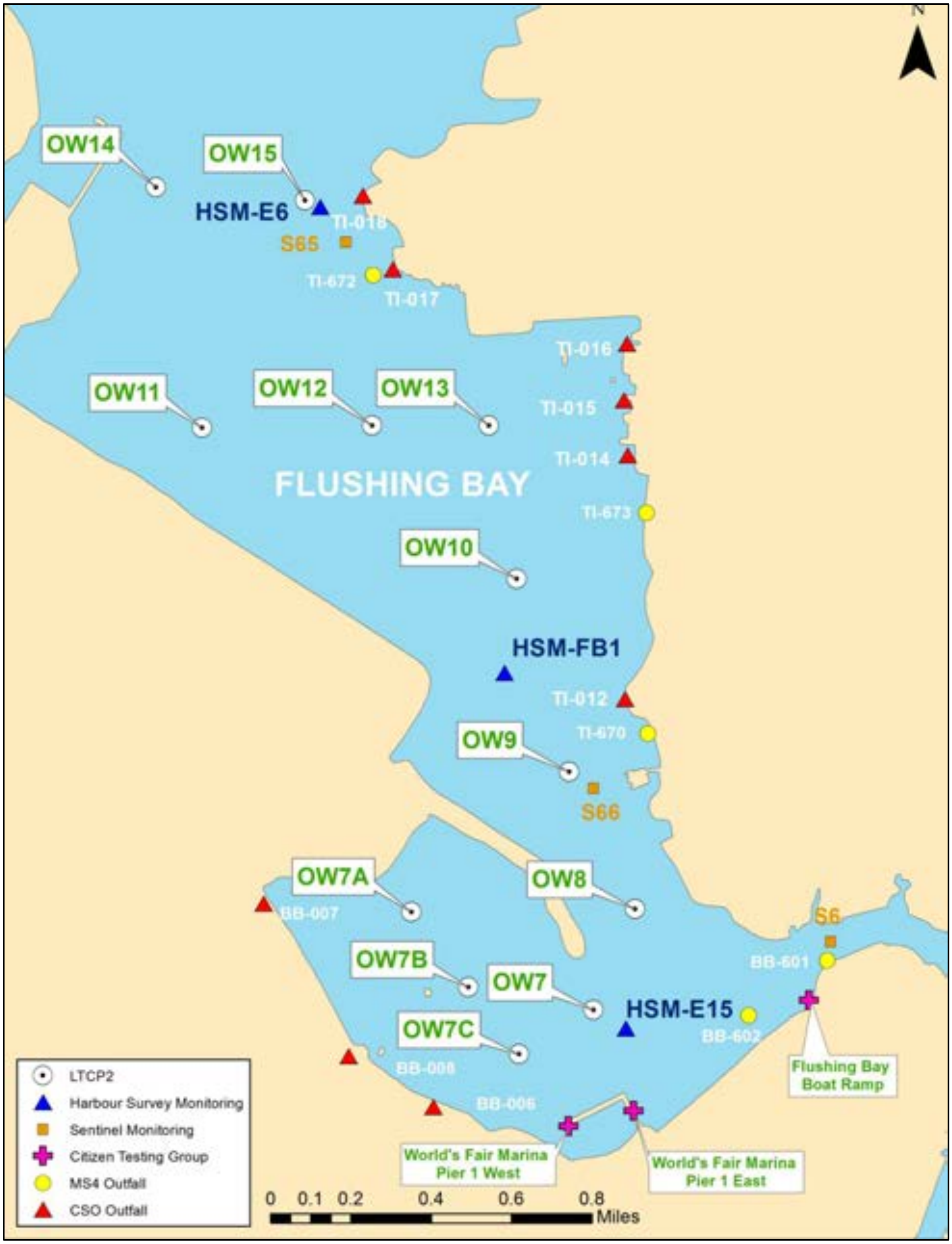

Figure 2-27. LTCP Field Sampling Analysis Program and Harbor Survey Monitoring Program Sampling Locations

AECOM with Hazen

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 a sampling station along the southwestern shore of Flushing Bay, in close proximity with the mouth of Flushing Creek, as shown in Figure 2-27. These data are available at the Riverkeeper Group's website http://www.riverkeeper.org/ and, consistent with the LTCP and HSM data, showed a relationship between wet-weather conditions and higher enterococci concentrations throughout the years 2013, 2014 and 2015.

Figure 2-32 depicts the DO averages derived from the LTCP dataset measured during late 2013/early 2014. The measured DO concentrations portray winter conditions and hence do not capture the lower DO values expected to occur during the summer periods. However, throughout 2013, 2014 and 2015, based on the HSM program DO dataset, no DO values were observed below 4.0 mg/L, except in three instances in which the DO concentration was measured slightly below the Class I criterion, as previously noted.

2.2.a.7 Water Quality Modeling

In addition to the collection, compilation, and analysis of measurements described in Section 2.2.a.6, water quality modeling was also used to characterize and assess Flushing Bay water quality. A model computational grid as part of the East River Tributaries Model (ERTM) was used in the LTCP analysis to represent Flushing Bay. The model computational grid, shown in Figure 2-28, was used for LTCP hydrodynamic, pathogens, and dissolved oxygen modeling. The validation of these water quality models using measurements collected during 2013 and 2014 is described in the Flushing Bay LTCP Sewer System and Water Quality Modeling Report (DEP, 2016). 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 will be presented in Sections 6 and 8.

Figure 2-28. Computational Grid for Flushing Bay Water Quality Modeling

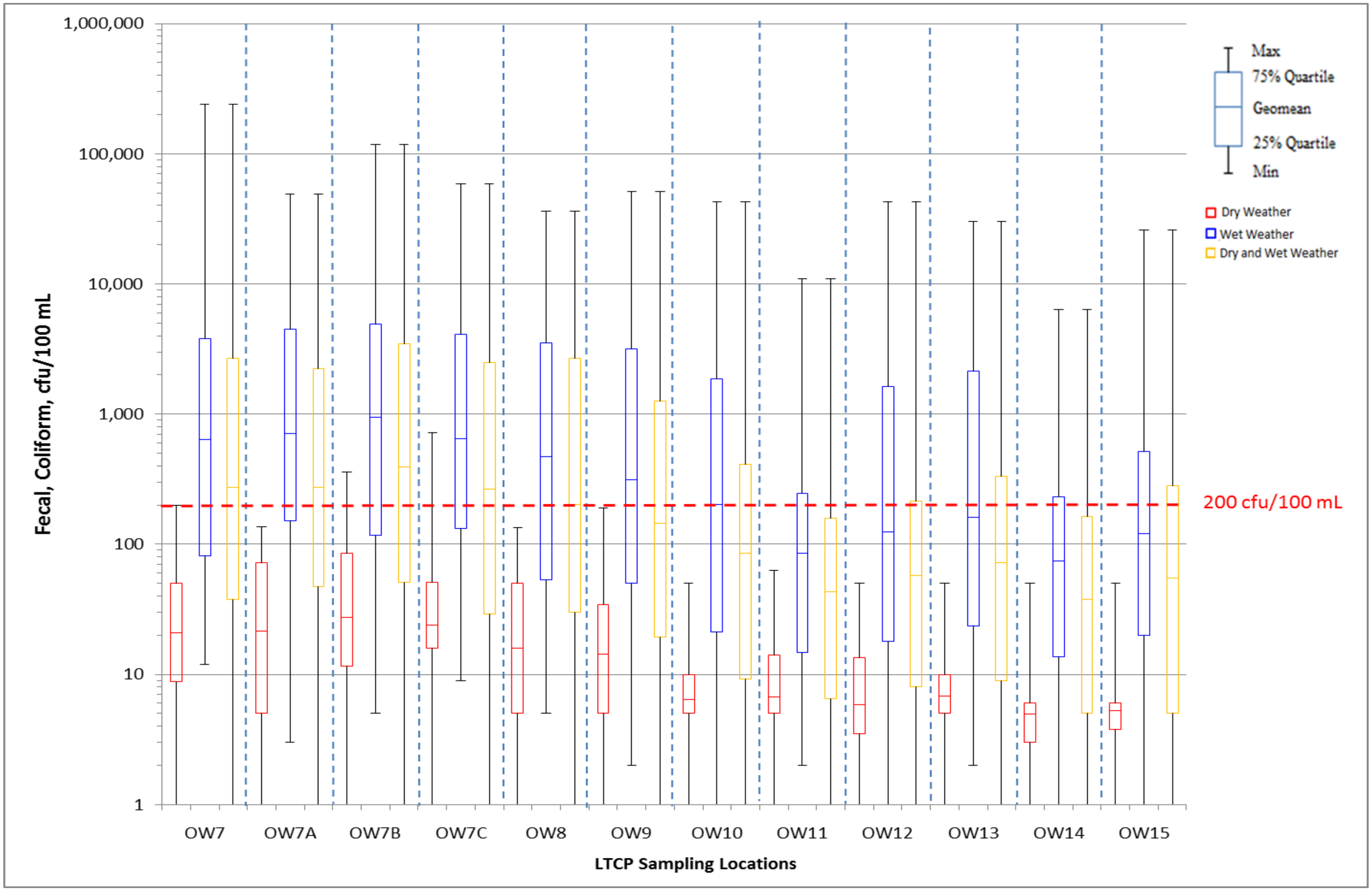

Figure 2-29. Fecal Coliform Concentrations at Flushing Bay LTCP Monitoring Station

