TECHNICAL MEMORANDUM

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DATE: September 9, 2020

RE: Contract CSO-BXR-DES
Bronx River Long Term Control Plan
HP-007/009 Relief Sewer CSO Control Compliance Summary

FILE: Bronx River CSO Project\Drawings and Documents\Wade Trim\
Tech Memos

1 EXECUTIVE SUMMARY

The Department of Environmental Protection (DEP) of New York City submitted a Bronx River Combined Sewer Overflow (CSO) Long Term Control Plan (LTCP) with a CSO control recommended plan to the New York State Department of Environmental Conservation (DEC) in June 2015 which was subsequently approved for implementation (reference: https://www1.nyc.gov/assets/dep/downloads/pdf/water/nyc-waterways/bronx-river/bronx-river-ltcp-201506.pdf). In 2018, the DEP initiated the design of the recommended plan improvements that included the following work in three areas within the Borough of Bronx:

- A relief sewer from Relief Structure 27, upstream of CSO outfall HP-007 near Bronx Park Avenue and E. 178th Street, to an existing sewer at Metcalf Avenue and E. 172nd Street. Referred to as Work Area HP-007 during the design phase.

- A relief sewer from Regulator 13, upstream of CSO outfall HP-009 to the Bronx River Siphon in Soundview Park. Referred to as Work Area HP-009 during the design phase.

- Construction of a new Regulator 5 upstream of CSO outfall HP-011 near White Plains Road and Bronx River Avenue, with a bending weir and underflow baffle to capture floatables. Referred to as Work Area HP-011 during the design phase.

The level of CSO control identified in the approved Bronx River CSO LTCP was based on an annual typical year reduction in volume anticipated after completion of the recommended plan improvements compared to a baseline condition. The baseline condition included the existing system configurations at the time of the development of the LTCP plus known improvements assumed to be completed prior to the implementation of the recommended plan. These included the recently completed Pugsley Creek relief sewer project, constructed by DEP as part of the Westchester Creek CSO Waterbody/Watershed Facility Plan (WWFP), and the green infrastructure committed by DEP as per the CSO consent order. As a result, the approved Bronx River LTCP recommended plan resulted in a 37% reduction in CSO volumes into the Bronx River during the typical year compared to the baseline condition, thus achieving the desired water quality outcomes. The typical year used for the LTCP was the rainfall data from the 2008 rainfall record at the John F. Kennedy International Airport measured by National Oceanic and Atmospheric Administration (NOAA), and the corresponding time-varying tides from NOAA, that were used uniformly by DEP for the citywide LTCP projects. For this typical year, the expected reduction identified in the approved LTCP was equivalent to approximately 170 million gallons per year (MGY) from the 455 MGY under baseline conditions, resulting in approximately 285 MGY of remaining overflow volume into the Bronx River.

The hydraulic model for the Bronx River sewershed area used to simulate these annual volumes has since been updated based on several factors including collection system records research, field surveys, model detail refinement, and base dry weather flow allocations. These hydraulic model refinements included:

- Sewer network configuration modifications required from minor model discrepancies found during existing record drawings and sewer maps research and closed-circuit television (CCTV) and confined space entry inspections.
- Drainage area clarifications within various tributary areas that re-allocated relatively small acreage to the Bronx River sewershed.
- Model hydraulic detail refinement that included adding piping network for sewers 24-inch in equivalent diameter and larger and associated manholes. (Original LTCP model used a piping network greater than or equal to 60-inch in equivalent diameter.)
- Sanitary sewer distribution allocations to better represent the estimated daily base dry weather flows within the impacted service area. This increased the dry weather flow allocation in the Bronx River service area by approximately 14 million gallon per day (MGD) impacting both the baseline and LTCP recommended plan annual overflow volumes.
- Minor sewerage facility clarifications received from the DEP LTCP team.

In addition, there has been a reduction in green infrastructure implementation in the Bronx River watershed from the 2015 Baseline/Recommended Plan due to high bedrock and narrow sidewalks. Collectively, these changes resulted in the annual overflow volumes in the Bronx River outfalls to increase in both the current baseline and completed recommended plan conditions. The refinements listed above were incorporated into both the baseline and recommended plan model conditions. The baseline condition increased from approximately 455 MGY to 625 MGY and the recommended plan condition increased from 285 MGY to 375 MGY. This resulted in a revised reduction of 250 MGY of annual overflow volume equivalent to a 40% reduction in volume of CSO to the Bronx River.

The Bronx River LTCP also provided the results of Water Quality (WQ) modeling for the Bronx River that used same typical year rainfall data from 2008 and assumed that the upstream pollutant sources from Westchester County were controlled and in attainment of the WQ goals. The WQ modeling results concluded that there was no difference in annual dissolved oxygen and bacteria water quality criteria attainment using these assumptions between the baseline condition and the 100% control of CSO overflows condition in the Bronx River. This further supported the recommended plan condition for cost-effective removal of CSO to the Bronx River (i.e., at least 37% reduction of annual Bronx River CSO in the typical year of rainfall). Therefore, for the purposes of advancing the recommended configurations in the HP-007 and HP-009 work area relief systems, the resulting maximum remaining typical year CSO volume of 375 MGY and minimum 40% annual volumetric reduction from these outfalls to the Bronx River compared to the baseline condition was used as the minimum performance objective to meet the WQ goals of the project for all design alternatives developed.

During the design phase, the LTCP Recommended Plan improvements were evaluated against optimized alternatives that considered constructability, community impacts, operational efficiency, and costs while also achieving the required CSO control performance objectives identified in the approved LTCP. This resulted in identifying selected alternatives in the three project areas that were documented in the Basis of Design Reports (BODRs) submitted to the

DEP in February 2020. The recommended alternatives contained in the BODRs proposed the following modifications to the LTCP recommended plan as follows:

- Relocated the HP-007 and HP-009 relief sewers upstream of the original alignments to preferred tunnel routes along E. 178th Street and the Soundview Park Compost Facility, respectively.
- Relocated the downstream connection of the HP-007 relief sewer upstream to a more open area in an existing park north of E. 174th Street and Metcalf Avenue to facilitate the construction
- Moved the proposed new Regulator 5 upstream into the public right of way of White Plains Road and Bronx River Avenue for better operational access and to take advantage of the tide gates in the existing Regulator 5 to protect the excavation from East River high tide conditions.

There were other modifications made to configurations within the three project areas to remove flow restrictions and to adjust relief sewer elevations to ensure only wet weather flows were conveyed through the proposed relief sewers. The adjustments were made to improve the overall hydraulic performance of the relief and floatables control systems for the Bronx River CSO LTCP Project. These changes resulted in a BODR alternative that exceeded the CSO control performance of the original LTCP Recommended Plan. In further evaluating the relative performance of the relief sewers located in the HP-007 and HP-009 work areas, it became apparent that the relative benefit of the HP-007 relief sewer compared to the benefits of the HP-009 were very minor, particularly when considering the relative cost and construction challenges associated with the HP-007 relief sewer. Therefore, as part of the 30% design phase, an analysis was conducted to consider the elimination of the HP-007 relief sewer resulting in a new alternative that still achieved the required CSO control performance for the Bronx CSO LTCP Project.

Table ES-1 illustrates that the targeted total remaining maximum overflow volume of 375 MGY and associated 40% reduction could still be achieved without constructing the HP-007 relief sewer. With the optimizations recommended in the BODR for the HP-009 relief sewer along with the elimination of the HP-007 relief sewer, the remaining net annual overflow volume anticipated in the Bronx River CSO outfalls would be 364 MGY representing a 41.8% reduction in volume, exceeding the targeted remaining annual overflow volume and associated percent reduction anticipated for the LTCP Recommended Plan improvements that included both relief sewers in the HP-007 and HP-009 work areas. Therefore, the elimination of the HP-007 relief sewer with the construction of the HP-009 relief sewer and new Regulator 5 floatables control facility was considered a feasible alternative to compare to the BODR alternative.

Table ES-1 Comparison of CSO Volumes for LTCP and HP-007/009 and HP-009 BODR Alternatives

		Baseline		LTCP Recommended Plan		BODR Alternative with (HP-007/009) Relief Sewers		30% Design Alternative with (HP-009)* Relief Sewer Only	
Outfall	Regulator	CSO Vol MG	Overflow Frequency	CSO Vol MG	Overflow Frequency	CSO Vol MG	Overflow Frequency	CSO Vol MG	Overflow Frequency
HP-004	CSO28, 28A	24.7	19	24.7	19	24.6	19	24.6	19
HP-007	CSO27, 27A	38.3	11	18.7	9	23.0	10	38.5	11
HP-008	CSO26	1.5	2	1.5	2	1.4	2	1.4	2
HP-009	Reg #13	560.6	41	330.6	37	308.1	39	299.2	39
HP-010	CSO25	0.0	0	0.0	0	0.0	0	0.0	0
Total Annual CSO Volume in Bronx River (Nearest MG)		***625***		***375***		***357***		***364***	
Total Annual CSO Volume Controlled		**-**		***250***		***268***		***261***	
Percent Annual CSO Volume Removed		**-**		***40.0%***		***42.9%***		***41.8%***	

**Includes elimination of the HP-007 Relief Sewer and construction of the HP-009 Relief Sewer and the new Regulator 5 Floatables Control Facility.*

When considering these alternatives from a cost-effective perspective, it is evident that the HP-007 relief sewer provides minimal CSO control benefit compared to the estimated cost of construction. Table ES-2 summarizes the estimated total construction costs for the HP-007/009 relief sewers and for the HP-009 relief sewer alone indicating that eliminating the HP-007 relief would result in over $60 million in construction costs savings escalated to 2025. The escalation factor was applied to account for the planned schedule of implementation. The elimination of the HP-007 relief sewer would also provide savings in the associated final design, construction management, and project implementation costs (i.e., permits, easements, etc.) that could result in an estimated $65-$70 million in total project savings. In addition, there would be avoidance of risks of tunnel construction and community disturbances in a highly urbanized congested area with critical highway and railroad infrastructure present.

