Appendix F

Water and Sewer Infrastructure: Gowanus Canal CSO and Flooding Assessment

New York City Department of Environmental Protection (DEP)

GOWANUS CANAL CSO AND FLOODING ASSESSMENT

Technical Memorandum

January 2021

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ACRONYMS AND ABBREVIATIONS

ADP	Amended Drainage Plan
BEPA	Bureau of Environmental Planning and Analysis of DEP
BHD	Brooklyn Highway Datum
BSD	Brooklyn Sewer Datum
BWSO	Bureau of Water and Sewer Operations of DEP
BWT	Bureau of Wastewater Treatment of DEP
CDH	Critical Duration Hyetograph
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CEQR	City Environmental Quality Review
CSO	Combined Sewer Overflow
DCIA	Directly Connected Impervious Area
DCP	Department of City Planning
DDWF	Design Dry Weather Flow
DEIS	Draft Environmental Impact Statement
DEM	Digital Elevation Model
DEP	New York City Department of Environmental Protection
DWF	Dry Weather Flow
EMC	Event Mean Concentration
FAR	Floor Area Ratio
GI	Green Infrastructure
GIS	Geographic Information Systems
GPS	Gowanus Pump Station
HGL	Hydraulic Gradient Line
HLSS	High Level Storm Sewers
ICM	InfoWorks Integrated Catchment Model
LTCP	Long-Term Control Plan
MG	Million Gallons
MGD	Million Gallons per Day
MHW	Mean High Water
NAVD88	North American Vertical Datum of 1988
NOAA	National Oceanic and Atmospheric Administration
NPL	National Priorities List
OH	Owls Head

RC	Runoff Coefficient
RH	Red Hook
ROD	Record of Decision
ROW	Right of Way
RWCDS	Reasonable Worse Case Development Scenario
SF	Square Feet
SPDES	State Pollutant Discharge Elimination System
TAZ	Transit Analysis Zone
TDA	Tributary Drainage Area
TSS	Total Suspended Solids
USEPA	United States Environmental Protection Agency
USWR	Unified Stormwater Rule
WRRF	Wastewater Resource Recovery Facility (formerly the Wastewater Treatment Plants)
WWF	Wet Weather Flow
WWFP	Waterbody Watershed Facility Plan

EXECUTIVE SUMMARY

Gowanus Rezoning is a major rezoning initiative in Brooklyn undertaken by the Department of City Planning (DCP) of NYC, covering approximately 47 acres of new/redevelopment within a drainage area of approximately 270 acres, referred to as the amended drainage plan (ADP) area. Both the rezoning area and ADP area are within the Gowanus Canal sewershed of approximately 1,760 acres and are distributed within the service areas of Red Hook and Owls Head Wastewater Resource Recovery Facilities (WRRF). As part of a draft environmental impact statement (DEIS), DEP initiated this study to assess the effects of rezoning on existing infrastructure within these two WRRF service areas.

A drainage, combined sewer overflow (CSO), and pollutant load assessment analysis was performed using hydrologic and hydraulic (H&H) models in Innovyze's InfoWorks Integrated Catchment Model (ICM) software. The ICM models used were developed under the DEP's long-term control planning (LTCP) and Superfund projects for the two WRRF service areas, and the models were peer-reviewed and approved by the New York State Department of Environmental Conservation and U.S. Environmental Protection Agency. Large subcatchments in these models that overlap with the ADP area were further delineated to represent drainage areas at a block and lot scale. Representation of the hydrologic conditions within the ADP area was consistent with DEP's prior LTCP and water quality studies that use a runoff coefficient approach (also referred to as Directly Connected Impervious Area, DCIA). Both Baseline and future scenarios maintained the same LTCP calibrated runoff coefficients. A Baseline Scenario was established to represent the existing conditions, that included 2019 sanitary flows and existing improvements to the wastewater collection system, to validate the model using monitored data. Outside of the ADP area, the spatial resolution of the urban watershed/sewer system was maintained the same as the LTCP and Superfund projects. The Baseline model with refined pipe network and subcatchments within the ADP drainage area was validated based on WRRF inflow data at Red Hook and Owls Head during the period of March to April 2019.

The project adopted a planning time horizon of 2035, at which all projected rezoned lots would be redeveloped. Population projections provided by DCP for the without-rezoning (No Action) and with-rezoning (Action) scenarios were combined with per-capita sanitary flow projections estimated by DEP to develop future dry weather flow distributions. The LTCP ICM models include a population distribution within each WRRF service area based on the 2010 census block data. For this Gowanus Rezoning analysis, the existing LTCP population distribution was removed from the models. Instead, a transit analysis zone (TAZ) based population distribution methodology developed under a separate task in RIPAS, as it reflected the future population growth and its distribution more accurately than the assumption of 2010 census block data.

A potential major infrastructure improvement projected to be completed by 2035 is dual CSO storage tanks with a combined storage volume of 12 million gallons (MG). Additional details on the storage tanks can be found in DEP (2018). Other pertinent infrastructure improvements were also added including high level storm sewers and green infrastructure assets built/under construction or final design as of July 2019. All redeveloped lots within the project area will adhere to the existing 2012 Stormwater Rule (DEP, 2012) or will be subjected to the upcoming Unified Stormwater Rule (DEP, 2020). Background growth in the Red Hook and Owls Head WRRF service areas outside of the Reasonable Worse Case Development Scenario (RWCDS) study area was assumed to be consistent with the LTCP project, which used the Department of Buildings' permit applications to estimate projected increases in new and redevelopment projects.

Typical year rainfall (2008 Calendar Year Rainfall data at John F. Kennedy International Airport) and tidal levels were used as boundary conditions for the annual CSO volume/frequency estimation at each of the CSO outfalls that discharge into Gowanus Canal. These boundary conditions have been approved by the United States Environmental Protection Agency (EPA) and the New York State Department of Environmental Conservation for DEP's LTCP analyses and Gowanus CSO facilities design. Sewer capacity analyses were also performed using a sample of DEP's 3-year critical duration hyetograph rainfall condition and a mean high water (MHW) tidal condition.

In order to estimate CSO pollutant loads to Gowanus Canal as a result of the proposed rezoning, the detailed analysis utilized the event mean pollution concentration (EMC) method, which is a methodology widely used nationally, and commonly reported in literature by various municipalities. Pollutant concentration varies throughout a wet weather event. The EMC is computed as representative concentration for the entire event, using the total mass of a pollutant discharged during an event divided by the total discharge volume. With the EMC methodology, any changes in EMC concentrations for different evaluated alternatives are assumed to be negligible and the pollutant loading is proportional to the CSO volume. The representative EMC is applied to CSO discharges in the typical year to calculate the resulting pollutant load from CSOs. Similarly, the representative effluent concentrations for the wastewater streams are used to compute the loadings from WRRFs.

Total suspended solids (TSS) is selected as surrogate for pollutant load comparison in this rezoning analysis. TSS is often targeted by EPA to address potential recontamination of the surface sediments by organic pollutants in superfund sites such as Gowanus Canal. Representative EMC concentration for total suspended solids (TSS) for CSOs, was compiled from literature review and a review of prior sampling data from DEP's LTCP projects. Similarly, the plant effluent TSS concentrations were derived from historic data provided by the DEP Bureau of Wastewater Treatment (BWT) to estimate the total pollutant loads discharged from the two WRRFs during the typical year.

Any new or redevelopment in New York City currently has to adhere to the 2012 Stormwater Rule (DEP, 2012), that achieves peak flow control through detention. DEP is in the process of adopting a Unified Stormwater Rule (DEP, 2020), which necessitates retention and/or more stringent detention requirements for new and redevelopment projects and will be effective from Calendar Year 2022. Stormwater infiltration and/or reduced release rates from retention and detention practices, when implemented under this rule for all the rezoned properties, results in additional CSO reduction and surcharge mitigation benefits.

The TSS loads at the two WRRFs and CSO outfalls were estimated using the compiled EMC concentrations, for both No Action and With Action scenarios using the existing 2012 performance standard (referred to as 2012 Stormwater Rule in this memo) and the Unified Stormwater Rule (USWR). There is a reduction in overall pollutant loads into Gowanus Canal, consistent with the CSO volume reductions for the Action scenario when the Unified Stormwater Rule was applied. On the other hand, the CSO volumes and TSS loads marginally increased with the Action scenario when the 2012 Stormwater Rule was applied, in comparison to the No Action scenario.

Historic investments have improved water quality in the Gowanus Canal significantly. DEP (2018) reported that, as part of the Gowanus CSO Facilities EIS, the RH-034 storage tank with 8-million gallon capacity would result in about 76 percent reduction in CSO volume at this outfall and the 4-million gallon tank at OH-007 would reduce the CSO volume at this outfall by about 85 percent, in comparison to the Pre-Waterbody Watershed Facility Planning conditions with no improvements in place. A percentage reduction in volume and sediment between 59 and 74 percent is required by EPA as part of the Record of Decision (ROD). The Gowanus CSO facilities are expected to exceed the ROD targets for the two largest CSO outfalls.

There have been revisions to the Nevins Street drainage area since DEP (2018) in terms of connecting this area to the RH-034 tank and the modification of weirs/closure of a CSO outfall to mitigate flooding within this drainage area. In addition, the hydrologic and hydraulic model used for Gowanus CSO facilities design (DEP, 2018) has been enhanced with more accurate population distribution and higher resolution of sewer system representation and drainage area delineation within the rezoning area in this rezoning analysis. In this enhanced InfoWorks ICM model, the stormwater controls that were implemented in the RWCDS lots using either the current 2012 Stormwater Rule or the upcoming USWR both achieve Gowanus Canal CSO discharges that are consistent with the 76 and 85 percent targets established by DEP in earlier model evaluations for the two CSO outfalls, RH-034 and OH-007, respectively.

Specifically, the percent reduction in RH-034 ranges between 83-84 percent for the 2012 Stormwater Rule and USWR, which is well above the 76 percent target. Similarly, the percent reduction in OH-007 ranges between 84.3 percent for the 2012 Stormwater Rule to 85.6 percent for USWR, which are well within the modeling accuracy for meeting the 85 percent target. The USWR is scheduled to be effective in 2022, therefore, the higher percent reductions presented in this technical memo for USWR are more appropriate as the expected 2035 Gowanus Rezoning outcomes. The overall CSO reduction from the 11 CSO outfalls in RH and OH areas is estimated to be 80 percent from the Pre-WWFP conditions, with rezoning and either the 2012 Stormwater Rule or USWR implemented in the RWCDS lots. The USWR would provide further reductions in surface flooding volumes and CSO volumes in comparison to the 2012 Stormwater Rule.

Annual pollutant loads into the WRRFs increase from No-Action to Action scenario, due to the increase in sanitary flows with rezoning in the two WRRF service areas. The increases in effluent pollutant loads are consistent with the percent increases in influent loads. The plant design capacities are well in excess of the projected 2035 sanitary flows including the increases in flows associated with rezoning. Based on this comprehensive analysis, the proposed Gowanus rezoning is not projected to have incremental impacts on CSO discharges or water quality in Gowanus Canal.

1 INTRODUCTION

The Gowanus Canal is a 1.8-mile-long waterbody located in the Borough of Brooklyn (see Figure 1-1). The Gowanus Canal sewershed encompasses the neighborhoods of Red Hook, Carroll Gardens, and Gowanus, all within South Brooklyn, to the west; Park Slope to the east; Boerum Hill and Cobble Hill to the north; and Sunset Park to the south. This sewershed covers an area of approximately 1,760 acres with about 1,600 acres serviced by combined sewers.