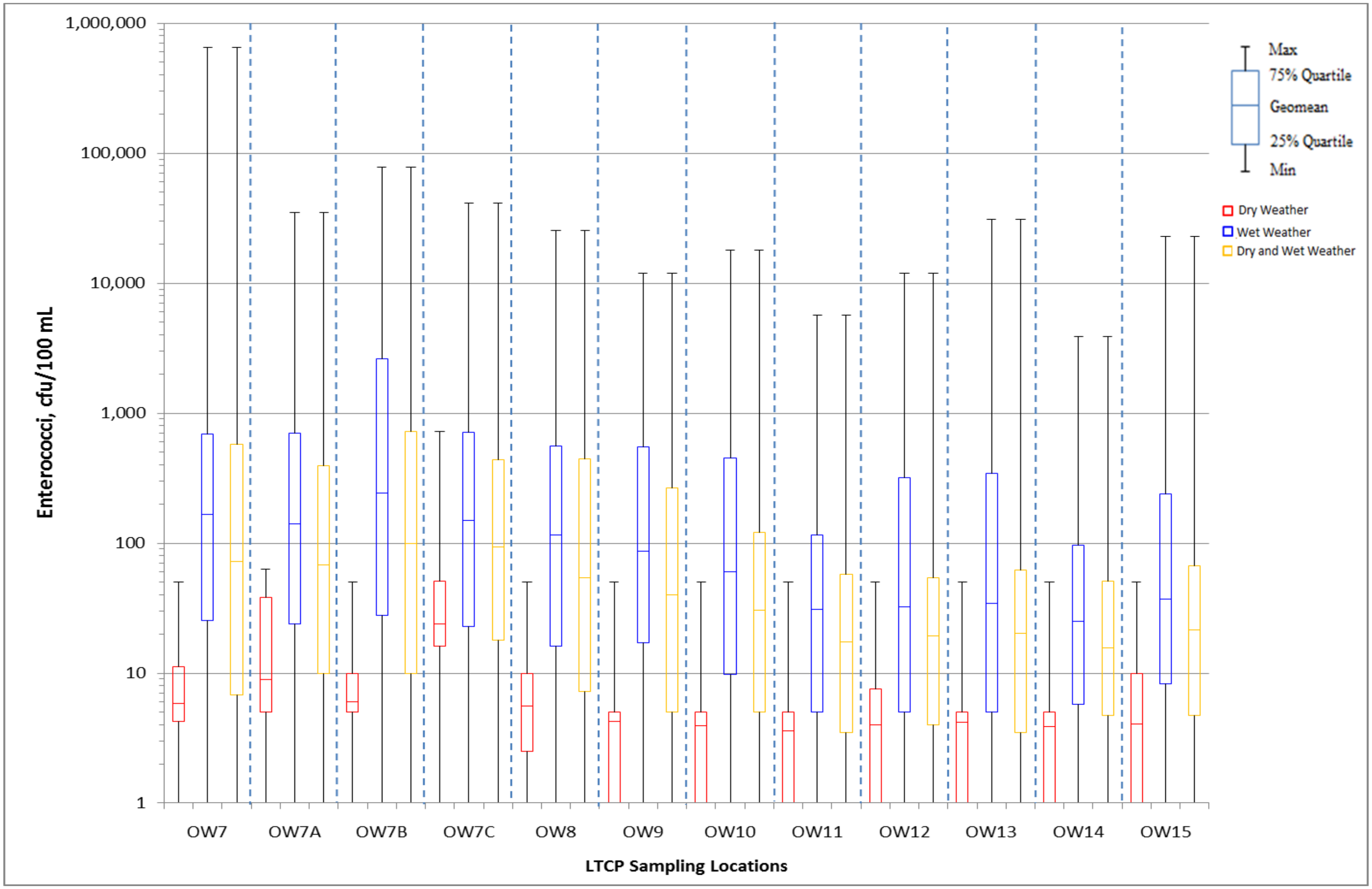

Figure 2-30. Enterococci Concentrations at Flushing Bay LTCP Monitoring Stations

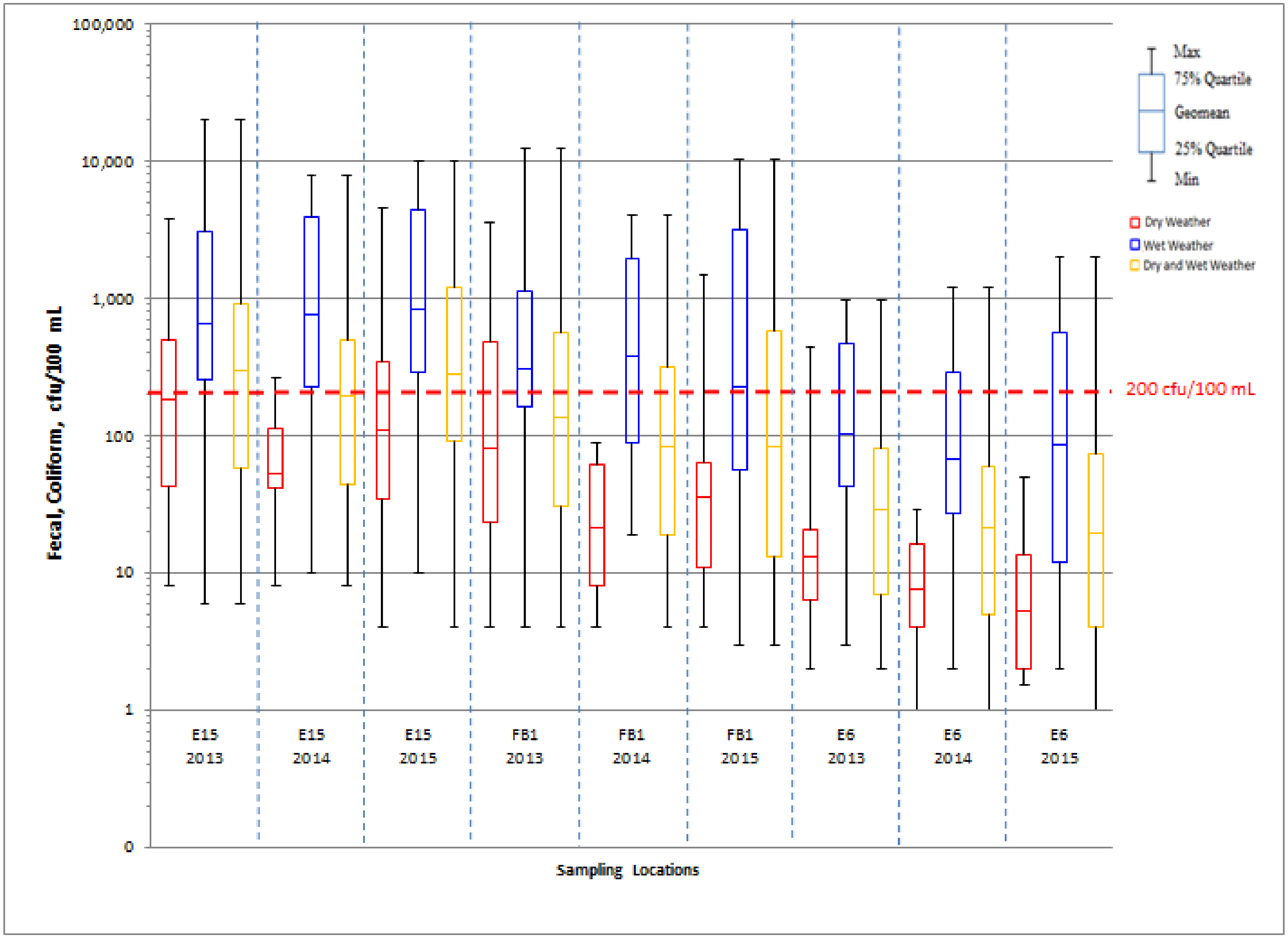

Figure 2-31. Fecal Coliform Concentrations at Flushing Bay Harbor Survey Monitoring Stations

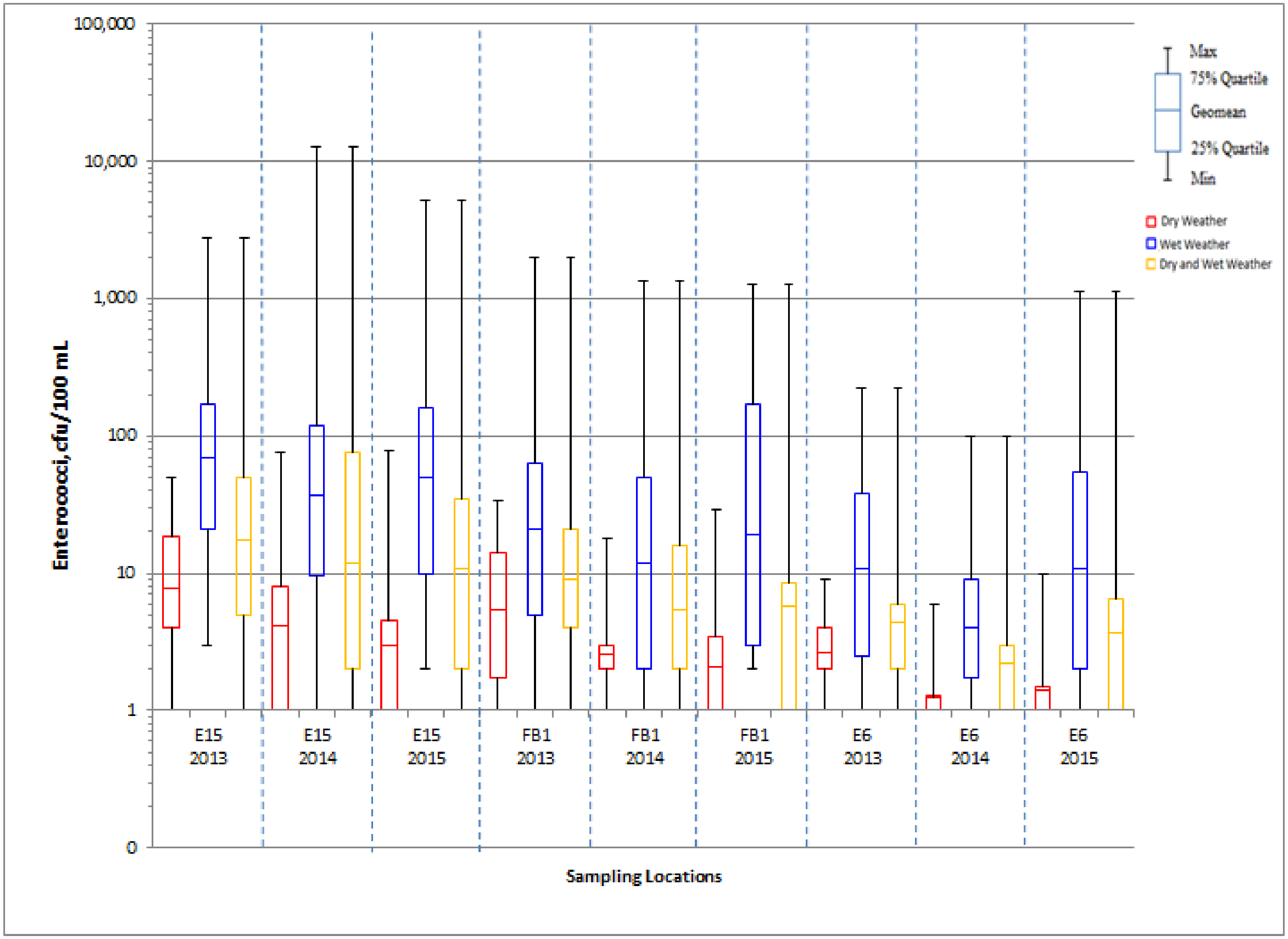

Figure 2-32. Enterococci Concentrations at Flushing Bay Harbor Survey Monitoring Stations

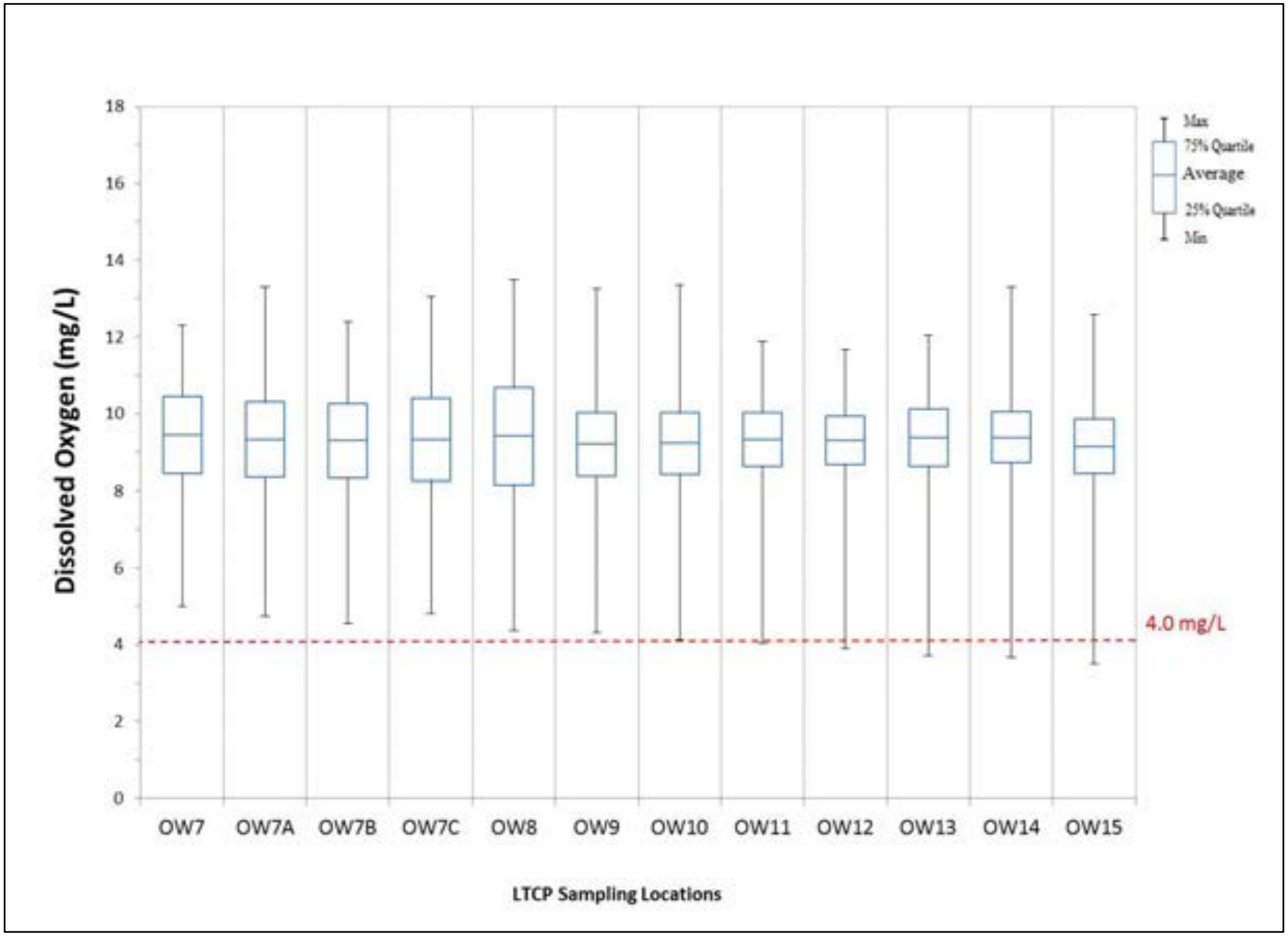

Figure 2-33. DO Concentration at Flushing Bay LTCP WQ Stations (November 2013 – May 2014)