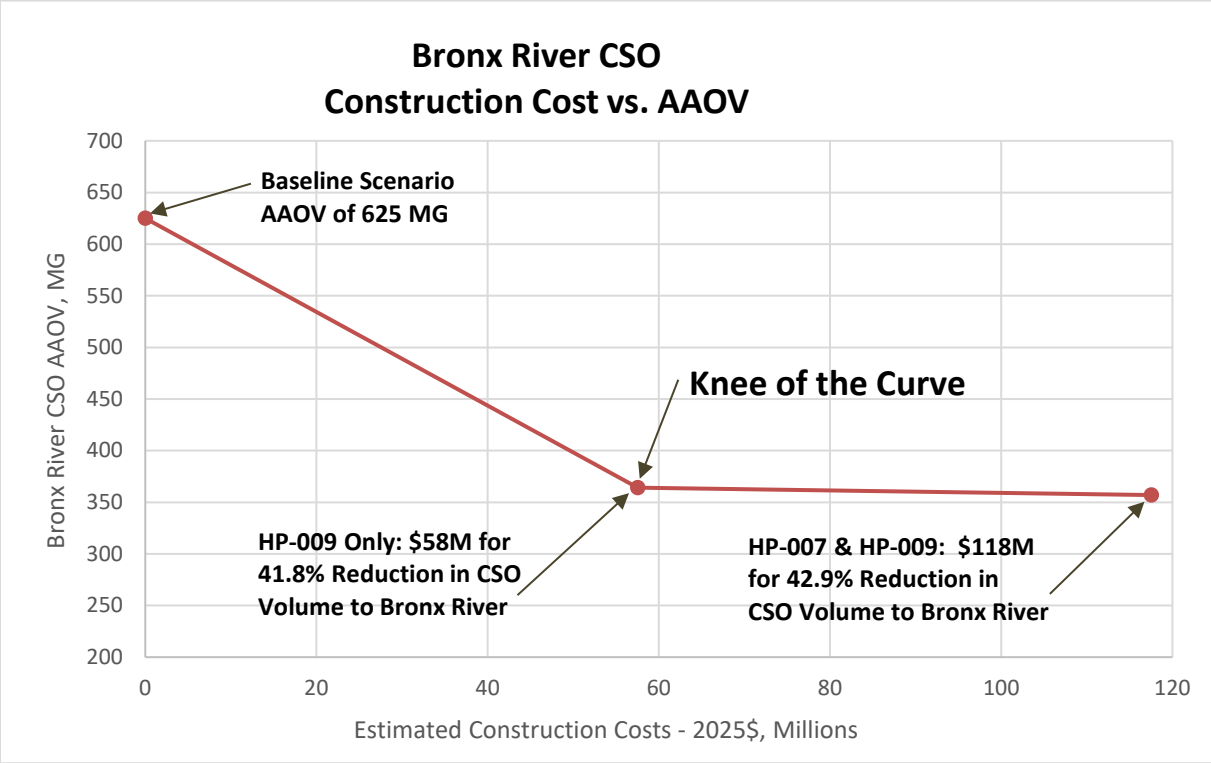
Table ES-2 Summary of Cost Estimates for HP-007/009 and HP-009 Relief Sewers (Dollars Escalated to 2025)

HP-007 & HP-009 Relief Sewers	HP-009 Relief Sewer	Difference
$117,537,000	**$57,521,000**	**$60,017,000**

As shown in Table ES-1, the total CSO volume controlled by installing both HP-007 and HP-009 relief sewers is 268 MGY as opposed to 261 MGY controlled by installing only HP-009, a

difference of approximately 7 MGY with about 97% of the Average Annual CSO Volume (AAOV) into the Bronx River being controlled by the HP-009 project alone. When considering the construction costs identified in Table ES-2, the implementation of the HP-009 relief sewer would result in unit construction cost per annual gallon controlled of approximately $0.22/gallon. To achieve the remaining 7 MG with the installation of the HP-007 relief sewer would require an additional $8.57/gallon in CSO mitigation construction cost. The inefficiency of the HP-007/009 relief sewer alternative is further illustrated graphically in a "knee of the curve" graph shown in Figure ES-1. It clearly demonstrates that the alternative to construct the HP-009 relief sewer only with the associated Regulator 5 floatables control facility is the most cost-effective means of achieving the required CSO control performance objectives for the Bronx River CSO LTCP Project by a substantial margin.

Figure ES-1 Cost Performance Curve for Remaining CSO for HP-007/009 and HP-009 Relief Sewer(s)



Considering the above factors, the Bronx River CSO LTCP Project design team recommends the elimination of the HP-007 relief sewer from the proposed improvements. As a result, the previously submitted HP-007/009 BODR would be updated accordingly to provide documentation for the advancement of the remaining design and construction phases consistent with the implementation of this recommendation.

2 INTRODUCTION

The Bronx River CSO LTCP Recommended Plan was submitted to New York State DEC in June 2015 by the DEP. After approval by the DEC, DEP initiated the CSO-BXR-DES design project for final design and construction of the Recommended Plan. The general recommended plan objective is to capture and convey controlled overflows at two outfalls, HP-007 and HP-009, that discharge into Bronx River to either the Hunts Point Wastewater Resource Recovery Facility (HP WWRF) for treatment, via a siphon in Soundview Park, or to the larger receiving water of the East River where a new regulator and floatables control facility is proposed near existing Regulator 5 that overflows at outfall HP-011.

PROJECT BACKGROUND

The recommended plan included an overall project consisting of three project areas near outfalls HP-007, HP-009 and HP-011 in the Borough of Bronx that are hydraulically interrelated from the furthest upstream point tributary to the Bronx River to the downstream termination at the East River. This plan included the following improvements to achieve the desired CSO control performance objectives:

- A relief sewer from Relief Structure 27, upstream of CSO outfall HP-007 near Bronx Park Avenue and E. 178th Street, to an existing sewer at Metcalf Avenue and E. 172nd Street where flows split between the Regulator 13 and Regulator 6 through a wet weather diversion structure at Internal Overflow Chamber 7 (referred to as I/O #7 in drawings)
- A relief sewer from Regulator 13 upstream of CSO outfall HP-009 to the Bronx River Siphon in Soundview Park
- Construction of a new Regulator 5 upstream of CSO outfall HP-011 near White Plains Road and Bronx River Avenue with a bending weir and underflow baffle to capture floatables while providing some level of upstream in-system storage to convey flow to the siphon leading to the HP WRRF.

The design of the Bronx River CSO LTCP project included evaluating and selecting alternatives in the three project areas that would meet the CSO control objectives with considerations that included constructability, community impacts, operational efficiency, and costs. This technical memorandum summarizes the advancement of the design to the Basis of Design stage and includes the hydrologic and hydraulic (H&H) evaluations performed to confirm the recommendations moving forward to final design with the most cost effective means for achieving the CSO control objectives.

SUMMARY OF CSO CONTROL PERFORMANCE OBJECTIVES

The Bronx River CSO LTCP identified the resulting annual CSO control performance for the Bronx River outfalls anticipated with the implementation of the Recommended Plan based on a typical year of rainfall simulated with a H&H model. This model, developed in InfoWorks Integrated Catchment Model (ICM) framework, has been calibrated and validated using field data during LTCP development and was provided to the design team to support the final design. The rainfall data from a typical year was analyzed to separate individual events assuming an

interevent time of 4 hours. For setting the targets for CSO reductions and tracking of performance of alternatives, the typical year of 2008 rainfall record at the John F. Kennedy International Airport measured by NOAA was used uniformly by DEP for the citywide LTCP projects.

The typical year time-series of rainfall data available at hourly interval is shown in Figure 1 below. The rainfall data was analyzed to separate individual events assuming an interevent time of four hours between events, consistent with the methodology used by DEP in other water quality improvement projects. The results of this analysis showing the statistical characteristics of the typical year rainfall are summarized in Table 1.

Figure 1 2008 Typical Year Rainfall Time-series

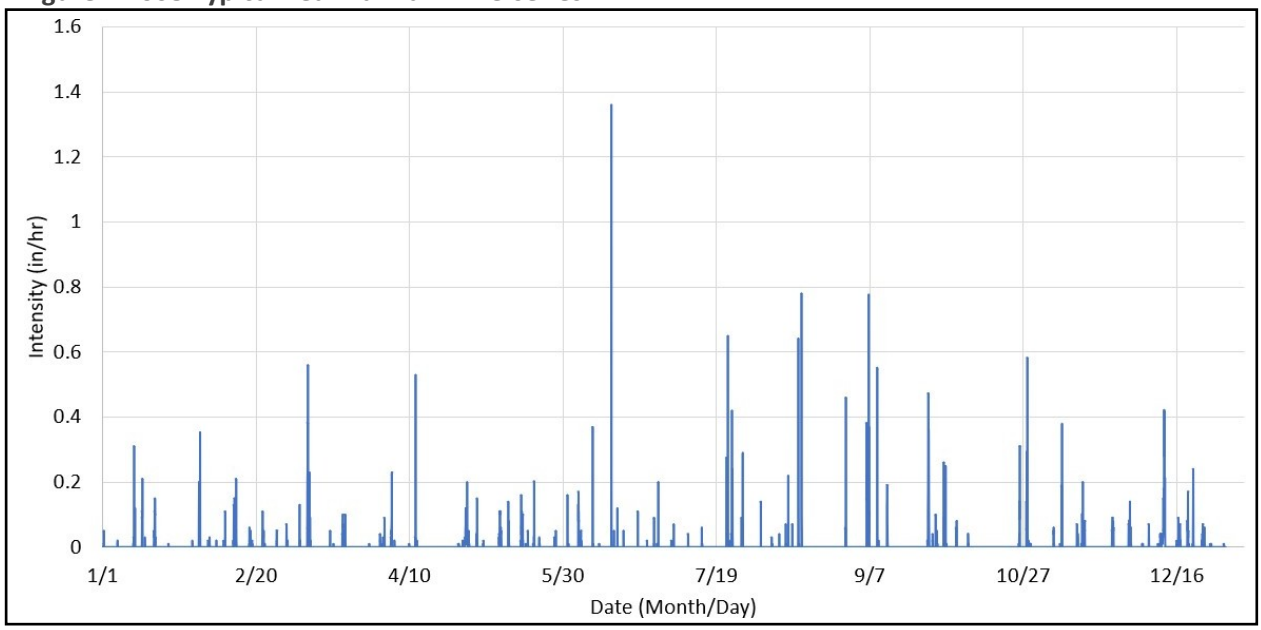


Table 1 Rainfall Characteristics in the Typical Year 2008	
Statistical Characteristic	Values
Number of Events	130
Maximum Intensity	1.36 inches/hour (6/14/2008 Event)
Maximum Volume	3.23 inches (12/11/2008 Event)
Average Peak Intensity	0.15 inches/hour
Average Volume	0.36 inches
Average Interevent Time	62.01 hours
Number of Events	130

CSO CONTROL PERFORMANCE CRITERIA

The approved Bronx River LTCP recommended plan resulted in a 37% reduction in CSO volumes into the Bronx River during the typical year, thus achieving the desired water quality outcomes. This expected reduction identified in the LTCP was equivalent to approximately 170 MGY from the 455 MGY under baseline conditions, resulting in approximately 285 MGY of remaining overflow volume into the Bronx River.