Subsequent to authorization of the canal construction by the State of New York in 1848, the construction of the canal began in 1860s by bulkheading and dredging the creek. Following its construction, the Canal quickly became one of the nation's busiest industrial waterways, serving heavy industries in the area. The City began operating the Gowanus Canal Flushing Tunnel in 1911, which was upgraded as part of the long-term control planning (LTCP) project to improve circulation and flush stagnant water from the Canal. On March 2, 2010, the Canal was designated a federal Superfund site under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and placed on the National Priorities List (NPL). On September 27, 2013, the United States Environmental Protection Agency (USEPA) issued a Record of Decision (ROD) identifying actions to be undertaken by various parties to remediate contamination in the Canal. As part of the USEPA ROD, USEPA mandated the design and construction of two CSO storage facilities (DEP, 2018).

The DEP has shown that the CERCLA requirement can be met with two storage tanks (8-million gallons at the CSO outfall RH-034 and 4-million gallons at outfall OH-007). DEP has also implemented a LTCP for Gowanus Canal pursuant to a CSO Order on Consent and had implemented the Gowanus Pump Station (GPS) upgrade and the force main constructed to convey the pump station flow into Red Hook interceptor along Columbia Street (DEP, 2015).

New York City uses an environmental review process, known as the City Environmental Quality Review (CEQR) to predict how rezoning and other major land use actions will impact neighborhoods. It is used to study changes to neighborhood character, the potential for residential displacement, and strains to existing infrastructure, as well as to develop ways to mitigate those impacts. DEP recently completed the Final Environmental Impact Statement for the Gowanus Canal CSO Facilities (DEP, 2018).

This technical memorandum serves as supporting documentation for assessing the potential impacts of Gowanus Rezoning and benefits achieved from additional infrastructure investments being made by the City in this Gowanus sewershed. In order to support the CEQR, specific scenarios of rezoning and population growth were considered for the projected year (2035). Modeling of the urban drainage areas and sewer system was performed using InfoWorks ICM in order to develop quantitative information needed to guide the CEQR process.

Figure 1-1. Gowanus Canal Study Area

(**Sources:** Gowanus Neighborhood Planning Study 2019 & CURBED 2019)

2 EXISTING CONDITIONS FOR THE STUDY AREA

The Gowanus Canal sewershed is served by Owls Head (OH) and Red Hook (RH) WRRFs. The Red Hook fraction of this sewershed is larger and includes portions on the north and west of the Gowanus Canal, as well as some part of the area on the eastern side of the canal. The Owls Head WRRF serves the remaining portion on the eastern side, as shown in Figure 2-1.

Figure 2-1. Gowanus Canal Sewershed

(**Source:** DEP, 2018)

2.1 Red Hook Service Area

From the RH area, seven CSOs discharge to the canal with RH-034 being the largest. Wet weather flow that exceeds the capacity of GPS overflows into the canal through RH-034. All dry weather flow and a portion of wet weather flow of up to 30 million gallons per day (MGD) is directed to the RH WRRF through a force main located within the Flushing Tunnel. Four CSO outfalls (RH-033, RH-036, RH-037, and RH-038) are located along the eastern shore of the canal within the tributary area of Nevins Street pump station (located on Nevins Street near the intersection of DeGraw Street). Considering that the current capacity of this pump station is small in comparison to its contributing drainage area, DEP intends to eliminate this pump station and drain the combined sewage by gravity to the RH-034 tank.

Prior to the GPS and force main upgrades, the GPS flows were routed to the WRRF through Bond-Lorraine sewer along the western edge of the canal. Three CSO outfalls (RH-035, RH-032, and RH-031) can overflow when the wet weather flow within this Bond-Lorraine drainage area exceeds the capacity of the corresponding regulating structures.

2.2 Owls Head Service Area

Eight CSOs from OH service area, namely, OH-002, OH-003, OH-004, OH-005, OH-006, OH-007, OH-023, and OH-024 discharge into Gowanus Canal, Gowanus Bay, and New York Bay. Among these, only OH-005, OH-006, and OH-007 discharge into Gowanus Canal, with OH-007 being the largest outfall located at the northern end of 2nd Avenue.

The 2nd Avenue Pumping Station (shown in Figure 2-2) diverts up to 1.0 MGD of flow from the OH-007 outfall and pumps it back to the 72-inch-diameter sewer via a 6-inch diameter force main. Wet weather flow that exceeds the 7th Street regulator weir elevation goes through a grit chamber and then into the canal. The pump station will be incorporated into the Owls Head tank in the future conditions' scenarios.

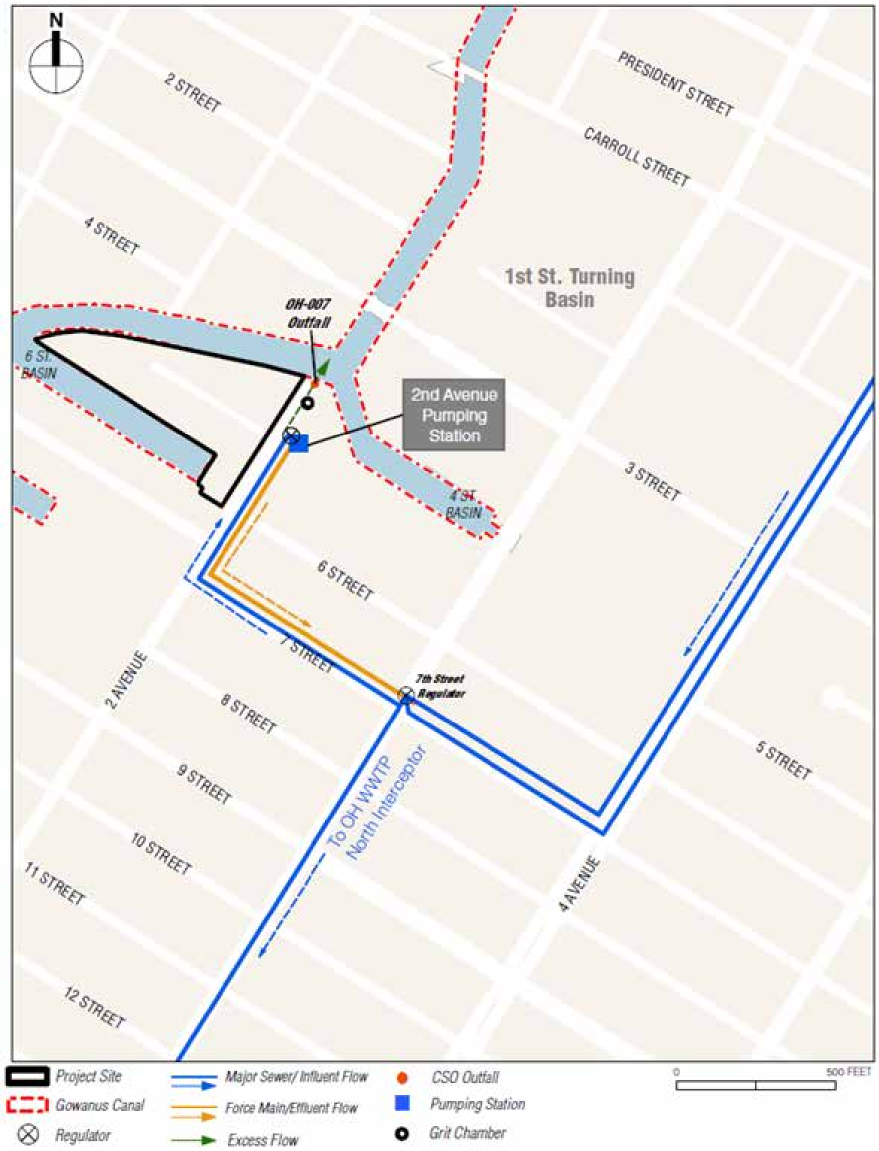

Figure 2-2. OH-007 Tributary Connections

(**Source**: DEP, 2018)

2.3 Existing and Proposed Zoning/Land Use

Historically, the Gowanus Canal sewershed has comprised of a mixture of commercial, light-industrial and residential uses. In recent years, the area has experienced a significant real estate investment and the associated new development or redevelopment. Figure 2-3 shows the current land uses within this sewershed, with the dominant land use being residential outside of the ADP area and primarily industrial and manufacturing within the ADP area adjacent to the canal. The proposed rezoning within the project area would convert much of these areas to residential and mixed-use districts.

Based on a Reasonable Worst Case Development Scenario (RWCDS) analysis performed by DCP, which sought to estimate the likely amount of redevelopment by 2035, 63 projected redevelopment sites were identified (Figure 2-4.). The assessment of the incremental CSO discharges and sewer surcharging associated with this growth requires the use of ICM models, already developed in prior DEP projects, with specific refinements performed to reflect the distribution and extent of new and redevelopment under RWCDS.