3.0 CSO BEST MANAGEMENT PRACTICES

The SPDES permits for all 14 WWTPs in NYC require DEP to report annually on the progress of the following 13 CSO Best Management Practices (BMPs):

1. CSO Maintenance and Inspection Program
2. Maximum Use of Collection Systems for Storage
3. Maximize Flow to Publicly Owned Treatment Plant (POTW)
4. Wet Weather Operating Plan (WWOP)
5. Prohibition of Dry Weather Flow (DWF)
6. Industrial Pretreatment
7. Control of Floatable and Settleable Solids
8. Combined Sewer Replacement
9. Combined Sewer Extension
10. Sewer Connection and Extension Prohibitions
11. Septage and Hauled Waste
12. Control of Runoff
13. Public Notification

The 2015 BMP Annual Report included a section on Additional CSO BMP Special Conditions. This section was submitted pursuant to Item 5.c. in Appendix B of Additional CSO BMP Special Conditions in the SPDES Permits. Item 5.b 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. For the first year after the effective date of the 2014 CSO BMP Order, Item 5.b also required DEP to quarterly "submit for New York State Department of Environmental Conservation approval an engineering analysis of the cause(s) for each discharge and an analysis of options to reduce or eliminate similar future events." Subsequent updates of the engineering analyses are to be provided in the CSO BMP Annual Reports. On February 1, 2016, DEP submitted the Regulator(s) with CSO Monitoring Equipment Identification Program Report which identified BBH-06 as a key regulator with known or suspected discharges outside the period of a critical wet-weather event. The evaluation of CSO control alternatives and selection of the LTCP Recommendation will consider and seek to address these "early tipping" discharges from this key regulator.

The 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 Systems 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 Floatables and Settleable Solids
NMC 7: Pollution Prevention	BMP 6: Industrial Pretreatment BMP 7: Control of Floatables 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 Floatables and Settleable Solids

On May 8, 2014 DEP and DEC entered into an administrative Consent Order[1] that superseded the parties' 2010 CSO BMP Consent Order. The 2014 CSO BMP Order on Consent (2014 CSO BMP Order) identified certain new milestones 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 SPDES Best Management Practices for Combined Sewer Overflows 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
- Data Submission

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

Additional CSO BMP Special Conditions – Appendix B

- Maximizing Flow to WWTP;
- Maximizing Flow at WWTP;
- CSO Monitoring and Equipment;
- Wet Weather Operating Plan;
- Event Reporting and Corrective Actions;
- Hydraulic Modeling Verification.

This section presents a brief summary of each BMP and its respective relationship to the federal NMCs. In general, the 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.

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 System 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. DEP provides general information in the 2015 BMP Annual Report, describing the status of citywide Supervisory Control and Data Acquisition, regulators, tide gates, interceptors, in-line storage projects, and collection system inspections and cleaning.

Additional data gathered in accordance with the requirements of the 2014 CSO BMP Consent Order, such as CSO monitoring, will be used to verify and/or further calibrate the hydraulic model developed for the CSO LTCPs.

3.3 Maximizing Wet Weather Flow 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 regarding the ability of the WWTP 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 2015 BMP Annual Report indicate that DEP's WWTPs generally complied with this BMP during 2014.

The 2014 CSO BMP Consent Order has a number of requirements related to maximizing wet-weather flows to WWTPs including, but not limited to:

- An enforceable compliance schedule to ensure that DEP maximizes 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 the DEC per the 2014 CSO BMP Consent Order.

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 drainage area; and,
- Process control procedures and set points to maintain the stability and efficiency of BNR processes, if required.

As required by the 2014 CSO BMP Consent Order, DEP resubmitted all WWOPs to DEC, including the Bowery Bay WWTP WWOP in March 2014 and the Tallman Island WWTP WWOP in December 2014.

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.

The 2015 data for regulators and pump stations reveal that there were two (2) dry-weather overflows to Flushing Bay due to a regulator blockage. The event took place at the TI-06 and TI-07 regulators and resulted in a 4,535-gallon overflow.

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 tributary to CSOs, this BMP addresses the maximization of persistent toxics treatment from industrial sources upstream of CSOs. Specific components of this BMP include:

- Consideration of CSOs in the calculation of local limits for indirect discharges of toxic pollutants;
- 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 .

Since 2000, the average total industrial metals loading to NYC WWTPs has been declining. As described in the 2015 BMP Annual Report, the average total metals discharged by all regulated industries to the WWTPs was 12.2 lbs/day, and the total amount of metals discharged by regulated industrial users remained very low. Applying the same percentage of CSO bypass (1.5 percent) from the CSO report to the current data, it is estimated that, on average, less than 0.18 lbs/day of total metals from regulated industries bypassed to CSOs in 2015 (DEP, 2016).

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 ensure proper operations of basins.

- Catch Basin Retrofitting: By upgrading basins with obsolete designs to contemporary designs with appropriate street litter capture capability; this program is intended to increase the control of floatable and settleable solids citywide.

- 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.

3.8 Combined Sewer Replacement

This BMP addresses NMC 1 (Proper Operations and Regular Maintenance Programs for the Sewer Systems and the CSOs), requiring all combined sewer replacements to be approved by the DOH and to be specified within the 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 Bowery Bay WWTP and Tallman Island WWTP sewersheds in the 2015 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). A brief status report is provided in the 2015 BMP Annual Report. According to the report, DEP completed four private sewer extensions in 2015. 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.

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 2015, 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, and 26th Ward WWTP sewersheds. The program remained unchanged through the 2015 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 ensures 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. There are no bathing beaches in or near Flushing Bay; Local Law explicitly prohibits bathing beaches in the upper East River and its tributaries.

3.14 Characterization and Monitoring

Previous studies have characterized and described the Bowery Bay WWTP collection system, Tallman Island WWTP collection system, and the water quality for Flushing Bay (see Chapters 3 and 4 of the Flushing Bay WWFP, 2009). 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.

Future monitoring includes 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 (2014 CSO BMP Consent Order). Following installation of the CSO monitoring equipment, a monthly report of all known or suspected CSO discharges from key regulators, outside the period of a critical wet-weather event, will be submitted to DEC. Additional quarterly reports and one comprehensive report summarizing one year of known or suspected CSO discharges will be submitted to DEC describing the cause of each discharge and providing options to reduce or eliminate similar future events with an implementation schedule.

3.15 CSO BMP Report Summaries

In accordance with the SPDES permit requirements, annual reports summarizing the citywide implementation of the 13 BMPs described above are submitted to DEC. DEP has submitted 13 annual reports to-date, covering calendar years 2003 through 2015. The 2015 BMP Annual Report is divided into 14 sections, one for each of the BMPs in the SPDES permits and one section for the SPDES Permit CSO BMP Special Conditions. Each section of the annual 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

CSO planning for Flushing Bay began via the East River CSO Facility Planning Project. This planning focused on quantifying and assessing the impacts of CSO discharges to the Upper East River, Western Long Island Sound, and their tributaries. For this planning project, which was published in 1989, Flushing Creek and Flushing Bay were studied as a single waterbody. The report recommended a storage facility with 43 MG of capacity (28 MG in tank, 15 MG in upstream sewers). During the development of the Flushing Bay Waterbody/Watershed Facility Plan Report, DEC required that Flushing Creek and Flushing Bay be separated into two distinct CSO planning areas – with the Flushing Bay CSO Retention Facility falling under the Flushing Creek Waterbody/Watershed Facility Plan Report (DEP, 2011). A Flushing Bay Waterbody/Watershed Facility Plan Report was subsequently submitted to DEC August 2011 with the following recommended CSO construction projects:

1. Construction of a Low Level Diversion Sewer to redirect a portion of the flow from the high level interceptor into the low level interceptor;

2. Raising the Regulator BB-R02 weir height from -1.75 to +2.5;

3. Environmental dredging of selected areas of Flushing Bay; and

4. Bending weirs at Regulators BB-R03 through BB-R10, BB-R26 and 24th Avenue Weir that was later modified to regulator modifications at BB-R04 through BB-R06, BB-R09, and BB-R10.

4.1.a Completed Projects

With the exception of the 43 MG Flushing Bay CSO Retention Facility, which falls under the Flushing Creek LTCP, there are no completed projects within the Flushing Bay planning area.

4.1.b Ongoing Projects

All three projects recommended in the Flushing Bay WWFP Report have moved forward and are ongoing. Below is a brief summary of each project:

1. Raising Regulator BB-R02

   - <u>*Project Summary*</u>: Divert low-lying sewers in the vicinity of Bowery Bay WWTP into the Bowery Bay High Level Interceptor and raise the weir at Regulator BB-R02 from -1.75 to +2.5 to capture more wet-weather flow. See Figure 4-1 for further information.

   - <u>*Status*</u>: Project is scheduled to be completed by December 2017.

2. Regulator Modifications at BB-R04 through BB-R06, BB-R09, and BB-R10

   - <u>*Project Summary*</u>: The regulator improvements include raising the existing weir crest elevation and lengthening the weirs to allow greater storage within the interceptor system. The regulator sites are all within the existing Bowery Bay WWTP High Level Interceptor collection system. See Figure 4-2 for further information.

- *Status*: The Construction Notice to Proceed was granted to the contractor December 2015 with construction scheduled to continue through June 2018.

Figure 4-1. Diversion of Low-Lying Sewers near Bowery Bay WWTP into the High Level Interceptor

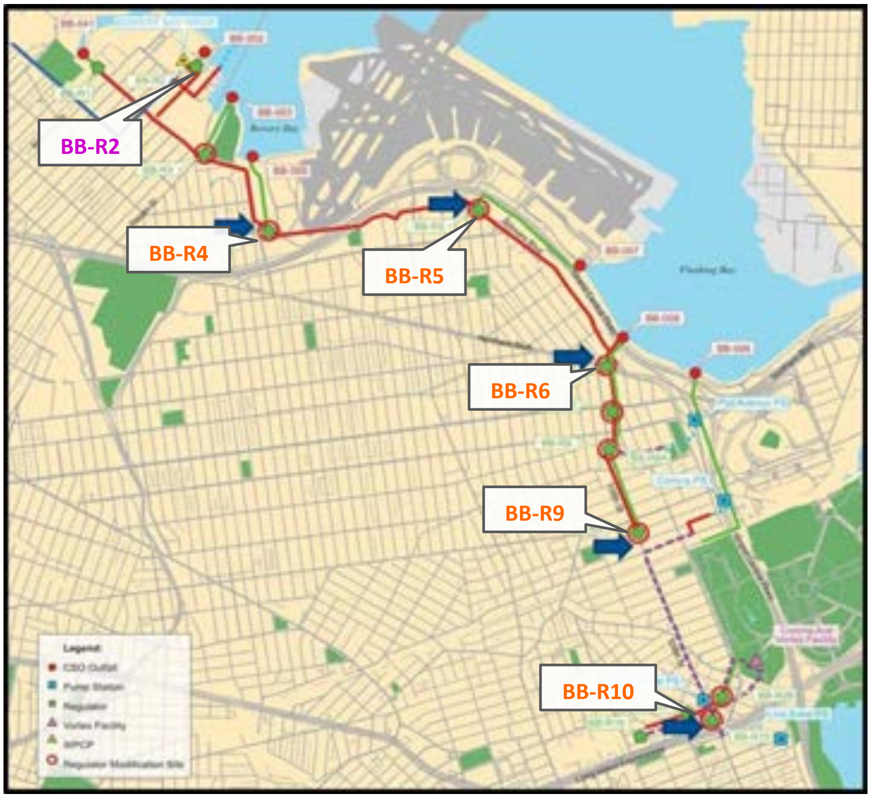

Figure 4-2. Flushing Bay High Level Interceptor Regulator Improvements

3. Environmental Dredging of Flushing Bay

   - _Project Summary_: Under the proposed project, approximately 17.5 acres of Flushing Bay will be dredged to about five feet below mean lower low water. The proposed dredging will remove accumulated sediment mounds exposed at low tide in the area of CSO Outfalls BB-006 and BB-008 to reduce associated nuisance odors in locations adjacent to Flushing Bay. In addition, the bottom two feet will then be capped to cover any exposed sediments that might be classified as Class C (per DEC guidance). The dredging area is depicted in Figure 4–3.