As detailed in Section 3, the hydraulic model used to simulate these annual volumes has since been updated based on several factors including base dry weather flow allocations, collection system records research, and field surveys. This resulted in the annual overflow volumes in the Bronx River outfalls increasing both the current baseline and completed recommended plan conditions. The baseline condition increased from approximately 455 MGY to 625 MGY and the recommended plan condition increased from 285 MGY to 375 MGY. This resulted in a reduction of 250 MGY of annual overflow volume which is equivalent to a 40% reduction in volume of CSO to the Bronx River. Therefore, for the purposes of advancing the recommended configurations in the HP-007 and HP-009 work area relief systems, the maximum remaining typical year CSO volume of 375 MGY from these outfalls to the Bronx River was used as the minimum performance objective to meet the WQ goals of the project for all alternatives developed during the design.

The Bronx River LTCP also provided the results of WQ modeling that incorporated data from multiple sampling stations throughout the reaches of the Bronx River. The model utilized the same typical year rainfall data from 2008 and assumed that the upstream pollutant sources from Westchester County were controlled and in attainment of the WQ goals. The subsequent modeling results concluded that there was no difference in annual attainment of dissolved oxygen and bacteria WQ criteria using these assumptions between the baseline condition and the 100% control of CSO overflows condition in the Bronx River. This further supported the recommended plan condition for cost effective removal of CSO to the Bronx River (*i.e., at least 37% reduction of annual Bronx River CSO in the typical year of rainfall*).

In addition to the Bronx River CSO control reduction performance objective, the resulting overflow volumes to the East River from the new Regulator 5 equipped with floatables control facilities were also compared to those identified in the original LTCP summary tables. As was the case with the Bronx River Baseline and Recommended Plan conditions, the associated overflow volumes to the East River via outfall HP-011 also increased due to the model updates described in Section 3. The updated overflow volumes were used to compare remaining overflow volumes at Regulator 5 (HP-011) with the BODR alternative analyses.

3 BASIS OF DESIGNS FOR WORK AREAS HP-007, HP-009 AND HP-011

The following sections summarize the configurations of the relief sewers and associated CSO control diversion, regulator, and floatables control facilities that were developed through the Facilities Planning Phase. These configurations are detailed in the Basis of Design Reports (BODR) for the HP-007/HP-009 and HP-011 work areas.

WORK AREA HP-007 – RELIEF STRUCTURE 27 RELIEF SEWER

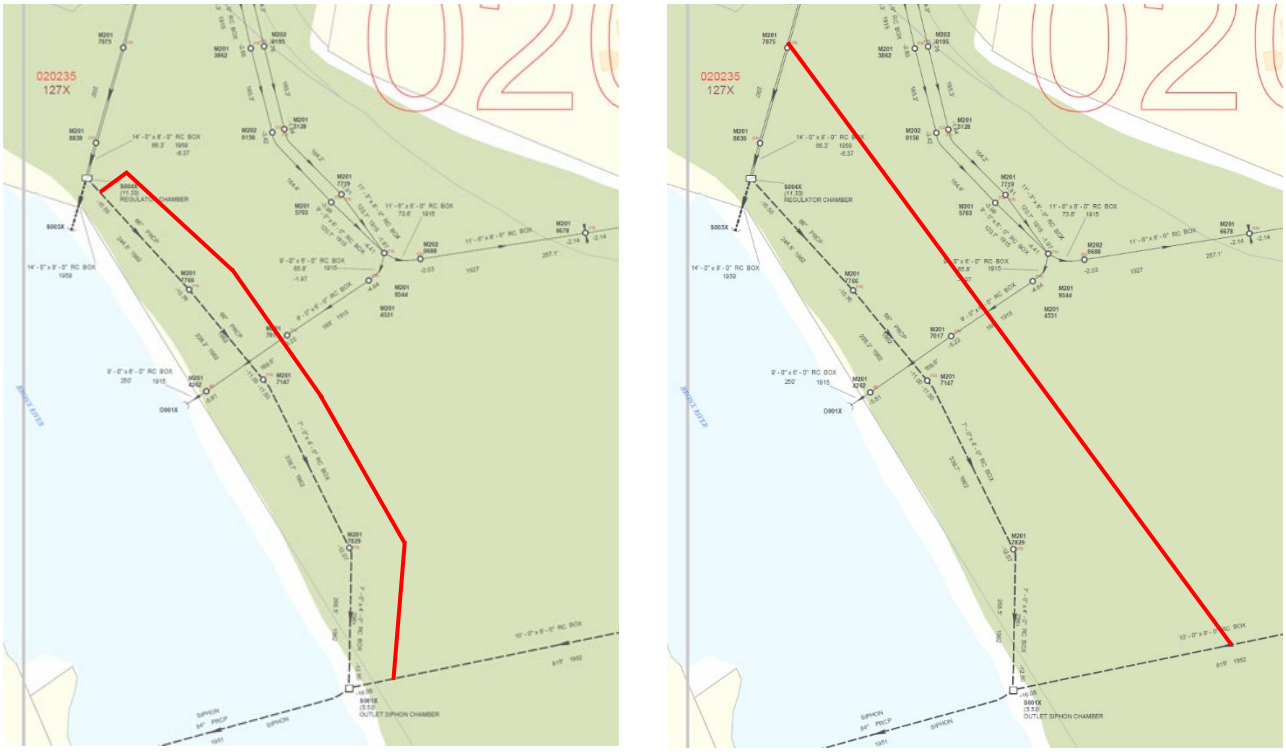
At the HP-007 work area. variations of the recommended alignment for the proposed relief sewer near Regulators 27/27A (Relief Structure 27), near the intersection of Bronx River Ave. and E. 177th St., were evaluated based on cost and non-cost implementation considerations. As a result of the alternatives evaluated through the Basis of Design Phase, an updated layout was developed that relocated the proposed relief sewer further upstream on Bronx River Avenue originating at the intersection of E. 178th Street. This avoided a busy intersection to construct within and provided better operational access for the upstream relief sewer diversion structure. There were also several construction issues along the downstream section of the relocated relief sewer within the Metcalf Avenue corridor between E. 174th Street and E. 172nd Street. It is a busy street with significant traffic, residential dwellings, and conflicting utilities. Furthermore, operational access to the new relief sewer and connection would be situated within the limits of the street, including the intersection of Metcalf Avenue and E. 172nd Street. Therefore, the design team evaluated an alternative with a shorter relief sewer connecting further upstream, at the existing sewer, near the intersection of E. 174th Street and Metcalf Avenue. This alternative was identified as Sub-Alternative 1a in the BODR and is depicted in Figure 2. Connecting the relief sewer near 174th Street reduces the length of the new relief sewer by approximately 1,000 feet and also reduces traffic interruptions, community disruption, and construction risks and associated costs.

Figure 2 Comparison of relief sewer configuration in LTCP (left) and BODR (right) at HP-007

WORK AREA HP-009 – REGULATOR 13 MODIFICATION AND RELIEF SEWER

The LTCP recommended alignment for this area in Soundview Park was adjacent to the existing intercepting sewer from Regulator 13, servicing outfall HP-009, connecting downstream to one of the two Bronx River siphons that convey flow to the HP WWRF for treatment. The proposed work also included raising the existing weir by approximately 1 foot to capture more wet weather flow to reduce annual CSO at this outfall with largest CSO volume into the Bronx River. When evaluating the proposed route, it was discovered that this alignment substantially impacted the Soundview Park community usage and posed a significant construction stability risk because it would be situated in an embankment. Furthermore, the existing outfall HP-010 was a restriction due to its relative elevation. This resulted in a sewer profile that restricts flow causing unwanted head losses. Therefore, the design team developed an alternative that relocated the relief sewer upstream to mitigate impacts to the park while providing additional clearance under the existing outfall HP-010 that passes over the proposed relief sewer near its mid-span. This layout is detailed in the BODR and illustrated in Figure 3.