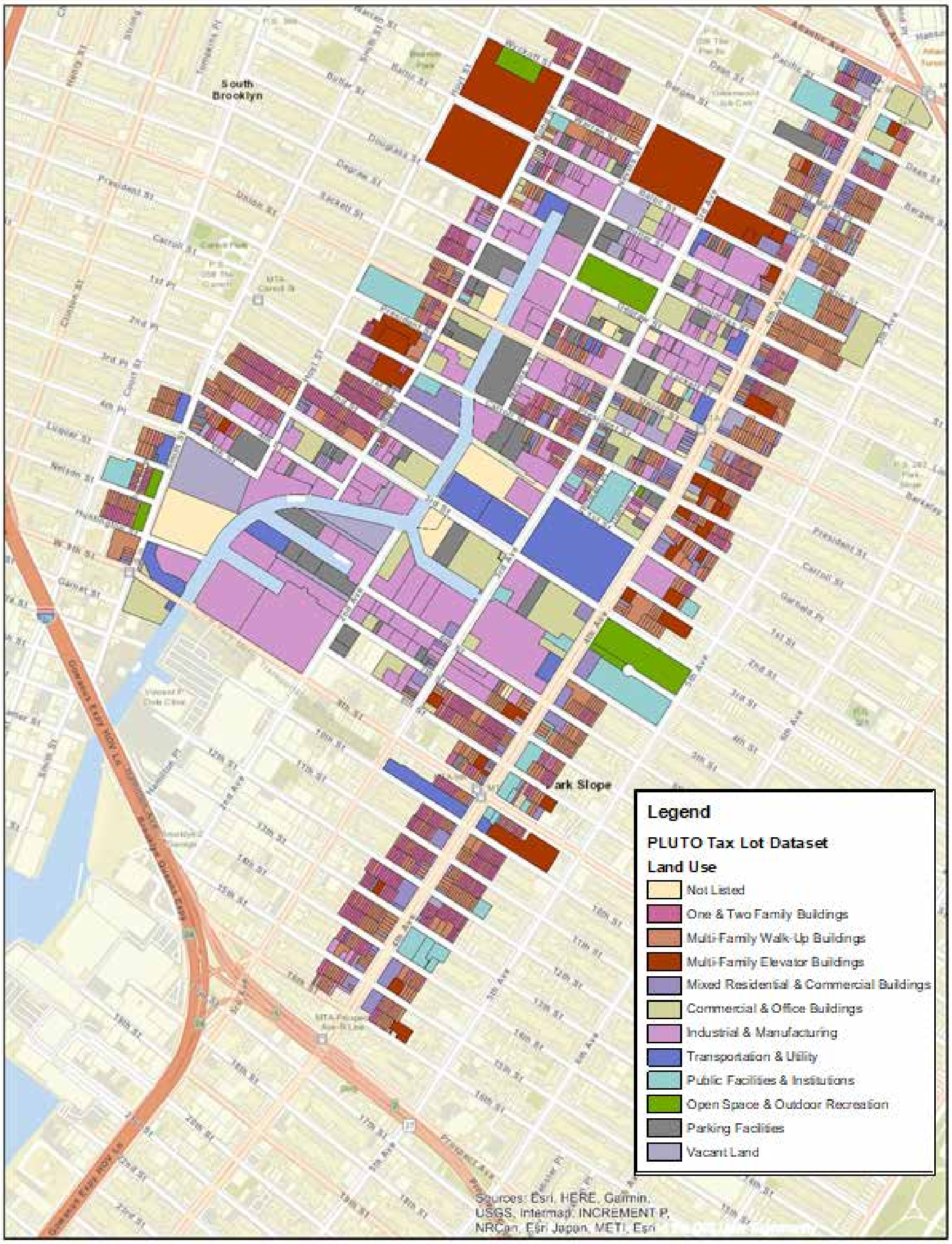

Figure 2-3. Current Zoning/Land uses

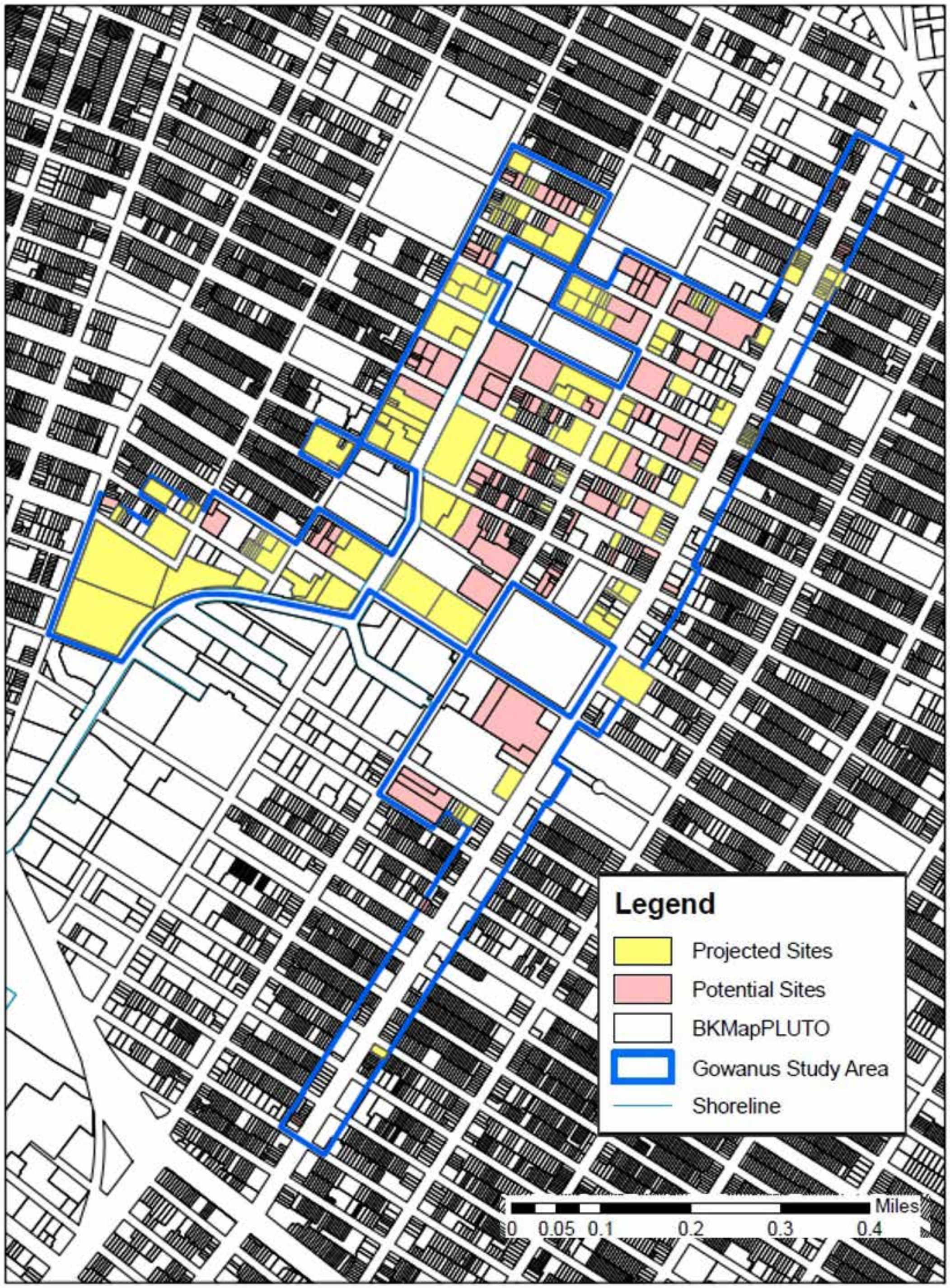

Figure 2-4. Anticipated Redevelopment Sites Within the ADP Area

(**Note:** Only the Projected Sites Included in Rezoning Analysis)

3 HYDROLOGIC AND HYDRAULIC MODELING FRAMEWORK

This study adopted InfoWorks ICM framework and previously developed LTCP models of the Red Hook (RH) and Owls Head (OH) WRRF service areas for sewer surcharging and CSO analyses. Several scenarios, including the RWCDS, were developed by DCP and DEP. Initially, a baseline model was constructed for the existing conditions with greater resolution within the ADP area and validated against the observed data from DEP. Surcharging and flooding analyses were first performed to identify the current hydraulic conditions within the study area. The baseline model was then updated to enable the representation of RWCDS reflecting the No Action and With Action scenarios. The following sections describe the baseline model construction and validation and the inputs associated with RWCDSs.

3.1 Baseline Model Construction and Validation

The baseline model was constructed from the existing separate LTCP models for the RH and OH WRRF service areas, which were first combined into one model, and refined using high-resolution sewer and land use data within the project area. The original RH model was in Brooklyn Highway Datum (BHD) and the OH model was in Brooklyn Sewer Datum (BSD). Integration of these two models was performed in BSD with the applicable adjustment factor. Relatively large LTCP subcatchments were divided into smaller parts in order to exclude the ADP area shown in blue in Figure 3-1. Higher resolution subcatchments and sewer networks developed in Geographic Information System (GIS) by DEP's Bureau of Water and Sewer Operations (BWSO) in a separate ADP project were then imported into the model. Finally, the ADP subcatchments were divided to include the RWCDS lots as individual tributary drainage areas. In summary, the baseline model included all sewers generally larger than 10-inches within the ADP area, while subcatchments in the LTCP drainage areas in the RH and OH WRRF service areas included pipes larger than 60-inches and few smaller sewers.

Two approaches were developed for model validation for existing conditions, one for dry weather flow (DWF) and another for wet weather flow (WWF) that are shown in Figure 3-2.A and 3-2B, respectively. The assumptions for RH WRRF include a design dry weather flow (DDWF) of 60 MGD, maximum capacity of 120 MGD, and a sanitary inflow of 24.29 MGD during the baseline 2019 conditions. Similarly, the assumptions for OH WRRF include a design DWF of 120 MGD, maximum capacity of 240 MGD and a sanitary inflow of 79.36 MGD for baseline conditions. For DWF validation shown in Figure 3-2A, the latest ICM models used by DEP in 2018 State Pollutant Discharge Elimination System (SPDES) best management practices' operational modeling and reporting (DEP, 2019) were used. 2010 census block population information was used for the distribution of DWF, consistent with the LTCP/Superfund projects. The modeled DWF at RH and OH WRRFs were compared with inflows monitored during the period of March-April 2019. Wastewater generation per capita was adjusted marginally to establish greater levels of correlation between the monitored and modeled inflows at the two WRRFs.

For WWF validation, the definition of four runoff surfaces from LTCP/superfund models, associated with directly connected impervious area factors (DCIAs), roughness coefficients, depression storage, and the plant capacities from 2018 SPDES report (DEP, 2019) were used. After calculating runoff coefficients (RC) for the ADP areas consistent with the DEP drainage planning manual (DEP, 2000), the model was run for specific storms observed in the March-April 2019 period and the modeled combined sewage flow at both RH and OH plants were compared with the monitored data. These results showed that the refinements made within the ADP area maintained high levels of correlation to monitored inflows at each WRRF.

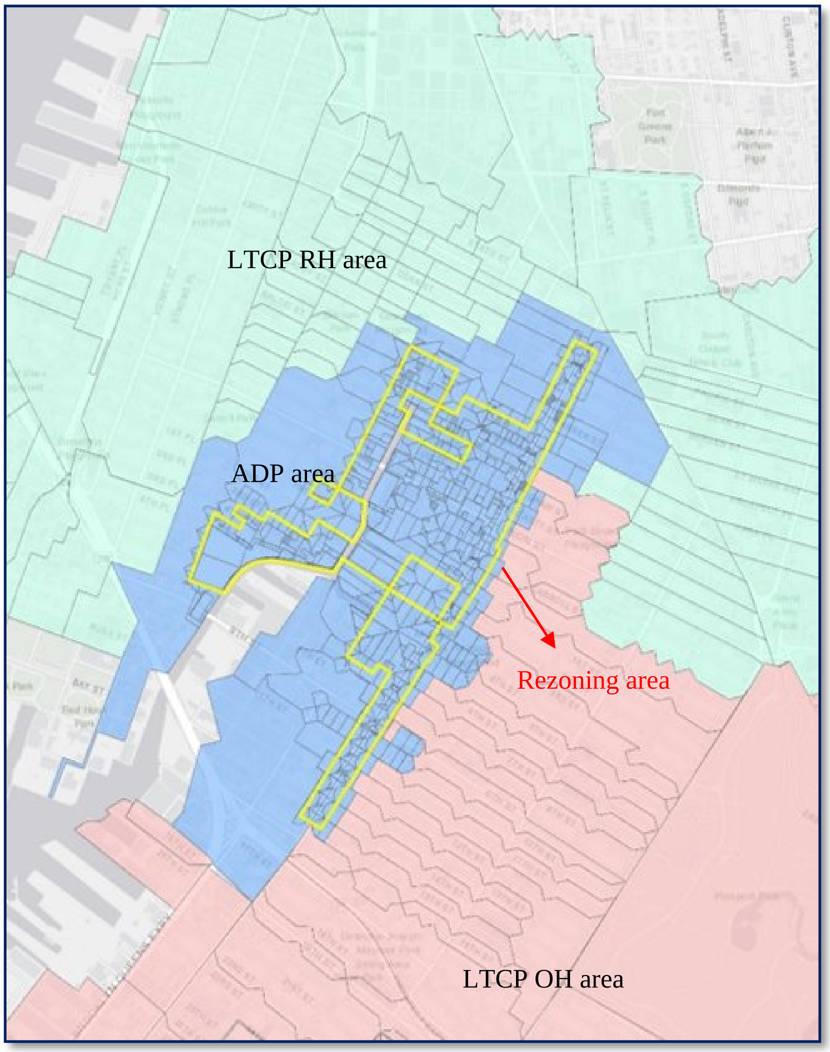

Figure 3-1. Delineation of Subcatchments Within Gowanus Study Area

Water quality assessment in receiving waters is typically performed by DEP with inputting flows and pollutant loads from CSOs, MS4 and direct drainage outfalls and applying the applicable boundary conditions (DEP, 2013 and DEP, 2015). First, an end-of-pipe (outfall) assessment of water quality is performed and if there are significant increases in pollutant loads, then the comprehensive receiving water quality modeling is undertaken to assess the impacts on water quality. DEP has been using event mean concentrations (EMCs), derived from literature search, for stormwater, sanitary flow and combined sewage in many water quality studies. This is a commonly used approach for the quantification of pollutant loads, used in CSO LTCP and stormwater planning studies (USEPA, 1983; Geosyntec, 2015). Consistent with this approach, literature review and review of prior sampling data compiled during DEP's LTCP studies were performed to develop EMCs for combined sewage (USEPA, 1983; Shaver et al., 2007; Geosyntec and Wright Water Engineers, 2011; DEP, 2013; DEP, 2015; and Pitt et al., 2018), and the plant effluent concentrations were compiled from BWT to estimate effluent loads from the two WRRFs. Model-derived volumes for CSO discharges and WRRF effluents in association with the corresponding EMCs allow for the estimation of pollutant loads discharged into the waterbodies. CSO loads represent the pollutant mass discharged into waterbodies in a typical year during wet weather periods, whereas the plant effluent load includes the mass discharged from the two WRRFs after treatment to the waterbodies during wet and dry weather periods in a typical year.