     Status: An Order to Commence Work became effective on July 5, 2016 before the Consent Order Milestone Date of September 2016 and dredging is to be completed by March 2019.

Figure 4-3. Dredging Location in Flushing Bay

4.1.c Planned Projects

DEP proposes a variety of resiliency improvements for the Bowery Bay WWTP and pumping stations within the Flushing Bay sewershed, consistent with the October 2013 NYC Wastewater Resiliency Plan. However, no other CSO-related grey infrastructure projects are planned. Impacts on the frequency and/or amount of CSO overflows from the proposed WWTP and pumping station improvements will be determined when the specific projects are identified.

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

With the exception of the environmental dredging project discussed in Section 4.2, no additional water quality improvement measures were recommended for Flushing Bay.

4.3 Post-Construction Monitoring

The PCM program is integral to the optimization of the Flushing Bay LTCP, providing data for model validation and feedback on system performance. Each year's data set will be compiled and evaluated to refine the understanding of the impacts of the interaction between Flushing Bay and the actions identified in this LTCP, with the ultimate goal of fully attaining compliance with current WQS or supporting a UAA to revise such standards, if appropriate. The PCM program contains two basic components:

1. Receiving water data collection in Flushing Bay at the stations of DEP's HSM and Sentinel Monitoring (SM) programs; and

2. Modeling the collection system and receiving waters to characterize water quality using the existing InfoWorks CS™ (IW) and East River Tributaries Model (ERTM), respectively.

The details provided herein are limited to the Flushing Bay PCM and may be modified as DEP's CSO planning advances through the completion of other LTCPs, including the Citywide LTCP.

In a letter dated March 13, 2008, DEC approved the plan dated January 25, 2008 which superseded a series of earlier submissions and incorporated revisions per DEC comments. PCM sampling commenced in the summer of 2007 and monitoring will continue for a ten-year duration after the grey infrastructure controls are in place in order to quantify the difference between the expected and actual performance. Any gap 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 alone will not result in full attainment of applicable WQS, DEP will pursue the necessary regulatory mechanism for a UAA.

The first PCM report was submitted April 1, 2008 and was limited to the presentation of the results of the monitoring performed in 2007 for the Flushing Bay CSO Retention Facility and each of the other retention facilities. Subsequent annual PCM reports, starting with the April 1, 2009 report, addressed the monitoring data and included the presentation of hydraulic and water quality modeling analyses performed for each of the CSO retention treatment facilities.

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

PCM sampling in the Flushing Bay Stations HSM-E6, HSM-FB-1 and HSM-E15 commenced in the summer of 2007 when the Flushing Bay CSO Retention Facility became fully operational. Figure 4-4 shows the locations of LTCP2 PCM Stations FB1, E6 and E15, as well as FLC1 and FLC2 in Flushing Creek. Sampling at all stations related to the Flushing 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 Flushing Bay and Creek by the LTCP2 team to calibrate and validate the landside and water quality models. It is anticipated that the PCM associated with any additional CSO controls identified for implementation as part of this LTCP would require a subsequent PCM program in Flushing Bay (and Flushing Creek).

Measured parameters relating to receiving water quality include: dissolved oxygen (DO), 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.

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

DEP performed monitoring and evaluation of the Corona Avenue Vortex Facility. The following reports were prepared and submitted to DEC on the facility performance:

1. "Evaluation of Corona Avenue Vortex Facility," City of New York Department of Environmental Protection September 29, 2003 2-volumes; and

2. "Corona Avenue Vortex Facility Underflow Evaluation," City of New York Department of Environmental Protection, October 2005.

Based upon the findings of these reports, the Corona Avenue Vortex Facility was decommissioned. As a result, performance monitoring identified in the permit is no longer performed.

Any flow and effluent quality monitoring program would be dependent on the types and sizes of proposed CSO controls recommended under this LTCP. 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 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 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.

Figure 4-4. LTCP2 and PCM Sampling Locations in Flushing Bay

Because precipitation patterns are primary drivers of wet-weather overflows, accurate representation of precipitation is important to enable models to accurately calculate CSO discharges. For that reason, modeling analyses of actual conditions now rely on precipitation estimates developed using a combination of rainfall radar and local rain gauge measurements. These so-called "gauge-adjusted radar rainfall" estimates provide high-resolution (1-km^2) geographically distributed rainfall estimates on a 5-minute interval. Other DEP studies have shown that model calculations of CSO volumes can be more reliable than in-situ sensor results, and so assessments of hydraulic performance will use results of both methods where applicable.

The PCM report will show the results of the hydraulic performance assessment through comparison of observed and modeled overflow results on an annual, monthly, and storm-by-storm basis, and in the context of the design performance metrics established for the Flushing Bay Retention Facility. In this way, the PCM report will provide a determination of whether or not the Flushing Bay Retention Facility achieved its hydraulic performance metrics during the subject period.

Assessments of water quality conditions during the monitoring period will be based upon the ambient water quality measurements during the subject period compared to the modeled range for the LTCP long term analysis period (2002-2011). The PCM report will present the monitoring results graphically along with the long term expected range and commentary about how the subject year's rainfall statistics compared to those for the long term period. In this way, the PCM report will provide a determination of whether or not the water quality improvements were achieved during the subject period as expected with the operation of the Flushing Bay Retention Facility and the Tallman Island collection system as a whole. The subsequent PCM program will be conducted for five years to capture a wide range of events and compare monitored results versus the modeling projections.

5.0 GREEN INFRASTRUCTURE

The New York City Green Infrastructure (GI) Program was initiated to manage stormwater to reduce combined sewer overflow in NYC and also provide resiliency and other co-benefits to local communities. More details on the overall program elements are described below. DEP publishes the *Green Infrastructure Annual Report* every April 30th to provide details on GI implementation and related efforts. These reports can be found at www.nyc.gov/dep/greeninfrastructure.

5.1 NYC Green Infrastructure Plan (GI Plan)

In January 2011, DEP launched the GI Program and committed $1.5B in funding through 2030 to implement green infrastructure on public property, including $5M in Environmental Benefit Project (EBP) funds.[1] DEP's green infrastructure staff focuses on a wide variety tasks to accomplish GI Program goals ranging from planning, design, construction, maintenance of the assets to improving knowledge on how they function and perform through extensive peer-reviewed scientific research, assessments and modeling. In addition to its primary objective of improving water quality, the Program will yield climate change resiliency resulting in co-benefits including: improved air quality; urban heat island mitigation; and carbon sequestration and biodiversity co-benefits, including increased urban habitat for pollinators and wildlife.

5.2 Citywide Coordination and Implementation

DEP works directly with its partner agencies on retrofit projects at public schools, public housing, parkland, and other NYC-owned property within the target areas. 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 for rights-of-way and on-site GI practices. The New York City Economic Development Corporation, the NYC Department of Parks and Recreation (DPR), and the Department of Design and Construction manage the design and construction of several of these Area-wide contracts in conjunction with DEP. For GI Program status, please refer to the *2015 Green Infrastructure Annual Report* on DEP's website. DEP has developed design standards for Right-of-Way (ROW) GI Practices and is developing additional GI standards to address various certain field conditions and restrictions. New standards include the ROW Infiltration Basins, Green Strips, and porous pavement. The Office of Green Infrastructure is also developing on-site GI standards to retrofit city-owned properties. These standards include porous pavement, rain gardens, retention systems, and synthetic turf.

DEP's GI database contained information for approximately 4,500 assets that have already been constructed, are in construction, or are designed and awaiting construction bid.

[1] EBP projects are undertaken in connection with the settlement of an enforcement action taken by New York State and DEC for violations of New York State law and DEC regulations.

5.2.a Community Engagement

Stakeholder participation is a critical success factor for the effective implementation of decentralized GI projects. To this end, DEP engages and educates local neighborhoods, community groups, and other environmental and urban planning stakeholders about their role in the management of stormwater. 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 searchable on-line map to view the status of green infrastructure assets (Final Design, In Construction, or Constructed) in the context of Area-wide contracts. This addition expands the way users can now easily access information on the GI Program, including Reports and Standard Designs for ROW GI practices at www.nyc.gov/dep/greeninfrastructure.

DEP also created an educational video on the GI Program. This video gives a brief explanation of the environmental challenges posed by CSOs, while featuring GI technologies, such as retention/detention systems, green/blue roofs, rain gardens, porous paving and permeable pavers. The video is available at DEP's YouTube© page (https://www.youtube.com/user/nycwater).

To provide more information about the GI Program, DEP developed an informational brochure that describes the site selection and construction process for projects in the ROW. The brochure also includes frequently asked questions and answers, and explains the co-benefits of GI.

DEP 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. The contact information for the construction liaison is affixed to the door hangers for use if the need to alert NYC to a problem arises during construction.

As part of its ongoing outreach efforts, DEP continues to make presentations to elected officials and their staffs, community boards, and other civic and environmental organizations about the GI Program, upcoming construction schedules, and final GI locations.

5.3 Completed Green Infrastructure to Reduce CSOs (Citywide and Watershed)

DEP's Green Infrastructure Annual Reports contain the most up-to-date information on completed projects and can be found on the DEP website. In addition, Quarterly Progress Reports are posted on the DEP 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, based on information collected and evaluated from lessons learned in the field and performance monitoring results.

Pilot Site Monitoring Program

DEP initiated site selection and design of its Pilot Monitoring Program in 2009. This Program provided DEP opportunities to test different designs and monitoring techniques, and to determine the most cost-effective, adaptable, and efficient GI strategies. Specifically, the pilot monitoring aimed to assess the effectiveness of each of the evaluated source controls at reducing the volume and/or rate of stormwater runoff from the drainage area by measuring quantitative aspects (e.g., source control inflow and outflow rates), as well as qualitative issues (e.g., maintenance requirements, appearance and community perception). Starting in 2010, more than 30 individual pilot GI practices were constructed and monitored as part of the citywide Pilot Program. These practices include: ROW GI, such as bioswale rain gardens; rooftop practices, such as blue roofs and green roofs; subsurface detention/retention systems with open bottoms for infiltration; porous pavement; and bioretention facilities. Data collection began in 2010, as construction for each of the monitoring sites has been completed. Pilot Monitoring Program results assisted greatly in validating modeling methods and parameters.

Additional performance monitoring work is planned over the next five years as a part of the GI-RD project and will provide field-collected data for further documenting GI performance and improving modeling representation. This significant undertaking will create inputs for evaluating GI life cycle costs, volumetric stormwater runoff and CSO reduction performance and co-benefits. This work will be used to compare GI to traditional grey infrastructure options, incorporating the real cost of maintenance into financial consideration.