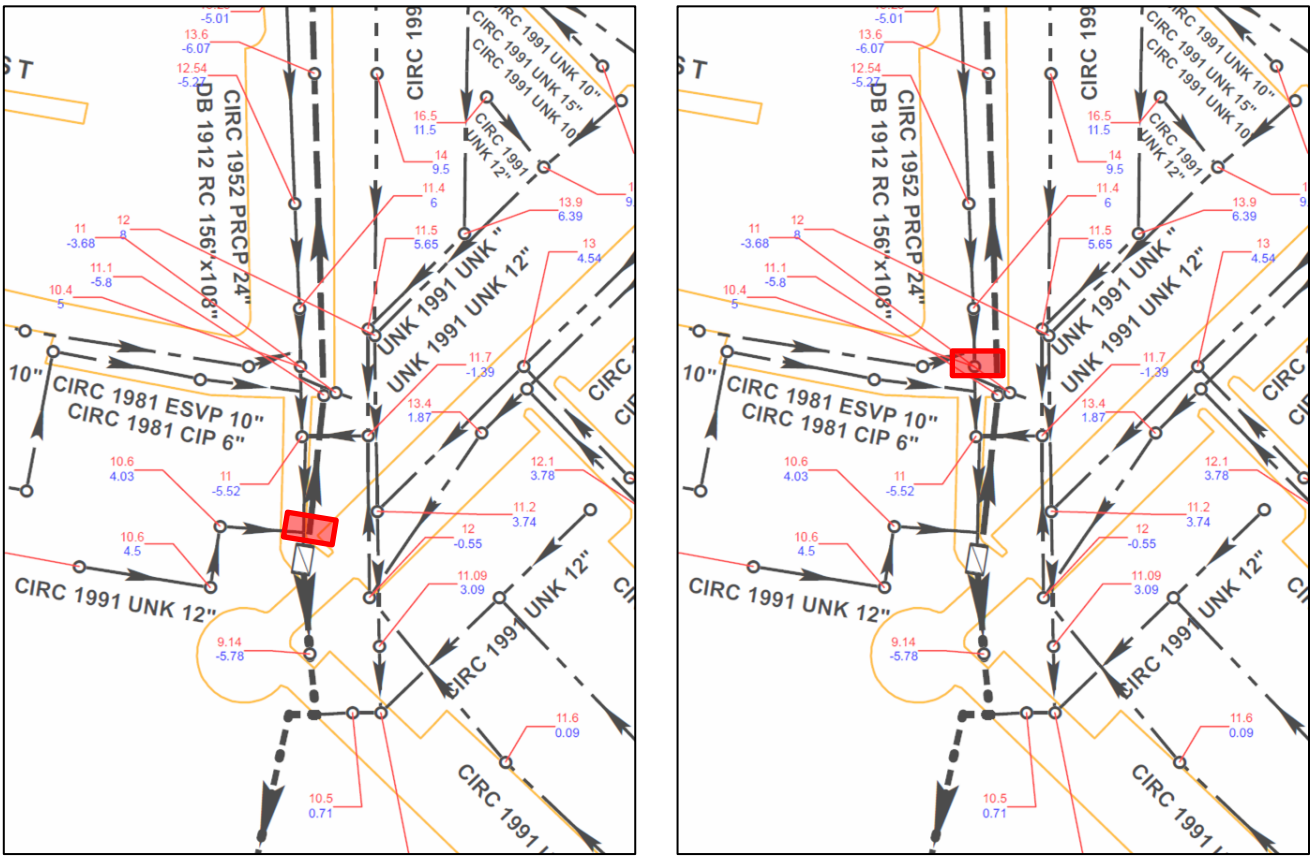
Figure 3 Comparison of relief sewer configuration in LTCP (left) and BODR (right) at HP-009



WORK AREA HP-011 – NEW REGULATOR 5 FLOATABLES CONTROL FACILITY

The LTCP recommended configuration for this area showed replacing Regulator 5 near the existing regulator in private property. The proposed work included installing an underflow baffle and a bending weir within the new facility to provide floatables control for overflows that discharge to the East River via outfall HP-011, as well as some level of in-system storage, resulting from the higher bending weir for typical year storms. When evaluating the proposed configuration, it was determined that locating the new regulator at the intersection of White Plains Road and Bronx River Avenue provides better maintenance access. This location also takes advantage of utilizing the tide gates in existing Regulator 5 to manage the impacts of rising tides to the required construction excavations for the new Regulator 5 structure. This layout is detailed in the BODR and illustrated in Figure 4.

Figure 4 Comparison of new Regulator 5 in LTCP (left) and BODR (right) at HP-011



HYDROLOGIC AND HYDRAULIC MODEL UPDATES

During the Facility Plan and 30% design phases of the Bronx River CSO LTCP design project, numerous updates were made to the original hydraulic model utilized in the development of the Bronx River CSO LTCP. These updates were made to incorporate the findings from subsequent comprehensive field investigations and existing sewer record drawings data sources conducted during the design project as well as further updates received from the DEP LTCP team relative to base dry weather flow distributions and system configurations. This section summarizes the refinements to the LTCP hydraulic H&H model.

HYDRAULIC MODEL UPDATES FROM FIELD INVESTIGATIONS AND SEWER RECORDS DATA SOURCES

Electronic versions of the infiltration and inflow (I&I) sewer maps were available from prior projects performed for DEP in this drainage area. In addition, the following list of data sources supported the model update:

- Elevation data from digital elevation model (DEM) available from the City Open GIS databases (The vertical datum used in ICM is Bronx Sewer Datum, therefore, any information obtained from these sources were converted with the applicable datum correction factors).

- New York City sewer maps available in the E-Builder system.
- Information gathered during site assessments and field inspections by the project team that included closed circuit televisions (CCTV) and confined space entry inspections.
- Information from other LTCP documents such as Westchester Creek and Citywide.

The field investigations and sewer records utilized to update the hydraulic model representation are detailed in the Facility Plan Report and associated attachments as well as the BODRs for the Bronx River CSO Projects, HP-007/009 and HP-011.

Delineations of the drainage areas (sewersheds) contributing flows to sewers tributary to different waterbodies were reviewed to ensure accurate representation of the drainage patterns. The primary information available to support this task was the DEP's I&I maps. Invert levels and connectivity of sewers were checked and compared with sewershed delineations in the LTCP model. Several differences were noted based on this review and the boundaries for areas draining towards Bronx River, Pugsley Creek, and East River within and adjacent to the study area were adjusted to ensure accurate flow direction. Figure 5 and 6 show a comparison between the LTCP (hatched colors) and BODR (solid colors) models in terms of the sewershed boundaries and sewershed acreages, respectively.

Figure 5 Comparison of Sewershed Boundaries in the LTCP and BODR Models

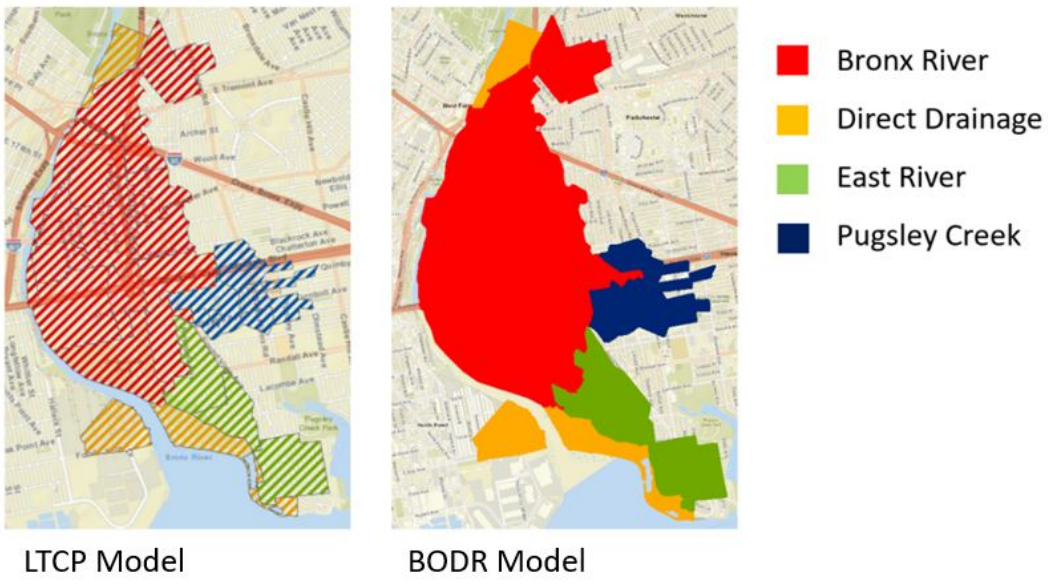
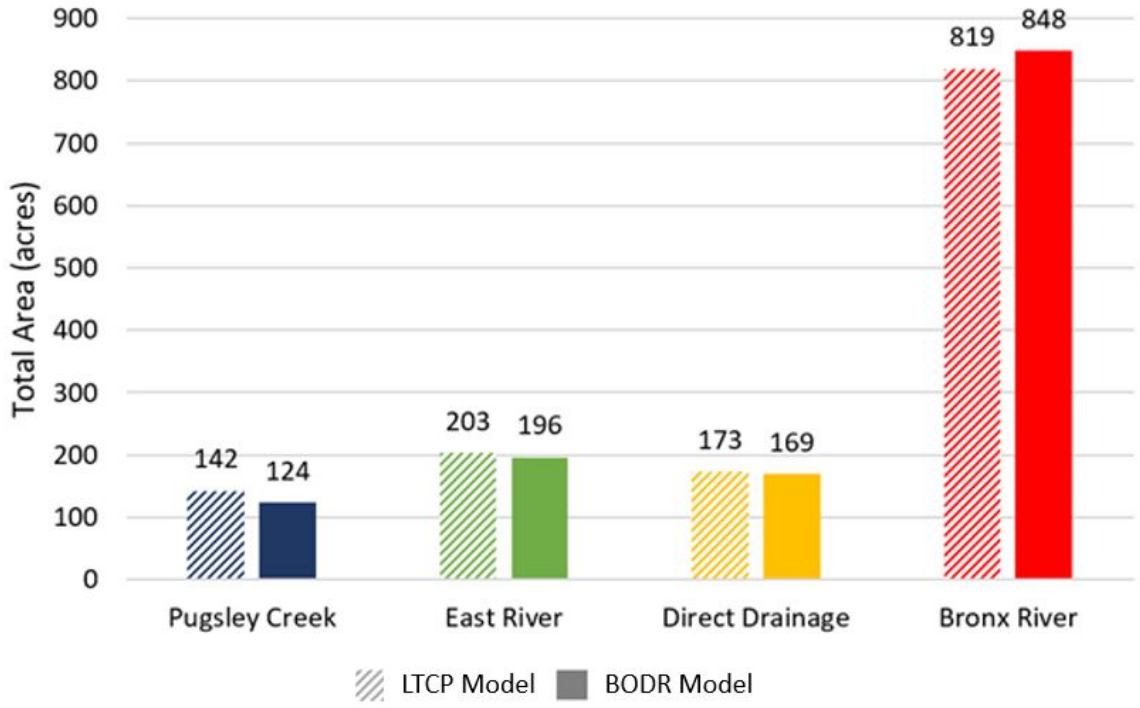


Figure 6 Comparison of Sewershed Acreages in LTCP and BODR Models



As shown, the updates resulted in a modest redistribution of sewershed acreages and an increase of about 30 acres to the Bronx River sewershed area. Additional information on these delineation changes for each of the drainage area categories are summarized below.

Pugsley Creek Sewershed

About 7 acres along the Bruckner Expressway, between White Plains Road and Thieriot Avenue, were rerouted to the Bronx River sewershed based on the flow direction in sewers. Further south in the Pugsley Creek sewershed, 11 acres surrounding the intersection of Story Avenue and Rosedale Avenue were rerouted to the Bronx River based on sewer connections and flow direction.