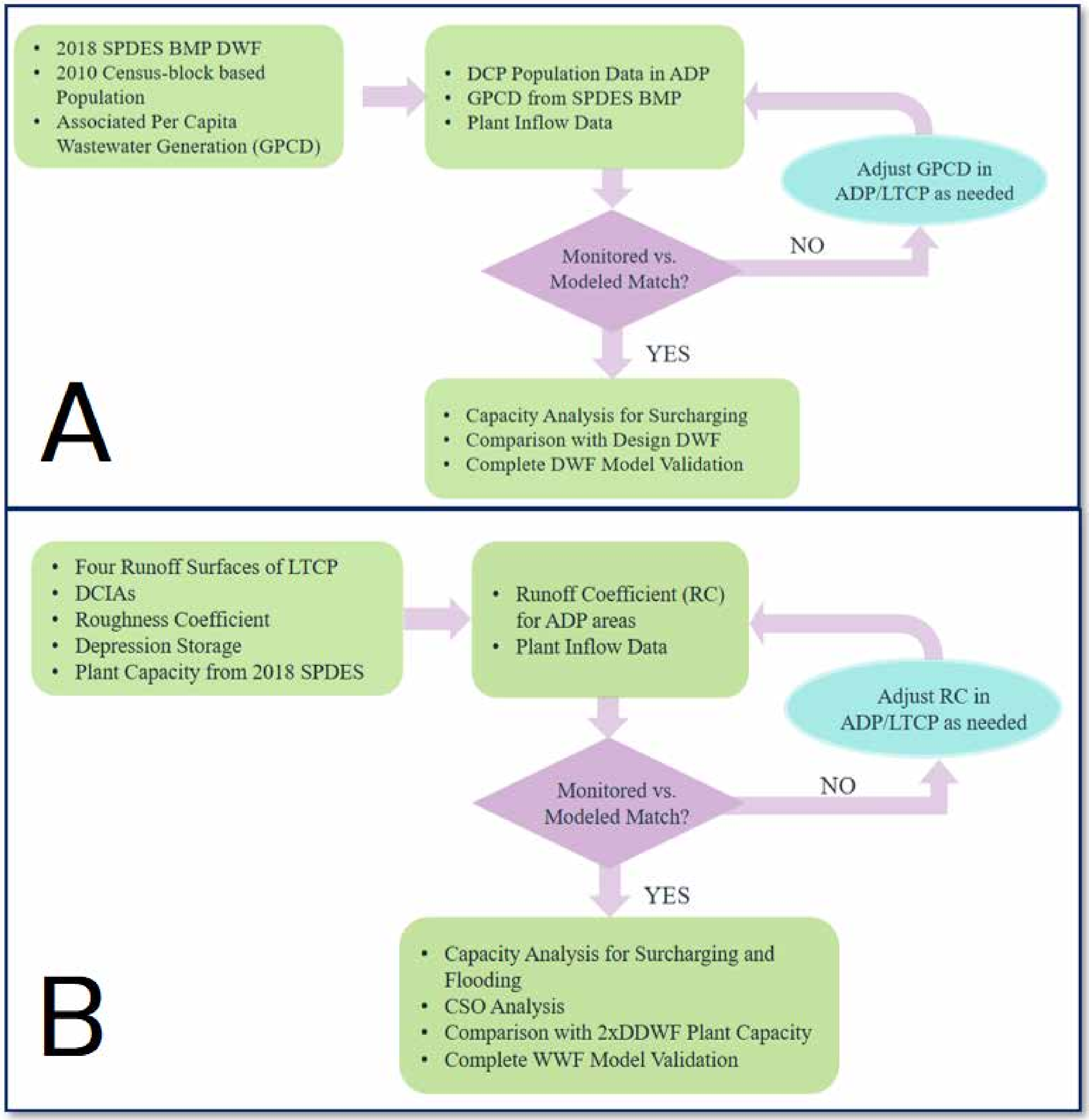

Figure 3-2. Model Validation Approaches for (A) DWF; and (B) WWF

A literature review and a review of prior sampling data compiled in DEP's LTCP studies were performed to determine the typical concentration for TSS in combined sewage (USEPA, 1983; Shaver et al., 2007; Geosyntec and Wright Water Engineers, 2011; DEP, 2013; DEP, 2015; and Pitt et al., 2018). In addition, the effluent concentrations for TSS were analyzed from the data provided by the Bureau of Wastewater Treatment (BWT) for treated sanitary flows. The selected values for effluent concentrations at the two WRRFs and CSO concentrations for TSS are shown in Table 3-1 and Table 3-2, respectively.

Table 3-1. Selected Sanitary Flow Concentration from BWT Data

WRRF	Average Effluent Concentration for TSS (mg/L)
RH	6
OH	18

Table 3-2. Selected EMC Concentration for CSOs

Flow Type	WRRF	Concentration for TSS (mg/L)
CSO	RH and OH	127

From a drainage system impact evaluation, DEP BWSO typically requires a hydraulic grade line (HGL) analysis on existing system using a spreadsheet-based methodology. An ADP is required to assess the effectiveness of maintaining HGLs associated with the existing conditions under a 3-year design storm, estimated using Steel's equation:

$$\mathbf{I = 120/(t + 20);}$$

where I is the intensity in inches per hour (in/hour) and t is the time of concentration in minutes.

This equation is used by BWSO as the storm basis for retrofitting of existing sewers/new design in older parts of the City where the original sewers have been designed for a 3-year storm. Calculations are performed in an Excel spreadsheet starting with the most upstream sewer segment and working downstream using Manning's equation and the sewer upsizing/ new sewer sizing to contain the HGL below the pipe crown. Assuming a time of concentration of 6-minutes, flow from an upstream subcatchment is routed through a downstream sewer using Manning's equation to calculate the effect of routing and reduced peak/time for travel in the downstream sewer. These calculations are continued through to the outfall to complete the ADP.

This approach has been modified recently by BWSO to include the HGL analysis using ICM with a critical duration hyetograph (CDH) as rainfall boundary and a constant Mean High Water (MHW) as tidal boundary condition. Any differences in HGLs due to rezoning projects must be noted and reviewed in detail to assess if those are acceptable based on the original drainage plan for the local sewers. Unlike the spreadsheet method, ICM provides a complete picture of the surcharging in each type of sewers (e.g., lateral, trunk or interceptor sewers) in the form of HGLs and also the areal extent to which surcharging can impact the lateral and trunk sewers (e.g., block, neighborhood or regulator scale). Consequently, it is important to review the surcharging extents for both manholes and pipes to characterize the surcharging and consequent flooding conditions. Surface flooding risk in this rezoning analysis is quantified by observing the number of flooded manholes within the ADP area, and the total flood volume lost through those manholes, for the No Action and With Action scenarios.

The CDH is a set of rainfall events of a given return period used to assess the sewer capacities in existing systems, serving as an equivalent ICM-based modeling approach to replicate and improve the original spreadsheet methodology. This hyetograph contains 81 synthetic storms of uniform frequency (taken from the 1903-1951 New York City Intensity-Duration-Frequency curve developed by the US Department of Commerce) but with varying duration and intensity. Each storm is applied uniformly throughout the drainage area. It is designed to identify the 'critical duration' rainfall intensity that would result in the highest flow at any given pipe in a drainage network. The CDH for a 3-year return period is shown in Figure 3-3. A short-duration high-intensity rainfall is likely to be critical at the most upstream portion of a sewershed and the latter ones for the sewers downstream. In order to capture this variability in critical duration, this study used a three-storm sample from the CDH to represent the highest, lowest, and median rainfall intensities. These specific duration storms along with the peak intensity and volume are summarized in Table 3-3. Each storm was simulated, in conjunction with a fixed tidal boundary condition representing the MHW level observed at the nearby National Oceanic and Atmospheric Administration (NOAA) Battery Tide Gauge (2.16 feet NAVD88), to estimate the flooding extents. Flooding extents from the three storms were then post-processed to select the most conservative (largest) flooding for each sewer segment.

Table 3-3. Summary of Three Critical Duration Storms

Critical Duration #	Peak Intensity (in/hr)	Volume (in)	Duration (Minutes)
1	4.62	0.46	6
51	3.43	0.86	15
81	2.40	1.20	30

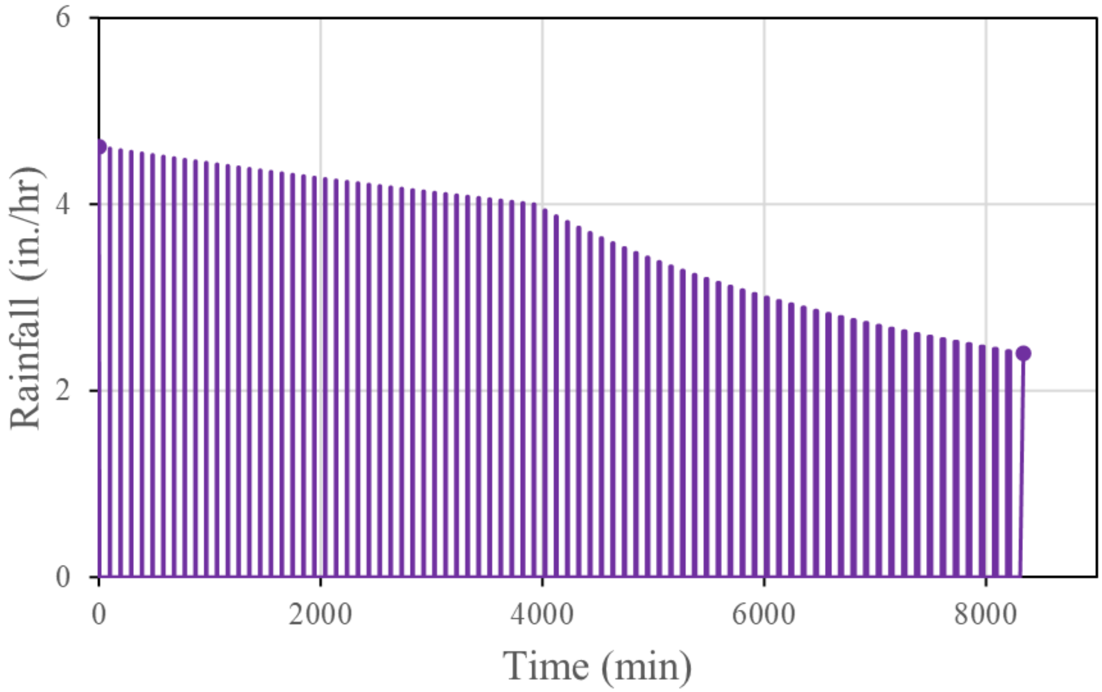

Figure 3-3. Sequence of 3-year CDH Events

It must be noted that, as part of the tanks facility planning, DEP has been evaluating potential upgrades to the collection system to reduce flooding in some local areas such as the Nevins Street Pump Station drainage area and Bond-Lorraine sewer tributary area.

3.2 Model Inputs for Future Conditions Without and With Rezoning

In the CEQR analysis, a future year is chosen as reference for establishing consistency in modeling assumptions pertinent to Without Rezoning (No Action) and With Rezoning (Action) scenarios. Year 2035 was chosen as reference timeline for these scenarios. The assumptions and associated analyses in this study reflect full RWCDS in Year 2035, in order to develop conservative assessments of CSOs and pollutant loads into CSOs and WRRFs.

The infrastructure upgrades already completed by DEP including the GPS and force main upgrades were included in the model. Specific inputs provided by the DEP and DCP are described below. Additional assumptions used to complete the inputs needed for the CSO and surcharging analyses are also described.