Neighborhood Demonstration Area Projects

The 2012 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 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. A PCM Report was submitted to DEC in August 2014. DEP received requests for clarification from DEC, and resubmitted an updated PCM Report in January 2015.

While DEP's Pilot Monitoring Program provides 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 both multiple installations within identified sub-TDAs. 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.

5.3.b Public Projects

In coordination with NYC agency and non-profit partners, DEP continues to identify, design and construct public property GI retrofit projects. In 2015, DEP initiated design on over 100 publicly owned properties, and has identified approximately 150 more. These projects will advance design through 2016 and construction is expected to start in 2017 and continue as more projects are added to the pipeline. 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.

5.3.c Other Private Projects (Grant Program)

Green Infrastructure Grant Program

Since its introduction in 2011, the Grant Program has sought to strengthen public-private partnerships and public engagement in the design, construction and maintenance of GI.

The 2012 CSO Order requires the Grant Program to commit $3M of EBP funds[2] to projects by 2015. DEP met this commitment in 2014. To date, the Grant Program has committed more than $14M to 32 private property owners to build green infrastructure projects. In 2015, two projects started construction and six others were completed. Also in 2015, DEP transitioned the Grant Program application process from a single annual submission date to a year-round, open application process.

In September 2016, DEP released a Request for Information (RFI) for Management of a green infrastructure private property incentive program. The goal of the RFI, and potential subsequent program development, is to build on DEP's experience administering the Grant Program and scale it up considerably. Ultimately, DEP would like to offer an easier application process and engage additional property owners to participate in retrofitting their property with green infrastructure.

Green Roof Property Tax Abatement

Since 2008, the NYC Green Roof Tax Abatement (GRTA) has provided a fiscal incentive to install green roofs on private property. DEP has worked with the Mayor's Office of Sustainability, the Department of Buildings, the Department of Finance (DOF) and the Office of Management and Budget, as well as with environmental advocates and green roof designers, to modify and to extend the GRTA through 2018. DEP has met with stakeholders and incorporated much of their feedback to improve the next version and to help increase the number of green roofs in NYC. Additionally, DEP funded an outreach position to educate applicants and to assist them through the abatement process.

The tax abatement includes an increase to the value of the abatement from $4.50 to $5.23 per square foot, to continue offsetting construction costs by roughly the same value as the original tax abatement. Also, given that rooftop farms tend to be larger than typical green roofs (approximately one acre in size), the abatement value cap was also increased from $100,000 to $200,000 to allow such applicants to receive the full value of the abatement. Finally, based on the amount allocated for this abatement, the total annual amount available for applicants (i.e., in the aggregate) is $750,000 in the first year, and $1,000,000 in each subsequent year through March 15, 2018. The aggregate amount of abatements will be allocated by the DOF on a pro rata basis. More information on the Green Roof Property Tax Abatement can be found in the Green Infrastructure Annual Reports.

5.3.d Projected vs. Monitoring Results

See the 2016 Green Infrastructure Performance Metrics Report and Appendices which are available at http://www.nyc.gov/html/dep/html/ stormwater/nyc_green_infrastructure_plan.shtml.

5.4 Future Green Infrastructure in the Watershed

5.4.a Relationship Between Stormwater Capture and CSO Reduction

The 2016 Performance Metrics report describes CSO reductions based on the 1.5 percent GI implementation rate and a modeled CSO volume reduction based on the 10 percent implementation rate.

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[2] EBP Projects are undertaken by DEP in connection with the settlement of an enforcement action taken by NYS and DEC for violations of NYS law and DEC regulations.

The 1.5 percent equivalency rate incorporates data on the existing and planned GI implemented through the Program to-date, which has primarily included retention-based ROW bioswales using site-specific information to model individual, distributed assets. By contrast, the 10 percent equivalency rate incorporates a lumped approach to estimate future projects where GI asset specifics such as location, technology type and design details are currently unknown.

In order 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 (MG) of CSO eliminated on an annual basis per acre (Ac) of impervious area managed by GI."

For the Flushing Bay LTCP, the baseline model incorporated the 1.5 percent GI scenario described in the report that represents a 2.8 percent GI application rate.

5.4.b Opportunities for Cost-Effective CSO Reduction Analysis

As described above, the 2.8 percent application rate represents built or planned GI assets in the Flushing Bay watershed. At this time in the Flushing Bay area, the vast majority of ROW GI projects have been implemented or are in progress and have been incorporated into the baseline conditions. Additional GI projects planned for the watershed will include public property retrofits (such as schools and parks) and private property projects implemented through DEP's Grant Program. Benefits from these projects would exceed the baseline target rate (as described above and below). The GI Program will be implemented through 2030 and the final penetration rate will be reassessed as part of the adaptive management approach.

5.4.c Watershed Planning to Determine 20 Year Penetration Rate for Inclusion in Baseline Performance

Waterbody-specific penetration 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 tiers data.

The following criteria were applied to prioritize CSO tributary areas in order to determine waterbody-specific GI penetration 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 2012 CSO Order (i.e., high level storm sewers [HLSS]).

The overall goal for this prioritization is to saturate GI implementation rates within the priority watersheds, to maximize benefits based on the specific opportunities and field conditions in the Flushing Bay watershed, as well as costs.

Green Infrastructure Baseline Penetration Rate – Flushing Bay

Flushing Bay is a priority watershed for DEP's Green Infrastructure (GI) Program. The overall goal of the program is to saturate priority watersheds with GI to maximize benefits and cost effectiveness, based on the specific opportunities in each watershed. DEP has installed or plans to install over 1,000 GI assets, including right-of-way (ROW) practices, public property retrofits, and GI implementation on private properties, to manage approximately (2.8 percent impervious acres) in the Flushing Bay watershed. From these installations, modeling predicts a 52 MG reduction in annual CSO volume, based on the 2008 baseline rainfall condition.

Figure 5-1 below shows the current contracts in progress in the Flushing Bay CSO tributary areas of BB-006 and BB-008. As more information on field conditions, feasibility, and costs becomes known, and as GI projects progress, DEP will continue to model the GI penetration rates.

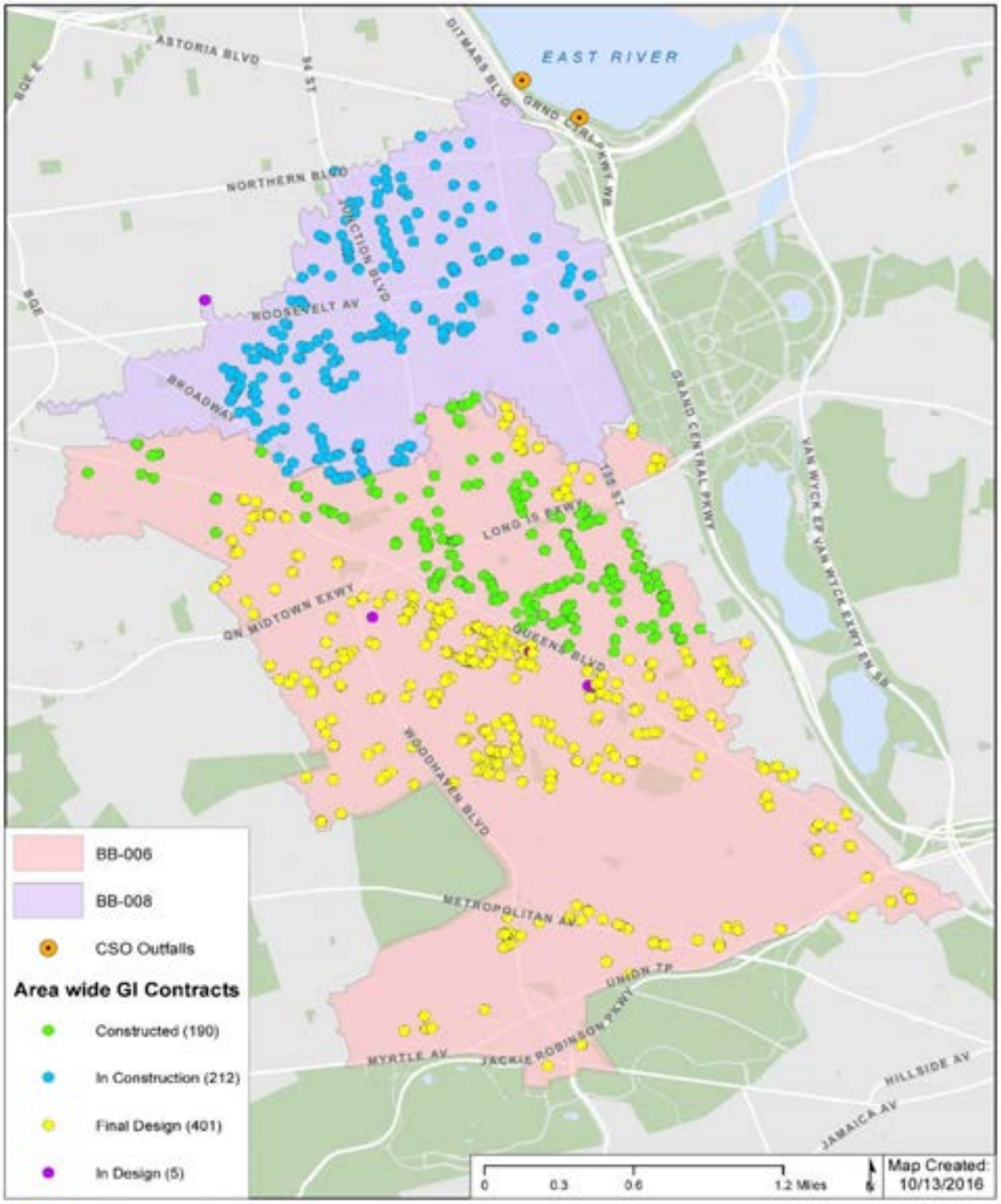

Figure 5-1. Green Infrastructure Projects in Flushing Bay

6.0 BASELINE CONDITIONS AND PERFORMANCE GAP

Key to development of the Flushing Bay LTCP was the assessment of water quality using applicable WQS within the waterbody. Water quality was assessed using the ERTM water quality model, verified with both Harbor Survey and the synoptic water quality data collected in 2013/2014 as part of the LTCP development. The ERTM water quality model was used to simulate ambient bacteria concentrations within Flushing 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 ERTM water quality model.

The assessment of water quality described herein started with a baseline condition simulation to determine the future bacterial levels without additional CSO controls beyond those already required under the CSO Order. Next a simulation was performed to determine bacteria levels under the assumption of 100% CSO control. The baseline condition was then compared to a 100% CSO control simulation. The gap between the two scenarios was then compared to assess whether bacteria criteria can 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 both the Existing WQ Criteria and the Potential Future Primary Contact WQ Criteria. As detailed below, a one-year simulation using 2008 JFK Airport rainfall was performed for bacteria and DO. This simulation 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 ERTM water quality model. It further describes the gap between calculated baseline bacteria concentrations and both the existing and potential future WQS. This section also assesses whether the gap can be closed through CSO reductions alone (100% CSO control).

It should be noted that enterococci criteria do not apply to the East River Tributaries, such as Flushing Bay, under the BEACH Act of 2000 for Existing WQS. Therefore, Flushing Bay water quality assessments for existing Class SB and proposed Class I criteria considered the fecal coliform criterion only. However, Potential Future Primary Contact WQ Criteria assessments took into account both enterococci 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 the identified preferred alternative LTCP is implemented. Baseline conditions for this LTCP were established in accordance with guidance set forth by the DEC to represent future conditions. Specifically, these conditions included the following assumptions:

- Dry-weather flow and loads to the Bowery Bay WWTP were based on CY2040 projections.
- The Bowery Bay and Tallman Island WWTPs can accept and treat peak flows at two times design dry-weather flow (2xDDWF).

- Green Infrastructure (GI) projects to control the first inch of runoff on selected impervious surfaces within the Bowery Bay and Tallman Island WWTP combined sewer service area.