East River Sewershed

Approximately 9 acres along Rosedale Avenue, between Seward Avenue and Story Avenue, which were part of the East River sewershed in the LTCP model, were rerouted to the Bronx River sewershed. Similarly, another 2 acres in the Soundview Park area were rerouted from East River sewershed in the LTCP model to the Bronx River sewershed.

Direct Drainage

About 10 acres in the direct drainage area on the southern end of Soundview park were rerouted to the combined sewer service area (CSS) in the East River sewershed, based on contour maps. Similarly, about 5.5 acres of area in the southern end of the Bronx near Regulator 5, which were draining to the CSS in the East River sewershed in the LTCP model, were rerouted as direct drainage areas based on the sewer connections.

Bronx River Sewershed

With the delineation changes listed above, the Bronx River sewershed area increased by about 30 acres in the BODR Model.

In addition to this significant network expansion, updates were made to the sewer system representations when discrepancies were found based on records search and/or field investigations. This included the following updates:

- Adding a 24-inch pipe at Metcalf Avenue, based on field investigations performed by the project team
- Updating the sewer pipe upstream of Regulator 13, along Colgate Avenue and between Bruckner Boulevard and Story Avenue, from a single barrel in the LTCP model to a double barrel pipe.
- Updating the connectivity between Bronx River and Pugsley Creek sewersheds based on the sewer maps.

SEWER NETWORK EXPANSION AND CLARIFICATIONS

Flow volumes and peak flow rates summarized in the Bronx River LTCP were derived from an InfoWorks H&H model that generally included pipes larger in internal cross-sectional area than 60 inches in diameter, or equivalent rectangular area. There are inherent limitations such as the loading of large volumes of runoff into individual manholes due to non-inclusion of upstream collection systems and consequent approximations in hydraulic gradient lines (HGLs) useful for capacity analysis. This is particularly important for conveyance interventions (relief sewers) being designed to address the Bronx River LTCP regulatory requirements.

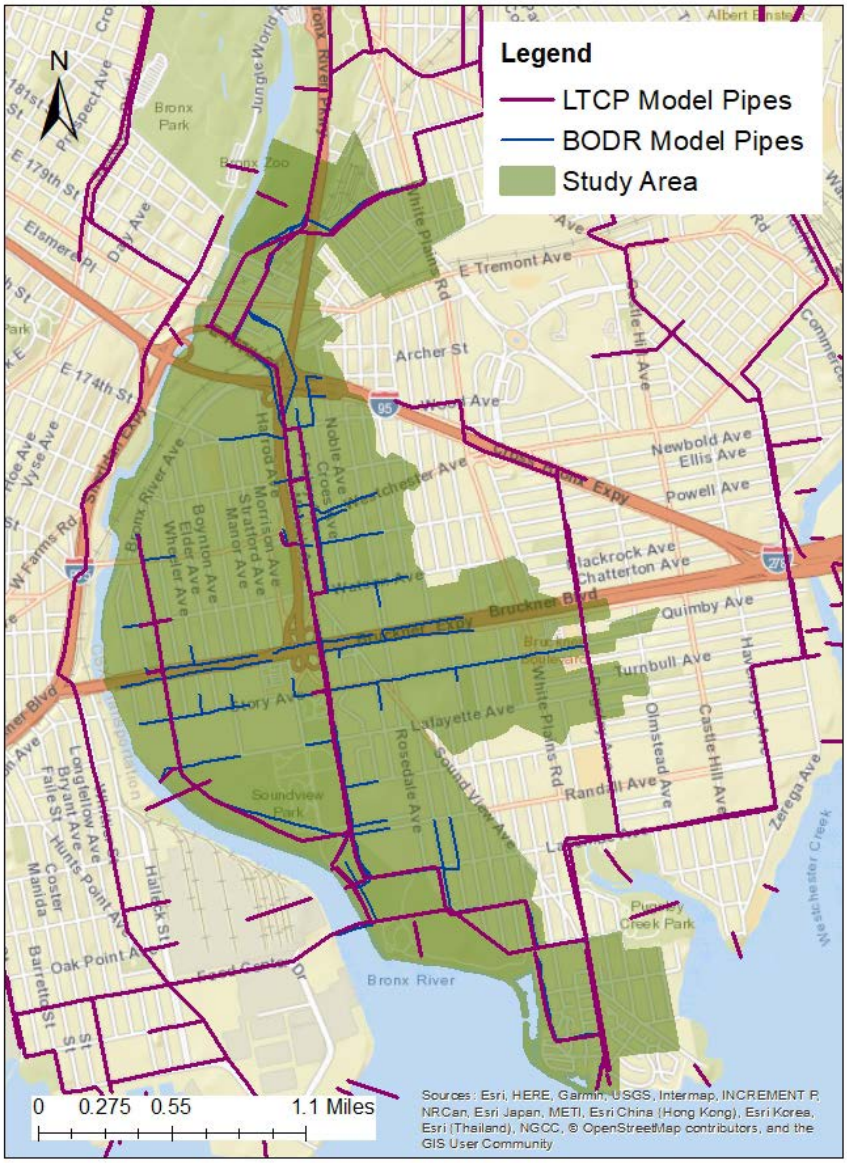
Therefore, the H&H model was refined to reflect a more definitive representation of the hydraulic network in the project sewershed area by expanding the sewer network representation to include pipes that are 24 inches and larger in diameter rather than the original 60-inch diameter criteria. To that end, subcatchment delineation was performed with the expanded model, often splitting the large LTCP model subcatchments to multiple smaller subcatchments within the Bronx River study area. In addition, the system representation was refined in multiple locations based on a review of as-built and construction drawings and available field inspection data. The updated model will be referred to as BODR model hereafter. Specific details on the model updating process, including the data sources used, updates to the sewershed subcatchments, and the sewer network are described in the following sub-sections.

To improve the refinement of the HP WRRF model representation to reflect the detailed orientation of the hydraulic pipe network within the Bronx River CSO LTCP project areas, all conduits with dimensions (height for non-circular sections and diameter for circular sections) greater than or equal to 24 inches were added within the Bronx River study area using the aforementioned sewer record data sources. HP sewersheds pertinent to Hutchinson River, Westchester Creek, and East River remained the same as in the LTCP model, except for the portions that intersected with and affected flow conditions within the Bronx River CSO LTCP

project area. The increased resolution in BODR sewer model network provides volumes and peak flow rates within a more refined model hydraulic representation necessary to support the relief sewer design.

Figure 7 shows the updates to the BODR model network, in comparison to the LTCP model. In addition to the refinement of the pipe network, the hydraulic model was expanded with an additional 570 manholes. Consistent with the model network expansion, the original LTCP model subcatchments were subdivided to load runoff at multiple locations. The 30 subcatchments in the LTCP model within the Bronx River study area were further delineated to a total of 158 subcatchments, as guided by the DEM and sewer drawings. Hydrology parameters for pervious and impervious areas were developed consistent with the InfoWorks Recalibration Report (DEP, 2012).

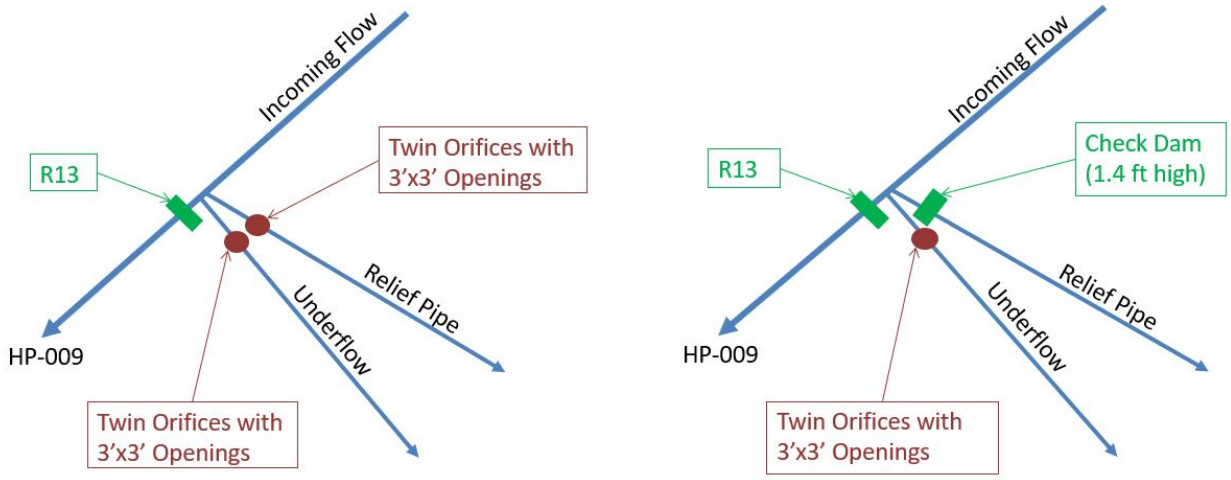
Figure 7 Sewer Network Expansion in the BODR Model



There were also model updates made to reflect design recommendations in the BODR phase. These were made to optimize wet weather flows within the proposed relief systems. These included the elimination of twin sluice gates (each with a size of 3'x3') from the relief pipe in the LTCP model at Regulator 13 that were restricting wet weather flows in the existing sewer and proposed new relief sewer. The record drawings show these twin sluice gates to be 3'x2.5' in size, but the BODR model assumes the same dimensions as the LTCP model to be twin 3'x3' in size. Representation of Regulator 13 in the LTCP and BODR models is shown in Figure 8.

The inverts of the proposed new 72-inch relief sewer at the HP-009 work area was also raised above the inverts of the existing sewers to levels above the dry weather elevations to ensure that the dry weather flow was conveyed through the existing branch interceptors and the proposed relief sewer was used only to convey wet weather flows. In the LTCP model, the relief pipe was at the same elevation as the branch interceptor, so there was flow in the relief pipe even during dry weather. Based on a sensitivity analysis performed by the project team, this representation of raised relief pipe and sluice gates eliminated from the relief pipe (in comparison to the LTCP model) marginally reduced the CSO discharges at HP-009 in the BODR model.