3.2.1 Population Distribution

All the facility planning and LTCP modeling efforts conducted by DEP so far use the latest official information of 2010 census block data for distribution of sanitary flows in various portions of the WRRF service areas. Total flow monitored at a WRRF is used with this 2010 population to derive the applicable per capita wastewater generation. This official data is about 10-years old and therefore alternate ways of deriving the population distribution were explored. The DCP uses a transit analysis zone (TAZ) based data for projecting population increases in neighborhoods. As such, the TAZ-based methodology was used to estimate the distribution at the scale of subcatchments (tributary drainage areas) currently included in the LTCP models. This methodology and its implementation for population distribution are summarized below.

The TAZ-methodology uses growth estimates of residential and worker populations allocated to tax lots by utilizing each tax lot's land area, existing building area, and the maximum allowable floor area ratio (FAR). This method first begins with estimating the population for Year 2020 and then escalating the projection to the planning year of 2035.

The TAZ 2020 residential population estimate was distributed based on each lot's share of residential building area compared to the total residential building area built within the surrounding TAZ. The TAZ 2020 worker population estimate was distributed similarly. The total residential and commercial building area within each TAZ is the summation of total residential or commercial built area on tax lots falling within the same TAZ. The 2020 estimates were used for the Baseline Scenario.

For 2035, the estimated residential and commercial population growth between 2020 and 2035 as provided by DCP within the rezoning area and by TAZ outside the rezoning area was divided among tax lots based on each lot's share of potential residential or commercial building area. The 63 projected development sites intersect portions of nine individual TAZs (see Figure 3-4). The total potential residential and commercial building area within each TAZ was then calculated and each lot's share of growth between the 2020 and 2035 population and worker estimates was allocated based on the proportion of potential residential or commercial building area on each tax lot compared to the TAZ as a whole.

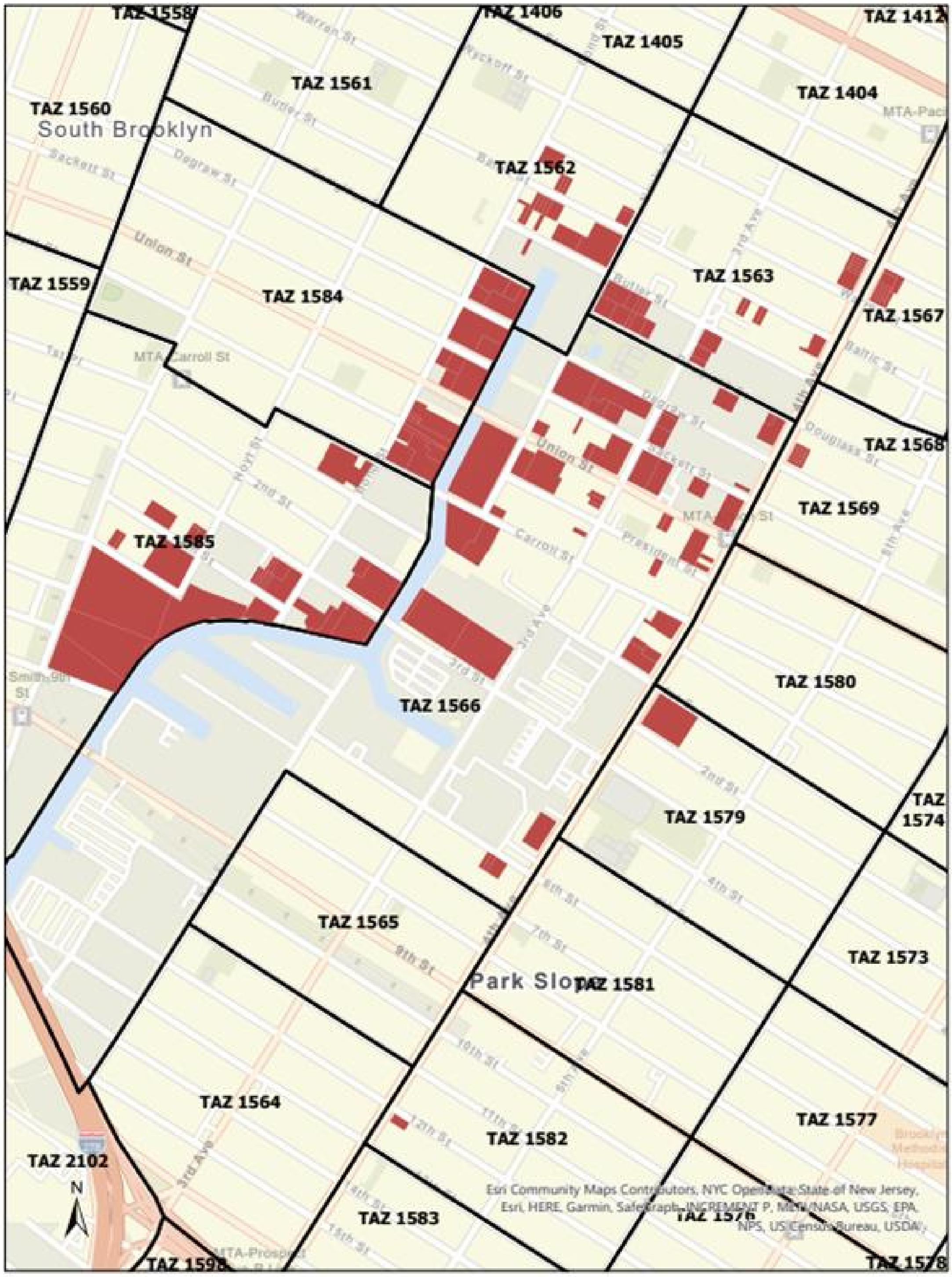

Figure 3-4. TAZ Polygons and the RWCDS Lots

3.2.2 Sanitary Flows

DEP's (DEP, 2014) projected sanitary flows on a WRRF-scale for Year 2035 were used for the No Action and With Action scenarios. These flows were used as background sanitary flows, distributed in accordance with the TAZ methodology. The projected sanitary flows for the Red Hook and Owls Head WRRF's are 27.9 MGD and 85.2 MGD, respectively.

The daily per capita wastewater generation within the RWCDS lots was assumed to be 73 gallons. This per-capita from Bureau of Environmental Planning and Analysis of DEP (BEPA) is based on the proactive water conservation efforts undertaken by developers in recent projects and the comprehensive efforts undertaken by DEP and others to reduce potable water demand over the past two decades. Additional DWF contributions were estimated based on the population increases provided by DCP for the 154 rezoning lots projected to be developed by Year 2035 (see Figure 3-4). The population estimates and the resulting DWF projections using the above wastewater generation per capita were developed for the rezoned area, as summarized in Table 3-4 for the Without Rezoning and With Rezoning scenarios.

Table 3-4. Population and Sanitary Flow in Rezoned Area

Scenario	Population in Rezoned Area	Sanitary Flow in Rezoned Area (MGD)
Baseline	6,541*	0.640
2035, Without Rezoning	8,746	0.960
2035, With Rezoning	27,035	2.245

*This value projected using TAZ methodology was comparable to the RWCDS projection for Year 2019 of 6,524 people, so the TAZ value was used for Baseline.

Adjustments to per capita wastewater generation were made to reflect the 2035 DWF distribution for areas outside of the ADP drainage area throughout the RH and OH sewersheds.

3.2.3 Green Infrastructure

DEP has been constructing green infrastructure (GI) assets in the public right of way (ROW) and, through partnerships and grants, has been implementing GI on public and private properties throughout the city. A database of assets, as they go through the preliminary to final design and into construction, is maintained by DEP for implementation tracking. This database (referred to as GreenHUB) was reviewed to capture a snapshot of GI assets that were constructed, under construction, or in final design as of July 2019.

Table 3-5 shows the types and numbers of various GI assets that were constructed, under construction, or in final design as of July 2019 within the evaluated drainage area.

Table 3-5. Summary of GI Assets

Asset Type	Number of Assets
ROW Bioswales	87
Blue Roof	1
Bioretention	5
Subsurface Detention System	7
Permeable Pavements	8
ROW Stormwater Greenstreets	2
Green Roof	1
Synthetic Turf Field Storage Layer	2
ROW Permeable Pavement	2
Grand Total	**115**

About 5.9 acres of total GI asset area in OH and RH drainage areas and 1.1 acres within the RH-034 and OH-007 areas were included as managed areas with retention or detention or hybrid GI, as applicable. Distribution of these GI assets within the RH and OH drainage areas is shown in Figure 3-5. Consistent with the LTCP and superfund projects, a lumped retention approach was used for representing these GI assets in the RWCDS scenarios, based on whether the asset is retention or detention dominated.

Redevelopment must adhere to DEP's current 2012 Stormwater Rule that established detention-based stormwater controls in accordance with the description provided in Table 3-6.

Table 3-6. Summary of the 2012 Stormwater Rule

Description
§ 31-03 Stormwater performance standard for connections to combined sewer system:
For a New Development: – Stormwater Release Rate will be the greater of 0.25 cfs or 10 percent of the Allowable Flow – If Allowable Flow is less than 0.25 cfs, the Stormwater Release Rate shall be the Allowable Flow – Allowable Flow is the stormwater flow from a development that can be released into existing storm or combined sewer based on drainage plan and built sewers
For Alterations: – Stormwater Release Rate for the altered area will be directly proportional to the ratio of the altered area to the total site area and no new points of discharge are permitted – Alterations are as defined in the Construction Codes and related requirements for any horizontal building enlargement or any proposed increase in impervious surfaces

DEP is finalizing a Unified Stormwater Rule (USWR) for implementation in 2022, which includes two major criteria aimed at improving water quality and maintaining optimal flow rates in the City's sewer system. Criteria to improve water quality apply to project areas that are 20,000 SF or larger or create 5,000 SF or more of impervious cover. Water quality criteria include retention-first requirements for managing runoff followed by detention as a secondary control measure in combined sewer system areas. Criteria to maintain sewer operations apply to any project that requires a Site or House Connection Proposal. The sewer operations criteria include updated release rate requirements to reduce the peak rate of discharge to the city sewer system.

According to USWR, the new developments must either retain or detain each of the water quality volume (WQv) and the sewer operation volume (Vv) requirements, depending on the size of the project, new impervious area, and whether the site needs a Site or House Connection Proposal. The USWR (DEP, 2020) requires detention elements to restrict runoff to a greater degree when compared to the current 2012 Stormwater Rule (DEP, 2012). A summary of the steps necessary to calculate the retention and detention requirements for the USWR is provided in Table 3-7.

Table 3-7. Summary of Unified Stormwater Rule

Equations	Justification
$WQv = (1.5 / 12) \times A \times Rv$	Where Rv = Runoff Coefficient based on impervious cover Why: water quality requirements

Rd = 1.1" for house connection permit (1-3 family homes <20,000 SF)

Rd = 1.5" for site connection permit

Release Rate: greater of 1.0 cfs/acre or 0.046 cfs

An example detention unit from DEP (2012) guidance document is shown in Figure 3-6 to review how the detention tanks reduce the peak flow from redeveloped lots and contribute to overall improvement in surcharging, flooding and CSO flows. The orifice at the downstream end of this structure limits the peak flow based on the calculated release rate.

Evaluations were performed with both the 2012 Stormwater Rule and USWR to assess the potential stormwater control benefits associated with redevelopment. Independent of the RWCDS lots, there is background growth in the RH and OH service areas. As a result, a background growth rate (new and redevelopment) was assumed for a 15-year period (2021-2035) for the entire WRRF service areas, consistent with the approved Gowanus LTCP project (DEP, 2015). About 35.8 acres are assumed to be managed by either the 2012 Stormwater Rule or USWR in the two WRRF service areas as part of the background growth. This background growth is modeled in both No Action and With Action scenarios. For the With Rezoning scenario with USWR, the 154 lots were reviewed to determine if each lot fell under new development or alteration and modeled as listed Table 3-8. The lot sizes were compared with the soil disturbance threshold of 20,000 SF and the applicable rules described inTable 3-7 were used to represent the stormwater control performance. For the 2012 Stormwater Rule, all the RWCDS lots were modeled with detention in accordance with the rules described in Table 3-6 . About 46.7 additional acres of RWCDS lots were subjected to the 2012 Stormwater Rule or USWR in the With Action scenario and were modeled with stormwater controls, whereas the No Action scenario assumed no stormwater controls at these lots, and the results are discussed in Section 4.