- Cost-effective Grey Infrastructure CSO controls included in the 2012 CSO Order. For Flushing Bay, this includes Environmental Dredging, diversion of low-lying sewers and modifications to regulators along the HLI.

- The precipitation characteristics from 2008 at the JFK rainfall gauge which has been selected as the typical year rainfall.

- Flushing Creek disinfection facilities at Outfalls TI-010 and TI-011. Sensitivity analysis of the Flushing Bay and Creek loadings in terms of the selected CSO controls in Flushing Bay was also evaluated (Section 8.3c).

Mathematical modeling tools were used to calculate the CSO volume and loads and their impacts on water quality. The performance gap was assessed by comparing the baseline conditions with the WQS. In addition, complete removal or control of CSO loadings was evaluated. Further analyses were conducted for CSO control alternatives as presented in Section 8.0.

The IW model was used to develop stormwater flows, conveyance system flows and CSO volumes for the Flushing Bay sewershed for a defined set of future or baseline conditions. For the Flushing Bay LTCP, the baseline conditions were developed in a manner consistent with the earlier WWFPs for other waterbodies. However, based on more recent data, WWFPs as well as the 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, June 2012*) that used improved impervious surface satellite data.

Minor improvements, including an updated and more refined model segmentation, were also made as part of this LTCP to the water quality model. Changes to, and recalibration of, the IW and water quality models are discussed in *Flushing Bay LTCP – Sewer System and Water Quality Modeling – April 2016, Revised December 2016.* The new IW model network was then used to calculate CSOs and loads for the baseline conditions and was used as a tool to evaluate the impact on CSOs of potential alternative operating strategies and other possible physical changes to the collection system.

The baseline modeling conditions primarily related to DWF rates, wet-weather capacity for the Bowery Bay WWTP, sewer conditions, loadings and boundary conditions, precipitation conditions, and tidal boundary conditions are briefly discussed in the following:

- **Rainfall/Tides:** The 2008 year rainfall and tides were used in the model, in addition to evaluating a 10-year period (2002-2011).

- **Dry-Weather Flows:** The 2040 projected dry-weather flow rates used for the Bowery Bay WWTP was 113.5 MGD and Tallman Island WWTP was 57.1 MGD.

- **Wet-Weather Capacity**: The rated wet-weather capacity at the Bowery Bay WWTP is 300 MGD (2xDDWF) and Tallman Island WWTP is 160 MGD.

- **Sewer Conditions**: The IW model was developed to represent the sewer system on a macro scale, including all conveyance elements greater than 48-inches in equivalent diameter, along with all regulator structures and CSO outfall pipes. 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.

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.

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 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 Flushing Bay CSOs, along with a brief summary of each and their respective relationship to the EPA NMCs appear in Section 3.0. In general, the BMPs address 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 Flushing Bay:

- Sentinel Monitoring: In accordance with BMPs #1 and #5, DEP collects quarterly samples of bacteria water quality at two locations in Flushing Bay (Stations S-65 and S-66 as shown in Figure 2-27) in dry-weather to assess whether dry-weather sewage overflows occur, or whether illicit connections to storm sewers exist. No evidence of illicit sanitary sewer connections was observed based on these data and 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 Bowery Bay and Tallman Island WWTPs treat wet-weather flows that are conveyed to the plant, up to 2xDDWF. DEP follows the WWOP to receive and regularly treat 2xDDWF. Cleaning of the interceptor sediments has increased the ability of the system to convey 2xDDWF to the WWTP.

- Wet Weather Operating Plan: The Bowery Bay and Tallman Island WWOPs (BMP #4) establish procedures for pumping at the plant headworks to facilitate treatment of 2xDDWF.

6.1.d Elements of Facility Plan and GI Plan

DEP maintains containment booms to control floatables at CSO Outfalls BB-005, BB-006 and BB-008. The captured floatables are removed using skimmer vessels. Results of this program are provided in the Annual CSO BMP Report. The Flushing Bay LTCP also includes the following grey projects that are currently under construction as recommended in the Flushing Bay 2011 WWFP:

- Modification to regulator structure BB-02 that discharges to Outfall BB-002 and construction of a new sanitary sewer to reroute this direct connection from the HLI to the LLI to avoid potential flooding from the increased hydraulic grade line due to the regulator modifications. These improvements allow the regulator weir at BB-02 to be raised to convey more wet-weather flow to the Bowery Bay WWTP.

- Modifications to regulator structures BB-04, BB-05, BB-06, BB-09, BB-010 that discharge to Outfalls BB-005, BB-006, BB-007, BB-008 to reduce CSO discharges to Flushing Bay and allow more wet-weather flow to be delivered to the Bowery Bay WWTP.

- Flushing Creek LTCP recommended alternative consisting of seasonal disinfection of the TI-010 Outfall Disinfection at the Flushing Bay CSO Retention Tank, Diversion Chamber 5 and Outfall TI-011 Outfall Disinfection.

These capital projects were included in the 2012 CSO Order with milestones for the modifications associated with BB-02 to be completed by December 2017 and the other Bowery Bay regulator modifications to be completed by June 2018.

As discussed in Section 5.0, the Flushing Bay watershed has 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 had no real meaning since both areas were assigned the same runoff characteristics. As part of DEP's LTCP work, a distinction was made to further refine these areas. Direct drainage areas (parks, cemeteries, large un-occupied open areas, etc.) are now assigned lower pathogen runoff concentrations than are assigned to more urbanized non-CSO drainage areas (residential, commercial areas with a separate storm sewer system). In addition, highway runoff has been established as a category, but in many cases highway runoff is lumped together with other stormwater discharges.

In several sections of the Bowery Bay and Tallman Island WWTP sewersheds, runoff drains directly to receiving waters via overland flow, open channels, or privately owned pipes, without entering the combined sewer system or separate storm sewer system. These areas were depicted as "Direct Drainage" in Figure 6-1 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 consist of parks, marinas, sporting venues and trailways. These areas, however, also contain industrial properties, LaGuardia Airport, and sections of highways adjacent to Flushing Bay (Grand Central Parkway, Whitestone Expressway, etc.). In total, these areas comprise approximately 1,105 acres of the 6,603 acres of drainage area tributary to Flushing Bay.

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 associated with the regulator modifications for the Tallman Island and Bowery Bay sewersheds, respectively. Using these overflow volumes, CSO loadings were generated using the enterococci, fecal coliform and BOD concentrations and provided input to the receiving water quality model, ERTM. ERTM was assessed using 2013 and 2014 monitoring data collected during the Flushing Creek LTCP, as well as 2014 Sentinel Monitoring data. The assessment employed an hourly Monte Carlo randomization of the measured range of CSO concentrations assigned to the hourly overflows simulated by IW for the two outfalls contributing the most annual volume of CSO to Flushing Bay (BB-006 and BB-008). Other smaller CSO outfalls were assigned loadings based on a mass balance procedure, described below. The model validation consisted of comparing the time series and cumulative frequency distributions of 2013 and 2014 concentration data against the time series and cumulative frequency distribution output from the model for storms of similar sizes. Further details on the modeling validation analyses are provided in the technical memorandum *"Flushing Bay LTCP Sewer System and Water Quality Modeling, April 2016, Revised December 2016."*

In addition to CSO loadings, storm sewer discharges and direct drainage impact the water quality in Flushing Bay. The concentrations assigned to the various discharge sources to Flushing Bay are summarized in Table 6-1. Concentrations in Table 6-1 represent typical stormwater, direct drainage and sanitary sewage concentrations for the Flushing Bay watershed are based on water quality data collected in the Flushing Bay watershed.

For the outfalls where a mass balance approach was used, CSO concentrations were calculated using the stormwater and sanitary concentrations assigned in Table 6-1, multiplied by the flow calculated by the IW model.

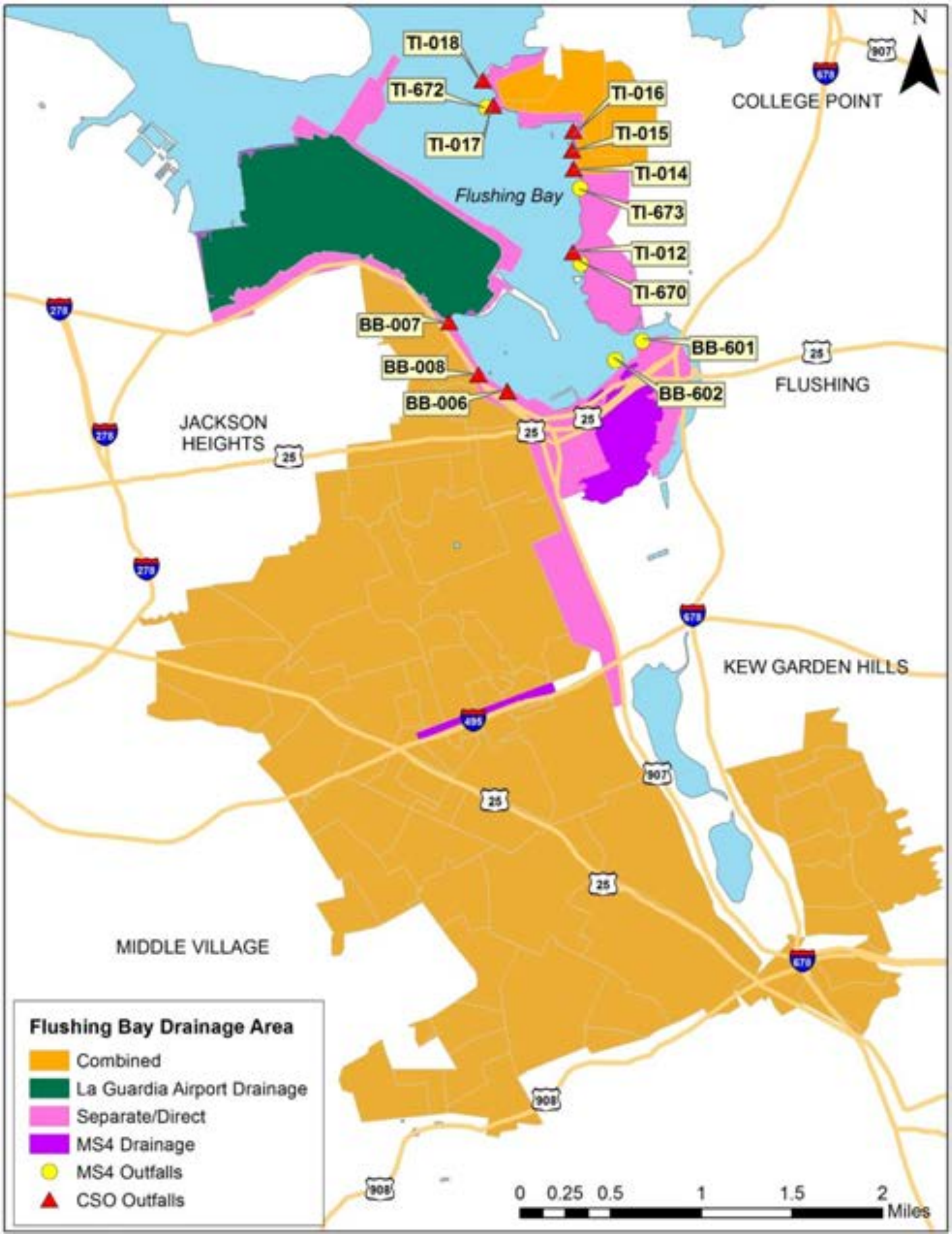

Figure 6-1. InfoWorks CSO and MS4 Subcatchments within the Flushing Bay

The 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

Table 6-1. Source Concentrations from NYC Sources

Source	Enterococci (cfu/100mL)	Fecal Coliform (cfu/100mL)	BOD_5 (mg/L)
Urban Stormwater[(2)]	15,000	35,000	15
CSOs (BB-006 and BB-008)[(1)]	Monte Carlo	Monte Carlo	Mass Balance (Sanitary =140)
Sanitary for Mass Balance CSOs[(1)]	600,000	4,000,000	Mass Balance (Sanitary=140)
Highway/Airport Runoff [(3)]	8,000	20,000	15
Direct Drainage[(3)]	6,000	4,000	15

Notes:

(1) Flushing Bay LTCP Sewer System and Water Quality Modeling, 2016.
(2) HydroQual Memo to DEP, 2005a.
(3) Basis – NYS Stormwater Manual, Charles River LTCP, National Stormwater Data Base.