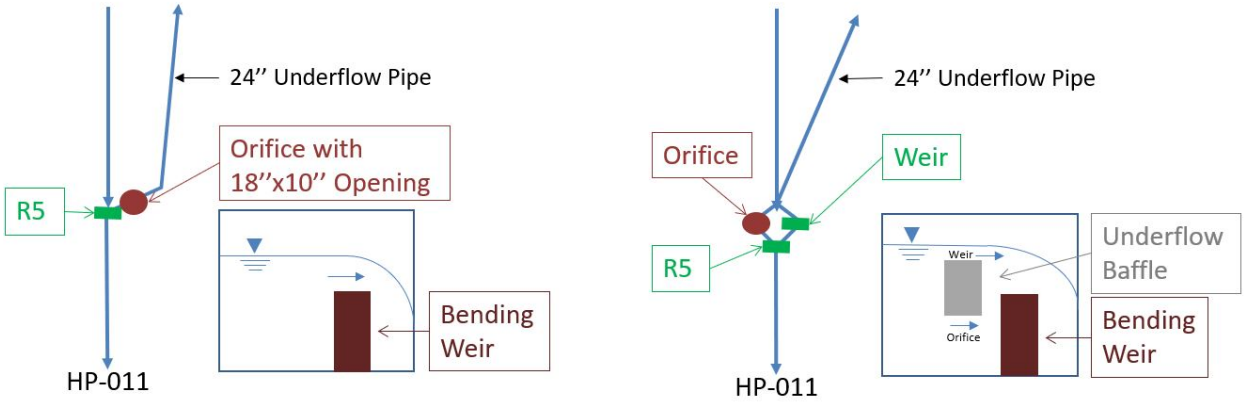
Figure 8 Regulator 13 in LTCP Model (left) and BODR Model (right)



Similarly, the LTCP model included a sluice gate of size 18"x10" at Regulator 5 to control inflow into the 24-inch underflow pipe that conveys captured wet weather flow towards Regulator 6. This gate currently exists in Regulator 5 to control the underflow towards Regulator 6. However, the CSO performance goal at HP-011 is to implement an underflow baffle and a 4-foot high bending weir to induce inline storage and capture floatables at Regulator 5. To optimize the design, the sluice gate was removed from the new Regulator 5 configuration to allow more flow and to remove restrictions that could inhibit the capture and conveyance of floatables materials in the existing 24-inch sewer from the new regulator. This sluice gate has been deleted from the BODR model and the 24-inch connection has been moved to Bronx River

Avenue as part of the Regulator 5 reconstruction in the BODR model. The representation in the LTCP and BODR models is shown in Figure 9.

Figure 9 Regulator 5 in the LTCP (left) and BODR (right) Models



SANITARY FLOW DISTRIBUTION UPDATES

The LTCP model included nine wastewater profiles that were used to define the wastewater generation in gallons per capita per day (gpcd). Based on the assignment of wastewater profile and the population specified at a subcatchments scale, the sanitary flow for each subcatchment is calculated and used in ICM. Subsequent coordination with the DEP and Bronx River CSO LTCP team resulted in updates to the sanitary flow distributions in the model. Based on the design team review, 14 wastewater profiles in the H&H model were analyzed. The LTCP H&H model had 14 profiles, but the wastewater generation in gpcd was defined only for nine of these profiles. As a result, it was found that the sanitary flow within the Bronx River study area was significantly underrepresented. This was updated in the H&H model used for the BODR to adequately represent sanitary flow using all the 14 wastewater profiles. The LTCP H&H model was also updated to reflect a revised HP WRRF treatment capacity from 400 million gallons per day (MGD) to 408 MGD in the BODR H&H model version. Table 2 summarizes the impact to base dry weather flows resulting from these changes. As expected, the additional base dry weather flow impacted the extent of resulting overflow volumes for all conditions, including baseline and the condition after recommended improvements are completed as discussed in Section 4 below.

Table 2 Comparison of Dry Weather Flow Representations

System Description	Dry Weather Flow (DWF) from LTCP Model Version (MGD)	DWF from Updated BODR Model Version (MGD)	Net Increase of DWF (MGD)
HP WRRF Service Area	94.9	111.7	16.8
Bronx River Service Area	1.2	15.3	14.1

4 CSO CONTROL PERFORMANCE OF BODR ALTERNATIVES

The H&H model with the associated updates described in Section 3 was used to simulate peak flows and overflow volumes within Bronx River CSO LTCP Project areas for the baseline, LTCP recommended plan, and BODR conditions. This included simulating the 2008 typical year as well as running larger storms to evaluate conveyance of the relief sewer flows. The typical year simulations were used to ensure adequate reductions of annual CSO volumes consistent with the intent of the Bronx River CSO LTCP. As part of the analyses, the impact of the implementation of the relief sewer at HP-007 was evaluated for relative benefit considering annual overflow conditions. As shown in Table 3, the updated BODR H&H model showed reductions in the BODR recommended improvements in excess of the original LTCP Recommended Plan. The LTCP Recommended Plan showed a remaining annual CSO discharge of 375 MGY into Bronx River compared to the 625 MGY Baseline Condition, a reduction of approximately 40% compared to the 37% reduction originally identified in the approved Bronx River CSO LTCP (DEP, 2015). The BODR recommended improvements that included relief sewers at both HP-007 and HP-009 resulted in a remaining overflow volume of 357 MGY, an improvement of an additional 18 MGY reduction for the Recommended Plan. The BODR model was trimmed to eliminate the Bronx River projects to estimate the baseline CSO volume of approximately 625 MGY. This resulted in an annual CSO reduction of approximately 43% into Bronx River when the BODR improvements were implemented.

When considering the relative benefits of these relief sewers, an alternative was considered that eliminated the construction of the HP-007 relief sewer. This was considered due to the relatively small net reductions of CSO volume to the Bronx River resulting from the difficult construction of the proposed new relief sewer at Relief Structure 27. The typical year simulation was run with the updated BODR H&H model to estimate the remaining Bronx River overflow volumes with the HP-007 relief sewer eliminated. As can be seen in Table 3, the elimination of the HP-007 relief sewer resulted in less remaining overflows than the LTCP Recommended Plan. This alternative resulted in approximately 364 MGY of remaining typical year overflow volume, 11 MGY less than the LTCP Recommended Plan, and an approximate 42% reduction compared to the Baseline Condition. In addition, the elimination of the HP-007 relief sewer resulted in a reduction of remaining annual overflows to the East River at proposed new Regulator 5 and CSO outfall HP-011 of approximately 5 to 6 MGY compared to the LTCP Recommended Plan and BODR recommendation conditions, respectively. This was due to the reduction of captured wet weather flows encountered in the overall system without the relieved flows from the Relief Structure 27 area. Therefore, the alternative to eliminate the HP-007 was considered in compliance with the approved Bronx River CSO LTCP and further considered from a cost effectiveness perspective as detailed in Section 5 below.

Table 3 Estimated Annual Typical Year CSO Volumes, Overflow Frequencies and HP WRRF Volumes Simulated Using Updated BODR Model									
		Baseline		LTCP Recommended Plan		BODR Alternative with (HP-007/009) Relief Sewers		30% Design Alternative with (HP-009)* Relief Sewer Only	
Outfall	Regulator	CSO Vol MG	Overflow Frequency	CSO Vol MG	Overflow Frequency	CSO Vol MG	Overflow Frequency	CSO Vol MG	Overflow Frequency
HP-004	CSO28, 28A	24.7	19	24.7	19	24.6	19	24.6	19
HP-007	CSO27, 27A	38.3	11	18.7	9	23.0	10	38.5	11
HP-008	CSO26	1.5	2	1.5	2	1.4	2	1.4	2
HP-009	Reg #13	560.6	41	330.6	37	308.1	39	299.2	39
HP-010	CSO25	0.0	0	0.0	0	0.0	0	0.0	0
Total Annual CSO Volume in Bronx River (Nearest MG)		***625***		***375***		***357***		***364***	
Total Annual CSO Volume Controlled		**-**		***250***		***268***		***261***	
Percent Annual CSO Volume Removed		**-**		***40.0%***		***42.9%***		***41.8%***	

** Elimination of the HP-007 Relief Sewer with the HP-009 Relief Sewer and the new Regulator 5 Floatables Control Facility.*

5 COST-EFFECTIVENESS ANALYSIS FOR REMOVAL OF HP-007 RELIEF SEWER

The relative performance of the CSO reductions to the Bronx River, anticipated for projects included in the BODRs, showed that the CSO controlled by HP-007 proposed relief sewer was very low compared to the other proposed improvements at HP-009. Furthermore, the weir adjustment at Regulator 13, along with the proposed relief sewer in the HP-009 work area, achieved the remaining overflow levels identified in the Bronx River CSO LTCP as summarized in Section 4. This section evaluates the cost effectiveness of achieving the prescribed CSO control level without the installation of the proposed HP-007 relief sewer.

The construction cost estimate for HP-007 can be found in Appendix H of the BODR. Both relief sewers included diversion and connecting structures and were assumed to be constructed using trenchless construction in the form of microtunneling in a dense urban environment for HP-007 and a recreational area in Soundview Park for HP-009. Since the project was envisioned to include all relief sewer work in one contract, the cost estimates for HP-007 and HP-009 were combined and therefore had some shared construction costs. Table 4 summarizes the construction cost estimate components for the work associated with both the HP-007 and HP-009 relief sewers.

Although the projects require different diameter relief sewers, they are close enough in size to utilize the same Microtunnel Boring Machine (MTBM). The cost of the MTBM was therefore divided between the two projects in the BODR cost estimate. This cost was fully assigned to HP-009 only in the adjusted costs shown in Table 4 to determine the proper cost impact of non-performing HP-007. It is also worth noting that the even with the adjusted MTBM cost for HP-009, the HP-007 microtunneling and equipment line item is still more expensive. This is due to additional microtunneling drives, MTBM operations setup, and additional sewer footage associated with the proposed HP-007 relief sewer work. The remainder of costs were directly associated with constructing the HP-007 relief sewer and were therefore a direct removal from the overall project cost. All soft costs and escalation percentages were kept the same as those used in the BODR for comparison purposes.