Table 3-8. Summary of USWR application on projected redevelopment sites

USWR	Sites / Number of lots	Type of development
Applied	1-58, and 63 (150 lots)	New development
Applied	7 and 57 (2 lots)	Partial new development
Not applied	59 and 60 (2 lots)	No new development

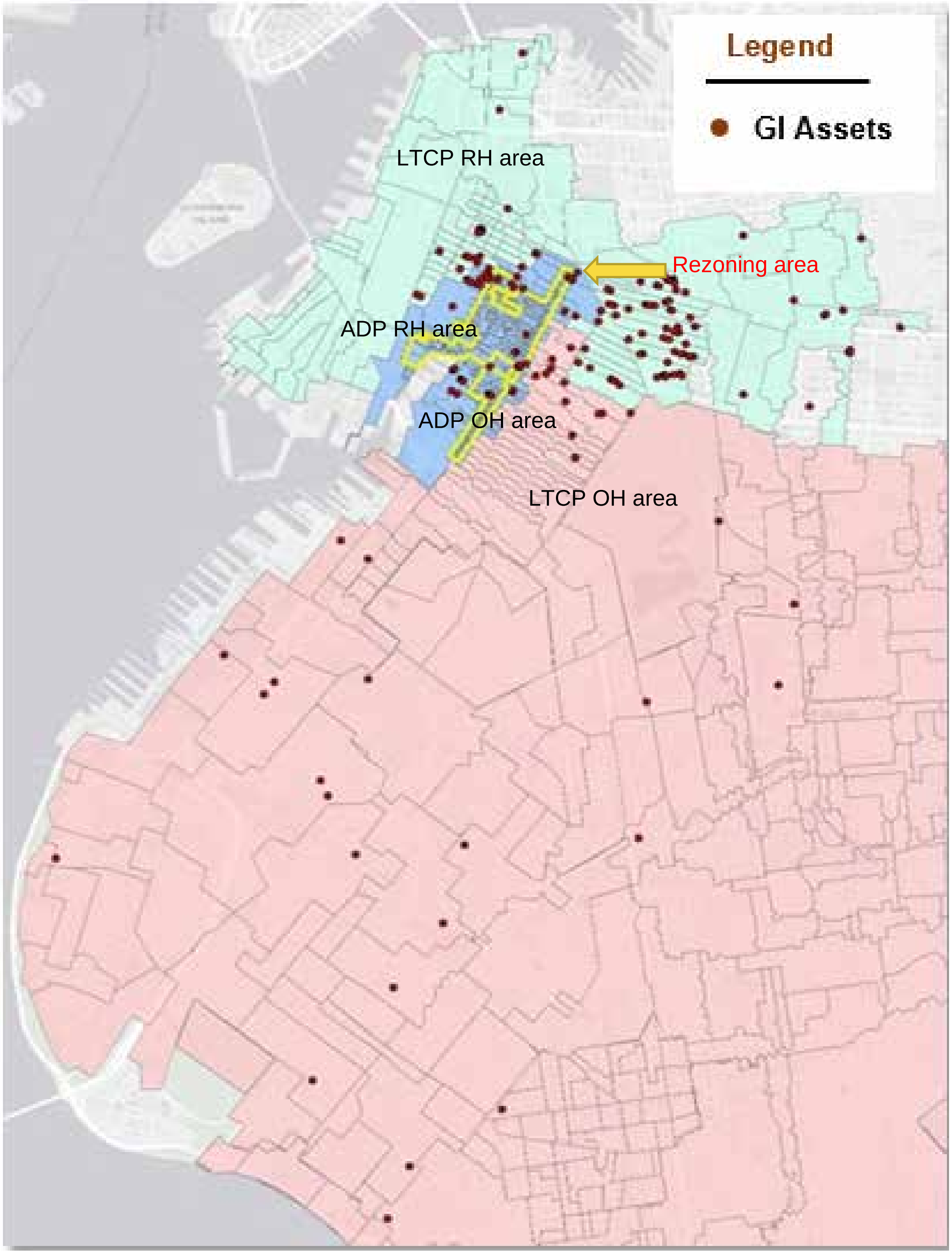

Figure 3-5. Distribution of Current GI Assets in the two WRRF Service Areas

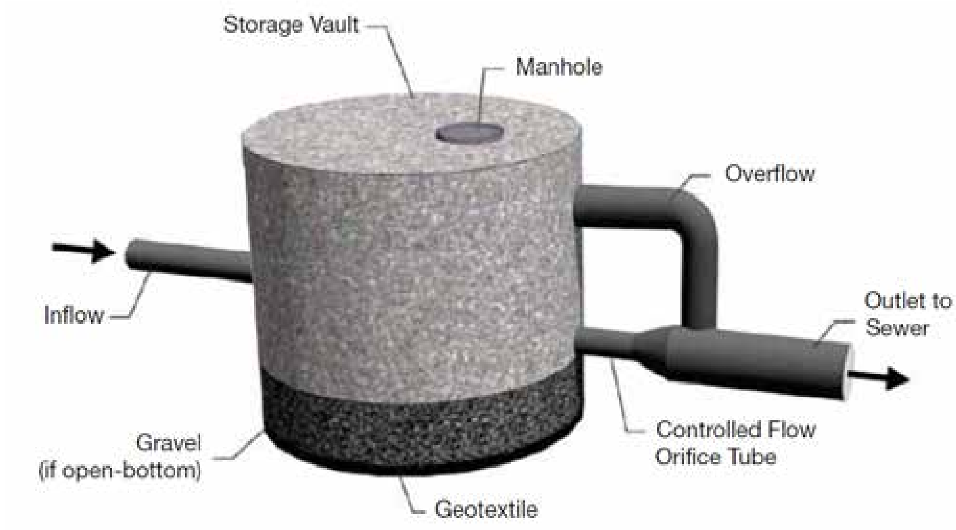

Figure 3-6. An example of Detention Tank

(**Source**: DEP, 2012)

3.2.4 High Level Storm Sewers

DEP is implementing high level storm sewer (HLSS) projects in portions of the combined sewer systems that experience significant surcharging and flooding. These projects (consisting of shallow sewers) are constructed to intercept runoff from the right of way and route to new stormwater outfalls, thereby relieving capacity in the existing combined sewers. HLSS is under construction in the Gowanus sewershed in two phases, within a total drainage area of approximately 96 acres bounded by 1st Place, 4th Avenue, State Street and 3rd Avenue, as shown in Figure 3-7. Both phases would be completed well before the reference timeline of 2035 and, therefore, were included in the No Action and Action scenarios.

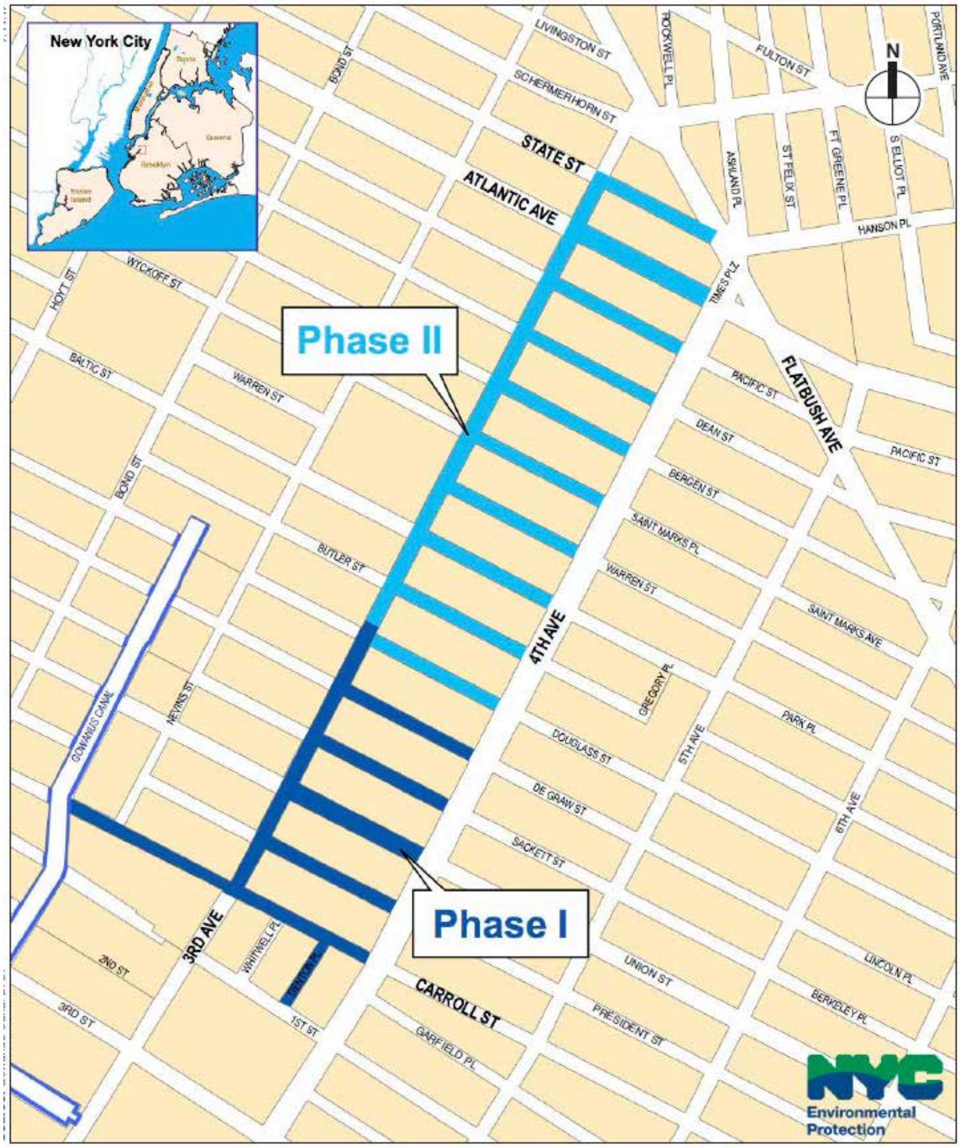

Figure 3-7. Gowanus Canal High Level Storm Sewers
(**Source**: DEP, 2018)

3.2.5 CSO Storage Tanks

The CSO Facilities are being designed to meet the goals of the USEPA ROD, specifically a 59 to 74 percent reduction in CSO solids discharging to the Canal from the RH-034 and OH-007 outfalls (DEP, 2018). TSS is frequently targeted by EPA for the Superfund sites as surrogate parameter to address potential recontamination of sediments with organic substances.

With the capture and dewatering of tanks to convey the captured CSOs to WRRFs for treatment and disposal, solids loading to the Canal through CSO discharges are reduced significantly. The storage tanks are designed with multiple cells and this design would further improve solids settling including the capture of first flush. Therefore, the solids reduction estimate using the

EMC approach is conservative and the actual performance of the two storage tanks is expected to be better than the CSO volume-reduction based estimates presented in this memorandum. DEP (2018) reported that the typical year solids load reduction on a volume basis (i.e., EMC method) for the 8 MG tank was estimated to be 76 percent at the RH-034 outfall and 85 percent with the 4 MG tank at OH-007.