MS4 areas in the IW model were updated based on desk-top analysis conducted by DEP. Non-MS4 stormwater areas and direct drainage areas are meant to represent the remaining areas of the drainage areas, and do not always consider the drainage area of each individual outfall. Figure 6-1 presents the IW subcatchments within the drainage area of Flushing Bay.

Baseline volumes of CSO to Flushing Bay for the 2008 typical year by outfall are summarized in Table 6-2, and the total baseline volumes of CSO, stormwater and direct drainage to Flushing Bay along with the associated fecal coliform, enterococci, and BOD annual loadings are summarized in Table 6-3 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

CSO	Volume(1) Total Discharge (MG/yr)	Annual Overflow Events Total (No./yr)
BB-006U	631	45
BB-006L	258	29
BB-007	38	40
BB-008	478	47
TI-012	0	0
TI-014	10	37
TI-015	3	20
TI-016	29	45
TI-017	2	21
TI-018	4	34
Total	1,453	-

Note:
(1) Volumes are rounded to the nearest MG.

Table 6-3. 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)**
Flushing Bay	CSO	1,453	32,804	42,781	515,687
	MS4 SW	110	62	144	13,582
	Non-MS4 SW	119	68	158	14,876
	LGA & Highway	220	66	166	27,430
	Direct Drainage	163	37	25	20,359
Total		**2,065**	**33,037**	**43,274**	**591,934**

As indicated in Table 6-2, the majority of the total CSO discharge volume originates from Outfalls BB-006 and BB-008 with 888 MG and 478 MG of CSO volume, respectively, under 2008 conditions. The CSO outfalls from the Bowery Bay sewershed discharge relatively frequently on the order of two to four times per month on average and account for over 95 percent of the CSO volume discharge to the Bay annually. CSO discharges from the Tallman Island sewershed that discharge directly to the Bay are much smaller by volume and less frequent. These outfalls account for less than 5 percent of the CSO discharged to the Bay annually.

The loadings for the two largest CSOs presented in Table 6-3 was developed using the Monte Carlo approach based on sampling data. For the remaining CSOs, the mass balance approach was used. An example of the IW CSO mass balance concentration calculation for CSO enterococci concentration is presented below using sanitary and storm runoff concentrations from Table 6-1:

$$73{,}500 \text{ cfu/100mL} = 0.10 \times 600{,}000 \text{ cfu/100mL} + 0.90 \times 15{,}000 \text{ cfu/100mL}$$

6.3 Performance Gap

Bacteria and DO concentrations in Flushing Bay are controlled by a number of factors, including the volumes of all sources, the concentrations of the respective loadings, flow entering from Flushing Creek, and the exchange of tidal flow with the East River. Because much of the flow and loads discharged into this waterbody are the result of runoff from rainfall events, the frequency, duration, and amounts of rainfall strongly influence Flushing Bay's water quality.

The Flushing Bay portion of the ERTM model was used to simulate bacteria and DO concentrations for the baseline conditions using 2008 rainfall and tidal data. Hourly model calculations were saved for post-processing and comparison with the Existing WQ Criteria, Primary Contact Criteria and the Potential Future Primary Contact 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 is developed to address the following three sets of criteria:

- Existing WQ Criteria (Class I);
- Bacteria Primary Contact WQ Criteria and DO next higher use classification (Class SC); and
- Bacteria Potential Future Primary Contact Recreational WQ Criteria (2012 EPA RWQC).

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 water quality criteria over the entire year and in the case of enterococci, during the recreational season of May 1st through October 31st.

A summary of the criteria that were applied is shown in Table 6-4. Analyses in this LTCP were performed using the 30-day rolling GM of 30 cfu/100mL and the STV of 110 cfu/100mL for enterococci.

Table 6-4. Classifications and Standards Applied

Analysis	Numerical Criteria Applied	
Existing WQ Criteria	(Class I)	Fecal Monthly GM ≤ 200; DO never < 4.0 mg/L
Bacteria Primary Contact WQ Criteria / DO Class SC[1]	(Class SC)	Fecal Monthly GM ≤ 200 DO between > 3.0 & ≤4.8 mg/L[1, 3]; DO never < 3.0 mg/L[1]
Potential Future Primary Contact WQ Criteria[2]	Entero: rolling 30-day GM – 30 cfu/100mL Entero: STV – 110 cfu/100mL	

Notes:
GM = Geometric Mean; STV = 90 Percent Statistical Threshold Value
(1) This water quality standard is not currently assigned to Flushing Bay.
(2) DEC has not yet adopted the Potential Future Primary Contact 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

Assessing the performance gap required calculating Flushing Bay fecal coliform concentrations under baseline conditions and then establishing whether the gap could be closed through reductions to, or control of, CSOs. The assessment was to determine if Flushing Bay water quality would comply with Existing WQ Criteria. The water quality monitoring stations are shown in Figure 6-2.

2008 Annual Rainfall Simulation – Bacteria

A one-year simulation of bacteria water quality was performed for the 2008 baseline loading conditions, assuming all known dry-weather illicit discharges have been eliminated. The results of these simulations are summarized in Table 6-5. The results shown in this table summarize the highest calculated monthly GM on an annual basis and during the recreational season (May 1st through October 31st). The maximum monthly GM is presented for each sampling location in Flushing Bay.

Table 6-5. Model Calculated 2008 Baseline Fecal Coliform Maximum Monthly GM and Attainment of Existing WQ Criteria

Station	Maximum Monthly Geometric Means		% Attainment	
	Annual	Recreational Season	Annual	Recreational Season
OW7	129	15	100	100
OW7A	84	13	100	100
OW7B	148	16	100	100
OW7C	156	17	100	100
OW8	179	16	100	100
OW9	105	14	100	100
OW10	77	13	100	100
OW11	47	16	100	100
OW12	65	14	100	100
OW13	62	13	100	100
OW14	49	21	100	100
OW15	59	19	100	100

Table 6-5 also presents the annual attainment (percent) of the fecal coliform GM criterion of 200 cfu/100mL. Although the highest GMs were found to occur in the Inner Flushing Bay near the CSOs, 100 percent attainment is achieved at all of the stations within the Bay during the recreational season (May 1st through October 31st) and on an annual basis. As a result, there is no gap in attainment of the fecal coliform standard.

2008 Annual Rainfall Simulation – Dissolved Oxygen

Water quality model simulation DO attainment results are presented in Table 6-6 for year 2008 conditions as calculated for the entire water column. When assessing the water column in its entirety, attainment of the DO criterion is very high. All of the station locations that were assessed have a water column annual attainment of 97 percent or greater for year 2008 conditions, which is greater than the 95 percent target DEC uses to assess compliance.

Figure 6-2. LTCP2 Water Quality Monitoring Stations in Flushing Bay

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

Station	Annual Attainment (%)
	Entire Water Column
	>=4.0 mg/L
OW7	100
OW7A	100
OW7B	100
OW7C	100
OW8	100
OW9	100
OW10	99
OW11	99
OW12	99
OW13	99
OW14	97
OW15	98

Table 6-7 presents a comparison of the Class I DO criterion attainment under baseline and 100% CSO control. The model generally calculates changes of only a few tenths of one percent improvement in attainment with the DO criterion. Thus, CSO loads are not the controlling factor for DO concentrations and CSO controls will not improve DO concentrations substantially. This is not unexpected as the DO in Flushing Bay is influenced by many factors including stormwater loads, tidal flushing and the nitrogen discharged from WWTPs.

Table 6-7. Model Calculated Baseline and 100% CSO Control DO Attainment – Existing WQ Criteria (2008)

Station	Annual Attainment Percent Attainment (Entire Water Column)	
	Baseline	100% Flushing Bay CSO Control
OW7	100	100
OW7A	100	100
OW7B	100	100
OW7C	100	100
OW8	100	100
OW9	100	100
OW10	99	99
OW11	99	99
OW12	99	99
OW13	99	99
OW14	97	97
OW15	98	98

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

Bacteria

The next highest use for Flushing Bay is Class SC with fishing being the best usage. DEC has promulgated new regulations that require Class SD and I waterbodies to meet the primary contact (Class SC) bacteria criteria. The primary contact fecal coliform criterion is a monthly GM less than or equal to 200 cfu/100mL.

The 2008 baseline condition scenario was rerun with the Flushing Bay CSO loadings removed. This projection represents the maximum possible reduction of Flushing Bay CSO loads and is referred to as the 100% CSO control scenario. It should, however, be noted that there are numerous other CSO outfalls that discharge to the East River/Upper East River which remain at baseline conditions for this CSO control scenario. All other conditions from the baseline projection remain unchanged in the 100% CSO control scenario. Table 6-8 presents the maximum monthly coliform GM concentration and the annual attainment of the Class SC criterion for fecal coliform.

Table 6-8. Comparison of the Model Calculated 2008 Baseline and 100% Flushing Bay CSO Control Fecal Coliform Maximum Monthly GM and Attainment of Primary Contact WQ Criteria

Station	Maximum Monthly Geometric Means (Annual)		% Attainment (Annual)	
	Baseline	100% CSO Control	Baseline	100% CSO Control
OW7	129	77	100	100
OW7A	84	32	100	100
OW7B	148	63	100	100
OW7C	156	73	100	100
OW8	179	133	100	100
OW9	105	69	100	100
OW10	77	55	100	100
OW11	47	38	100	100
OW12	65	48	100	100
OW13	62	45	100	100
OW14	49	44	100	100
OW15	59	47	100	100

Table 6-8 shows that the CSOs have the largest impact in the vicinity of Stations OW7B and OW7C, where the removal of the CSO loadings results in a reduction of the maximum monthly fecal coliform GM concentration by 85 and 83 cfu/100mL, respectively. Improvements in the monthly fecal coliform GM (due to 100% CSO control) are less significant in the outer portions of Flushing Bay. Attainment with the fecal coliform monthly geomean criteria remains at 100 percent with the removal of the CSOs resulting in lower geomean concentrations at each of the monitoring locations.

Dissolved Oxygen

The attainment of the DO Class SC criteria for the entire water column is presented in Table 6-9, for the baseline and 100% Flushing Bay CSO control conditions. Determination of attainment with Class SC 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. 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 at all stations, except for Station OW-14. Under baseline conditions, stations in the Inner Flushing Bay have a greater than 95 percent attainment of the chronic DO criterion (greater than or equal to 4.8 mg/L), while Station OW14 in the Outer Flushing Bay has attainment less than 95 percent on an annual basis. 100% CSO control results in no improvement of percent annual attainment of the chronic DO criterion. All of the stations have 100 percent attainment of the acute criterion (never less than 3.0 mg/L) under baseline conditions based on the entire water column. Since 100% CSO control does not result in improvements in attainment of the Class SC criterion, there is no gap between attainment and non-attainment at all monitoring locations within Flushing Bay, regardless of the level of control implemented.

Table 6-9. Model Calculated 2008 Baseline and 100% CSO Control DO Attainment of Class SC WQ Criteria

Station	Annual Attainment Percent Attainment (Water Column)			
	Baseline		100% Flushing Bay CSO Control	
	Chronic(1)	Acute(2)	Chronic(1)	Acute(2)
OW7	100	100	100	100
OW7A	100	100	100	100
OW7B	100	100	100	100
OW7C	100	100	100	100
OW8	100	100	100	100
OW9	100	100	100	100
OW10	100	100	100	100
OW11	97	100	97	100
OW12	100	100	100	100
OW13	100	100	100	100
OW14	83	100	83	100
OW15	96	100	97	100

Notes:
(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.