Table 4 Construction Cost Comparison of HP-007 and HP-009 vs. HP-009 ONLY (2025 Dollars)

Type		BODR Alternative with HP-007 & HP-009 Relief Sewers	30% Design Alternative with HP-009 Relief Sewer Only	Difference
Civil Site Construction		$1,944,000	$998,000	$946,000
Shaft Construction		$10,748,000	$6,140,000	$4,608,000
Microtunneling and Equipment		$38,415,000	$17,873,000	$20,542,000
Base Construction Cost		**$51,107,000**	**$ 25,011,000**	**$26,096,000**
General Conditions	15%	$7,666,000	$3,752,000	$3,914,000
Contractor O&P	20%	$10,221,000	$5,002,000	$5,219,000
Bond and Insurance	3%	$2,070,000	$1,013,000	$1,057,000
Design Contingency	30%	$21,319,000	$10,433,000	$10,886,000
Total Cost (2020)		**$92,383,000**	**$45,211,000**	**$47,172,000**
Escalation	27%	$25,154,000	$12,310,000	$12,844,000
Total Cost (2025)		**$117,537,000**	**$57,521,000**	**$60,017,000**

As illustrated in Table 4, the cost for constructing the HP-007 relief sewer work is approximately $60.0 million and the cost for constructing the HP-007 relief sewer work is approximately $57.5 million, escalated to 2025 to account for the anticipated construction schedule. Therefore, the elimination of the HP-007 relief sewer saves approximately $60 million in construction costs as well as the associated final design, construction management and project implementation costs (i.e., permits, easements, etc.) that could result in estimated savings of $65 to $70 million.

The cost/benefit of the HP-007 relief sewer was further evaluated considering these costs compared to the overflow reductions anticipated upon completion of the HP-007 relief sewer.

The overflow reductions were estimated using the typical year simulations run with the updated hydraulic model summarized in Table 3 above. These volumes were used to calculate the cost per gallon of controlled CSO as a result of these proposed relief sewers. Table 5 summarizes these results.

As expected, the data in Table 5 shows that the majority of the AAOV control for CSO-BXR-DES is addressed by installing the proposed HP-009 relief sewer. Incorporating the estimated construction costs for both relief sewers from Table 4, this equates to approximately $0.44 per gallon. When broken down, this figure comprises a construction cost for the HP-007 relief sewer alone of $3.92 per gallon, and a construction cost for the HP-009 relief sewer alone of $0.23 per gallon. The AAOV controlled by installing both HP-007 and HP-009 relief sewers is 268 MGY as opposed to 261 MGY controlled by installing only HP-009, a difference of 6.4 MGY with approximately 97% of the AAOV into the Bronx River being controlled by the HP-009 project alone.

When considering the blended contribution costs for both outfalls with the two relief sewers constructed, it would cost an additional $60M in construction or $8.57 per gallon to control an additional net 7 MG AAOV above what would be controlled by installing only the HP-009 relief sewer.

Looking at this data graphically, there is a pronounced “knee of the curve” when comparing the relative volume of CSO controlled to the cost required to achieve these control volumes for the work associated with constructing the HP-009 relief sewer alone compared to constructing both relief sewers at HP-007 and HP-009. Figures 10 and 11 illustrates the knee of the curve from two perspectives, cost per CSO overflow volume controlled and cost per remaining CSO overflow volume, respectively.

Table 5 Average Annual Typical Year CSO Volumes and Cost Per Gallon Controlled Simulated Using Updated BODR Model										
				Baseline Conditions	BODR Alternative with HP007 and HP009 Relief Sewers			30% Design Alternative with HP-009 Relief Sewer ONLY		
Water Body	Outfall SPDES	Associated Regulator/ Facility Name	Model Selection/Key List (Citywide Baseline)	AAOV (MG)	AAOV (MG)	Controlled CSO Volume (MG)	$/Gal Controlled (USD)	AAOV (MG)	Controlled CSO Volume (MG)	$/Gal Controlled (USD)
Bronx River	HP-004	CSO 28	CSO28A&28_004_GI.1	24.7	24.6	0	NA	24.6	0	NA
		CSO 28A								
	HP-007	CSO 27	HP-007-dummy_GI.1	38.3	23	**15.3**	**$3.92**	38.5	0	NA
		CSO 27A								
		CSO 27A1								
	HP-008	CSO 26	CSO26_008_GI.1	1.5	1.4	0	NA	1.4	0	NA
	HP-009	Reg #13	R-13_Outfall_GI.1	560.6	308.1	**252.5**	**$0.23**	299.2	**261.4**	**$0.22**
	HP-010	CSO 25	CSO25.W	0	0	0	NA	0	0	NA
			Totals	**625**	**357**	**267.8**	**$0.44**	**364**	**261.4**	**$0.22**

Figure 10 Cost Performance Curve for Annual CSO Controlled for HP-007/009 and HP-009 Relief Sewer(s)

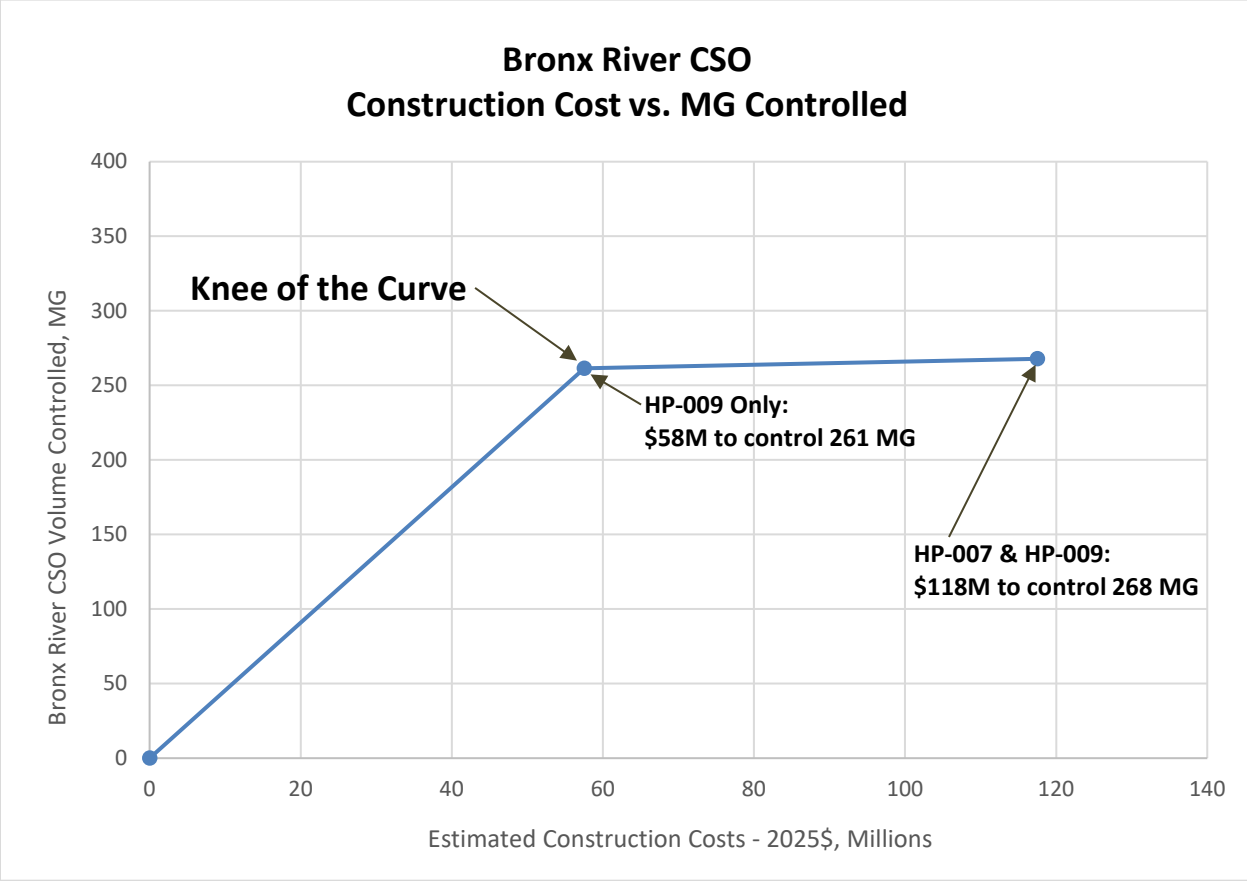
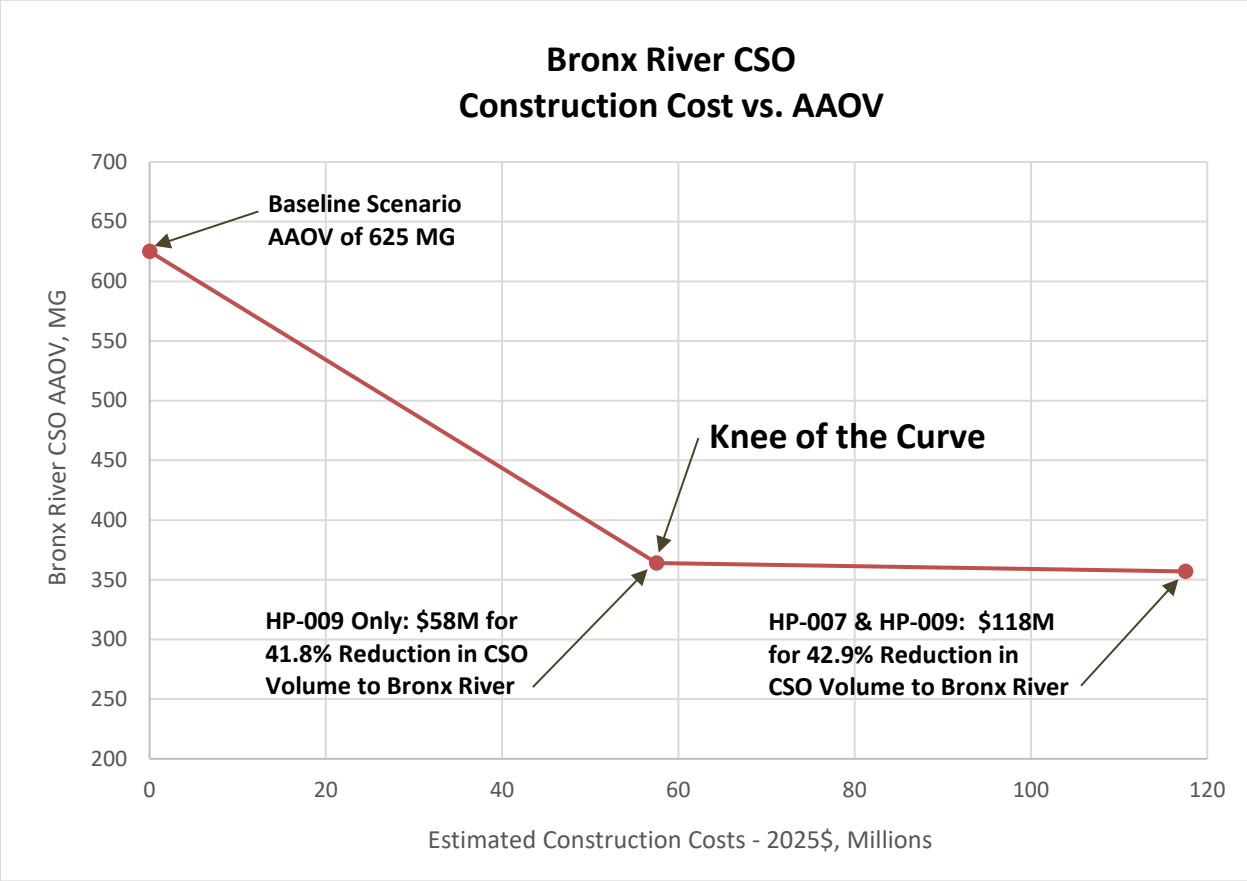