The configurations of the 8-million gallons (MG) tank at RH-034 and another 4-MG tank at OH-007 were represented in ICM based on the latest design information available from the Gowanus Superfund Project design team. The Nevins Street pump station was removed, and the drainage area was connected to the tank to drain by gravity. Figure 38 presents a schematic of the two storage tanks. The tanks with the Nevins Street drainage modification were included in ICM in both No Action and the Action scenarios.

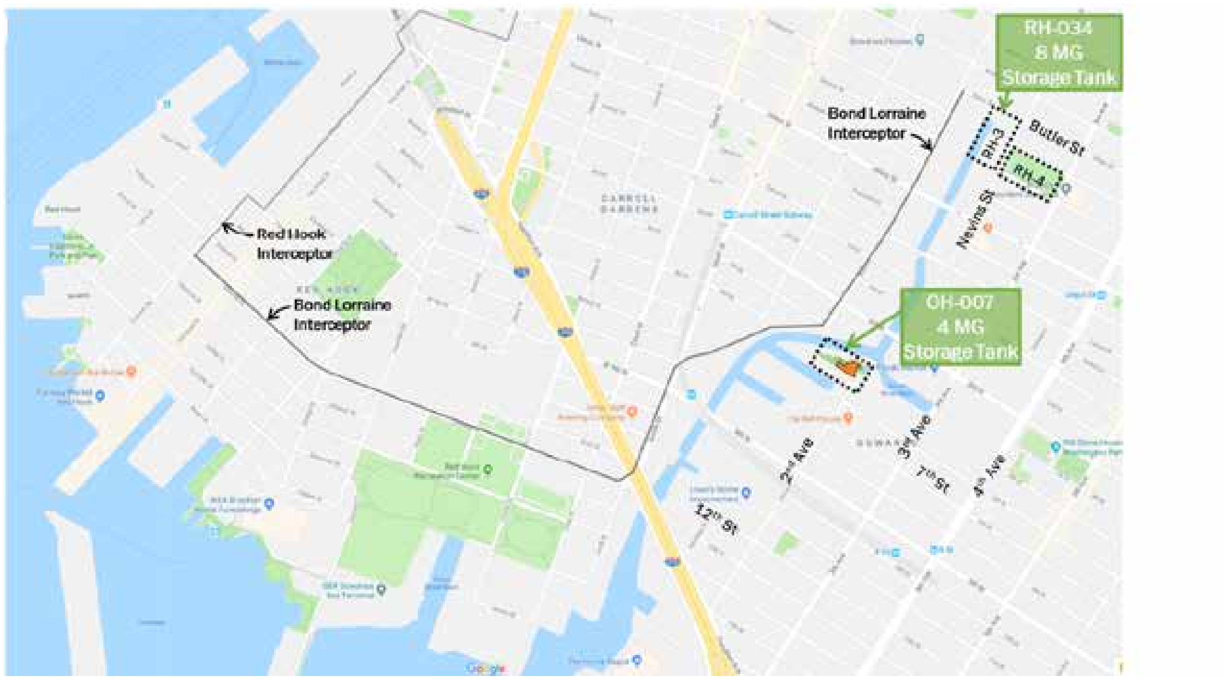

Figure 3-8. Schematic of Two Tanks at RH-034/OH-007

(**Source**: DEP, 2018)

4 FINDINGS AND DISCUSSIONS

Subsequent to model validation for the Baseline (2019) conditions, four scenarios were represented individually in ICM to quantify the CSO volumes/frequencies for a typical year and the flooding associated with the 3-year CDH and MHW boundary conditions. These scenarios are summarized below:

2035 Tanks' Without Rezoning (or No-Action) - with 2012 Stormwater Rule or USWR
2035 Tanks' With Rezoning (or Action) - with 2012 Stormwater Rule or USWR

The first evaluation focused on flooding using CDH and MHW. The impervious cover is very similar in the RWCDS lots between the No Action and Action scenarios. The increased sanitary flows associated with rezoning will cause minor localized increases in HGLs during dry weather when ample capacity is available in combined sewers. However, during wet weather events, the USWR at RWCDS lots in the Action scenario provided significant stormwater reductions onsite and reduced flooding extents in comparison to No Action scenario. The 2012 Stormwater Rule provided marginal reductions onsite and reduced the surface flooding volume marginally in comparison to the No Action scenario. A quantification of the number of manholes that depicted potential flooding due to increased HGL was developed for the two scenarios and summarized in Table 4-1 for the 3-year CDH. These results indicated that the stormwater controls implemented at RWCDS lots in compliance with either the 2012 Stormwater Rule or USWR would provide flood mitigation benefits in comparison to the No Action scenario. The benefits in terms of the number of flooded manholes for both the 2012 Stormwater Rule and USWR look similar since this evaluation of flooding was performed for a design storm and the 2012 Stormwater Rule would provide considerable reduction in peak flow rates from the RWCDS lots for this large storm. On the other hand, the USWR also includes more stringent detention and some retention, therefore, its benefit could be seen in terms of further reductions in the total surface flooding volume.

Table 4-1. Number of Flooded Manholes and Total Surface Flooding Volumes

Flooding Attribute	Scenario			
	2012 Stormwater Rule		USWR	
	2035 No Action	2035 Action	2035 No Action	2035 Action
Number of Flooded Manholes	39	34	39	34
Total Surface Flooding Volume (MG)	2.67	2.55	2.50	2.45

The second evaluation focused on CSO flows into Gowanus Canal during the typical year of 2008 for the No Action and Action scenarios. The annual CSO volumes for the four scenarios are summarized in Table 4-2. Similarly, the CSO frequencies are shown in Table 4-3. As seen, the USWR in RWCDS lots under the Action scenario achieves stormwater reductions onsite and CSO reductions into the Gowanus Canal in comparison to the No Action scenario. On the other hand, the 2012 Stormwater Rule marginally increased the CSO volumes but maintained the frequency of discharges into the Canal when compared to the No Action scenario. The 2012 Stormwater Rule would provide negligible benefits for small to medium-sized storms that occur in the typical year, but some benefit would be realized for the larger storms. The annual evaluations and results presented here are based on all storms that occurred in the typical year (2008) and the net result of the 2012 Stormwater Rule showed an increase in CSO discharges for the typical year.

Table 4-2. Summary of CSO Volumes in the Vicinity of ADP Area

Outfall #	CSO Volumes (Million Gallons, MG)			
	2012 Stormwater Rule		USWR	
	2035 No action	2035 Action	2035 No Action	2035 Action
OH-005	1.0	0.9	0.95	0.88
OH-006	18.6	18.7	18.39	18.32
OH-007	10.3	10.8	10.19	9.94
RH-030	17.4	17.8	17.13	16.24
RH-031	19.8	20.2	19.36	18.21
RH-033	0.0	0.0	0.0	0.0
RH-034	30.0	31.5	29.88	28.49
RH-035	8.3	8.4	8.06	7.02
RH-036	0.4	0.3	0.44	0.10
RH-037	0.04	0.04	0.04	0.02
RH-038	1.1	1.2	0.99	0.88
TOTAL	**106.94**	**109.84**	**105.43**	**100.12**

Table 4-3. Summary of Frequency of CSOs in the Vicinity of ADP Area

Outfall #	CSO Event Frequencies			
	2012 Stormwater Rule		USWR	
	2035 No action	2035 Action	2035 No Action	2035 Action
OH-005	1	1	1	1
OH-006	34	34	34	34
OH-007	6	6	6	5
RH-030	17	17	17	15
RH-031	16	16	16	14
RH-033	0	0	0	0
RH-034	5	5	5	5
RH-035	15	15	15	15
RH-036	9	6	9	2
RH-037	2	2	2	1
RH-038	5	5	5	5

Pollutant loads discharged into waterbodies through the effluents of RH and OH WRRFs and into Gowanus Canal through CSOs were quantified for the No Action and Action scenarios using the EMC approach. Figure 4-1, Figure 4-2, and Table 4-4 show the load summaries for the two WRRFs and Gowanus Canal CSOs for TSS, for both the 2012 Stormwater Rule and USWR. Consistent with the observed CSO volume trends, the CSO TSS loads showed marginal increases (2.8 percent) for the 2012 Stormwater Rule. The USWR results in pronounced decreases (5.0%) in TSS loads into Gowanus Canal. Rezoning increases the effluent pollutant loads at both WRRFs due to increases in sanitary flows. The increases are greater at the Red Hook WRRF (3.1 percent with the 2012 Stormwater Rule and 2.9 percent with USWR) than at the Owls Head WRRF (0.3 percent for 2012 Stormwater Rule and 0.4 percent for USWR), as most of rezoning occurs in the Red Hook WRRF service area.

DEP continues to make significant investments in this watershed over the past two decades. Figure 4-3 shows the comparative CSO volumes into Gowanus Canal. Pre-waterbody watershed facility plan (WWFP) shows the CSO discharges prior to these recent infrastructure improvements and the LTCP Baseline shows the remnant discharges after the GPS and force main upgrades and green infrastructure are implemented. The Pre-WWFP and LTCP Baseline comparisons have been presented in prior public meetings held for the Gowanus LTCP (DEP, 2015) and superfund (DEP, 2018) projects.

A comparison of CSO volumes for the 2035 No Action and Action scenarios, corresponding to the 2012 Stormwater Rule and USWR, are also included in Figure 4-3 to provide a comparative perspective on how the additional DEP investments such as the two storage tanks and HLSS will well exceed the ROD performance target for TSS of 59-74 percent reduction pertinent to the Superfund project. As seen in Figure 4-4, both the 2012 Stormwater Rule and USWR achieve this ROD-based performance targets for the two large CSO outfalls (RH-034 and OH-007) and also meet or exceed the 76 and 85 percent reductions reported in DEP (2018) for these two outfalls, in comparison to the Pre-WWFP conditions.

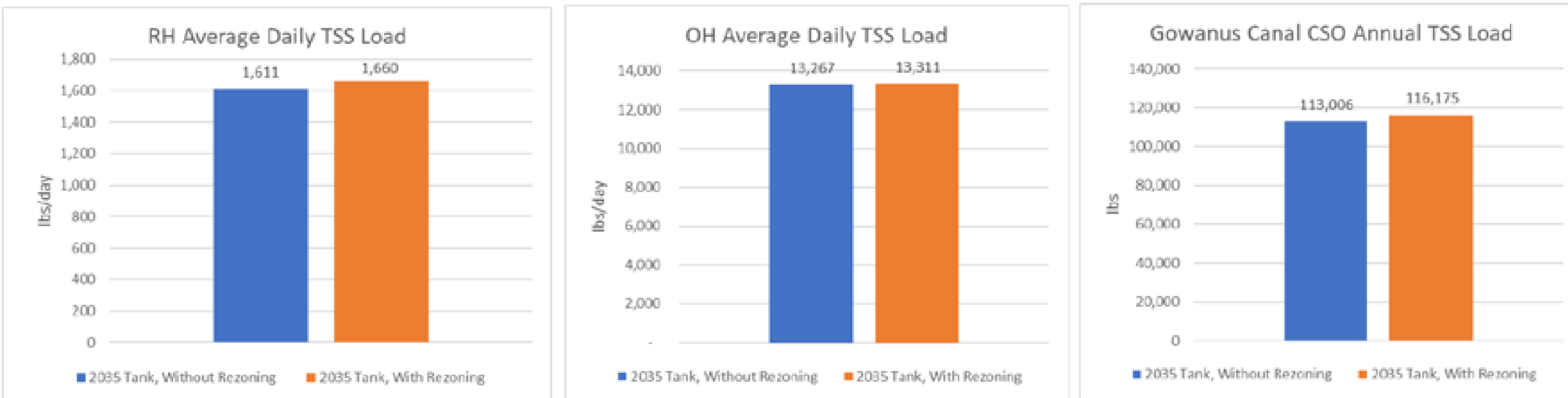

Figure 4-1. TSS Loading Summary (2012 Stormwater Rule)