6.3.c Potential Future Primary Contact WQ Criteria

As noted in Section 2.0, EPA released its RWQC recommendations in December 2012. These included recommendations for recreational water quality criteria for protecting human health in all coastal and non-coastal waters designated for primary contact recreation use. The standards would include a rolling 30-day GM of either 30 cfu/100mL or 35 cfu/100mL and a 90th percentile STV during the rolling 30-day period of either 110 cfu/100mL or 130 cfu/100mL. An analysis using the 2008 baseline and 100% CSO control condition model simulation results was conducted using both the 30 cfu/100mL GM and 110 cfu/100mL 90th percentile STV criteria, to assess attainment with these potential future RWQC.

6.3.d Load Reductions Needed to Attain the Potential Future Primary Contact 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 Flushing Bay. That analysis consisted of first assessing the baseline conditions for enterococci and then determining whether complete Flushing Bay CSO reduction (100% CSO control) could close the gap between the baseline conditions and the potential future recreational water quality criterion of a 30-day rolling GM enterococci concentration of 30 cfu/100mL. The results of the analyses are presented in Table 6-10 for the maximum 30-day GM and attainment of the rolling 30-day GM criterion. All results are for the attainment of the Potential Future Primary Contact WQ Criteria during the May 1st through October 31st recreational season defined by the DEC.

Table 6-10. Model Calculated 2008 Baseline Enterococci Maximum 30-day GM and Attainment of Potential Future Primary Contact WQ Criteria

Station	Maximum Recreational Season 30-day Enterococci (cfu/100mL)		% Attainment	
	GM	90th Percentile STV	GM	90th Percentile STV
OW7	18	2,890	100	9
OW7A	18	4,417	100	9
OW7B	22	5,696	100	9
OW7C	22	6,166	100	9
OW8	17	1,274	100	12
OW9	14	1,565	100	13
OW10	12	930	100	29
OW11	11	288	100	78
OW12	12	475	100	57
OW13	13	648	100	60
OW14	13	243	100	77
OW15	13	327	100	72

Under 2008 baseline conditions, 100 percent attainment of the rolling 30-day GM enterococci criteria of 30 cfu/100mL is achieved during the recreational season (May 1st through October 31st). Attainment of the 90th percentile STV criterion of 110 cfu/100mL within Outer Flushing Bay (Stations OW10 through OW15), ranges from 29 to 78 percent, while Inner Flushing Bay (Stations OW7 through OW9), ranges from 9 to 13 percent. These results indicate that while rainfall events have significant short term impacts, particularly within the Inner Flushing Bay, bacteria impacts dissipate before the 30-day GM criterion is violated.

Water quality modeling analyses conducted to assess attainment of the enterococci criteria with complete removal of the CSO enterococci loadings, as provided in Table 6-11, show that 100% CSO control would result in full attainment of the 30-day rolling GM enterococci criterion. Attainment of the 90th percentile STV enterococci criterion ranges from 81 to 100 percent. The improvement in STV attainment with 100% CSO controls, as calculated for Flushing Bay, is high in comparison to other waterways. The high degree of attainment with 100% CSO control indicates that the 90th percentile enterococci concentrations are predominantly generated by CSOs and therefore can be altered with CSO controls. This is further supported by Table 6-3 above, which shows that CSOs are the source of an overwhelming majority of the bacteria loading to Flushing Bay. With 100% control of CSOs, the model calculates comparatively high attainment of the 90th percentile STV criterion. However, other non-CSO sources of bacteria, such as storm sewers, direct runoff, Flushing Creek and the East River also contribute to the non-attainment of the criterion.

Table 6-11. Model Calculated 2008 100% CSO Control Enterococci Maximum 30-day GM and Attainment of Potential Contact WQ Criteria

Station	Maximum Recreational Season 30-day Enterococci (cfu/100mL)		% Attainment	
	GM	90th Percentile STV	GM	90th Percentile STV
OW7	5	120	100	93
OW7A	4	43	100	100
OW7B	5	74	100	100
OW7C	5	92	100	100
OW8	7	180	100	81
OW9	6	94	100	100
OW10	6	117	100	99
OW11	8	118	100	99
OW12	8	123	100	97
OW13	7	114	100	97
OW14	11	151	100	87
OW15	10	140	100	95

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 Flushing Bay. The source types include CSOs, stormwater, direct drainage, Flushing Creek, and the East River. Since the stormwater contribution to bacteria loads is relatively small when compared to CSOs, the MS4 and non-MS4 loads were lumped together as one source, and the direct drainage and LaGuardia Airport runoff was analyzed as one source. The analysis included the calculation of fecal coliform and enterococci bacteria GMs in total and from each component. For fecal coliform, a maximum winter month (December) was analyzed because the decay rate is lower in winter, resulting in generally higher fecal coliform concentrations. Enterococci was evaluated on a maximum recreational season (May 1st through October 31st) 30-day GM basis. The 30-day period chosen for the enterococci component analysis included both the maximum 30-day period and the 30-day period where the maximum contribution of CSOs to the geometric mean was observed.

Table 6-12 summarizes the fecal coliform component analysis for the maximum winter month during 2008. The fecal coliform criterion (monthly GM less than or equal to 200 cfu/100mL) is not exceeded during this maximum winter month (December) at all locations. The maximum monthly CSO contribution is 85 cfu/100mL at Station OW7C. CSOs are the largest contributor to the monthly GM fecal coliform concentration in the Inner Flushing Bay at Stations OW7A, OW7B, and OW7C. Monthly GM fecal coliform concentrations at Stations OW7, OW8, OW9, OW10, OW12, and OW13 are more heavily influenced by Flushing Creek, while Stations OW11, OW14, and OW15 are most heavily influenced by the East River. A review of Figure 6-2 indicates that in each case the source of fecal coliform in closest proximity to a particular monitoring station has the greatest influence on the monthly GM fecal coliform concentration at that station. Regardless of the source of fecal coliform, all stations achieved attainment with a maximum monthly fecal coliform GM less than the criterion of 200 cfu/100mL.

Table 6-12 also summarizes the enterococci component analysis. CSO is the largest contributor to the 30-day GM at Stations OW7 and OW10 with a maximum contribution at Inner Flushing Bay Stations OW7B and OW7C of 17 cfu/100mL. The East River is the largest influence on Outer Flushing Bay at Stations OW11 through OW15 with a maximum contribution of 11 cfu/100mL at Station OW14. None of the stations had a 30-day enterococci GM greater than the potential future criterion of 30 cfu/100mL.

Table 6-12 indicates that CSO impacts to attainment are most evident within Inner Flushing Bay, although the extent of CSO contribution varies both spatially and temporally. As such, the alternatives analysis described in Section 8.0 focuses on reduction of the CSO discharges to Flushing Bay.

Table 6-12. Fecal and Enterococci GM Source Components

Source	Station	Fecal Coliform Contribution (cfu/100mL)	Enterococcus Contribution (cfu/100mL)
		Annual Worst Month December Monthly GM	Max 30-Day Rolling GM during the Recreational Season (May 1st through October 31st)
Flushing Creek	OW7	68	3
Direct Drainage	OW7	2	0
Stormwater	OW7	3	0
CSO	OW7	52	13
East River	OW7	4	2
Total	OW7	**129**	**18**
Flushing Creek	OW7A	26	2
Direct Drainage	OW7A	3	1
Stormwater	OW7A	1	0
CSO	OW7A	52	15
East River	OW7A	2	1
Total	OW7A	**84**	**18**
Flushing Creek	OW7B	55	3
Direct Drainage	OW7B	3	1
Stormwater	OW7B	2	0

Table 6-12. Fecal and Enterococci GM Source Components

Source	Station	Fecal Coliform Contribution (cfu/100mL)	Enterococcus Contribution (cfu/100mL)
		Annual Worst Month December Monthly GM	Max 30-Day Rolling GM during the Recreational Season (May 1st through October 31st)
CSO	OW7B	85	17
East River	OW7B	3	1
Total	OW7B	**148**	**22**
Flushing Creek	OW7C	63	3
Direct Drainage	OW7C	4	1
Stormwater	OW7C	3	0
CSO	OW7C	83	17
East River	OW7C	3	1
Total	OW7C	**156**	**22**
Flushing Creek	OW8	121	5
Direct Drainage	OW8	0	1
Stormwater	OW8	6	0
CSO	OW8	46	10
East River	OW8	6	2
Total	OW8	**179**	**17**
Flushing Creek	OW9	55	2
Direct Drainage	OW9	3	0
Stormwater	OW9	2	0
CSO	OW9	36	8
East River	OW9	9	3
Total	OW9	**105**	**13**
Flushing Creek	OW10	40	2
Direct Drainage	OW10	1	0
Stormwater	OW10	1	0
CSO	OW10	22	6
East River	OW10	13	4
Total	OW10	**77**	**12**
Flushing Creek	OW11	6	0
Direct Drainage	OW11	2	0
Stormwater	OW11	2	0
CSO	OW11	9	3
East River	OW11	28	8
Total	OW11	**47**	**11**
Flushing Creek	OW12	25	1
Direct Drainage	OW12	1	0

Table 6-12. Fecal and Enterococci GM Source Components

Source	Station	Fecal Coliform Contribution (cfu/100mL)	Enterococcus Contribution (cfu/100mL)
		Annual Worst Month December Monthly GM	Max 30-Day Rolling GM during the Recreational Season (May 1st through October 31st)
Stormwater	OW12	1	0
CSO	OW12	17	5
East River	OW12	21	6
Total	OW12	**65**	**12**
Flushing Creek	OW13	23	1
Direct Drainage	OW13	0	0
Stormwater	OW13	2	0
CSO	OW13	17	6
East River	OW13	20	6
Total	OW13	**62**	**13**
Flushing Creek	OW14	2	0
Direct Drainage	OW14	1	0
Stormwater	OW14	0	0
CSO	OW14	5	2
East River	OW14	41	11
Total	OW14	**49**	**13**
Flushing Creek	OW15	11	0
Direct Drainage	OW15	0	0
Stormwater	OW15	1	0
CSO	OW15	12	3
East River	OW15	35	9
Total	OW15	**59**	**12**

6.3.d Time to Recovery

The analyses provided above examine the long term impacts of wet-weather sources, as is required by Existing and Potential Future Primary Contact WQ Criteria (monthly GM and 30-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 Flushing Bay to recover and return to concentrations of less than 1,000 cfu/100mL.

LGA rainfall data were first analyzed for the period of 2002-2011. The Synoptic Surface Plotting Models (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. Based on this information, a storm approximating the 90th percentile storm was chosen from the 2008 recreational season (May 1st through October 31st) as a design storm. This design storm was the August 15, 2008 JFK rainfall event, which resulted in 1.02 inches of precipitation. A principal feature of this storm, aside from its volume, was the time until the next rainfall event, which allows concentrations to reach the fecal coliform target concentration. The period of dry-weather following this event allows for sufficient time to assess a wide range of recovery times that may occur depending on the characteristics of the CSO discharges and the receiving waterbodies.

Table 6-13 presents the time to recovery for the baseline condition and the 100% Flushing Bay CSO control scenario. Under the baseline conditions, Stations OW7, OW7B, OW7C, and OW9 have the longest time to recovery of 23 hours. DEC has indicated that it is desirable to have a time to recovery of less than 24 hours. The other Flushing Bay stations have time to recovery ranging between 9 and 21 hours.

Once CSOs are removed in Flushing Bay (100% CSO control), there is a fairly significant reduction in the time to recovery compared to baseline conditions. In most areas within Flushing Bay, the time to recovery will be decreased by 10 hours or more. In areas influenced by other sources such as OW14, there would be little change in the time to recovery.

Table 6-13. Time to Recovery

Station	Time to Recovery (hours) Fecal Threshold (1,000 cfu/100mL)	
	Baseline	100% CSO Control
OW7	23	10
OW7A	21	0
OW7B	23	0
OW7C	23	0
OW8	22	10
OW9	23	10
OW10	21	9
OW11	11	0
OW12	21	0
OW13	20	5
OW14	9	9
OW15	20	10

In summary, the time to recovery for baseline conditions appears to be on the order of DEC's desired target of 24 hours. However, there is a significant decrease in the time to recovery if CSO loadings are removed.