Figure 11 Cost Performance Curve for Remaining CSO for HP-007/009 and HP-009 Relief Sewer(s)



SCHEDULE IMPACT FROM THE ELIMINATION OF HP-007 PROJECT

The schedule to construct HP-007 and HP-009 relief sewers has a total estimated duration of 36 months as detailed in the BODR. This assumes a linear work sequence of performing HP-009 after HP-007 microtunneling is completed because the same MTBM is anticipated to be used for both projects. When considering construction of only the HP-009 project, the MTBM procurement and delivery period had to be transferred from HP-007. In addition, full project mobilization and setup, early administrative items including overall project permits, EHS, and key submittals moved into the HP-009-only construction schedule. This resulted in a 24-month estimated duration for constructing only HP-009, thereby reducing the original schedule of constructing both relief sewers by 12 months.

Table 6 shows the adjusted key project milestones assuming removal of HP-007 from the project compared to the original project milestone dates for constructing both HP-007 and HP-009.

Table 6 Key Schedule Milestones and Time Savings			
Project Milestone	(HP-007 and HP-009)	(HP-009 Only)	Time Reduction in Months
Design NTP	August 1, 2018	August 1, 2018	0
Design Completion	August 4, 2023	March 30, 2023	4
Construction NTP	July 16, 2024	March 16, 2024	4
Construction Completion	June 30, 2028	February 24, 2027	16

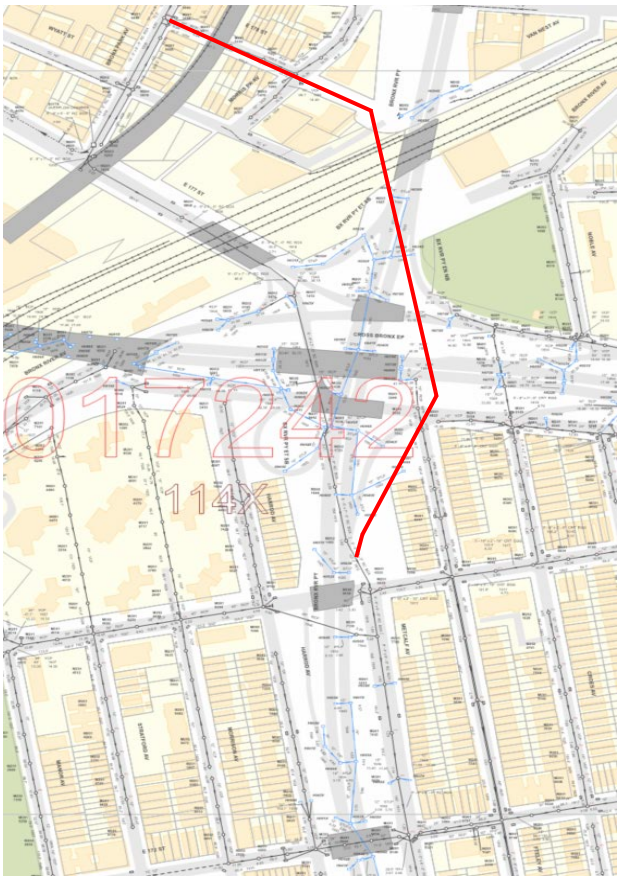
6 SUMMARY AND UPDATED RECOMMENDATION FOR BRONX RIVER CSO LTCP PROJECT BODR

As part of the design implementation of the Bronx River CSO LTCP Project, several alternatives were developed and evaluated in the three project work areas during the Facility Plan Phase to optimize performance, mitigate short- and long-term construction and operational impacts, and minimize community disturbances, while also maintaining the recommended CSO control performance criteria described in Section 2.3. This alternatives analysis resulted in the recommendation of the alternative configurations summarized in Section 3. In further evaluating the relative performance of the relief sewers located in the HP-007 and HP-009 work areas, it became apparent that the relative benefit of the HP-007 relief sewer compared to the benefits of the HP-009 were very minor. This is particularly evident when considering the relative cost and construction challenges associated with the HP-007 relief sewer in the densely populated urban setting in the proposed project area as detailed in the HP-007/HP-009 BODR. Therefore, as part of the 30% design phase, an analysis was conducted to consider the elimination of the HP-007 with the documentation of this analysis provided in this technical memorandum.

To eliminate the HP-007 relief sewer as part of the HP-007/HP-009 BODR recommended improvements, construction of only the HP-009 relief sewer, along with the new proposed Regulator 5 floatables control system, must fully meet the CSO control performance objectives of the original, approved Bronx River CSO LTCP (summarized in Section 2). As noted above, model updates conducted during the design phase impacted both the baseline and recommended plan improvements conditions, however, the extent of CSO reduction from a percent of annual overflow volume eliminated remained consistent. Therefore, for the purposes of advancing the recommended configurations in the HP-007 and HP-009 work area relief systems, the maximum remaining “post improvements” typical year CSO volume of 369 MGY from the Bronx River CSO outfalls was used as the minimum performance objective to meet the WQ goals of the project. This was further supported by the WQ modeling results that confirmed that there was no difference in annual attainment of dissolved oxygen and bacteria WQ criteria using the LTCP assumptions between the baseline condition and the 100% control of CSO overflows condition in the Bronx River.

With that being the case, the alternative to construct only the HP-009 relief sewer in the HP-007/009 work area was deemed to be a compliant and feasible alternative for achieving the WQ objectives of the Bronx River CSO LTCP Project. The remaining overflow volume from the HP-009 relief sewer alone, working in concert with the Regulator 5 floatables control facility, was estimated to be 364 MGY, which is 11 MGY less than the original LTCP Recommended Plan remaining annual overflow volume of 375 MGY that included both relief sewers. This represents a 41.8% reduction over the updated baseline condition.

Figure 12 Proposed Elimination of HP-007 Relief Sewer



When considering cost effectiveness of the feasible alternatives, it is evident that the elimination of the HP-007 relief sewer resulted in an alternative that is clearly the most cost effective to achieve the CSO control goals of the project, as detailed in Section 6 above. The elimination of the HP-007 relief sewer provides approximately $60 million in construction savings in roughly $65 -70 million in estimated total project savings. It also eliminates considerable construction and community disturbance impacts expected with constructing a relief sewer in this Bronx urban area. For these reasons, the Bronx River CSO LTCP Project design team recommends the elimination of the HP-007 relief sewer from the proposed improvements and will update the previously submitted HP-007/009 BODR to provide documentation for the advancement of the remaining design and construction phases consistent with the implementation of this recommendation.

REFERENCES

1. Task 2.5 Field Investigation Reports:
    a. Task 2.5c Preliminary Hazards Inventory
    Submitted to NYCDEP on July 3, 2019

    b. Task 2.5d Confined Space Entry and CCTV Investigations Report, Revision 1
    Submitted to NYCDEP on October 4, 2019

    c. Task 2.5j Existing Conditions Facility Assessment Report
    Submitted to NYCDEP on October 4, 2019

    d. Task 2.5i Geotechnical Data Report
    Submitted to NYCDEP on October 4, 2019

2. Task 2.8 Technical Memoranda:

    a. Task 2.8a Hazardous Materials Investigation Findings and Recommendations Technical Memorandum
    Submitted to NYCDEP on October 9, 2019

    b. Task 2.8a Geotechnical Investigations Findings and Recommendations Technical Memorandum - Final
    Submitted to NYCDEP on July 23, 2020

    c. Task 2.8a Hydraulic Analysis Findings and Recommendations Technical Memorandum
    Submitted to NYCDEP on October 11, 2019

    d. Task 2.8a Proposed Regulator Modifications and Relief Sewer Alternatives and Recommendations Technical Memorandum
    Submitted to NYCDEP on October 11, 2019

3. Task 2.8a Facility Plan Report – Final, with Attachments
Submitted to NYCDEP on July 23, 2020

4. Task 2.10a Basis of Design Report-HP-007 and HP-009-Draft, with Attachments
Submitted to NYCDEP on February 7, 2010

5. Task 2.10a Basis of Design Report - HP-011 Project Area - Draft, with Attachments
Submitted to NYCDEP on February 12, 2010

6. Sewer maps in project area provided by NYCDEP

7. As-built drawings in project area provided by NYCDEP

8. InfoWorks ICM models provided in August 2019 by NYCDEP and in June 2020 by the LTCP Team

9. NYCDEP Bronx River Long Term Control Plan (2015)

    https://www1.nyc.gov/assets/dep/downloads/pdf/water/nyc-waterways/bronx-river/bronx-river-ltcp-201506.pdf

10. NYCDEP, InfoWorks Citywide Recalibration Report – Updates to and Recalibration of October 2007 NYC Landside Models (2012)

https://www1.nyc.gov/assets/dep/downloads/pdf/water/nyc-waterways/citywide-ltcp/infoworks-citywide-recalibration-report.pdf