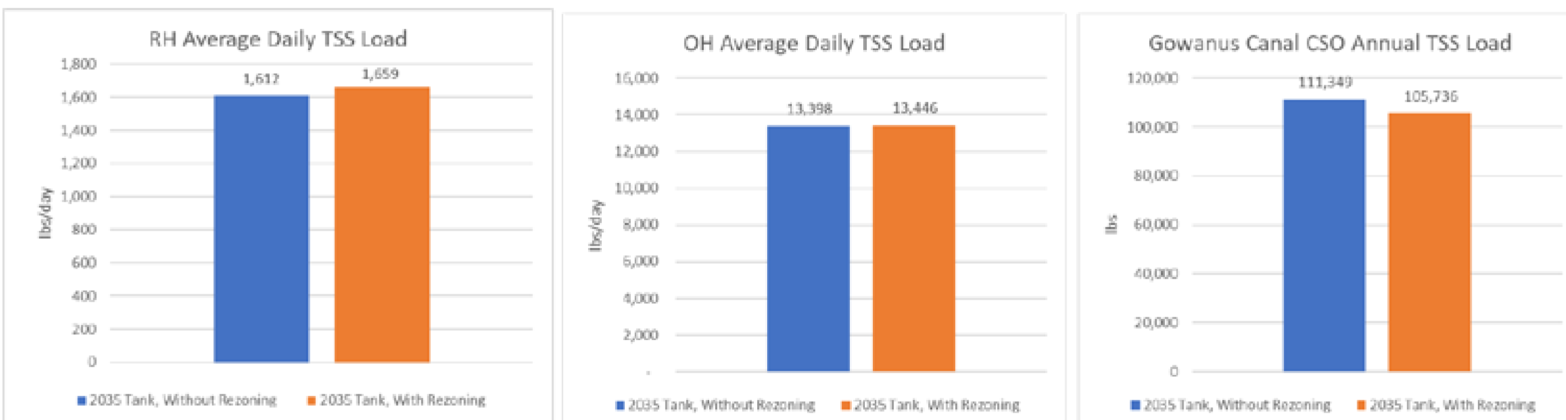

Figure 4-2. TSS Loading Summary (USWR)

Table 4-4: TSS Load Summary

	Scenario	Location	TSS Load	% Increase Due to Rezoning
2012 Stormwater Rule	2035 No Action	RH WRRF Effluent (lb/day)	1,611	-
		OH WRRF Effluent (lb/day)	13,267	
		Gowanus Canal CSOs (lb/year)	113,006	
	2035 Action	RH WRRF Effluent (lb/day)	1,660	3.1 percent
		OH WRRF Effluent (lb/day)	13,311	0.3 percent
		Gowanus Canal CSOs (lb/year)	116,175	2.8 percent
USWR	2035 No Action	RH WRRF Effluent (lb/day)	1,612	
		OH WRRF Effluent (lb/day)	13,398	
		Gowanus Canal CSOs (lb/year)	111,349	
	2035 Action	RH WRRF Effluent (lb/day)	1,659	2.9 percent
		OH WRRF Effluent (lb/day)	13,446	0.4 percent
		Gowanus Canal CSOs (lb/year)	105,736	-5.0 percent

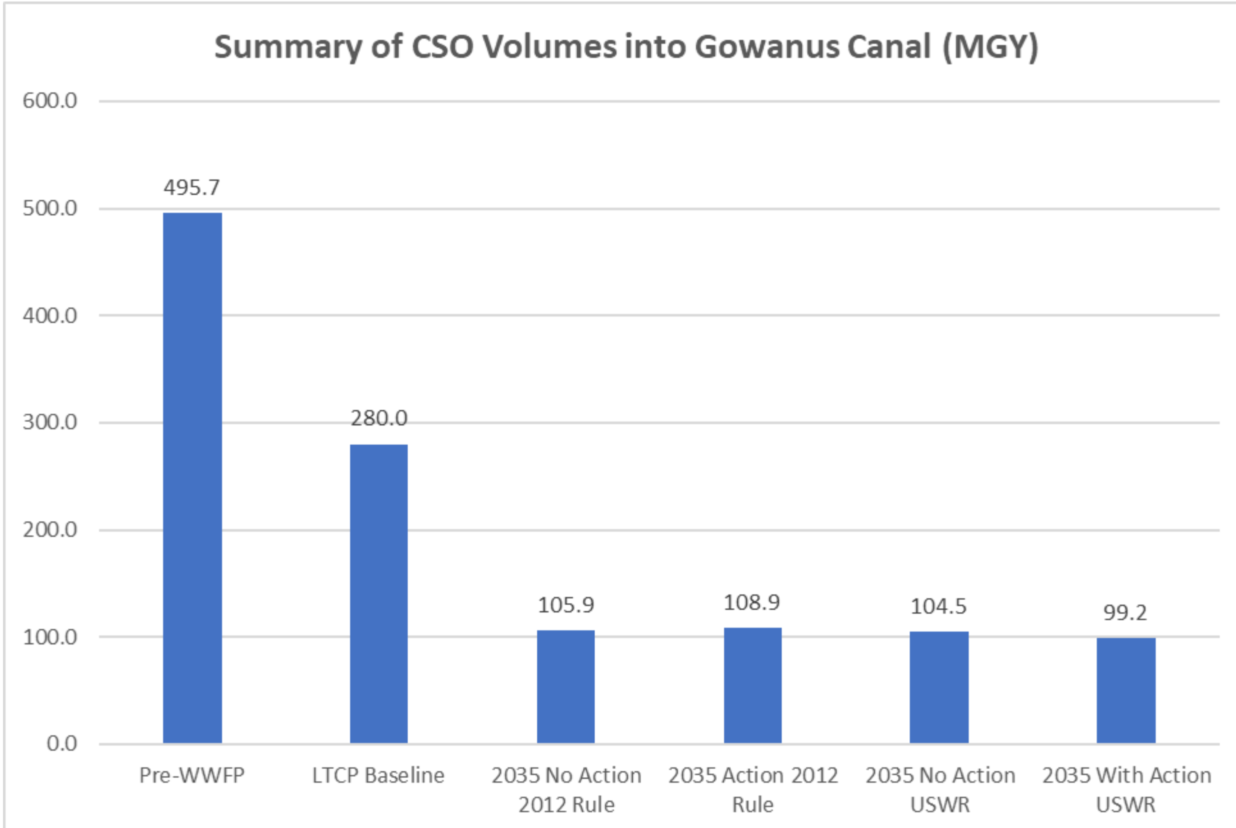

Figure 4-3: Comparison of CSO Volumes from DEP Projects

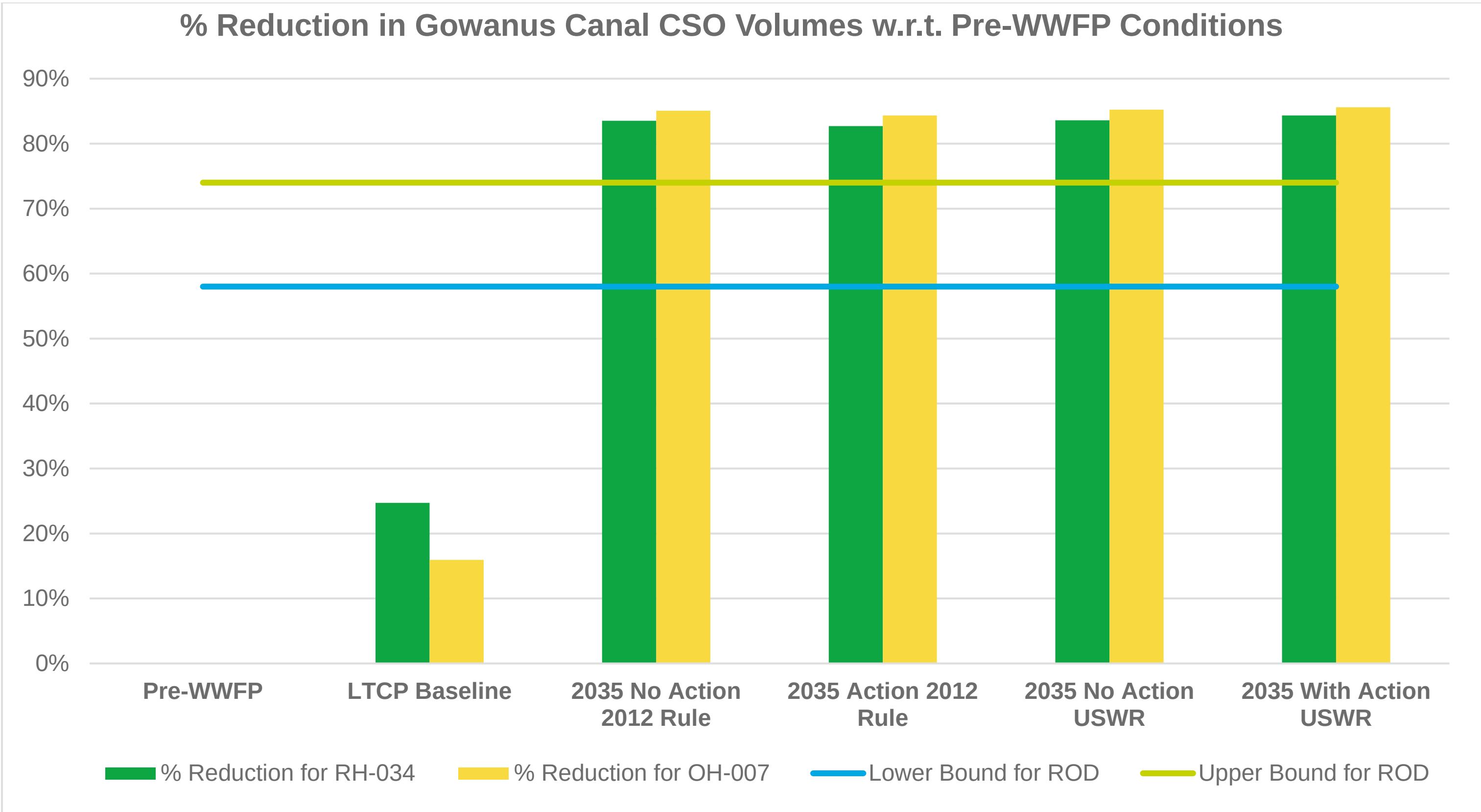

Figure 4-4: Percent Reductions in CSO Volumes w.r.t. Pre-WWFP

5 CONCLUSIONS

A comparative evaluation of the Without Rezoning and With Rezoning scenarios showed that the upcoming Unified Stormwater Rule implemented in RWCDS lots in the With Rezoning scenario would reduce flooding extent within the ADP drainage area that includes the rezoning area. CSO volumes discharged into Gowanus Canal (by about 5 percent) and their frequencies of discharges in the typical year of 2008 would also be reduced.

With the use of 2012 Stormwater Rule for the RWCDS lots and background growth, the flooding extent and surface flooding volume decrease for the With Action scenario. USWR provides further reduction in surface flooding volume due to the restricted detention and some retention. A marginal increase in CSO discharges is expected with the 2012 Stormwater Rule as it would provide negligible benefits for small to medium storms that occur in the typical year.

The flows into the two WRRFs would increase due to increases in sanitary flows associated with rezoning. Flow projections performed by DEP for the WRRFs account for rezoning initiatives such as Gowanus Rezoning and the total dry weather flows including the increased sanitary flows from RWCDS lots are well within the DDWF capacities for the RH and OH WRRFs. Effluent loads increase by about 3 percent in the RH WRRF and by 0.4 percent in the OH WRRF and the increased sanitary flows are treated in accordance with the respective SPDES permits for the two WRRFs.

Based on the comprehensive analyses on sewer flooding, CSO pollutant loads, and the effluent loads at the two WRRFs, the proposed Gowanus rezoning is not projected to have incremental impacts on water quality in Gowanus Canal or the East River and Lower New York Bay where the two WRRF effluents are discharged into.

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